Research paper

Sleep problems during COVID-19 pandemic and its’ association to psychological distress: A systematic review and meta-analysis

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ABSTRACT

Background: The emerging novel coronavirus disease 2019 (COVID-19) has become one of the leading cause of deaths worldwide in 2020. The present systematic review and meta-analysis estimated the magnitude of sleep problems during the COVID-19 pandemic and its relationship with psychological distress.

Methods: Five academic databases (Scopus, PubMed Central, ProQuest, ISI Web of Knowledge, and Embase) were searched. Observational studies including case-control studies and cross-sectional studies were included if relevant data relationships were reported (i.e., sleep assessed utilizing the Pittsburgh Sleep Quality Index or Insomnia Severity Index). All the studies were English, peer-reviewed papers published between December 2019 and February 2021. PROSPERO registration number: CRD42020181644.

Findings: 168 cross-sectional, four case-control, and five longitudinal design papers comprising 345,270 participants from 39 countries were identified. The corrected pooled estimated prevalence of sleep problems were 31% among healthcare professionals, 18% among the general population, and 57% among COVID-19 patients (all p-values < 0.05). Sleep problems were associated with depression among healthcare professionals, the general population, and COVID-19 patients, with Fisher’s Z scores of -0.28, -0.30, and -0.36, respectively. Sleep problems were positively (and moderately) associated with anxiety among healthcare professionals, the general population, and COVID-19 patients, with Fisher’s z scores of 0.55, 0.48, and 0.49, respectively.

Interpretation: Sleep problems appear to have been common during the ongoing COVID-19 pandemic. Moreover, sleep problems were found to be associated with higher levels of psychological distress. With the use of effective programs treating sleep problems, psychological distress may be reduced. Vice versa, the use of effective programs treating psychological distress, sleep problems may be reduced.

Funding: The present study received no funding.

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1. Introduction

Prior to 2020, respiratory diseases were the fourth leading cause of death [1]. However, with the outbreak of the novel coronavirus disease 2019 (COVID-19) in December 2019, respiratory infections caused more deaths due to COVID-19 [2]. According to the World Health Organization (WHO) as of April 16, 2021, there were over 137,866,000 known cases of COVID-19 and over 2,965,000 cases of COVID-19 death worldwide [3].

Prior research has found that the prevalence of COVID-19 is associated with major psychological distress and significant symptoms of mental health illness [4-8]. The sudden onset of a threatening illness
puts great pressure on healthcare workers [9]. Consequently, healthcare workers may have impaired sleep because they need to deal with the illness, suffer from the high risk of death, and adapt to irregular work schedules and frequent shifts [10-15]. They may experience sleep problems, anxiety, depression, and stress when faced with this major public health threat [16-18]. Due to their job demands, they are in frequent contact with patients and therefore suffer from extremely high-level stress. Therefore, they may develop acute sleep problems, including poor sleep quality and experience too little sleep [19]. Given that healthcare professionals are the frontline workers who take care of patients, their health is extremely important. More specifically, if healthcare providers have any health issues that prevent them from taking care of patients, their local communities more specifically, and their country more generally, will encounter a huge challenge of healthcare burden and consequently impact on all residents’ health.

In addition to healthcare workers, the general population is likely to develop mental health and sleep problems due to the impacts of COVID-19 [20] because a substantial change in lifestyle is a huge stressor [21,22]. For example, individuals may need to self-isolate and quarantine at home, avoid social activities for leisure and recreation that they had participated in previously, and strictly obey the new policies to minimize spread of the virus (e.g., wearing a mask in public areas) [23,24]. The general population may also receive threatening information such as daily statistics concerning COVID-19 infection and deaths reported from the news or social media [25,26]. With the lifestyle changes and threatening information, the general population may avoid contact with other individuals due to great fear of infection, developing feelings of helplessness or suffering from panic [27]. In other words, the general population might experience psychological problems directly due to the COVID-19 pandemic [28].

Different factors contributing to insomnia and psychological problems have been reported. The most important risk factors for insomnia and mental health problems during the COVID-19 pandemic are being a healthcare worker, having an underlying illness, living in rural areas, being a woman, and being at risk of contact with COVID-19 infected patients. Among non-medical healthcare workers, having an underlying disease is a risk factor for insomnia and mental health problems [29]. Indeed, among the natural and non-natural disasters that can occur to humans, the COVID-19 pandemic has caused severe psychological distress due to the large number of individuals affected globally and the contagious and deadly nature of the virus [30]. The COVID-19 pandemic as a worldwide public health issue is a traumatic event that has affected both the sleep and mental health of the general public and healthcare providers [31-35]. Moreover, several policies implemented to reduce the spread of COVID-19 (e.g., quarantine) have been found to have some negative effects on individuals’ psychological health [34].

Because sleep is important for human beings to maintain daily functions [36], several studies have focused on sleep problems all with the use of self-report data during the COVID-19 pandemic. Different findings regarding the sleep and psychological problems during COVID-19 in different populations have been reported among these studies. For example, Zhang et al. reported that the prevalence of insomnia was higher among non-medical healthcare workers (e.g., students, community workers, and volunteers) than among medical healthcare workers (prevalence rate of 38.4 vs. 30.5%, p<.01). Wang et al. reported higher prevalence of sleep problem among medical staff compared to non-medical staff comprising students, community workers, and volunteers (66.1% vs. 47.8, p<.01) and frontline healthcare providers compared to non-frontline medical workers (68.1 vs. 64.5, p=0.14) [37].

The quality of sleep during the COVID-19 pandemic and its related factors have been reported in an increasing number of studies. A recent study conducted a meta-analysis to understand the sleep problems during the COVID-19 pandemic [38]. The study found that the pooled prevalence rate of sleep problems globally was 35.7%, with the most affected group being patients with COVID-19 (74.8%), followed by healthcare providers (36.0%), and the general population (31.0%). In addition, sleep difficulties and psychological distress due to COVID-19 on those patients with COVID-19 were reported in a cohort study [39]. Patients with COVID-19 had sleep difficulties, depression, and anxiety at six months after acute infection. Another systematic review found the associations between COVID-19 and psychiatric symptoms among patients with mental illness, healthcare workers, and non-healthcare workers [40]. However, only the information on sleep difficulties has been well analyzed using robust meta-analysis method. Therefore, psychological distress and the associations between sleep problems and psychological distress have yet to be synthesized. Given the significant number of published studies on sleep quality, psychological distress, and related factors, and the importance of systematic reviews and meta-analyses in summarizing and analyzing the results of existing studies, the present study was designed and conducted with the aim of estimating sleep problems during the COVID-19 period (January to October, 2020) and its relationship with psychological distress.

2. Methods

The present systematic review was conducted utilizing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [41]. A systematic literature search was carried out utilizing five academic databases, and relevant studies were extracted and their methodological quality was assessed using the Newcastle Ottawa Scale (NOS) checklist. Findings were synthesized using a meta-analysis approach. The protocol was registered in the PROSPERO International prospective register of systematic reviews (ID code: CRD42020181644 [42]).

2.1. Search strategy

Five academic databases including Scopus, PubMed Central, ProQuest, ISI Web of Knowledge, and Embase were searched
systematically between February 17 to 19, 2021. The search terms were extracted from published reviews and primary studies in addition to PubMed Medical Subject Headings (MeSH). The main search terms were ‘sleep’ and ‘COVID-19’. The Boolean search method (AND/OR/NOT) was used to develop the search. Search syntax was customized based on the advanced search attributes of each database. The full search strategy for each database is provided in Supplementary Table 1. Additionally, further sources (i.e., reference lists of included studies and systematic reviews of published papers) were searched to increase the likelihood of retrieving relevant empirical studies.

2.2. Inclusion criteria

Observational studies including case-control studies and cross-sectional studies were included if relevant data relationships were reported (i.e., sleep assessed using the Pittsburgh Sleep Quality Index or Insomnia Severity Index). More specifically, if the studies were included if they estimated the prevalence of sleep disorders and/or examined the relationship between sleep and psychological distress using Pearson’s correlation coefficient (e.g., if the odds ratio [OR] information reported by the studies could be converted into Pearson’s correlation coefficient; detailed information in 2.6 Data synthesis). English, peer-reviewed papers published between December 2019 and August 2020 were included. There were no limitations regarding participants’ characteristics.

2.2.1. Primary outcome

Estimation of sleep problems frequency was the primary outcome. Sleep problems were defined in a broad category of sleep disorders characterized by either hypersomnolence or insomnia. The three major subcategories of sleep problems were intrinsic (i.e., arising from within the body), extrinsic (secondary to environmental or pathological conditions), and disturbances of circadian rhythm. Sleep problems had to have been assessed using valid and reliable psychometric scales or confirmed with defined cut-off points for characterizing as sleep problems. More specifically, Pittsburgh Sleep Quality Index (PSQI) and Insomnia Severity Index (ISI) were used to assess the primary outcomes because PSQI and ISI have items assessing the three major subcategories of the aforementioned sleep problems. For instance, a global score of 5 or more indicates poor sleep quality on the Pittsburgh Sleep Quality Index [43], or total score of 8 or more on the Insomnia Severity Index [44].

2.2.2. Secondary outcomes

There were three secondary outcomes: (i) association of sleep problems with psychological distress in the context of the COVID-19 pandemic; (ii) heterogeneity and its possible sources; and (iii) moderator variables in association of sleep problems and psychological distress related to COVID-19 pandemic. Ridner defined psychological distress (PD) as: “a state in response to stressors marked by perceived discomfort and inability to cope” [45]. In the present study, psychological distress was considered as either depression (defined as having depressed mood) and/or anxiety (defined as having excessive worry and being nervous). These had to have been assessed using valid and reliable psychometric scales. That is, studies were excluded if psychological distress was assessed using a non-psychometrically validated self-designed questionnaire. Moreover, in the present systematic review and meta-analysis, depression, and anxiety were treated as continuous variables.

2.3. Study screening and selection

In the first step, title and abstract of all retrieved papers were screened independently by two researchers based on the inclusion criteria. The full texts of potentially relevant studies were further
| ID | Authors | Year | Country | Collection Date | Lockdown Period | Design | Participant Group | Sample Size | Sex % Female | % Married | Mean Age/Age range (Years) | NOS | Sleep Problem Scale | Psychological Distress Scale |
|----|---------|------|---------|-----------------|-----------------|--------|-------------------|-------------|--------------|-----------|--------------------------|-----|------------------|---------------------------|
| 2  | Xiao [67] | 2020 | China   | January and February 2020 | no | Cross-sectional | Medical Staff | 180 | 71.7 | 67.8 | 32.3 | 5 | PSQI | Self-Rating Anxiety Scale |
| 3  | Zhang [68] | 2020 | China | 29 January to 3 February 2020 | no | Cross-sectional | Medical staff | 1563 | 82.73 | 63.92 | 18 to above 60 | 5 | ISI | GAD-7, PHQ-9 |
| 4  | Huang [69] | 2020 | China | 3 February to 10 February 2020 | no | Cross-sectional | Volunteer population | 603 | 69 | 36.5 | 5 | PSQI |
| 5  | Xiao [70] | 2020 | China | January 2020 | yes | Cross-sectional | Individuals who self-isolated | 170 | 40.5 | 64.7 | 37.78 | 4 | PSQI |
| 6  | Zhang [29] | 2020 | China | January 19 to March 6, 2020 | no | Cross-sectional | Medical health workers | 2182 | 64.2 | 82 | less than 18 to above 60 | 5 | ISI |
| 7  | Wang [68] | 2020 | China | 26 February and 3 March, 2020 | no | Cross-sectional | Medical staff | 274 | 77.4 | 81.8 | 37 | 5 | PSQI |
| 8  | Marelli [84] | 2020 | Italy | March 24 to May 3, 2020 | no | Cross-sectional | University students and staff | 400 | 75.8 | 29.93 | 5 | PSQI |
| 9  | Wu [85] | 2020 | China | February 2020 | no | Case-control | Frontline vs. non-frontline clinical staff | 120 | 74.15 | 33.65 | 4 | PSQI |
| 10 | Gualano [86] | 2020 | Italy | April 19th and May 3rd 2020 | yes | Cross-sectional | General population | 1515 | 65.6 | 61.1 | 42 | 5 | ISI | GAD-7, PHQ-9 | (continued on next page)
| ID | Authors | Year | Country | Collection Date | Lockdown Period | Design | Participant Group | Sample Size | Sex % | % Married | Mean Age/Age range (Years) | NOS | Sleep Problem Scale | Psychological Distress Scale |
|----|---------|------|---------|-----------------|-----------------|--------|-------------------|-------------|-------|-----------|-------------------------|------|---------------------|-----------------------------|
| 53 | Peng [87] | 2020 | China   | February 14 to March 4, 2020 | yes | Cross-sectional | General population | 2237 | 41.66 | 68.44 | 35.93 | 5 | PSQI | Zung’s Self-Rating Depression Scale (SDS) & Self-rating anxiety scale |
| 57 | Pieh [88] | 2020 | Austria | April 15th to 30th, 2020 | yes | Cross-sectional | General population | 1005 | 52.7 | | 18 to above 65 | 6 | IBI | Self-Rating Anxiety Scale |
| 59 | Zhao [89] | 2020 | China   | February 18 to 25, 2020 | no | Cross-sectional | General population | 1630 | | | | 5 | PSQI | |
| 61 | Huang [90] | 2020 | China   | February 3 to 17, 2020 | no | Cross-sectional | General public | 7236 | 54.6 | | | 4 | PSQI | |
| 63 | Assenza [91] | 2020 | Italy   | April 11, 2020 | no | Cross-sectional | General population | 928 | 74.46 | 41.81 | 40.10 | 5 | PSQI | Beck Depression Inventory- II |
| 64 | Que [92] | 2020 | China   | February 2020 | no | Cross-sectional | Healthcare workers | 2285 | 69.06 | | | 5 | IBI | |
| 65 | Zhuo [67] | 2020 | China   | March 2020 | no | Cross-sectional | Medical staff | 26 | 46.15 | | | 5 | IBI | |
| 67 | Mazza [93] | 2020 | Italy   | April 6 to June 9, 2020 | no | Cross-sectional | COVID-19 survivors | 402 | 65.92 | | | 6 | MOSS | |
| 68 | Song [94] | 2020 | China   | 9–22 April, 2020 | no | Cross-sectional | People resuming Work Medical staff | 709 | 74.2 | | 35.35 | 5 | IBI | |
| 69 | Wang [95] | 2020 | China   | 2nd and 3rd February 2020 | no | Cross-sectional | | 1045 | 85.8 | | | 7 | IBI | |
| 70 | Shi [96] | 2020 | China   | February 28 to March 11, 2020 | no | Cross-sectional | General population | 56932 | 52.1 | 77.2 | 35.97 | 7 | IBI | GAD-7 |
| 71 | Hao [97] | 2020 | China   | 19 to 22 February 2020 | yes | Case control | Psychiatric patients (n = 76); Healthy controls (n = 109) | 185 | 49.75 | | 32.95 | 4 | IBI | DASS-21 |
| 72 | Cabañero-Domínguez [98] | 2020 | Colombia | March 30 to April 8, 2020 | yes | Cross-sectional | | 700 | 68.0 | 48 | 37.1 | 6 | AS | WHO-5 (Depression) |
| 73 | Liu [99] | 2020 | USA     | April 13 to May 19, 2020 | no | Cross-sectional | Young adults with suspected and reported psychiatric diagnoses | 898 | 81.3 | | 24.47 | 5 | MOSS | Sleep Problems |
| 74 | Stojanov [100] | 2020 | Serbia  | | no | Cross-sectional | Healthcare professionals | 201 | 65.95 | | 40.8 | 3 | PSQI | GAD-7, Self-rating Depression Scale |
| 76 | Cheng [101] | 2020 | China   | February 9th to the 13th, 2020 | no | Cross-sectional | Medical staff | 534 | 82.4 | | | 6 | PSQI | self-rating anxiety scale |
| 77 | Cellini [102] | 2020 | Italy   | March 24 to 28, 2020 | yes | Cross-sectional | COVID-19 lockdown | 1310 | 67.18 | | | 3 | PSQI | |
| 78 | Amelio [103] | 2020 | Italy   | March 15 to April 15, 2020 | no | Cross-sectional | General practitioners | 131 | 48.1 | 70.2 | 52.31 | 3 | IBI | |
| 79 | Cai [104] | 2020 | China   | February 11 to 26, 2020 | no | Case-control | Frontline and non-frontline medical workers | 2346 | 70 | 83.2 | 30.55 | 5 | IBI | |

(continued on next page)
| ID | Authors          | Year | Country       | Collection Date | Lock down Period | Design          | Participant Group                              | Sample Size | Sex % | Married Mean Age/Age range (Years) | NOS | Sleep Problem Scale | Psychological Distress Scale |
|----|-----------------|------|---------------|-----------------|------------------|-----------------|----------------|---------------------------------|-------------|-------|---------------------------------|-----|---------------------|-----------------------------|
| 82 | Wang [37]       | 2020 | China         | March 4 to 9, 2020 | no               | Cross-sectional | Healthcare workers | 2737           | 64.5  | 70.9 18-65                      | 6   | PSQI                 | HADS                        |
| 85 | Idissi [105]    | 2020 | Morocco       | April 1 to May 1, 2020 | yes             | Cross-sectional | General population | 846            | 52.2  | 35.9                            | 5   | AS, ESS               | Hamilton Anxiety Rating Scale (HARS) and Beck Depression Inventory (BDI) GAD-7 PHQ-9 |
| ID  | Authors                  | Year | Country    | Collection Date                          | Lockdown Period | Design            | Participant Group                          | Sample Size | Sex % Female | % Married | Mean Age (Years) | NOS  | Sleep Problem Scale                  | Psychological Distress Scale |
|-----|--------------------------|------|------------|------------------------------------------|-----------------|-------------------|-------------------------------------------|-------------|--------------|-----------|----------------|-------|---------------------------------------|-----------------------------|
| 495 | Yang [128]               | 2020 | China      | January to May 2020                       | no              | Cross-sectional   | Young cancer patients                      | 197         | 54.82        | 36.50     | less than 30 to above 60          | 5     | PSQI                                 | self-rating Anxiety Scale |
| 490 | Cabraller-o-Dominguez     | 2020 | Colombia   | March 30 to April 8, 2020                 | yes             | Cross-sectional   | General population                         | 700         | 68           | 48        | 37.10          | 8     | AIS                                  | Well-Being Index            |
| 462 | Khames [130]             | 2020 | Oman       | First two weeks of April 2020             | no              | Cross-sectional   | Healthcare professionals                    | 402         | 100          | 77.30     | 36.40          | 5     | SQS                                  | GAD-7                      |
| 472 | Sariudo [131]            | 2020 | Spain       | One-week period from February 2020        | no              | Cross-sectional   | General population                         | 20          | 47           | 22.60     | 6 ISI           | 8     | PSQI                                 | GAD-7                      |
| 460 | Jain [132]               | 2020 | India      | 12 to 22 May 2020                         | no              | Cross-sectional   | Anesthesiologists                           | 512         | 44.30        | 64.70     | 7 ISI           | 6     | ISI                                  | GAD-7                      |
| 454 | Agberotimi [133]         | 2020 | Nigeria     | March 20 to April 19, 2020                | yes             | Cross-sectional   | General population + healthcare professionals | 884         | 45.50        | 65.30     | less than 18 to above 60          | 6     | ISI                                  | GAD-7                      |
| 447 | Bhat [134]               | 2020 | Kashmir     | 4 to 10 April 2020                        | no              | Cross-sectional   | General population                         | 264         | 27.70        | 55.00     | 36.90          | 6     | ISI                                  | GAD-7                      |
| 442 | McCracken [135]          | 2021 | Sweden      | 14th of May and the June 11, 2020         | no              | Cross-sectional   | General population                         | 1102        | 75.20        | 56.30     | less than 18 to above 60          | 6     | ISI                                  | GAD-7                      |
| 439 | Trabelsi [136]           | 2021 | Multi-country | 6 April to 28 June 2020                    | no              | Cross-sectional   | General population                         | 5056        | 59.40        | 50.20     | 64.30          | 6     | ISI                                  | GAD-7                      |
| 438 | Chi [137]                | 2020 | China       | May 13 and 20, 2020                       | no              | Cross-sectional   | Adolescents                                 | 1794        | 43.90        | 54.90     | less than 18 to above 55          | 6     | ISI                                  | GAD-7                      |
| 420 | Liu [138]                | 2021 | China       | February 1 to 10th in 2020                | no              | Cross-sectional   | General population                         | 2858        | 53.60        | 60.20     | 15.26          | 7     | YSIS                                 | GAD-7                      |
| 410 | Alamrawy [139]           | 2021 | Egypt       | 2 July to 23 July 2020                    | no              | Cross-sectional   | Young adults aged between 14 and 24 years   | 447         | 70.20        | 22.60     | 64.00          | 8     | PSQI                                 | GAD-7                      |
| 408 | Harauvuri [140]          | 2020 | Finland     | 4 June to 26 June 2020                    | no              | Cross-sectional   | General population + healthcare professionals | 4804        | 87.50        | 45        | 6 ISI           | 6     | ISI                                  | GAD-7                      |
| 405 | Khaled [141]             | 2021 | Qatar       | Feb-20                                    | no              | Cross-sectional   | General population                         | 1160        | 53.20        | 79.30     | above 18         | 8     | Sleep Condition Indicator (SCI-02) | GAD-7                      |
| 403 | Alomayri [142]           | 2020 | Saudi Arabia | July and August 2020                      | no              | Cross-sectional   | General population + healthcare professionals | 400         | 86           | 18 to above 55 | less than 18 to above 60 | 7     | PSQI                                 | GAD-7                      |
| 397 | Akina [143]              | 2021 | Turkey      | April and May of 2020                     | no              | Cross-sectional   | Patients hospitalized with COVID-19          | 189         | 41           | 82.50     | 46.27          | 6     | ISI                                  | HADS                       |
| 394 | Barua [144]              | 2021 | Bangladesh  | 1st April to 30th May 2020                | no              | Cross-sectional   | Healthcare professionals                    | 370         | 39.70        | 66.80     | 30.50          | 8     | Sleep Condition Indicator (SCI-02) | GAD-7                      |
| 391 | Wang [145]               | 2020 | China       | February 3 to 7, 2020                     | no              | Cross-sectional   | General population                         | 19372       | 51.96        | 11 or older | less than 18 to above 60 | 6     | ISI                                  | GAD-7                      |
| 389 | Fidanoci [146]           | 2020 | Turkey      | May-20                                    | no              | Cross-sectional   | Healthcare professionals                    | 153         | 67.30        | 33.40     | 30.50          | 5     | PSQI                                 | GAD-7                      |
| 382 | Chouchou [147]           | 2020 | France      | 0                                         | no              | Cross-sectional   | General population                         | 400         | 58.25        | 29.80     | 6 ISI           | 6     | PSQI                                 | GAD-7                      |
| 378 | Cheng [148]              | 2020 | UK & US     | 16 - 22 March 2020- 18 - 24 May 2020      | no              | Cross-sectional   | General population                         | 2278        | 53.5         | 95.90     | 18 to above 50    | 5     | PSQI                                 | PROMIS                     |
| 376 | Gu [187]                 | 2020 | China       | February 15-22, 2020                      | no              | Cross-sectional   | Patients with COVID-19                      | 461         | 64.90        | 95.90     | 18 to above 50    | 5     | ISI                                  | GAD-7                      | (continued on next page)
| ID | Authors          | Year | Country      | Design          | Collection Date          | Sample Size | Age/Mean Age (Years) | Gender | Marital Status     | Anxiety Depression Scale | Psychological Distress Scale | Sleep Disturbance Scale |
|----|------------------|------|--------------|-----------------|--------------------------|-------------|----------------------|--------|-------------------|--------------------------|------------------------------|------------------------|
| 371| Pedrozo-Pupo     | 2020 | Colombia     | Cross-sectional | April 28 to May 12, 2020 | 106         | 25-50                | Female | 64.70             | 60.40                     | PSQI                          | PHQ-9                   |
| 370| Targa           | 2020 | Spain        | Cross-sectional | March 10 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 357| Ge              | 2020 | Vietnam      | Cross-sectional | March 18 to April 4, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 356| Than            | 2020 | China        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 355| Youssef          | 2020 | Egypt        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 354| Massicotte       | 2021 | Canada       | Cross-sectional | April 28 to May 12, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 353| Zhang           | 2020 | China        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 352| Zreik           | 2021 | Israel       | Cross-sectional | April 28 to May 12, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 351| Li              | 2020 | China        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 350| Xie             | 2020 | China        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 349| Wang            | 2020 | China        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 348| Almater         | 2020 | Saudi Arabia | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 347| Gupta           | 2020 | India        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 346| Martínez-de-Quel | 2021 | Spain        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 345| Khoury          | 2021 | Canada       | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 344| Yang            | 2020 | China        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 343| Zhang           | 2020 | China        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 342| Z. Alimoradi     | 2021 | Canada       | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 341| Poyraz          | 2021 | Istanbul     | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 340| Chen            | 2021 | China        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 339| Lahiri          | 2021 | India        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 338| Essangri        | 2021 | Morocco      | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 337| Yitayih         | 2020 | Ethiopia     | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 336| Xie             | 2020 | China        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |
| 335| Zhang           | 2020 | China        | Cross-sectional | April 6 to April 18, 2020 | 106         | 25-50                | Female | 40.70             | 30.30                     | PSQI                          | PHQ-9                   |

(continued on next page)
| ID | Authors | Year | Country | Collection Date | Design | Participant Group | Sample Size | Sex % Female | % Married | Mean Age/Age range (Years) | NOS | Sleep Problem Scale | Psychological Distress Scale |
|----|---------|------|---------|-----------------|--------|--------------------|-------------|-------------|----------|--------------------------|-----|------------------|--------------------------|
| 70 | Cellini [174] | 2021 | Italy & Belgium | April 1st to May 19th, 2020 | Data on both prior and during locking period | Cross-sectional | General population | 2272 | 75.25 | 38.55 | 6 PSQI | - |
| 75 | Lin [119] | 2021 | Hong Kong | 20 February to 29 February 2020 | no | Cross-sectional | General population | 1897 | 43.6 | 36.6 | 7 PSQI | 0 |
| 80 | Sunil [175] | 2021 | India | June to July 2020 | no | Cross-sectional | Medical staff | 313 | 64.5 | - | 8 ISI | PSQI, GAD |
| 81 | Yadav [176] | 2021 | India | June to August 2020 | no | Cross-sectional | COVID-19 patients | 100 | 27 | 42.9 | 5 ISI | PSQI, GAD |
| 82 | Scotta [177] | 2020 | Argentina | 0 | yes | Cross-sectional | University students | 584 | 81 | 42 | 6 ISI | 0 |
| 84 | He [178] | 2020 | China | 29 February 2020 to 1 May 2020 | no | Cross-sectional | General population, healthcare workers and quarantined population | 2689 | 70.1 | 42.84 | 56.84 | 6 PSQI | PSQI, GAD |
| 85 | Zhang [179] | 2020 | China | February 16th to 2020 March 20th, 24 to 31 March 2020 | no | Cross-sectional | General population | 524 | 74.4 | 80 | 34.87 | 6 ISI | PSQI, GAD |
| 87 | Demartini [180] | 2020 | Italy | February 1 to 19, 2020 | no | Cross-sectional | Breast cancer patients and female nurses | 432 | 72 | 35.9 | 6 PSQI | DASS-21 |
| 91 | Cui [181] | 2020 | China | February 16th to 2020 March 20th, 24 to 31 March 2020 | no | Cross-sectional | General population + healthcare professionals | 891 | 100 | 74.21 | 18 to above 40 | 9 ISI | PSQI, GAD |
| 92 | Bacaró [182] | 2020 | Italy | 1st of April to 4th May 2020 | yes | Cross-sectional | General population | 1989 | 76.17 | 38.4 | 7 ISI | HADS |
| 93 | Gu [183] | 2020 | China | February 21 to 28, 2020 | no | Cross-sectional | General population | 522 | 77.6 | 62.1 | 18 to above 40 | 9 ISI | PSQI, GAD |
| 95 | Liu [184] | 2020 | China | February 14 to March 29, 2020 | no | Cross-sectional | Healthcare workers | 606 | 81.2 | 74.91 | 35.77 | 9 ISI | PSQI, GAD |
| 96 | Wang [185] | 2020 | China | February 10-20, 2020 | no | Cross-sectional | General population | 4191 | 62 | 81.63 | 36.15 | 9 ISI | PSQI, GAD |
| 106 | Zhou [80] | 2020 | China | February 28-March 12, 2020 | no | Cross-sectional | General population of pregnant and non-pregnant women | 859 | 100 | 93.25 | 33.25 | 9 ISI | PSQI, GAD |
| 109 | Abdulah [186] | 2020 | Iraq | 0 | no | Cross-sectional | Healthcare workers | 268 | 29.9 | 35.06 | 8 Athens Insomnia Scale | 0 |
| 112 | Zhou [106] | 2020 | China | February 14 to March 29, 2020 | no | Cross-sectional | General population + healthcare professionals | 1705 | 73.61 | 50.85 | 32.5 | 9 ISI | PSQI, GAD |
| 113 | Ren [95] | 2020 | China | February 14 to March 29, 2020 | no | Cross-sectional | General population | 1705 | 73.61 | 50.85 | 32.5 | 9 ISI | PSQI, GAD |
| 114 | Cai [187] | 2020 | China | February 28-March 12, 2020 | no | Cross-sectional | General population | 1172 | 69.3 | 39.3 | 22 | 7 ISI | PSQI, GAD |
| 116 | Giardino [82] | 2020 | Argentina | Jun-20 | no | Cross-sectional | Healthcare workers | 1059 | 72.7 | 41.7 | 7 ISI | 0 |
| 118 | Koorevaara [188] | 2020 | Netherlands | 0 | yes | Cross-sectional | General population | 667 | 7 | 0 |
| 119 | Zhang [189] | 2020 | China | February 5, 2020, to March 6, 2020 | no | Cross-sectional | COVID-19 patients | 30 | 50 | 80 | 42.5 | 9 ISI | PSQI, GAD |
| 120 | Fazeli [190] | 2020 | Iran | 2 May to 26 August 2020 | no | Cross-sectional | Adolescents | 1512 | 43.6 | 15.51 | 9 ISI | DMSS-21 |
| 123 | Bajaj [191] | 2020 | India | yes | Cross-sectional | General population | 391 | 53.45 | 18 to above 40 | 7 ISI | 0 |

(continued on next page)
| ID | Authors          | Year | Country           | Collection Date                  | Lock down Period | Design          | Participant Group                        | Sample Size | Sex % | Married | Mean Age/ Age range (Years) | NOS | Sleep Problem Scale | Psychological Distress Scale |
|----|------------------|------|-------------------|-----------------------------------|-----------------|----------------|------------------------------------------|-------------|-------|---------|-------------------------|-----|----------------------|----------------------------|
| 125 | Kilani [192]     | 2020 | Arab Countries    | 25th March 2020 - 1st April 2020 | 17th - 24th April 2020 | no | Cross-sectional | General population | 1723 | 46.78 | 55 | 34.9 | 9 | PSQI | 0 |
| 126 | Necho [193]      | 2020 | Ethiopia          | 17th/C0                          | 24th, April 2020 | no | Cross-sectional | General population | 423 | 40.7 | 51.4 | 36.66 | 9 | ISI | PHQ |
| 127 | Şahin [194]      | 2020 | Turkey            | 23 April and 23 May 2020 - 15-May-20 | no | Cross-sectional | Healthcare workers | 939 | 66 | 65.7 | 18 to above 40 | 9 | ISI | PHQ | PHQ |
| 128 | Call [195]       | 2020 | USA               | 25th March 2020 - 1st April 2020 | no | Cross-sectional | Healthcare workers | 573 | 72 | 72 | 43.4 | 9 | RDC definition of insomnia disorder |
| 129 | Lai [196]        | 2020 | UK                | April 28 through May 12, 2020    | no | Cross-sectional | International university students | 124 | 63.7 | 63.7 | 9 | PSQI | 0 |
| 130 | Wang [197]       | 2020 | China             | February 21 to March 7, 2020     | no | Cross-sectional | College students | 3092 | 66.4 | 66.4 | 9 | ISI | PHQ |
| 131 | Sahin [198]      | 2020 | Turkey            | 23 April and 23 May 2020 - 15-May-20 | no | Cross-sectional | Healthcare workers | 939 | 66 | 65.7 | 18 to above 40 | 9 | ISI | PHQ | PHQ |
| 132 | Lai [199]        | 2020 | USA               | March 18th to April 2nd, 2020    | no | Cross-sectional | General population | 2291 | 74.6 | 74.6 | above 18 | 9 | PSQI | 0 |
| 133 | Wang [200]       | 2020 | Italy             | March 1st to April 30th, 2020    | no | Cross-sectional | General population | 435 | 46.4 | 46.4 | 39.2 | 9 | ISI | CESD |
| 134 | Wang [201]       | 2020 | China             | April 10 to April 19, 2020       | yes | Cross-sectional | General population | 1515 | 44.3 | 44.3 | 45.2 | 9 | ISI | HADS |
| 135 | Zhang [202]      | 2020 | China             | March 2nd to 8, 2020             | no | Cross-sectional | General population | 3237 | 62.7 | 62.7 | 18 to above 64 | 9 | ISI | PHQ |
| 136 | Xia [203]        | 2020 | Italy             | April 20 to 30, 2020             | no | Cross-sectional | Patients with Parkinson’s disease | 288 | 51.85 | 51.85 | 60.50 | 9 | PSQI | 0 |
| 137 | Zanghi [204]     | 2020 | Italy             | 4 May to 22 May 2020              | no | Cross-sectional | Multiple sclerosis patients | 432 | 70.3 | 70.3 | 40.4 | 9 | ISI | 0 |
| 138 | Saracoglu [205]  | 2020 | Turkey            | 0                               | no | Cross-sectional | Healthcare workers | 220 | 29 | 29 | 9 | PSQI | PHQ |
| 139 | Ahsan [206]      | 2020 | Saudi Arabia      | May 2020 to August 2020          | no | Cross-sectional | Healthcare workers | 340 | 49.1 | 49.1 | 20-60 | 9 | PSQI | 0 |
| 140 | Sarawat- Dorinda | 2020 | India             | 0                               | no | Cross-sectional | Medical students in a COVID-19 treating | 217 | 20 | 20 | 9 | PSQI | DASS-21 |
| 141 | Alshekaili [207] | 2020 | Oman              | 8-17 April 2020                  | no | Cross-sectional | General population | 1985 | 75.9 | 75.9 | 36.83 | 9 | ISI | PHQ |
| 142 | Amin [208]       | 2020 | China             | February 16-19, 2020             | no | Cross-sectional | General population | 103 | 39 | 39 | 9 | ISI | PHQ | GAD |
| 143 | Yu [209]         | 2020 | China             | 6-20 April 2020                  | yes | Cross-sectional | Healthcare workers | 658 | 100 | 100 | 88.9 | 9 | ISI | PHQ |
| 144 | Wang [210]       | 2020 | China             | February 4 to February 18, 2020  | no | Cross-sectional | General population | 6347 | 56.13 | 56.13 | 38.99 | 9 | PSQI | 0 |
| 145 | Xia [211]        | 2020 | China             | April 20 to 30, 2020             | no | Cross-sectional | Healthcare workers | 270 | 73.7 | 73.7 | 18 to above 75 | 9 | AIS | PHQ |
| 146 | Khanal [212]     | 2020 | Nepal             | April 20 and May 12, 2020        | no | Cross-sectional | Healthcare workers | 475 | 37.1 | 37.1 | 28.2 | 8 | ISI | HADS |

(continued on next page)
examined based on the aforementioned criteria. In this process, relevant studies were selected.

2.4. Quality assessment

The Newcastle Ottawa Scale (NOS) was used to evaluate the methodological quality of the studies in observational studies. Three characteristics (i.e., selection, comparability, and outcome) were examined with the NOS checklist. The checklist has three versions for evaluating cross-sectional studies (seven items), case-control studies (eight items), and cohort studies (eight items). Despite a slight difference in number and content of items, each item is rated with a score, except comparability which can have two stars. This results in a maximum quality score of 9 for each study. Studies with less than 5 points are classified as having a high risk of bias [46]. No studies were excluded based on the quality rating. However, subgroup analysis was conducted to assess the impact of quality on pooled effect size.

2.5. Data extraction

A pre-designed form was prepared to extract data from included studies. Data including first author’s name, collection date, study design, country, number of participants, gender, mean age, scales used to assess psychological distress and sleep problems, numerical results regarding the frequency of sleep problems, and relationship between sleep problems and psychological distress. It should also be noted that study selection, quality assessment, and data extraction were processes performed independently by two reviewers. Disagreements were resolved through discussion.

2.6. Data synthesis

A quantitative synthesis using STATA software version 14 was conducted. Meta-analysis was run using random effect model because included studies were taken from different populations, and both within-study and between-study variances should be accounted for [47]. The Q Cochran statistic was used to assess heterogeneity. Also, the severity of heterogeneity was estimated using the I2 index. Heterogeneity is interpreted as (i) mild when I2 is less than 25%, (ii) moderate when I2 is 25 to 50%, (iii) severe when I2 is 50 to 75%, and (iv) highly severe when I2 is greater than 75% [48].

Two key measures were selected for present study: (i) prevalence of sleep problems and (ii) correlation of sleep problem with psychological distress. The numerical findings regarding prevalence of sleep problems were reported consistently in 177 included studies. This key measure and its 95% confidence interval (CI) are reported. However, the association between sleep problems and psychological distress was reported differently in the included studies. Pearson's correlation coefficient was the selected effect size for meta-analysis. Due to the inconsistency in reporting numerical findings of this association, the other effect sizes of standardized mean difference and crude odds ratio were transformed into Pearson’s correlation coefficients [49,50] using the Psychometrica website [51]. Also, Pearson’s r correlation coefficient was converted to Fisher’s z, due to the potential instability of variance. Consequently, all analyses were performed using Fisher’s z values as effect size (ES) [52,53]. Fisher’s z-transformation was applied using the following formula: \( z = 0.5 \times \ln \left(1+\frac{r}{1-r}\right) \). The standard error of z was calculated based on the following formula: \( SE_z = 1/\sqrt{(n-3)} \) [54]. Therefore, the selected measure of effect, selected for current meta-analysis, is expressed as Fisher’s z score and its 95% CI.

For assessing moderator analysis and finding the possible sources of heterogeneity, subgroup analysis or meta-regression was carried out based on the number of studies in each group. Moreover, the three subgroups for synthesized analyses (i.e., general population,
healthcare professionals, and patients) did not have any overlapping participants. More specifically, the general population did not include healthcare professionals or patients. If the number of studies in any group was less than four studies, meta-regression was used. Funnel plot and the Begg’s Test were used to assess publication bias [55]. The Jackknife method was used for sensitivity analysis [56].

2.7. Role of the funding source

The present systematic review and meta-analysis did not receive any specific funding. However, one of the authors (Dr. C-Y Lin) received a grant on COVID-19 research to support his works on COVID-19. The grant that Dr. Lin received had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

3. Results

3.1. Study screening and selection process

The initial search in five databases resulted in 7263 studies: Scopus (n=2518), ISI Web of Knowledge (n=474), PubMed (n=338), Embase (n=1426), and ProQuest (n=2507). After removing duplicate papers, a further 5647 papers were screened based on title and abstract. Finally, 555 papers appeared to be potentially eligible and their full-texts were reviewed. In this process, 177 studies met the eligibility criteria and were pooled in the meta-analysis. Figure 1 shows the search process based on the PRISMA flowchart.

3.2. Study description

All the included studies (N=177) collected the data online and comprised 345,270 participants from 39 different countries (Algeria, Argentina, Australia, Austria, Bahrain, Bangladesh, Belgium, Brazil, Canada, China, Colombia, Egypt, Ethiopia, Finland, France, Greece, India, Iran, Iraq, Israel, Italy, Lebanon, Malaysia, Morocco, Nepal, Netherlands, Nigeria, Oman, Pakistan, Palestine, Poland, Qatar, Saudi Arabia, Serbia, Spain, Sweden, Syria, Turkey, Tunisia, United Arab Emirates, UK, USA, and Vietnam). Of these, 28 studies collected data during the national lockdown period in the respective countries. The two countries with the highest number of eligible studies were China (N=76) and Italy (n=17). The smallest sample size was 20, and the largest sample size was 56,932. The mean age of participants varied from 15.26 years to 69.85 years. Approximately two-thirds of overall participants were females (63.5%) and one-third were married (35.33%). The most frequently used study design was cross-sectional (n=168). Four studies had a case-control design and five studies had a longitudinal design. In longitudinal studies, collected data during the COVID-19 pandemic were extracted. Various measures were used to assess sleep problems, with the Insomnia Severity Scale (ISI; n=93) and Pittsburgh Sleep Quality Index (PSQI; n=60) being the most frequently used scales in the studies. Psychological distress was also assessed with different measures, with the Patient Health Questionnaire (PHQ; n=73) and Generalized Anxiety Disorder Scale (GAD; n=75) being the most frequently used scales in the studies. Table 1 provides the summary characteristics of all included studies.

3.3. Quality assessment

As aforementioned, the maximum score on the NOS is 9 and a score less than 5 is classified as having a high risk of bias [46]. Based on this criterion, 130 studies were categorized as being high quality studies. The impacts of study quality were further assessed and reported in subgroup analysis. The most common problems were in selection of participants. Online sampling leads to non-representativeness of the sample, sample size being not estimated or justified, and number of non-respondents being not reported. The results of the quality assessment are provided in Figure 2.

3.4. Outcome measures

Three target groups of participants were studied: healthcare professionals (n=62), general population (n=105), and COVID-19 patients (n=10). Outcome measures are reported based on these target groups.

3.4.1. Sleep problems pooled prevalence based on participant target groups

3.4.1.1. Healthcare professionals. The pooled estimated prevalence of sleep problems among healthcare professionals was 43% [95% CI: 39-47%, I²:99.29%, Tau²:0.03]. Figure 3 provides the forest plot showing the pooled prevalence. Subgroup analysis (Table 2) and uni-variable meta-regression (Table 3), and multivariable meta-regression (Table 4) showed that none of the examined variables influenced the prevalence of sleep problems or heterogeneity. The probability of publication bias was assessed using Begg’s test and funnel plot. Based on Begg’s test (p=0.12) and funnel plot (Figure 4), the probability of
publication bias was confirmed. Due to probability of publication bias in estimation of pooled prevalence of sleep problems in healthcare professions, the fill-and-trim method was used to correct the results. In this method, 20 studies were imputed and the corrected results based on this method showed that pooled prevalence of sleep problems among healthcare professions was 0.31 (95% CI: 0.27 to 0.36; \( p < .001 \)). Funnel plot after trimming is provided in Figure 5. Also, sensitivity analysis showed that pooled effect size was not affected by a single study effect.

3.4.1.2. General population. The pooled estimated prevalence of sleep problems among the general population was 37% [95% CI: 35–40%; \( I^2: 99.77\% \), Tau\(^2\): 0.02]. Figure 6 provides the forest plot showing the pooled prevalence. Subgroup analysis (Table 2) showed that during lockdown, participants in longitudinal studies showed a significantly higher prevalence of sleep problems. Based on uni-variable meta-regression (Table 3), the country of residence was the other significant variable in prediction of prevalence of sleep problems among the general population. Also, multivariable meta-regression (Table 4) confirmed that country and lockdown period were significant influential factors on prevalence of sleep problems, explaining 26.32% of variance.

The probability of publication bias was assessed using Begg’s test and funnel plot. Based on Begg’s test (\( p = 0.01 \)) and funnel plot (Figure 7), the probability of publication bias was confirmed. Due to probability of publication bias in estimation of pooled prevalence of

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Figure 3. Forest plot displaying the estimated pooled prevalence of sleep problems among health professionals.
### Table 2
Results of subgroup analysis regarding estimated pooled prevalence

| Variable                  | Healthcare professionals (N=62) | General Population (N=105) | Covid-19 patients (N=10) |
|---------------------------|---------------------------------|-----------------------------|--------------------------|
|                          | No. of studies | Pooled prevalence (95% CI) | I² (%) | p for I² | No. of studies | Pooled prevalence and 95% CI | I² (%) | p for I² | No. of studies | Pooled prevalence and 95% CI | I² (%) | p for I² |
| Quality                   |                  |                             |        |          |                  |                             |        |          |                  |                             |        |          |
| Low quality               | 17               | 41 (33-48)                  | 98.99  | 0.47     | 23               | 33 (27-39)                  | 99.61  | 0.10     | 3                | 42 (27-57)                  | 97.8   | 0.04     |
| High quality              | 45               | 44 (39-49)                  | 99.76  | 0.71     | 82               | 38 (35-42)                  | 99.76  | 0.01     | 7                | 64 (49-71)                  | -      | -        |
| Lockdown period           |                  |                             |        |          |                  |                             |        |          |                  |                             |        |          |
| Yes                       | 3                | 45 (32-57)                  | -      | 0.81     | 29               | 46 (37-55)                  | 99.79  | 0.01     | -                | -                            | -      | -        |
| No                        | 59               | 43 (39-47)                  | 99.32  | 0.10     | 76               | 34 (31-37)                  | 99.71  | 0.01     | 10               | 57 (42-72)                  | 98.5   | 0.01     |
| Gender group              |                  |                             |        |          |                  |                             |        |          |                  |                             |        |          |
| Female only               | 21               | 40 (34-47)                  | 99.33  | 0.34     | 32               | 34 (30-38)                  | 99.74  | 0.11     | 1                | 82 (78-85)                  | -      | -0.001   |
| Both gender              | 41               | 44 (39-50)                  | 99.28  | 0.001    | 73               | 39 (35-43)                  | 99.75  | 0.96     | 9                | 54 (40-69)                  | 98.10  | 0.01     |
| Study design              |                  |                             |        |          |                  |                             |        |          |                  |                             |        |          |
| Cross Sectional          | 60               | 42 (38-47)                  | 99.3   | 0.96     | 99               | 36 (33-39)                  | 99.77  | <0.001   | 9                | 57 (41-73)                  | 98.67  | 0.01     |
| Case-control              | 2                | 42 (41-44)                  | -      |          | 2                | 50 (32-38)                  | -      |          | -                | -                            | -      | -        |
| Longitudinal             |                  |                             |        |          |                  |                             |        |          |                  |                             |        |          |
| Measure of sleep         |                  |                             |        |          |                  |                             |        |          |                  |                             |        |          |
| PSQI                      | 19               | 48 (38-58)                  | 99.29  | 0.24     | 38               | 45 (39-50)                  | 99.73  | <0.001   | 3                | 65 (42-88)                  | -      | <0.001   |
| ISI                       | 34               | 39 (34-45)                  | 99.37  | 0.34     | 53               | 31 (28-35)                  | 99.75  | 0.11     | 6                | 48 (38-58)                  | 92.81  | 0.01     |
| Other                     | 9                | 46 (35-56)                  | 98.12  |          | 14               | 39 (29-49)                  | 99.68  |          | 1                | 82 (78-85)                  | -      |          |
| Overall estimated prevalence | 62               | 43 (39-47)                  | 99.29  |          | 105              | 37 (35-40)                  | 99.75  |          | 10               | 57 (42-72)                  | 98.5   |          |

95% CI=95% confidence interval. PSQI=Pittsburgh Sleep Quality Index. ISI=Insomnia Severity Index.

### Table 3
Results of Univariable meta-regression regarding estimated pooled prevalence

| Variable                  | Healthcare professionals (N=62) | General Population (N=105) | Covid-19 patients (N=10) |
|---------------------------|---------------------------------|-----------------------------|--------------------------|
|                          | No. of studies | Coeff. | S.E. | I² res. (%) | Adj. R² (%) | Tau² | No. of studies | Coeff. | S.E. | I² res. (%) | Adj. R² (%) | Tau² | No. of studies | Coeff. | S.E. | I² res. (%) | Adj. R² (%) | Tau² |
| Country                   | 62               | 0.002  | 0.002 | 0.38       | 99.26       | -0.26 | 0.04 | 105              | 0.006  | 0.001 | -0.001       | 99.68       | 12.34 | 0.04 | 10               | -0.004  | 0.01  | 0.77       | 98.64       | -11.13 | 0.04 |
| Age                       | 34               | 0.005  | 0.007 | 0.46       | 99.2        | -1.5  | 0.04 | 69               | 0.002  | 0.002 | 0.48       | 99.8        | -0.7  | 0.04 | 8               | 0.0005  | 0.003 | 0.88       | 98.66       | -12.57 | 0.04 |
| Female % of participants  | 62               | 0.001  | 0.001 | 0.72       | 99.29       | -1.45 | 0.04 | 103              | -0.0001 | 0.001 | 0.95       | 99.73       | -0.9  | 0.04 | 10               | -0.002  | 0.006 | 0.71       | 98.05       | -10.51 | 0.04 |
| Married % of participants | 39               | 0.001  | 0.002 | 0.51       | 99.30       | -1.54 | 0.04 | 52               | 0.001  | 0.001 | 0.37       | 99.74       | -0.4  | 0.04 | 8               | -0.002  | 0.007 | 0.80       | 98.46       | -16.04 | 0.04 |

Coeff.=coefficient. S.E.=standard error. I² res.=I² residual. Adj. R²=adjusted R².
sleep problems among the general population, the fill-and-trim method was used to correct the results. In this method, 50 studies were imputed and the corrected results based on this method showed that pooled prevalence of sleep problems was 18% (95% CI: 15-21%; \( p < .001 \)). Funnel plot after trimming is provided in Figure 8.

Also, sensitivity analysis showed that pooled effect size was not affected by a single study effect.

3.4.1.3. COVID-19 patients. The pooled estimated prevalence of sleep problems was 57% among COVID-19 patients [95% CI: 42 to 72%, \( I^2:98.5\% \), \( \text{Tau}^2:0.06 \)]. Figure 9 provides the forest plot showing the pooled prevalence. Subgroup analysis (Table 2) showed studies with female-only participants had a higher prevalence of sleep problems significantly (82% vs. 54% respectively). Other variables did not influence heterogeneity or estimated pooled prevalence in this participants group. The probability of publication bias was assessed using Begg’s test and funnel plot. Based on Begg’s test (\( p=0.53 \)) and funnel plot (Figure 10), the probability of publication bias was rejected. Also, sensitivity analysis showed that pooled effect size was not affected by a single study effect.

| Variable                      | Healthcare professionals | General Population |
|-------------------------------|--------------------------|--------------------|
|                               | Coefficient | S.E. | \( p \) | Coefficient | S.E. | \( p \) |
| Country                       | -0.003       | 0.007 | 0.64 | 0.006 | 0.001 | <.0001 |
| Design                        | 0.06         | 0.24  | 0.81 | **     | **   | **     |
| Lockdown period (yes vs. no) | 0.23         | 0.17  | 0.21 | 0.08 | 0.04 | 0.03 |
| Study quality (low vs. high quality) | 0.12 | 0.13 | 0.40 | 0.04 | 0.04 | 0.39 |
| Age                           | -0.003       | 0.01  | 0.78 | 0.001 | 0.001 | 0.26 |
| % Female of participants      | 0.03         | 0.003 | 0.39 | 0.001 | 0.001 | 0.30 |
| % Married of participants     | 0.003        | 0.004 | 0.35 | -0.001 | 0.001 | 0.11 |
| Measure of sleep              | -0.06        | 0.09  | 0.50 | -0.03 | 0.032 | 0.20 |
| Between-study variance (\( \text{tau}^2 \)) | 0.03 |         | 0.03 | 99.27 | 99.68 |
| % Residual variation due to heterogeneity (\( I^2 \) residual) | 99.27 |             | | -26.23 | 26.33 |
| Proportion of between-study variance explained (adjusted \( R^2 \)) | -26.23 |             | | 26.33 |          |

N.B. Due to insufficient observations, meta-regression was not conducted for COVID-19 patients subgroup.

** Due to collinearity design was omitted.

Figure 4. Funnel plot assessing publication bias in studies regarding prevalence of sleep problems among health professionals

Figure 5. Corrected funnel plot assessing publication bias in studies regarding prevalence of sleep problems among health professionals

Table 4 Results of multivariable meta-regression regarding estimated pooled prevalence
Overall, the prevalence of sleep problems was significantly different in target participants considering 95% confidence interval of sleep prevalence. The corrected pooled estimated prevalence of sleep problems was 31% (95% CI: 27-36%), 18% (95% CI: 15-21%) and 57% (95% CI: 42-72%), among healthcare professional, general population and COVID-19 patients respectively. The highest prevalence of sleep problems was seen among COVID-19 patients.

3.4.2. Association of sleep problems with psychological distress

3.4.2.1. Healthcare professionals.

The association of sleep problems with depression and anxiety among health professionals were reported in 14 and 15 studies respectively. The pooled estimated effect size showed poor correlation between sleep problems and depression with Fisher’s z score of -0.28 [95% CI: -0.32 to -0.24, p<0.001, I²=82.9%; Tau² = 0.004]. However, a moderate correlation was found between sleep problems and anxiety with Fisher’s z score of 0.55 [95% CI: 0.49 to 0.59, p<0.001, I²=82.7%; Tau² = 0.10]. The forest plots are shown in Figures 11 and 12.

Based on subgroup analysis (Table 5), quality of studies (low vs. high), gender group of participants (female vs. both gender), and measure of sleep problems (PSQI vs. others) influenced heterogeneity of association of sleep problems and depression among health professionals. Meta-regression (Table 7) showed that age and marital status (married vs. others) significantly decreased the heterogeneity and explained substantial proportion of variance (72.8% and 43.85% respectively). Examined variables in subgroup analysis and meta-regression were not identified as possible source of heterogeneity or influential in the estimated pooled effect size in the association of sleep problems and anxiety (Table 6). Publication bias and small study effect was not found in association of sleep problems and depression/anxiety based on Begg’s test (p=0.87 and p=0.81 respectively).

3.4.2.2. General population.

The association of sleep problems with depression and anxiety among the general population were reported in 14 and 15 studies respectively. The pooled estimated effect size showed moderate correlation between sleep problems and
Figure 8. Corrected funnel plot assessing publication bias in studies regarding prevalence of sleep problems among general population.

Figure 9. Forest plot displaying the estimated pooled prevalence of sleep problems among COVID-19 patients.
depression with Fisher's $z$ score of -0.30 (95% CI: -0.32 to -0.28, $p<0.001$, $I^2=74.4$; $Tau^2=0.001$). Also, a moderate correlation was found between sleep problems and anxiety with Fisher's $z$ score of 0.54 (95% CI: 0.48 to 0.60, $p<0.001$, $I^2=95.2$; $Tau^2=0.001$). The forest plots are shown in Figures 13 and 14. Based on subgroup analysis (Table 5 and 6), lockdown status (no vs. yes) reduced the heterogeneity in association of sleep problems and depression. Based on meta-regression (Table 7), age was a significant moderator in association between sleep problems and anxiety, which explained 50.37% of variance. However, the other examined variables were not identified as possible sources of heterogeneity or influential on the estimated pooled effect size in the association between sleep problems and depression/anxiety.

Based on Beggs' test, publication bias and small study effect were not found in the association between sleep problems and depression ($p=0.52$). Although publication bias was not significant in association between sleep problems and anxiety ($p=0.41$), based on funnel plot, publication bias was probable. Consequently, fill and trim method was used to correct probable publication bias. After imputation of three studies, the association between sleep problems and anxiety was estimated as Fisher's $z$ score of 0.48 (95% CI: 0.41 to 0.54).

### 3.4.3. COVID-19 patients

The association of sleep problems with depression and anxiety among general population was reported in only two studies. The pooled estimated effect size showed moderate correlation between sleep problems and depression with Fisher's $z$ score of -0.36 (95% CI: -0.49 to -0.24, $p=0.0007$, $I^2=7.4$; $Tau^2=0.001$). Also, a moderate correlation was found between sleep problems and anxiety with Fisher's $z$ score 0.49 (95% CI: -0.12 to 1.1, $p<0.001$, $I^2=95.2$; $Tau^2=0.001$). The forest plots are shown in Figures 15 and 16. The number of studies was too few to conduct further secondary analysis including subgroup/meta-regression analysis, controlling publication bias, and small study effect.

### 4. Discussion

The present systematic review and meta-analysis synthesized data from 177 recently published studies on this topic to more rigorously investigate the prevalence of sleep problems and how sleep associated with psychological distress. The synthesized results showed that the pooled estimated prevalence of sleep problems regardless of gender and population was 37% during the COVID-19 outbreak. Additionally, a much higher prevalence rate of sleep problems was identified among patients with COVID-19 infection (55%) and healthcare professionals (43%). These findings concur with Jahrami et al. [38] who reported in their meta-analysis that the highest prevalence rate of sleep problems was found among COVID-19 patients. Meta-regression in the present review further indicated that country, age, gender, and marital status did not contribute to the estimated prevalence in sleep problems.

The nonsignificant finding for gender contradicts prior evidence showing that being female is a risk factor for insomnia and mental health problems [27, 56]. This may be explained by the samples recruited because the analyzed studies in the present review comprised a large proportion of females. The imbalanced gender distribution may have led to a reduced gender effect, which in turn, resulted in a nonsignificant finding. Regarding the association between sleep problems and psychological distress, sleep problems were found to be moderately correlated with depression (ES=0.54) and anxiety (ES=0.55). Subgroup analysis and meta-regression additionally showed that being a COVID-19 patient and being of older age were significant predictors of a higher association between sleep problems and psychological distress.

The high prevalence of sleep problems found in the present review can be explained by fear of COVID-19 and sleep-related factors (e.g., the changes in sleep-wake habits with delayed bedtime, lights off time, and sleep onset time due to quarantine and lockdown) [57]. The national and global COVID-19 death statistics are commonly and routinely reported by the social media and news [57]. Therefore, prior research has found the higher levels of psychological distress and significant symptoms of mental illness in various populations since the start of the pandemic [4-6]. Indeed, evidence prior to the pandemic has demonstrated that individuals may experience sleep problems when they experience major public health threats [16-19]. The higher prevalence of sleep problems found among healthcare professionals can be further explained by their job nature. Health professionals, especially those who are frontline workers dealing with COVID-19 infected patients on a daily basis, encounter much higher risk of infection and irregular work schedules than those working in other occupations [10-15].

Lockdown was found to be a significant factor in explaining sleep problems. However, this finding may be confounded by the different policies implemented to inhibit the spread of COVID-19 across the 39 countries analyzed in the present review. For example, mainland China launched a strict lockdown policy to prohibit almost all outdoor activities, while the lockdown policy in other countries was not as strict. Nevertheless, the present findings support prior evidence that lockdown negatively impacted individuals' psychological health and sleep [57].

There are several clinical implications from the present study's findings. First, government and healthcare providers worldwide need to design and implement appropriate programs and treatments to assist different populations, including healthcare professionals, patients, and the general population, in overcoming sleep problems. For example, effective programs (e.g., cognitive behavioral therapy for insomnia and meditation) [58] reported in prior research can be embedded in smartphone apps and healthcare professional training to prevent or deal with the sleep problems for different populations. Second, the associations between sleep problems and psychological distress provide the empirical evidence that healthcare providers should simultaneously tackle sleep problems and psychological distress. Consequently, psychological distress can be reduced when an individual's sleep is improved (and vice versa). Third, special attention may need to be paid to COVID-19 patients and older individuals because the present review showed a higher association between their sleep problems and psychological distress. Moreover, specific populations such as children and their caregivers should not be ignored regarding their psychological needs and sleep issues.
Although the present review did not provide evidence on pediatric populations, the present findings concerning the specific group of older individuals may generalize to other specific populations. It is recommended that programs comprising psychological support for family having children to overcome the difficulties during COVID-19 pandemic are implemented [60].

The present review has some strengths. First, the prevalence of sleep problems has been estimated across different populations and this information provides healthcare providers with a greater and more contextualized picture regarding the impacts of COVID-19 on sleep problems. Second, methodological quality of each analyzed study was assessed using the NOS checklist. Within the meta-analysis findings, subgroup analysis and meta-regression were used to provide thorough information and therefore the meta-analysis findings are robust. Third, generalizability of the present review's findings is good because the synthesized sample size was large (N=345,270) and the participants were recruited from 39 countries.

The present review has some limitations. First, most of the studies adopted a cross-sectional design (n=56) and only seven studies (three which used a case-control design and four which used a longitudinal design) considered the time effect in the causal relationship. Therefore, the relationships between sleep problems and psychological distress found in the present review do not have strong causality evidence. Diverse evidence in the causality has been proposed. Using longitudinal designs, Vaghela and Sutin [59] found that psychological distress might lead to poor sleep, while Mazzer and Linton [60] found that shorter sleep duration might lead to higher levels of psychological distress. Moreover, the lack of pre-COVID-19 pandemic information on sleep problems hinders the understanding of changes of sleep problems caused by COVID-19. Second, different measures were used in the studies that were evaluated (e.g., PSQI, ISI, and ASI for sleep problems). Given that different measures may have different features in capturing the severity of sleep problems, there may have some biases in estimating prevalence for sleep problems and effect sizes for the associations between sleep problem and psychological distress.

Figure 11. Forest plot displaying the estimated pooled Fishers' Z score in association of sleep problems and depression among health professionals

![Forest plot](image-url)
distress. All the studies evaluated here used self-report methods in assessing sleep problems and psychological distress. Therefore, findings in the present review cannot rule out social desirability and memory recall biases. Third, the impacts of COVID-19 on sleep and mental health problems are dynamic. That is, individuals may have different levels of sleep and mental health problems according to the severity of COVID-19 outbreak in their localities or countries. Moreover, the policies in controlling the COVID-19 outbreak are different across countries [57,61-66]. Therefore, the estimated findings in the present review cannot represent the impacts of COVID-19 during a specific period. Fourth, the analyzed studies in the present review had a large proportion of Chinese and Italian populations. Similarly, the synthesized samples were mostly young adults. Therefore, the generalizability of the present review’s findings to different ethnic populations and age groups (i.e., older people and children) is restricted. Given that China and Italy were the first two countries to be severely impacted by the COVID-19 pandemic, there is understandably more research carried out in these two countries. However, the contributions of other countries, especially the American and African populations, should not be ignored. Further research should be carried out in other ethnic populations and different countries to balance the findings and maximize the generalizability. Fifth, the present meta-analysis had very large heterogeneity (as shown in Fig. 3) and evidence of publication bias (as shown in Fig. 4). Therefore, the findings without removing the heterogeneity in the meta-regression and subgroup analysis might be biased. Finally, most of the studies included in the meta-analysis were not of high quality (as shown in Fig. 2). Therefore, future studies require higher quality designs to investigate sleep problems during COVID-19 pandemic.

In conclusion, sleep problems appear to have been common during the COVID-19 pandemic. One in every three individuals reported the sleep problems. Nearly half of the healthcare professionals (43%) encountered sleep problems during the pandemic period. Healthcare providers may want to design appropriate programs to help

| Study                                | ID          | % ES (95% CI) | Weight |
|--------------------------------------|-------------|--------------|--------|
| Wang (2020)                          |             | 0.27 (0.09, 0.45) | 4.27   |
| Saraswathi: During COVID-19 data (2020) |             | 0.41 (0.28, 0.54) | 5.68   |
| Yang (2020)                          |             | 0.45 (0.31, 0.59) | 5.44   |
| Qi (2020)                            |             | 0.47 (0.42, 0.53) | 8.75   |
| Schini (2020)                        |             | 0.48 (0.45, 0.50) | 9.56   |
| Wasim (2020)                         |             | 0.51 (0.41, 0.62) | 6.80   |
| Xiao (2020)                          |             | 0.53 (0.39, 0.68) | 5.22   |
| Magnavita (2020)                     |             | 0.54 (0.46, 0.62) | 7.76   |
| Korkmaz (2020)                       |             | 0.56 (0.39, 0.73) | 4.59   |
| Greya (2020)                         |             | 0.58 (0.53, 0.62) | 8.95   |
| Zhang (2021)                         |             | 0.60 (0.49, 0.71) | 8.57   |
| Ching (2020)                         |             | 0.61 (0.52, 0.69) | 7.58   |
| Zhang (2020)                         |             | 0.66 (0.61, 0.71) | 8.91   |
| Stojeov (2020)                       |             | 0.66 (0.52, 0.80) | 5.49   |
| Ameiro (2020)                        |             | 0.79 (0.62, 0.96) | 4.43   |
| Overall (I-squared = 82.7%, p < 0.001) |             | 0.54 (0.50, 0.59) | 100.00 |

NOTE: Weights are from random effects analysis

Figure 12. Forest plot displaying the estimated pooled fishers’ Z score in association of sleep problems and anxiety among health professionals
Table 5
Results of subgroup analysis regarding estimated pooled correlation between sleep and Depression

| Variable                | Healthcare professionals (N=14) | General Population(N=15) |
|-------------------------|---------------------------------|--------------------------|
|                         | No. of studies                  | ES (95% CI) | \( I^2 \) (%) | No. of studies | ES (95% CI) | \( I^2 \) (%) |
| Quality                 |                                 |             |               |               |             |               |
| Low quality             | 6                               | -0.30 (-0.35; -0.25) | 28            | 4             | -0.32 (-0.37; -0.26) | 71.2 |
| High quality            | 8                               | -0.32 (-0.33; -0.22) | 88.9          | 11            | -0.29 (-0.32; -0.27) | 76.2 |
| Gender group            |                                 |               |               |               |             |               |
| Female only             | 6                               | -0.30 (-0.34; -0.26) | 23.8          | 4             | -0.32 (-0.39; -0.25) | 79.7 |
| Both gender             | 8                               | -0.27 (-0.32; -0.21) | 88.7          | 11            | -0.29 (-0.32; -0.27) | 74.7 |
| Lockdown                |                                 |               |               |               |             |               |
| Yes                     | 1                               | -0.34 (-0.36; -0.31) | -            | 4             | -0.33 (-0.38; -0.28) | 78.6 |
| No                      | 13                              | -0.27 (-0.31; -0.24) | 60.8          | 11            | -0.29 (-0.31; -0.26) | 58.9 |
| Study design            |                                 |               |               |               |             |               |
| Cross-sectional         | 12                              | -0.28 (-0.32; -0.24) | 85.5          | 14            | -0.30 (-0.32; -0.27) | 75.5 |
| Case-control            | 1                               | -0.28 (-0.46; -0.1) | -            | -             | -            | -            |
| Longitudinal            | 1                               | -0.29 (-0.42; -0.15) | -            | 1             | -0.38 (-0.51; -0.24) | - |
| Measure of sleep        |                                 |               |               |               |             |               |
| PSQI                    | 7                               | -0.30 (-0.34; -0.27) | 46            | 7             | -0.30 (-0.33; -0.27) | 64.6 |
| ISI                     | 5                               | -0.22 (-0.24; -0.21) | -            | 7             | -0.29 (-0.33; -0.25) | 72.9 |
| Other                   | 2                               | -0.32 (-0.37; -0.28) | 35            | 1             | -0.34 (-0.36; -0.31) | - |
| Overall estimated prevalence | 14                       | -0.28 (-0.32; -0.24) | 82.9          | 15            | -0.30 (-0.32; -0.28) | 74.4 |

Table 6
Results of subgroup analysis regarding estimated pooled correlation between sleep and Anxiety

| Variable                | Healthcare professionals (N=15) | General Population(N=12) |
|-------------------------|---------------------------------|--------------------------|
|                         | No. of studies                  | ES (95% CI) | \( I^2 \) (%) | No. of studies | ES (95% CI) | \( I^2 \) (%) |
| Quality                 |                                 |             |               |               |             |               |
| Low quality             | 7                               | 0.59 (0.49; 0.68) | 82.5          | 3             | 0.55 (0.48; 0.62) | 73.5 |
| High quality            | 8                               | 0.52 (0.46; 0.58) | 78.1          | 9             | 0.53 (0.46; 0.61) | 96.2 |
| Lockdown period         |                                 |               |               |               |             |               |
| Yes                     | 1                               | 0.48 (0.45; 0.50) | -            | 3             | 0.45 (0.32; 0.58) | 78.4 |
| No                      | 14                              | 0.55 (0.50; 0.60) | 75.6          | 9             | 0.57 (0.49; 0.65) | 96.3 |
| Gender group            |                                 |               |               |               |             |               |
| Female only             | 7                               | 0.55 (0.47; 0.63) | 83.9          | 3             | 0.49 (0.31; 0.66) | 90.9 |
| Both gender             | 8                               | 0.54 (0.48; 0.60) | 76.8          | 9             | 0.56 (0.47; 0.64) | 95.8 |
| Study design            |                                 |               |               |               |             |               |
| Cross-sectional         | 14                              | 0.55 (0.50; 0.60) | 83.3          | 11            | 0.56 (0.49; 0.62) | 95.4 |
| Case-control            | -                               | -             | -             | -             | -            | -            |
| Longitudinal            | 1                               | 0.41 (0.28; 0.55) | -            | 1             | 0.28 (0.15; 0.42) | - |
| Measure of sleep        |                                 |               |               |               |             |               |
| PSQI                    | 10                              | 0.53 (0.47; 0.58) | 68.1          | 6             | 0.51 (0.47; 0.57) | 88.7 |
| ISI                     | 2                               | 0.64 (0.51; 0.77) | 60.1          | 5             | 0.60 (0.40; 0.80) | 97.7 |
| Other                   | 3                               | 0.50 (0.44; 0.56) | 78.1          | 1             | 0.48 (0.45; 0.50) | - |
| Overall estimated prevalence | 15                       | 0.55 (0.49 to 0.59) | 82.7          | 12            | 0.54 (0.48; 0.60) | 95.2 |

Table 7
Results of meta-regression regarding correlation between sleep and psychological distress

| Variable                | Healthcare professionals (N=14) | General Population(N=15) |
|-------------------------|---------------------------------|--------------------------|
|                         | No of studies                  | Coeff. | S.E. | \( p \) | \( R^2 \) res. (%) | Adj. \( R^2 \) (%) | Tau^2 | No of studies | Coeff. | S.E. | \( p \) | \( R^2 \) res. (%) | Adj. \( R^2 \) (%) | Tau^2 |
| Depression              |                                 |             |     |       |               |               |     |             |      |     |       |               |               |     |
| Country                 | 14                              | 0.002 | 0.003 | 0.62  | 83.99        | -8.4           | 0.002 | 15           | -0.0004 | 0.001 | 0.64  | 75.9         | -7.49          | 0.002 |
| Age                     | 12                              | -0.002 | 0.001 | 0.006 | 13.91       | 72.8           | 0.0004 | 13           | 0.002 | 0.001 | 0.21  | 77.65        | 1.88           | 0.002 |
| Female % of participants| 14                              | -0.002 | 0.001 | 0.12  | 71.23       | 15.31          | 0.001 | 15           | -0.001 | 0.001 | 0.38  | 68.46        | 3.93           | 0.002 |
| Married % of participants| 12                              | -0.001 | 0.004 | 0.08  | 37.2        | 43.85          | 0.001 | 6            | -0.001 | 0.0004 | 0.52  | 72.16        | -3.47          | 0.002 |
| Anxiety                 |                                 |             |     |       |               |               |     |             |      |     |       |               |               |     |
| Country                 | 15                              | -0.002 | 0.005 | 0.73  | 83.61       | -13.03         | 0.01  | 12           | -0.0005 | 0.003 | 0.89  | 95.62        | -10.62         | 0.02  |
| Age                     | 10                              | 0.011 | 0.005 | 0.05  | 62.52       | 54.77          | 0.01  | 10           | 0.01  | 0.005 | 0.02  | 95.03        | 50.37          | 0.02  |
| Female % of participants| 15                              | -0.002 | 0.002 | 0.38  | 83.37       | -12.64         | 0.01  | 11           | 0.001  | 0.003 | 0.70  | 95.68        | -9.10          | 0.03  |
| Married % of participants| 9                               | 0.006 | 0.003 | 0.46  | 87.86       | 21.25          | 0.01  | 5            | 0.0004 | 0.005 | 0.95  | 97.31        | -31.77         | 0.02  |
Figure 13. Forest plot displaying the estimated pooled Fishers’ Z score in association of sleep problems and depression among general population.
Figure 14. Forest plot displaying the estimated pooled Fishers’ Z score in association of sleep problems and anxiety among general population.
Figure 15. Forest plot displaying the estimated pooled Fishers' Z score in association of sleep problems and depression among COVID-19 patients.
individuals overcome their sleep problems. Moreover, sleep problems were found to be associated with higher levels of psychological distress (including depression and anxiety). Therefore, with the use of effective programs treating sleep problems, psychological distress may be reduced. Vice versa, the use of effective programs treating psychological distress, sleep problems may be reduced. However, it is possible that the association between sleep problems and psychological distress found in the present review is contributed by confounders. In other words, causality may not be happened between sleep problems and psychological distress. Therefore, more longitudinal studies and randomized controlled trials are needed to investigate the causality between sleep problems and psychological distress.

Declaration of Competing Interest

Chung-Ying Lin was supported in part by a research grant from the Ministry of Science and Technology, Taiwan (MOST109-2327-B-006-005). All other authors have nothing to declare.

Data sharing statement

No additional unpublished data are available.

Funding

No funding was received.

Authors’ contributions

Conceptualisation: Amir H Pakpour, Zainab Alimoradi and Chung-Ying Lin; writing original draft: Amir H Pakpour, Zainab Alimoradi and Chung-Ying Lin; writing (review and edit): all authors; literature search: Amir H Pakpour, Zainab Alimoradi; data sourcing and collection: Amir H Pakpour, Zainab Alimoradi; Project administration: Amir H Pakpour; Statistical analysis: Zainab Alimoradi and Amir H Pakpour; access to data: Zainab Alimoradi and Amir H Pakpour; figures: Zainab Alimoradi; data interpretation: all authors.
Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.eclinm.2021.100916.

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