Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
The prevalence and severity of insomnia symptoms during COVID-19: A global systematic review and individual participant data meta-analysis

Maha M. AlRasheed a, b, *, Feten Fekih-Romdhane c, d, Haitham Jahramie e, f, Gabriel Natan Pires g, Zahra Sait e, Ahmad F. Alenezi f, Ali Humood f, Wen Chen h, Haijiang Dai i, Nicola Bragazzi j, Seithikurippu R. Pandi-Perumal k, l, Ahmed S. BaHammam m, n, Michael V. Vitiello o, on behalf of the COMITY investigators1

a Clinical Pharmacy Department, College of Pharmacy, King Saud University, Riyadh, Saudi Arabia
b Princess Noura bint Abdul Rahman University, Riyadh, Saudi Arabia
c The Tunisian Center of Early Intervention in Psychosis, Psychiatry Department “Ibn Omrane”, Tunisia
d Tunis El Manar University, Faculty of Medicine of Tunis, Tunisia
e Ministry of Health, Manama, Bahrain
f Department of Psychiatry, College of Medicine and Medical Sciences, Arabian Gulf University, Manama, Bahrain
g Federal University of Sao Paulo, Brazil
h Department of Psychiatry, Xiamen Xianyue Hospital, Xiamen, 361000, China
i Department of Cardiology, The Third Xiangya Hospital, Central South University, Changsha, 410013, China
j Department of Mathematics and Statistics, Laboratory for Industrial and Applied Mathematics (LIAM), York University, Toronto, Canada
k Somnogen Canada Inc., College Street, Toronto, Canada
l Saveetha Medical College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India
m Department of Medicine, College of Medicine, University Sleep Disorders Center, King Saud University, Riyadh, 11324, Saudi Arabia
n The Strategic Technologies Program of the National Plan for Sciences and Technology and Innovation in the Kingdom of Saudi Arabia, Riyadh, Saudi Arabia
o Psychiatry & Behavioral Sciences, Gerontology & Geriatric Medicine, and Biobehavioral Nursing, University of Washington, Seattle, WA, 98195-6500, USA

ARTICLE INFO

Article history:
Received 23 May 2022
Received in revised form 20 June 2022
Accepted 24 June 2022
Available online 8 August 2022

Keywords:
Keywords: sleep disorder
Sleep disturbance
Insomnia
Sleep hygiene
Circadian rhythm

Abstract

Introduction: There have been no previous meta-analytic studies that have looked at the prevalence of insomnia symptoms in different COVID-19 groups using a single assessment instrument to evaluate insomnia symptoms while maintaining data homogeneity. The current review’s associated goal is to undertake an individual participant data (IPD) analysis to further investigate past meta-analyses, a method that has been shown to be more robust than standard meta-analyses.

Methods: Only studies that used the Insomnia Severity Index (ISI) to assess insomnia are used in this analysis. The IPDMA was performed and registered in PROSPERO in compliance with the PRISMA IPD Statement (CRD42021275817). From November 2019 to August 2021, researchers explored seventeen databases and six preprint services for relevant studies.

Results: The pooled estimate of insomnia symptoms (subthreshold and clinically significant) was 52.57%. An estimated 16.66% of the population suffered from clinically significant insomnia, of which 13.75% suffered from moderate insomnia, and 2.50% suffered from severe insomnia. The different populations’ grouping had no statistically significant differences in the prevalence of insomnia symptoms. Insomnia symptoms did not appear to be associated with age or sex.

Conclusion: Our findings imply that the COVID-19 pandemic is linked to a significant rise in subthreshold insomnia symptoms, but not to moderate or severe insomnia. Educating people from all walks of life about the importance of sleep and the risk of acquiring insomnia symptoms during this or future pandemics should be a top concern.

© 2022 Elsevier B.V. All rights reserved.

* Corresponding author. Clinical Pharmacy Department, College of Pharmacy, King Saud University, Riyadh, Saudi Arabia.

E-mail address: mahalrasheed@ksu.edu.sa (M.M. AlRasheed).

1 Complete list of the COMITY investigators can be found at the end of the manuscript (Appendix B).

https://doi.org/10.1016/j.sleep.2022.06.020
1389-9457/ © 2022 Elsevier B.V. All rights reserved.
1. Introduction

Since its emergence, the COVID-19 pandemic has threatened human physical and mental health leading to serious consequences, including sleep disturbances. Sleep problems related to the COVID-19 were highly prevalent in various populations, including COVID-19 patients (hospitalized: 33.3%–84.7%; discharged: 29.5–40%), healthcare workers (18.4–84.7%), and the general community (17.65–81%) [1]; and worsened health outcome in these populations [2–4]. COVID-19 related sleep disturbances may include poor sleep quality, sleepiness, or insomnia [4,5]. A systematic review and meta-analysis by Cénat et al. found a pooled prevalence of COVID-19 related insomnia of 16.45% in the general population and 36.52% in healthcare workers [6] with another review reporting a pooled prevalence of 36% among nurses [7].

Insomnia, difficulty initiating or maintaining sleep, is associated with multiple negative outcomes, including increased risk of depression, alcohol dependence, hypertension, metabolic syndrome, and coronary heart disease [8]. In addition, insomnia also leads to loss of productivity [8], increased healthcare utilization [8], and reduced quality of life [9]. Thus, providing a more accurate estimate of insomnia during COVID-19 across various at-risk populations has implications for developing specific, customized screening and intervention strategies to protect against the factors leading to the development of insomnia.

While critical appraisal of extant literature has emerged, to date, scant attention has been geared towards the establishing prevalence of COVID-19 related insomnia across different populations [10,11]. Prior systematic reviews have mainly focused on specific populations such as healthcare workers [7,12–17], students [10,18], COVID-19 patients [11], or children and adolescents [19]; whereas more limited research has compared prevalence rates of sleep disturbances across population types [1,5].

Further, no previous meta-analytic studies have investigated the prevalence of insomnia symptoms in various COVID-19 populations using a single assessment instrument to evaluate insomnia symptoms while maximizing data homogeneity. One previous meta-analysis focused on sleep quality using the Pittsburgh Sleep Quality Index [20] also included studies using other sleep measures with different scopes, scoring methodologies, and cutoff criteria utilized; leading to high levels of heterogeneity and limiting international comparisons of prevalence rates. In the current study, we utilize only studies that employed the Insomnia Severity Index (ISI) [21] to assess insomnia. The ISI is a widely used screening tool that has proven suitable for both clinical practice and research, and to be accurate in assessing the risk of insomnia symptoms in both clinical and community settings in various countries around the globe [22].

The related aim of the present review is to further scrutinize previous meta-analyses by conducting an individual participant data (IPD) analysis, an approach widely documented to be more robust compared to standard meta-analyses [23]. The IPD meta-analysis (IPDMA) allows disentangling study- and subject-level sources of heterogeneity. To our knowledge, this is the first IPD meta-analysis involving a large number of studies from across the globe evaluating the prevalence of insomnia symptoms during the COVID-19 pandemic. For these reasons, this IPDMA aimed to review available data on insomnia symptoms evaluated in different populations assessed by the ISI, specifically estimating raw and weighted prevalence rates of insomnia symptoms by severity for different population groups during the pandemic taking into account the effects of a single moderator and simultaneous interactions between several moderators.

2. Materials and methods

The IPDMA was completed in accordance with the PRISMA IPD Statement [24] and registered in PROSPERO (CRD42021275817). To avoid duplication, a comprehensive review of Prospero and the COVID-19 evidence network to support decision-making (COVID-END) resources was performed before registering our protocol. In addition, to avoid the shortcomings of some previous IPDMAs, we established an a priori protocol with a prespecified data syntheses plan.

2.1. Identification of studies

Seventeen databases and six preprint servers were searched for relevant studies from November 2019 through August 2021. The following databases were searched for relevant publications: 1) American Psychological Association PsycINFO; 2) Cochrane Library; 3) CNKI; 4) Cumulative Index to Nursing and Allied Health Literature (CINAHL); 5) EBSCoHost; 6) EMBASE; 7) Google Scholar; 8) LILACS; 9) MEDLINE; 10) Pro-Quest Medical; 11) SciELO; 12) ScienceDirect; 13) Scopus; 14) VIP; 15) WanFang; 16) Web of Science and 17) WHO Global research on coronavirus disease (COVID-19).

The following preprint servers were included: 1) arXiv.org; 2) bioRxiv.org; 3) medRxiv.org; 4) Preprints.org; 5) psyarxiv.com; and 6) SSRN.com.

Cross-matching keywords were selected using key terms, and PubMed MeSH headings were the search strategies used. The search was developed using the Boolean logic operators of (OR, AND, NOT). Search syntax was changed according to the advanced search characteristics of each database. Keywords included were: “COVID-19” OR “2019-nCoV” OR “2019 coronavirus” OR “SARS-CoV-2” AND “sleep” OR “sleep medicine” OR “sleep disturbances” OR “sleep disorders” OR “sleep problems” OR “sleep quality” OR “Insomnia Severity Index” OR “ISI” OR “insomnia” OR “circadian rhythm”. To increase the likelihood of finding relevant original studies, reference lists of included studies and previous systematic reviews and meta-analyses of published articles were manually searched. The final search results were converted into a Microsoft Excel spreadsheet 2019 to filter and eliminate duplicates. Citations were managed with EndNote X9.3.3 using the Research Information System files.

In the current IPDMA, the primary outcome was the prevalence and severity of insomnia symptoms during the COVID-19 pandemic measured by the ISI. Specific inclusion criteria for study selection included: (1) publication date between November 1, 2019, to August 31, 2021; (2) original research articles published in English, Chinese, Korean, Spanish, German, Portuguese, French, Italian, or Arabic languages; and (3) studies that reported numerical values (e.g., arithmetic mean with standard deviation or prevalence rate) for insomnia symptoms using the ISI. Exclusion criteria were applied to the retrieved articles to eliminate factors that may incur potential methodologic and quality issues: abstracts, case reports, infographics, letters, editorials, narrative reviews, opinions, systematic reviews, meta-analyses, and position statements. Fig. 1 shows the PRISMA2020 flow diagram for study selection.

2.2. Outcomes and assessment of insomnia symptoms

The primary outcome was the estimated prevalence and severity of insomnia symptoms during the COVID-19 pandemic measured by the ISI. The ISI is a 7-item self-report questionnaire
assessing the nature, severity, and impact of insomnia symptoms [21,25]. The usual recall period is the “last month,” and the dimensions evaluated were: severity of sleep onset, sleep maintenance, and early morning awakening problems, sleep dissatisfaction, interference of sleep difficulties with daytime functioning, noticeability of sleep problems by others, and distress caused by the sleep difficulties. A 5-point Likert scale is used to rate each item (e.g., 0 = no problem; 4 = very severe problem), yielding a total score ranging from 0 to 28. The total score is interpreted as follows (according to severity): absence of insomnia (0–7); sub-threshold insomnia (8–14); moderate insomnia (15–21); and severe insomnia (22–28) [21,25].

In presenting the results of this IPDMA, the term, “cumulative prevalence of insomnia symptoms”, refers to the combined three categories of subthreshold, moderate, and severe insomnia. On the other hand, the term, “cumulative prevalence of insomnia”, refers to only the combination of the moderate and severe insomnia categories.

2.3. Study screening and selection

Based on the inclusion criteria, two reviewers (depending on the language: HJ, AH, AFA, FFR, WC, HD, GNP) independently evaluated each entry, including titles and abstracts of all retrieved publications. In addition, the complete texts of possibly relevant papers were examined further using the above criteria. Finally, discussion/consultation with a blinded author (ASB) resolved any disagreements between the two reviewers.

2.4. Data extraction and obtaining individual participant data

Data extraction was limited to study information and complete citation. The corresponding author of each included study was contacted by the principal investigator seeking the relevant IPD in a standardized Microsoft Excel file. Instructions were provided about the data coding, which included four main variables for each individual participant (age in years, sex, ISI total score, and population grouping, e.g., general population). Developing data-sharing agreements to be signed by the participating research teams was also included in the logistical process. An independent Research Ethics Committee approved all studies and ensured they followed the ethical principles of the Helsinki Declaration (1996 and 2000), as well as applicable good clinical practice requirements in local guidelines.

Data collection agreements considered different regulations regarding data sharing across different countries to collect data from ongoing studies. For example, researchers in the United States were required to comply with the Health Insurance Portability and Accountability Act of 1996 (HIPAA), European researchers were required to satisfy the General Data Protection Regulation, and researchers in India were suggested to gain approval from the Indian Council of Medical Research for the sharing of research data. The corresponding author(s) (or their representative) of each participating study was invited to be an author in the project COVID-19 insomnia IPD meta-analysis (COMITY) collaboration. Invited authors were informed that they need to meet the authorship criteria of the international committee of medical journal editors to be listed as contributors. A secure data exchange protocol and
secure repository were established by the principal investigator specifically for this study. Anonymous, de-identified IPD were shared with the data analyst.

2.5. Quality assessment and risk of bias

We assessed the methodological quality and bias risk of the studies using the Newcastle-Ottawa Scale (NOS). As part of the NOS checklist, three aspects were analyzed (participant selection, comparability, and outcome and statistics). The checklist comes in three variations: for cross-sectional studies (seven items), for case-control studies (eight items), and cohort or longitudinal studies (eight items). Scores of 8–10 indicated good quality and low bias risk, 5–7 indicated moderate quality and moderate bias risk, and 0–4 indicated low quality and high bias risk [26]. The results of the quality assessment were presented visually in a traffic light plot, which provides the judgment for each study in each area of the NOS. In addition, the proportion of information within each judgment for each domain for all studies was also depicted using a summary plot (weighted).

2.6. Data analysis

For IPD meta-analysis, there are two competing statistical approaches: a two-stage or a one-stage approach [27]. In this IPD meta-analysis, we used a two-stage approach. First, we analyzed the IPD from each study separately to obtain aggregate (summary) data of interest (such as an effect estimate and its confidence interval), and then we combined these using a traditional random-effects meta-analysis model. Two-stage IPD meta-analyses are more robust, computationally intuitive, and easy to replicate [28,29].

In order to account for both within-study and between-study variations, a random effect model was used for the studies included [30]. DerSimonian and Laird estimates of effect size were used with the general inverse variance approach, the logit transformed proportions, and their standard errors [31]. We used logit transformation because a random intercept logistic regression model is used by default, i.e., argument method = “generalized linear mixed models = GLMM” [30]. The logit transform does not stabilize the variance, but prevents the pooled 95% CI from exceeding 0–1 [30]. The 95% confidence interval (95%CI) was calculated using the Cropper-Pearson interval [31,32]. A forest plot represents the findings of a meta-analysis as a point estimate with a 95% confidence interval. We also reported the 95% prediction interval (95%PI), which is defined as the range of effect sizes that a new study would fall into if it were randomly selected from the same population of studies already included in the meta-analysis [33].

To quantify the variability in sample size impact estimates across these studies, the I² statistic was applied [34]. The I² statistic shows how much variance between research is attributable to heterogeneity versus chance [35]. A heterogeneous population is classified as mild when the I² is less than 25%, moderate when the I² is 25–50%, severe when the I² is 50–75%, and extremely severe when the I² exceeds 75% [35]. We used a leave-one-out sensitivity analysis to demonstrate that no single study contributed to our findings jackknife approach was used [36].

To determine the degree of heterogeneity between the studies, Cochran’s Q test [37], τ² [38], and χ² [38] statistics were used. Cochran’s Q, with weights based on the pooling method, is the sum of squared differences between individual study effects and the pooled effect across studies [37]. Q was distributed using the chi-square statistic with k (number of studies) minus 1 freeing [37]. The τ² statistic measures variation in effect size parameters across all studies in a population, and it represents the variance in real effect sizes; τ denotes this integer’s square root [37]. As a means of further examining heterogeneity, the H statistic was defined as the ratio of a random-effects meta-analysis’ estimated overall effect size to a fixed-effects meta-analysis’ estimate of its effect size [34].

An analysis of publication bias was conducted using funnel plots [39]. A funnel plot is a basic scatter plot that shows the impact estimates of individual interventions versus some metric of study size or precision [39]. In a formal analysis of publication bias, Egger’s regression was used [39], as well as rank correlation test by Begg and Mazumdar [40]. Begg and Mazumdar’s rank correlation test is widely used in meta-analysis to check for publication bias in clinical and epidemiological studies [41]. It is based on using Kendall’s tau as the measure of association to correlate the standardized treatment effect with the variance of the treatment effect [41]. If necessary Duval and Tweedie’s trim and fill method were used to produce modified point estimates to account for funnel plot asymmetry due to possible publication bias [42]. This method can be used to estimate the number of studies missing from a meta-analysis since the most extreme results on one side of the funnel plot are suppressed. Adding data to the funnel plot makes it more symmetric [42]. A more valid assessment of the overall effect or outcome should not be the purpose of this approach; rather, it is to establish how sensitive the results are to one specific selection process [42].

A moderator analysis was performed to explain the dispersion of effect sizes or heterogeneity. We performed subgroup meta-analyses to see if the prevalence of insomnia symptoms varied across the populations studied. Analyses of subgroups based on categorical factors, such as the study population and country, were conducted. In addition to a meta-regression approach, we considered four covariates, including mean age and female sex proportion, as continuous variables of insomnia symptoms.

During the process of the IPDMA we have implemented two quality control procedures to ensure the integrity of the data and associated results. First, we invited all participating/contributing authors to a live webinar to present results upon completion of the analyses. Second, we sought critical revisions from all participating/contributing authors prior to submission to ensure that data are accurate and precise.

All data analyses and visualizations were performed using R for statistical computing version 4.1.0 [43]. The packages ‘meta’ [44] and ‘metafor’ [45] were used to perform all meta-analytics. Quality assessment plots were produced using risk-of-bias visualization ‘robsiv’ [46].

3. Results

A total of 48 studies from 25 countries during COVID-19 involved 133,006 participants (See Fig. 1), with a mean ISI of 8.70 ± 2.00. Using the raw data of the 133,006 participants 767850 (57.62%) reported no clinically significant insomnia (ISI<8); 39662 (29.81%) reported subthreshold insomnia (ISI>8). All data analyses and visualizations were performed using R for statistical computing version 4.1.0 [43]. The packages ‘meta’ [44] and ‘metafor’ [45] were used to perform all meta-analytics. Quality assessment plots were produced using risk-of-bias visualization ‘robsiv’ [46].

The characteristics of the participants are shown in Table 1.
The majority of the studies were mid-sample size with a median sample size of 605 participants (range 26–56679). The mean age of participants was 33.84 ± 7.14 years [95%CI 31.66; 36.03], and females accounted for a total of 65% of participants. Many of the studies involved healthcare workers (K = 14, 29%), the general adult population (K = 11, 23%) or multiple populations (K = 10, 21%). Others included special populations such as pregnant women, or people with medical or psychiatric comorbidity (K = 9, 19%), and university students (K = 4, 8%).

In the meta-analysis, the mean NOS quality score was 7.43 ± 1.10, with a range of 5.0–9.0. Fig. 51 describes the quality assessment process (traffic light plot) for each study included in the IPDMA. Overall, 85.5% of the studies were high quality (low risk of bias) and the remaining 14.6% were of moderate quality. Fig. 52 shows that most risk bias was associated with selection in terms of sample size and representativeness. Table 1 summarizes the geographic distribution and the number of studies per country.

![Fig. 2. The geographic distribution and the number of studies per country.](image-url)
3.1. Cumulative prevalence of insomnia symptoms (subthreshold, moderate and severe)

Using all available studies, a random-effects meta-analysis evaluated the prevalence of insomnia symptoms in all populations \((K = 48, N = 133,006)\) generated a pooled cumulative prevalence of insomnia symptoms using a random-effects model \(= 52.57\% \pm 47.44; 57.65\%\); 95\% PI \([20.40; 82.66]\%\); \(\tau^2 = 0.5143 \pm [0.2758; 0.8359]\); \(\tau = 0.7171 \pm [0.5252; 0.9143]\); \(I^2 = 99.6\%\); \(H = 16.09\) [15.50; 16.70]; \(Q = 12168.85\) (df = 47), \(p < 0.001\) See Fig. 3. A (leave-one-out) sensitivity analysis found that no study had a greater than 1% impact on the global prevalence estimate. Visual inspection of funnel plots indicated no clear publication bias, with Egger’s regression \(p = 0.4\), confirming the absence of publication bias. Meta-regression analysis revealed that neither age nor sex moderated the cumulative prevalence of insomnia symptoms during the COVID-19 pandemic \(p = 0.6\) and \(p = 0.5\), respectively. Detailed results are presented in Table 2 (see Table 3 and Table 4).

3.2. Cumulative prevalence of insomnia (moderate and severe)

Cumulative prevalence of insomnia symptoms (moderate and severe) using a random-effects model \(= 16.66\% \pm [13.57; 20.29]\%; 95\% PI \([3.49; 52.51]\%\); \(\tau^2 = 0.7069 \pm [0.3054; 0.8761]\); \(\tau = 0.8407 \pm [0.5527; 0.9360]\); \(I^2 = 99.4\% \pm [99.4%; 99.5\%]\); \(H = 13.46\) [12.90; 14.04]; \(Q = 8511.02\) (df = 47), \(p < 0.001\) See Fig. 4. A (leave-one-out) sensitivity analysis found that no study had a greater than 1% impact on the global prevalence estimate. Visual inspection to funnel plots indicated no clear publication bias, Egger’s regression \(p = 0.3\), confirmed the absence of publication bias. Meta-regression analysis revealed that neither age nor sex moderates the cumulative prevalence of insomnia symptoms (moderate and severe) during the COVID-19 pandemic \(p = 0.8\) and \(p = 0.5\), respectively. Detailed results are presented in Table 2.

![Fig. 3. Cumulative prevalence of insomnia symptoms (subthreshold, moderate and severe).](image-url)
Table 2
Insomnia symptoms during COVID-19 by severity: a meta-analysis, a moderator analysis, and assessment of heterogeneity.

| Component | K | N | Random-effects meta-analysis | Heterogeneity | Moderators | Publication Bias |
|-----------|---|---|-----------------------------|---------------|------------|-----------------|
|           |   |   | Pooled results [95%CI] | Forest Plot | $r^2$ | H | $r^2$ | Q | Age | Sex (% Female) |
| Cumulative prevalence of insomnia symptoms (subthreshold, moderate and severe) | 48 | 133006 | 52.57 [47.44; 57.65] | Fig. 3 | 99.6% | 16.09 | 0.5141 | 12168.85 | 0.6 | 0.5 | Egger's 0.4 — |
| Cumulative prevalence of insomnia (moderate and severe) | 48 | 133006 | 66.08 [61.37; 70.89] | Fig. 4 | 99.9% | 13.46 | 0.7069 | 8511.02 | 0.8 | 0.5 | Egger's 0.3; |
| Prevalence of subthreshold insomnia symptoms | 48 | 133006 | 33.42 [30.89; 36.04] | Fig. 5 | 98.7% | 8.62 | 0.1547 | 3490.18 | 0.5 | 0.6 | Egger's 0.4; |
| Prevalence of moderate insomnia symptoms | 48 | 133006 | 13.75 [11.18; 16.79] | Fig. 6 | 99.3% | 12.21 | 0.6695 | 7001.48 | 0.8 | 0.6 | Egger's 0.4; |
| Prevalence of severe insomnia symptoms | 48 | 133006 | 2.50 [1.93; 3.25] | Fig. 7 | 97.5% | 6.32 | 0.7803 | 1876.19 | 0.9 | 0.4 | Egger's 0.9; |

Abbreviations: CI, Confidence interval. K — denotes the number of studies. N — denotes the number of participants. NA — Not applicable. NI — Not indicated. NS — Not Significant.

Methodological details: $r^2$ statistic describes the percentage of variation across studies due to heterogeneity rather than chance. In a random-effects meta-analysis, the extent of variation among the effects observed in different studies (between-study variance) is referred to as $r^2$-squared. Cochran’s Q, which is 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. Meta-regression was performed using Method of Moments Estimator for Random Effect Multivariate Meta-Analysis. Publication bias was not observed in the Funnel plot. Adjusted results were calculated using trill-and-fill.

Table 3
Insomnia symptoms during COVID-19 by population: a meta-analysis, a moderator analysis, and assessment of heterogeneity.

| Population | K | N | Random-effects meta-analysis | Heterogeneity | Moderators | Publication Bias |
|------------|---|---|-----------------------------|---------------|------------|-----------------|
|            |   |   | Pooled results [95%CI] | Forest Plot | $r^2$ | H | $r^2$ | Q | Age | Sex (% Female) |
| General population | 11 | 24680 | 34.05 [30.12; 38.21] | 97.3% | 0.2941 | 0.0865 | 366.05 |
| - Subthreshold insomnia symptoms | 13.24 [9.78; 17.68] | 98.7% | 0.5653 | 0.3196 | 790.11 |
| - Moderate insomnia symptoms | 2.85 [1.91; 4.22] | 96.7% | 0.6261 | 0.3920 | 301.02 |
| Healthcare workers | 14 | 10445 | 32.61 [28.68; 36.81] | 94.3% | 0.3330 | 0.1109 | 229.46 |
| - Subthreshold insomnia symptoms | 14.91 [10.30; 21.10] | 98.1% | 0.7890 | 0.6225 | 682.67 |
| - Moderate insomnia symptoms | 2.32 [1.52; 3.52] | 90.1% | 0.7225 | 0.5220 | 131.87 |
| Multiple | 10 | 81389 | 33.73 [27.35; 40.76] | 99.5% | 0.4819 | 0.2322 | 1965.38 |
| - Subthreshold insomnia symptoms | 12.01 [7.94; 17.74] | 99.5% | 0.7335 | 0.5380 | 1908.85 |
| - Moderate insomnia symptoms | 2.00 [1.34; 2.98] | 96.7% | 0.6263 | 0.3923 | 272.14 |
| Special population | 9 | 3824 | 33.75 [30.73; 36.92] | 69.7% | 0.1638 | 0.0268 | 26.36 |
| - Subthreshold insomnia symptoms | 14.85 [11.73; 18.62] | 86.3% | 0.3587 | 0.1287 | 58.26 |
| - Moderate insomnia symptoms | 3.23 [2.06; 5.03] | 79.8% | 0.5884 | 0.3462 | 39.59 |
| University students | 4 | 81389 | 33.40 [25.53; 42.31] | 95.9% | 0.3700 | 0.1369 | 73.49 |
| - Subthreshold insomnia symptoms | 15.12 [12.45; 17.79] | 98.7% | 0.5653 | 0.3196 | 790.11 |
| - Moderate insomnia symptoms | 3.26 [1.97; 5.16] | 93.8% | 1.2295 | 1.1516 | 137.25 |

Abbreviations: CI, Confidence interval. K — denotes the number of studies. N — denotes the number of participants. NA — Not applicable. NI — Not indicated. NS — Not Significant.

Methodological details: $r^2$ statistic describes the percentage of variation across studies due to heterogeneity rather than chance. In a random-effects meta-analysis, the extent of variation among the effects observed in different studies (between-study variance) is referred to as $r^2$-squared. Cochran’s Q, which is 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. Meta-regression was performed using Method of Moments Estimator for Random Effect Multivariate Meta-Analysis. Publication bias was not observed in the Funnel plot. Adjusted results were calculated using trill-and-fill.

3.3. Prevalence of subthreshold insomnia symptoms

Prevalence of subthreshold insomnia symptoms using a random-effects model = 33.42% [30.89; 36.04%]; 95% PI [18.39; 52.78%]; $\tau^2 = 0.1547$ [0.0879; 0.2671]; $\tau = 0.3933$ [0.2965; 0.5169]; $I^2 = 98.7%$ [98.5%; 98.8%]; $H = 8.62$ [8.14; 9.12]; $Q = 3490.18$ (df = 47), $p < 0.001$ See Fig. 5. A (leave-one-out) sensitivity analysis found that no study had a greater than 1% impact on the global prevalence estimate. Visual inspection to funnel plots indicated no clear publication bias, Egger's regression $p = 0.4$, confirmed the absence publication bias. Meta-regression analysis revealed that neither age nor sex moderated the prevalence of subthreshold insomnia symptoms during the COVID-19 pandemic $p = 0.5$ and $p = 0.6$, respectively. Detailed results are presented in Table 2.

Subgroup analysis of the prevalence of subthreshold insomnia symptoms by population grouping revealed that no statistically difference was observed between groups $p = 0.99$. Rates of subthreshold insomnia symptoms were as follow: healthcare workers 32.61% [28.68; 36.81%]; multiple populations 33.73% [27.35; 40.76%]; general population 34.05% [30.12; 38.21%]; special population 33.75% [30.73; 36.92%]; university students 33.40% [25.53; 42.31%]. Subgroup analysis of the prevalence of subthreshold
insomnia symptoms by country revealed that a statistically significant difference existed between countries \( p < 0.001 \). Specifically significant rates of subthreshold insomnia symptoms were: China 27.27% [22.30; 32.88%]; India 28.91% [24.90; 33.28%]; Italy 46.82% [38.24; 55.61%]; Turkey 35.11% [32.45; 37.86%]; and United States 38.31% [28.54; 49.13%].

3.4. Prevalence of moderate insomnia symptoms

Prevalence of moderate insomnia symptoms using a random-effects model was 13.75% [11.18; 16.79%]; 95% PI [2.93; 45.71%]; \( I^2 = 0.6695 \) [0.2891; 0.8332]; \( \tau = 0.8182 \) [0.5377; 0.9128]; \( I^2 = 99.3\% \) [99.3%; 99.4%]; \( H = 12.21 \) [11.67; 12.77]; \( Q = 7001.48 \) (df = 47), \( p < 0.001 \). See Fig. 6 A (leave-one-out) sensitivity analysis found that no study had a greater than 0.5% impact on the global prevalence estimate. Visual inspection to funnel plots indicated no clear publication bias, Egger's regression \( p = 0.4 \), confirmed the absence of publication bias. Meta-regression analysis revealed that neither age nor sex moderates the prevalence of moderate insomnia symptoms during the COVID-19 pandemic \( p = 0.8 \) and \( p = 0.6 \), respectively. Detailed results are presented in Table 2.

Subgroup analysis of the prevalence of moderate insomnia symptoms by population grouping revealed that no statistically significant difference was observed between groups \( p = 0.89 \). Rates of subthreshold insomnia symptoms were as follow: healthcare workers 14.91% [10.30; 21.10%]; multiple populations 12.01% [07.94; 17.74%]; general population 13.24% [09.78; 17.68%]; special population 14.85% [11.73; 18.62%]; university students 15.12% [05.58; 34.95%]. Subgroup analysis of the prevalence of moderate insomnia symptoms by country revealed that a statistically significant difference existed between countries \( p < 0.001 \). Specifically rates of moderate insomnia symptoms were: China 07.52% [04.97; 11.23%]; India 12.53% [08.44; 18.20%]; Italy 14.29% [12.98; 15.71%]; Turkey 10.96% [07.38; 15.97%] and United States 25.55% [14.95; 40.10%].

3.5. Prevalence of severe insomnia symptoms

Prevalence of severe insomnia symptoms using a random-effects model was 2.50% [1.93; 3.25%]; 95% PI [0.42; 13.44%]; \( I^2 = 0.7803 \) [0.3593; 1.0806]; \( \tau = 0.8834 \) [0.5994; 1.0395]; \( I^2 = 97.5\% \) [97.1%; 97.8%]; \( H = 6.32 \) [5.89; 6.78]; \( Q = 1876.19 \) (df = 47), \( p < 0.001 \). See Fig. 7 A (leave-one-out) sensitivity analysis found that no study had a greater than 0.25% impact on the global prevalence estimate. Visual inspection to funnel plots indicated no clear publication bias, Egger's regression \( p = 0.9 \), confirmed the absence of publication bias. Meta-regression analysis revealed that neither age nor sex moderates the prevalence of severe insomnia symptoms during the COVID-19 pandemic \( p = 0.9 \) and \( p = 0.4 \), respectively. Detailed results are presented in Table 2.

Subgroup analysis of the prevalence of severe insomnia symptoms by population grouping revealed that no statistically significant difference was observed between groups \( p = 0.53 \). Rates of subthreshold insomnia symptoms were as follow: healthcare workers 02.32% [01.52; 03.52%]; multiple populations 02.00% [01.34; 02.98%]; general population 02.85% [01.91; 04.22%]; special population 03.23% [02.06; 05.03%]; university students 03.26% [0.97; 10.36%]. Subgroup analysis of the prevalence of severe insomnia symptoms by country revealed that a statistically significant difference existed between countries \( p < 0.001 \). Specifically rates of severe insomnia symptoms were: China 02.04% [00.87; 04.73%]; India 02.85% [01.52; 05.28%]; Italy 01.80% [01.27; 02.56%]; Turkey 02.12% [01.43; 03.12%] and United States 04.27% [02.69; 06.71%].

### Table 4

| Population       | N  | Pooled results [95%CI] | Heterogeneity |
|------------------|----|------------------------|---------------|
|                  | K  | \( \tau \)   | \( \tau^2 \) |
| China            | 9  | 82162                | 99.4%         |
| - Subthreshold insomnia symptoms | 27.27 [22.30; 32.88] | 0.3928 | 0.1543 | 1278.05 |
| - Moderate insomnia symptoms | 7.52 [4.97; 11.23] | 0.6548 | 0.4287 | 1242.59 |
| - Severe insomnia symptoms | 2.04 [0.87; 4.73] | 1.2692 | 1.6110 | 1367.59 |
| India            | 3135 |                  |               |
| - Subthreshold insomnia symptoms | 28.91 [24.90; 33.28] | 0.2227 | 0.0496 | 28.66 |
| - Moderate insomnia symptoms | 12.53 [8.44; 18.20] | 0.5177 | 0.2680 | 74.18 |
| - Severe insomnia symptoms | 2.85 [1.52; 5.28] | 0.7221 | 0.5214 | 36.30 |
| Italy            | 4  | 17665                | 98.4%         |
| - Subthreshold insomnia symptoms | 46.62 [38.24; 55.61] | 0.3531 | 0.1247 | 182.34 |
| - Moderate insomnia symptoms | 14.29 [12.98; 15.71] | 0.0858 | 0.0074 | 8.65 |
| - Severe insomnia symptoms | 1.80 [1.27; 2.56] | 0.2801 | 0.0785 | 12.67 |
| United States    | 3  | 1716                 | 94.9%         |
| - Subthreshold insomnia symptoms | 38.31 [28.54; 49.13] | 0.3797 | 0.1442 | 39.27 |
| - Moderate insomnia symptoms | 25.55 [14.95; 40.10] | 0.5811 | 0.3377 | 71.24 |
| - Severe insomnia symptoms | 4.27 [2.69; 6.71] | 0.3575 | 0.1278 | 7.64 |
| Turkey           | 3  | 1194                 | 99.9%         |
| - Subthreshold insomnia symptoms | 35.11 [32.45; 37.86] | 0.00 | 0 | 0.96 |
| - Moderate insomnia symptoms | 10.96 [7.38; 15.97] | 0.2978 | 0.0887 | 5.34 |
| - Severe insomnia symptoms | 2.12 [1.43; 3.12] | 0.00 | 0 | 0.52 |
symptoms (including subthreshold insomnia symptoms and moderate and severe insomnia) was 52.57%. The novel contribution of IPD meta-analysis was to standardize and improve the quality of the data analysis. Furthermore, providing an analysis of insomnia using ISI by subgroups according to symptoms severity was never reported before during the COVID-19 pandemic. The prevalence of clinically significant insomnia was 16.66% when modeled together or 13.75% moderate insomnia and 2.50% severe insomnia when modeled separately. No statistically significant differences were detected in the prevalence of insomnia symptoms or insomnia among different population groupings. However, a statistically significant difference was observed between countries for all severities of insomnia symptoms. Neither age nor sex appeared to be moderators of the prevalence of cumulative prevalence of subthreshold insomnia symptoms or of clinically significant insomnia.

Several studies have confirmed the concomitant increase in sleep disturbances in the general population caused by COVID-19 [3,4,7,47–51]. The pooled prevalence rate of insomnia symptoms during COVID-19 (40–50%) observed in the current study is consistent with two previous meta-analyses [5,48]. In addition, one of these meta-analyses reported that age and sex did not affect estimates of sleep disturbance prevalence [5]. Similar findings were reported in previous reviews [5,48,52]. A previous systematic review and meta-analysis conducted by our group reported a subgroup meta-analysis of aggregate ISI data and obtained an overall prevalence of insomnia symptoms of 30.98% [26.77; 35.54%] [53].

Insomnia is the most frequently occurring sleep disorder in the adult population [54], with a pre-COVID-19 prevalence of 5.0–20.0% using formal diagnostic procedures [55]. The findings of the current review showed that the post-COVID-19 prevalence of moderate to severe insomnia is similar to rates of pre-COVID-19 insomnia. This suggests that although the pandemic COVID-19 has been associated with increased rates of cumulative prevalence of subthreshold insomnia and insomnia, individuals meeting diagnostic criteria for insomnia remained the same, while prevalence of subthreshold insomnia increased [56].

| Study | Number | Total | Prevalence (%) | 95%CI | Events per 100 observations |
|-------|--------|-------|----------------|------|-----------------------------|
| Ageromini et al. 2020 | 130 | 884 | 14.71 [12.44; 17.21] |     |                             |
| Al Amrani et al. 2020 | 102 | 720 | 14.17 [11.70; 16.93] |     |                             |
| Alamrawy et al. 2021 | 122 | 447 | 27.29 [23.21; 31.68] |     |                             |
| AlAwadi et al. 2021 | 405 | 1313 | 30.85 [26.35; 33.42] |     |                             |
| Al et. al. 2021 | 42 | 294 | 14.29 [10.49; 18.82] |     |                             |
| Alshekhali et al. 2020 | 159 | 1136 | 14.00 [12.03; 16.15] |     |                             |
| Atac et al. 2020 | 22 | 149 | 14.77 [9.49; 21.50] |     |                             |
| Alas et al. 2021 | 7 | 106 | 6.60 [2.70; 13.13] |     |                             |
| Bacego et al. 2020 | 452 | 2652 | 17.04 [15.63; 18.53] |     |                             |
| Bajaj et al. 2020 | 64 | 391 | 16.37 [12.84; 20.42] |     |                             |
| Chatterjee et al. 2021 | 28 | 140 | 20.00 [13.72; 27.59] |     |                             |
| Elhadi et al. 2021 | 3417 | 10296 | 33.19 [32.28; 34.11] |     |                             |
| Erazo et al. 2021 | 172 | 1060 | 16.23 [14.06; 18.59] |     |                             |
| Essangri et al. 2021 | 186 | 549 | 33.88 [29.93; 38.01] |     |                             |
| Fekih-Romdhane et al. 2020 | 39 | 210 | 18.57 [13.55; 24.59] |     |                             |
| Giardino et al. 2020 | 348 | 1059 | 32.86 [30.04; 35.78] |     |                             |
| Gu et al. 2020 | 119 | 983 | 12.11 [10.13; 14.31] |     |                             |
| Guisano et al. 2020 | 109 | 624 | 17.47 [14.57; 20.68] |     |                             |
| Gupta et al. 2020 | 72 | 903 | 7.97 [6.29; 9.94] |     |                             |
| Hendrickson et al. 2020 | 240 | 694 | 34.58 [31.04; 38.25] |     |                             |
| Jahromi et al. 2021 | 81 | 549 | 14.75 [11.89; 18.00] |     |                             |
| Jain et al. 2020 | 147 | 512 | 28.71 [24.83; 32.84] |     |                             |
| Khanal et al. 2020 | 34 | 475 | 7.16 [5.01; 9.86] |     |                             |
| Khoury et al. 2021 | 62 | 303 | 20.46 [16.06; 25.45] |     |                             |
| Kim et al. 2021 | 55 | 221 | 24.89 [19.33; 31.13] |     |                             |
| Konig et al. 2021 | 101 | 484 | 20.87 [17.33; 24.76] |     |                             |
| Lahin et al. 2021 | 164 | 1081 | 15.17 [13.08; 17.45] |     |                             |
| Luaikala et al. 2021 | 131 | 1744 | 7.31 [6.32; 8.36] |     |                             |
| Marelli et al. 2021 | 64 | 400 | 16.00 [12.55; 19.97] |     |                             |
| Marroquin et al. 2020 | 67 | 435 | 15.40 [12.14; 19.14] |     |                             |
| Mongkol et al. 2020 | 581 | 4004 | 14.51 [13.43; 15.64] |     |                             |
| Qiao et al. 2020 | 155 | 2285 | 6.78 [5.79; 7.89] |     |                             |
| Saghari et al. 2020 | 256 | 587 | 43.61 [39.56; 47.73] |     |                             |
| Sahin et al. 2020 | 138 | 939 | 14.70 [12.49; 17.12] |     |                             |
| Safl et al. 2021 | 2095 | 13869 | 14.98 [14.38; 15.58] |     |                             |
| Samaniego et al. 2020 | 32 | 126 | 25.40 [20.07; 33.92] |     |                             |
| Scotta et al. 2020 | 156 | 584 | 26.71 [23.16; 30.50] |     |                             |
| Sekartaj et al. 2021 | 18 | 101 | 17.82 [10.92; 26.70] |     |                             |
| Sharma et al. 2020 | 12 | 108 | 11.11 [5.87; 18.60] |     |                             |
| Shi et. al. 2020 | 3256 | 5678 | 5.74 [5.55; 5.94] |     |                             |
| Song et al. 2020 | 26 | 709 | 3.67 [2.41; 5.33] |     |                             |
| Sun et al. 2020 | 1454 | 6905 | 21.05 [20.10; 22.04] |     |                             |
| Urzuza et al. 2020 | 29 | 125 | 23.20 [16.12; 31.59] |     |                             |
| Xu et al. 2021 | 758 | 11254 | 6.74 [6.28; 7.21] |     |                             |
| Youssf et al. 2020 | 104 | 450 | 23.11 [19.29; 27.29] |     |                             |
| Yu et al. 2020 | 270 | 1138 | 23.73 [21.28; 26.31] |     |                             |
| Zhang et al. 2020 | 208 | 2182 | 9.33 [8.33; 10.84] |     |                             |
| Zhuo et. al. 2020 | 5 | 26 | 19.23 [6.55; 39.35] |     |                             |

Random effects model 133006 16.66 [13.57; 20.29]

Heterogeneity: $I^2 = 99.49\%$, $t^2 = 0.71$, $p = 0$

![Fig. 4. Cumulative prevalence of insomnia (moderate and severe).](image-url)


It has been proposed that the term “coronasomnia” or “COVID-somnia” encompasses a constellation of symptoms of sleep dysfunction, such as insomnia symptoms, interrupted sleep continuity, and changes in sleep-wake patterns during the COVID-19 pandemic [57].

Our findings indicate that there was a significant rise in the frequencies of subthreshold insomnia symptoms from before the COVID-19 pandemic while no comparable rise was seen in moderate to severe insomnia [56]. Educating diverse demographic groups about the significance of sleep and the risk of developing symptoms of insomnia during this or future pandemics should be a concern for the sleep medicine community, as should be developing measures to prevent the development of subthreshold insomnia so that the development of full-blown insomnia disorders can be prevented.

Several factors may contribute to insomnia symptoms caused by issues related to COVID-19. There were high levels of anxiety, depression, post-traumatic stress disorder (PTSD), and stress in the general population across the globe during the COVID-19 pandemic [58]. Female gender, younger age group (< 35 years), history of psychiatric illnesses, unemployment, low educational status, and frequent exposure to social media/news regarding COVID-19 infection were reported as important risk factors [58]. The relationship between anxiety and depression and insomnia symptoms has long been recognized [59,60], and it has been found that mental distress has been more prevalent in the general population during the COVID-19 pandemic [61–63]. An analysis of 556 participants in a French study found that 19% of them met the diagnostic criteria for clinical insomnia and found that COVID-19-related worries and loneliness played a significant role in the development of their insomnia, as well as low education levels, virus infection, and preexisting mental health problems [64].

### Table: Prevalence of subthreshold insomnia symptoms.

| Study                  | Number | Total | Prevalence (%) | 95% CI | Events per 100 observations |
|------------------------|--------|-------|----------------|--------|----------------------------|
| Agberomri et al. 2020  | 262    | 884   | 29.64          | [26.64; 32.77] |
| Al Amri et al. 2020    | 207    | 720   | 28.75          | [25.47; 32.21] |
| Almrawi et al. 2021    | 175    | 447   | 39.15          | [34.60; 43.85] |
| AlAhmad et al. 2021    | 451    | 1313  | 34.35          | [31.78; 36.99] |
| Ali et al. 2021        | 88     | 294   | 29.93          | [24.75; 35.52] |
| Alshehri et al. 2020   | 337    | 1136  | 29.67          | [27.02; 32.42] |
| Atac et al. 2020       | 47     | 149   | 31.54          | [24.18; 39.65] |
| Atas et al. 2021       | 37     | 106   | 34.91          | [25.90; 44.78] |
| Bacaro et al. 2020     | 953    | 2652  | 35.94          | [34.11; 37.79] |
| Bajaj et al. 2020      | 145    | 391   | 37.08          | [32.28; 42.08] |
| Chatterjee et al. 2021 | 40     | 140   | 28.57          | [21.26; 36.81] |
| Elhadi et al. 2021     | 3747   | 10296 | 36.39          | [36.46; 37.33] |
| Erazo et al. 2021      | 406    | 1060  | 38.30          | [35.36; 41.30] |
| Essamri et al. 2021    | 158    | 549   | 28.72          | [25.02; 32.77] |
| Fakhri-Romdhane et al. 2020 | 48    | 210   | 22.86          | [17.36; 29.14] |
| Giardino et al. 2020   | 432    | 1059  | 40.79          | [37.82; 43.82] |
| Gu et al. 2020         | 201    | 983   | 20.45          | [17.97; 23.11] |
| Guellano et al. 2020   | 391    | 624   | 62.66          | [58.73; 66.47] |
| Gupta et al. 2020      | 219    | 903   | 24.25          | [21.49; 27.16] |
| Handrick et al. 2020   | 311    | 694   | 44.81          | [41.07; 48.60] |
| Jahrami et al. 2021    | 122    | 549   | 22.22          | [18.81; 25.94] |
| Jain et al. 2020       | 163    | 512   | 31.84          | [27.82; 36.00] |
| Khanal et al. 2020     | 127    | 475   | 26.74          | [22.81; 30.96] |
| Khoury et al. 2021     | 124    | 303   | 40.92          | [35.34; 46.69] |
| Kim et al. 2021        | 95     | 221   | 42.99          | [36.37; 49.80] |
| Kojic et al. 2021      | 177    | 484   | 36.57          | [32.27; 41.04] |
| Lahin et al. 2021      | 278    | 1081  | 25.72          | [23.13; 28.43] |
| Laskar et al. 2021     | 535    | 1744  | 30.68          | [28.52; 32.90] |
| Marello et al. 2021    | 209    | 400   | 52.25          | [47.23; 57.24] |
| Marquini et al. 2020   | 118    | 435   | 27.13          | [23.00; 31.57] |
| Mongkolth et al. 2021  | 1576   | 4004  | 39.39          | [37.84; 40.98] |
| Qiu et al. 2020        | 502    | 2285  | 21.97          | [20.29; 23.72] |
| Sagherian et al. 2020  | 257    | 587   | 43.78          | [39.72; 47.90] |
| Sahin et al. 2020      | 335    | 939   | 35.68          | [32.61; 38.83] |
| Saffi et al. 2021      | 5297   | 13989 | 37.87          | [37.06; 38.68] |
| Samanez et al. 2020    | 49     | 126   | 38.89          | [30.34; 47.98] |
| Scotta et al. 2020     | 263    | 584   | 45.03          | [40.95; 49.17] |
| Sekar et al. 2021      | 33     | 101   | 32.67          | [26.37; 42.72] |
| Sharma et al. 2020     | 29     | 108   | 26.85          | [18.78; 36.24] |
| Shi et al. 2020        | 13308  | 56679 | 23.48          | [23.13; 23.83] |
| Song et al. 2020       | 121    | 709   | 17.07          | [14.37; 20.04] |
| Sun et al. 2020        | 2820   | 6905  | 40.83          | [39.67; 42.00] |
| Uruzu et al. 2020      | 48     | 125   | 36.40          | [29.84; 47.52] |
| Xu et al. 2021         | 3181   | 11254 | 28.27          | [27.43; 29.11] |
| Youssf et al. 2020     | 171    | 450   | 38.00          | [33.50; 42.66] |
| Yu et al. 2020         | 530    | 1138  | 46.57          | [43.64; 49.52] |
| Zhang et al. 2020      | 531    | 2182  | 24.34          | [22.55; 26.19] |
| Zhuo et al. 2020       | 8      | 26    | 30.77          | [14.33; 51.79] |

**Random effects model**

133006

Heterogeneity: τ² = 98.65%, I² = 0.15, p < 0

**Fig. 5.** Prevalence of subthreshold insomnia symptoms.
severity was associated with poor sleep hygiene behaviors, dysfunctional beliefs about sleep, self-reported stress, anxiety, and depression [65].

In their study of 5461 Chinese participants, Lin and colleagues found that insomnia was more common among women and young people living in the ‘epicenter’ and experiencing a high level of threat from COVID-19 infection [66]. During the COVID-19 pandemic period, another large Chinese study of 12,000+ adolescents and young adults found that approximately 25% of them had insomnia symptoms with female sex, depression and anxiety, and living in the city were observed to be the greatest risk factors, while subjective and objective social support were protective [67]. Some researchers have attempted to study the effects of lockdown and quarantine periods, in particular, on both subthreshold insomnia symptoms and clinically significant insomnia symptoms among the general public, even though many of the studies pertaining to the general population include people in lockdown (as was the case in many countries during the pandemic).

An investigation by Papa et al. (2020) looked at the prevalence of subthreshold insomnia symptoms and clinically significant insomnia among healthcare providers dealing with COVID-19 patients; the study found that 39% of the healthcare providers had insomnia [17].

This systematic review and IPDMA has several strengths. The prevalence of insomnia symptoms has been estimated (by severity) in different populations using individual participants data providing a more accurate understanding of the effects of COVID-19 on insomnia symptoms. The NOS checklist was used to assess the methodological quality of each analyzed study. Subgroup analysis and meta-regression provided a robust approach in exploring heterogeneity in the findings. The present review’s findings are also generalizable since the synthesized sample size was large, and participants were recruited from 25 countries.

Nevertheless, this review also has limitations. The review focused only on ISI data and did not consider other insomnia symptom assessment measures, e.g., the Regensburg Insomnia

![Fig. 6. Prevalence of moderate insomnia symptoms.](image-url)
There may be bias in this study’s estimations of prevalence of insomnia, since other measures may capture insomnia severity differently. All of the studies reviewed here used the ISI self-report to assess insomnia as opposed to a formal interview and diagnostic process. Therefore, results in the present review might be influenced by the psychometric strength of each language translation. COVID-19 has dynamic effects on insomnia [48]; therefore, people may suffer from different levels of insomnia based on the severity of the COVID-19 outbreak in their area. The policies used to control the COVID-19 outbreak have also been different in different countries. Thus, the estimated results in this review do not necessarily reflect COVID-19’s impact over a specific period. The bulk of the included studies were from Chinese and Italian populations, a limitation to generalizability. Additionally, most synthesized samples were young adults from the general population or healthcare workers groups. Thus, the results of this review are not generalizable to various ethnic and age groups (i.e., older people and children). The elderly were identified as a high-risk group for insomnia during the COVID-19 pandemic; partially because COVID-19 infection is associated with increased vulnerability as a person ages [68]. Another limitation of this review was the response rate, whereby approximately 50% of authors agreed to participate and provided original datasets for secondary analyses. Finally, the generalization of the present review should be taken within the background of the observed high statistical heterogeneity. A high I² estimate is not necessarily synonymous with important heterogeneity [33]. In the same way, a low value of I² is not always an indicator of consistent and homogeneous results [33]. For example, a meta-analysis of prevalence commonly yields high I² estimates, and authors of meta-analyses sometimes conclude their results are heterogeneous [33]. However, the I² statistic is not an absolute index for the amount of variability observed, and its estimation can be impacted by some factors such as the number of studies or the pooled result. Therefore, the high I² must be interpreted along with the prediction intervals shown in our review [33].

![Fig. 7. Prevalence of severe insomnia symptoms.](image-url)
5. Conclusion

The pooled estimate of insomnia symptoms (subthreshold and clinically significant) was 52.57%. An estimated 16.66% of the population suffered from clinically significant insomnia, of which 13.75% suffered from moderate insomnia, and 2.50% suffered from severe insomnia. The different populations’ grouping had no statistically significant differences in the prevalence of insomnia symptoms. Insomnia symptoms did not appear to be associated with age or sex. Our data suggests that the COVID-19 pandemic is associated specifically with a marked increase in the rates of sub-threshold insomnia symptoms but not moderate or severe insomnia. Educating diverse demographic groups about the significance of sleep and the risk of developing symptoms of insomnia during this or future pandemics should be a concern for the sleep medicine community, as should be developing measures to prevent the development of subthreshold insomnia and from its progression to more severe forms of the disorder.

Author agreement

All authors were involved in writing the paper and have seen and approved the manuscript.

Ethical statement

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

For this type of study (meta-analysis) formal consent is not required.

The COMITY investigators

| Name | Affiliation |
|------|-------------|
| 1. Abyomi O. Olaseni | Department of Psychology, University of Ilorin, Ilorin, Nigeria. |
| 2. Agustín Ramiro Miranda | Health Sciences Research Institute (National University of Cordoba - National Scientific and Technical Research Council, Argentina). |
| 3. Alfonso Urzúa | Escuela de Psicología, Universidad Católica del Norte, Antofagasta, Chile. |
| 4. Amani H Alshahrani | Department of Clinical Pharmacy, College of Pharmacy, King Saud University, Riyadh, Saudi Arabia. |
| 5. Amine Souaied | Surgical Oncology Department, National Institute of Oncology, Medical school, Mohammed V University in Rabat Morocco. |
| 6. Ana Veronica Scotta | Health Sciences Research Institute (National University of Cordoba - National Scientific and Technical Research Council, Argentina). |
| 7. Antonio Samaniego | Universidad Nacional de Asunción, Paraguay. |
| 8. Arika Lahiri | Community Medicine, Dr. B. C. Roy Multi-Specialty Medical Research Centre, Indian Institute of Technology Kharagpur, West Bengal, India. |
| 9. Arturo Garay | Medicina del Sueño-Neurología-Centro de Educación Médica e Investigaciones Clínicas “Norberto Quirno” (CEMIC), Buenos Aires, Argentina. |
| 10. Arup Chakraborthy | Dept. of Community Medicine, Medical College and Hospital, 8B, College Street, Kolkata, 700073, West Bengal, India. |
| 11. Arzu VelisogluI | Division of Nephrology, Department of Internal Medicine, School of Medicine, Marmara University, Istanbul, Turkey. |
| 12. Aurora D’Atri | Department of Biotechnological and Applied Clinical Sciences, University of L’Aquila, L’Aquila, Italy. |
| 13. Ayushi Jain | Department of Anaesthesiology and Critical Care, Dr S N Medical College, Jodhpur, Rajasthan, India. |
| 14. Branda Yee-Man Yu | Department of Psychology, the University of Hong Kong, Hong Kong SAR, China. |
| 15. Brett Marroquin | Loyola Marymount University, Los Angeles, California, USA. |
| 16. Catherine McCall | Pulmonary, Critical Care, and Sleep Medicine, VA Puget Sound Health Care System, 1660 S. Columbian Way, S-111 PULM, Seattle, WA 98108 |
| 17. Chiara Baglioni | Department of Psychiatry and Behavioral Sciences, University of Washington School of Medicine, 1559 NE Pacific Street, Box 356560 Room BB1644, Seattle, WA 98195-6560, USA |
| 18. Cristian Huck-Iriart | Instituto de Tecnologías Emergentes y Ciencias Aplicadas (ITECA), UNSAM-CONICET, Escuela de Ciencia y Tecnología, Laboratorio de Cristalografía Aplicada, Campus Miguelete, (1650) San Martín, Buenos Aires, Argentina. |
| 19. Daniela L. Giardino | Medicina del Sueño-Neurología-Centro de Educación Médica e Investigaciones Clínicas “Norberto Quirno” (CEMIC), Buenos Aires, Argentina. |
| 20. Daniela Tempesta | Department of Biotechnological and Applied Clinical Sciences, University of L’Aquila, L’Aquila, Italy. |
| 21. Debanjan Banerjee | Consultant Geriatric Psychiatrist, Nehru Memorial Techno Global Hospital, Kolkata, India; Member, International Psychogeriatric Association (IPA). |
| 22. Deemah AlAteeq | Department of Clinical Sciences, College of Medicine, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia. |
| 23. Dilek Barutcu Atas | Division of Nephrology, Department of Internal Medicine, School of Medicine, Marmara University, Istanbul, Turkey. |
| 24. Dima Sweidan | Department of Nutrition, Faculty of Pharmacy and Medical Sciences, University of Petra, Amman, Jordan. |

Funding

Role of the funding source: This IPD systematic review and meta-analysis have not been funded by any government agency, private industry, or non-profit organization.

Contributors

HJ designed the study. MMR, FFR, GNP, ZS, AFA, AH, WC, HD coordinated data collection, data entry and data cleaning. HJ performed statistical analyses and MMR, FFR, GNP, ZS, AFA, AH, WC, HD, NB, SRP wrote the first draft. ASB, MVV provided intellectual contributions to strengthening the manuscript and edited original draft. All authors provided critical revisions of manuscript, involved in writing and approved the final version.

Declaration of competing interest

The authors do not have any conflicts of interest to disclose.

Acknowledgements

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2022.06.020.

Appendix B

(continued on next page)
| Name | Affiliation |
|------|-------------|
| M.M. AlRasheed, F. Fekih-Romdhane, H. Jahrami et al. | Department of Clinical and Biological Psychology, Catholic University of Eichstaett-Ingolstadt, Ostenstraße 25, 85072 Eichstaett, Germany. |
| 25. Edgar Efrain Pazmino Erazo | Department of Psychology, Chrisland University Abeokuta Nigeria. |
| 26. Federico Salfi | Multimodal Clinical Neuroimaging Laboratory (MCNL), Center for Neurobehavioral Research, Boys Town National Research Hospital, Boys Town, NE, United States of America. |
| 27. Geeta Singaraya | Department of Anaesthesiology and Critical Care, Dr N G Medical College, Jodhpur, Rajasthan, India. |
| 28. Ghada I Aboheimeed | Department of Clinical Pharmacy, College of Pharmacy, King Saud University, Riyadh, Saudi Arabia. |
| 29. Ghada Saad Altalha | Social psychology and personality staff development skills department, COMMON first year, King Saud University, Riyadh, Saudi Arabia. |
| 30. Gianluca Voglino | Department of Public Health Sciences and Paediatrics, University of Torino, 10124 Torino, Italy. |
| 31. Giulia Amicucci | Department of Psychology, Sapienza University of Rome, Rome, Italy. |
| 32. Giuseppina Lo Moro | Department of Public Health Sciences and Pediatrics, University of Torino, 10124 Torino, Italy. |
| 33. Hajer Elsafi | Social psychology and personality Self development skills department, COMMON first year, King Saud University, Riyadh, Saudi Arabia. |
| 34. Hong-xing Wang | Division of Neuropsychiatry and Psychosomatics, Department of Neurology, Xuanwu Hospital Capital Medical University. |
| 35. Jianyu Que | Peking University Sixth Hospital, Peking University Institute of Mental Health, NHC Key Laboratory of Mental Health (Peking University), National Clinical Research Center for Mental Disorders (Peking University Sixth Hospital), Chinese Academy of Medical Sciences Research Unit (No.2018RU0006), Peking University, Beijing 100191, China. |
| 36. Junya Konig | Department of Clinical and Biological Psychology, Catholic University of Eichstaett-Ingolstadt, Ostenstraße 25, 85072 Eichstaett, Germany. |
| 37. Kaiming Zhuo | Shanghai Mental Health Center, Shanghai Jiao Tong University School of Medicine, Shanghai, China. |
| 38. Khizra Sultana | Research Clinical Trial Services, King Abdullah International Medical Research Center (KAIMRC), Riyadh, Saudi Arabia. |
| 39. Knar Sagherian | King Saud Bin Abdulaziz University for Health Sciences (KSAU-HS), Riyadh, Saudi Arabia. |
| 40. Kun Wang | College of Nursing, The University of Tennessee Knoxville, Knoxville, Tennessee, USA. |
| 41. Kyumin Kim | Division of Neuropsychiatry and Psychosomatics, Department of Neurology, Xuanwu Hospital Capital Medical University, Beijing, China. |
| 42. Le Shi | Department of Psychiatry, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea. |
| 43. Lorenzo Viselli | Peking University Sixth Hospital, Peking University Institute of Mental Health, NHC Key Laboratory of Mental Health (Peking University), National Clinical Research Center for Mental Disorders (Peking University Sixth Hospital), Chinese Academy of Medical Sciences Research Unit (No.2018RU0006), Peking University, Beijing 100191, China. |
| 44. Lin Song | CAS Key Laboratory of Mental Health, Institute of Psychology, Beijing 100101, China. |
| 45. Lin Lu | Department of Psychology, University of Chinese Academy of Sciences, Beijing 100049, China. |
| 46. Lorenzo Viselli | National Institute on Drug Dependence and Beijing Key Laboratory of Drug Dependence, Peking University, Beijing, China. |
| 47. Luigi Ferrini-Strambi | Department of Biotechnological and Applied Clinical Sciences, University of L’Aquila, L’Aquila, Italy. |
| 48. Maha Al Ammari | National Clinical Research Center for Mental Disorders (Peking University Sixth Hospital), Chinese Academy of Medical Sciences Research Unit (No.2018RU0006), Peking University, Beijing 100191, China. |
| 49. Maria Rosaria Gualano | Peking-Tsinghua Centre for Life Sciences and PKU-IDC/McGovern Institute for Brain Research, Peking University, Beijing, China. |
| 50. Maria Sekartaji | Department of Psychology, University of Chinese Academy of Sciences, Beijing 100049, China. |
| 51. Michele Ferrara | National Institute on Drug Dependence and Beijing Key Laboratory of Drug Dependence, Peking University, Beijing, China. |
| 52. Mohamed El-Kassas | Lorenzo de Viterbo University, Naples, Italy. |
| 53. Mohammad Ali | Faculty of Psychology, “Vita-Salute” San Raffaele University, Milan, Italy. |
| 54. Mohammad Elhadi | Department of Biotechnological and Applied Clinical Sciences, University of L’Aquila, L’Aquila, Italy. |
| 55. Muna Alsheikali | Faculty of Medicine, University of Tripoli, Tripoli, Libya. |
| 56. Mustafa Kursat Sahin | Department of Psychiatry, University of Tripoli, Tripoli, Libya. |
| 57. Naglaa Youssef | Faculty of Medicine, University of Tripoli, Tripoli, Libya. |
| 58. Necipli Alci | General Administration of School Health, Ministry of Health, Riyadh, Saudi Arabia. |
| 59. Nea Mishra | National Institute on Drug Dependence and Beijing Key Laboratory of Drug Dependence, Peking University, Beijing, China. |
| 60. Neher Aftak | College of Nursing, University of Washington School of Medicine, 1959 NE Pacific Street, Box 356560 Room BB1644, Seattle, WA 98195-6560, USA. |
| 61. Pratik Khanal | Department of Public Health, International School of Medicine, Istanbul Medipol University, Istanbul, Turkey. |
| 62. QMSun | Department of Medicine, Faculty of Medicine, Public Health and Nursing, Gadjah Mada University, Jl. Farmak, Sekip Utara, Yogyakarta 55281, Indonesia. |
| 63. Ravi Gupta | Department of Medicine, Faculty of Medicine, Public Health and Nursing, Gadjah Mada University, Jl. Farmak, Sekip Utara, Yogyakarta 55281, Indonesia. |
| 64. Rebecca C. Hendrickson | Department of Obstetrics and Gynaecology, Government Institute of Medical Sciences, Greater Noida, IND. |
| 65. Ritu Sharma | Faculty of Pharmacy services Ministry of National Guard Health Affairs (MNGHA), Ministry of National Guard Health Affairs (MNGHA), King Abdullah International Medical Research Center (KAIMRC), Riyadh, Saudi Arabia. |
| 66. Roa Gamal Alarmrawy | Department of Obstetrics and Gynaecology, Government Institute of Medical Sciences, Greater Noida, IND. |
| 67. Rotimi Ogunyado | Department of Psychology, University of Ilorin Nigeria |
| 68. Sahil Bajaj | Social psychology and personality Self development skills department, COMMON first year, King Saud University, Riyadh, Saudi Arabia. |
| 69. Samir Al-Adawi | Department of Clinical Neurosciences, Neurology-Sleep Disorders Center, IRCCS San Raffaele Scientific Institute, Milan, Italy. |
| 70. Samson F. Agerotimi | Department of Psychology, Chrisland University Aboeokuta Nigeria. |
| 71. Sara Marelli | Department of Clinical Neurosciences, Neurology-Sleep Disorders Center, IRCCS San Raffaele Scientific Institute, Milan, Italy. |
References

[1] Lin YN, et al. Burden of sleep disturbance during COVID-19 pandemic: a systematic review. Nat Sci Sleep 2021;13:933–66.
[2] Zhang J, et al. Poor-sleep is associated with slow recovery from lymphopenia and an increased need for ICU care in hospitalized patients with COVID-19: a retrospective cohort study. Brain Behav Immun 2020;88:50–8.
[3] Abbas A, et al. Sleep quality among healthcare workers during the COVID-19 pandemic and its impact on medical errors: Kuwait experience. Turk Thorac J 2021;22(2):142–8.
[4] Almoradi Z, et al. Sleep problems during COVID-19 pandemic and its association to psychological distress: a systematic review and meta-analysis. EClinicalMedicine 2021;36:100916.
[5] Jahrami H, et al. Sleep problems during the COVID-19 pandemic by population: a systematic review and meta-analysis. J Clin Sleep Med 2021;17(2):299–313.
[6] Cenat JM, et al. Prevalence of symptoms of depression, anxiety, insomnia, posttraumatic stress disorder, and psychological distress among populations affected by the COVID-19 pandemic: a systematic review and meta-analysis. Psychiatr Res 2021;295:113999.
[7] Al Maqbali M, Al Sinani M, Al-Lenjawi B. Prevalence of stress, depression, anxiety and sleep disturbance among nurses during the COVID-19 pandemic: a systematic review and meta-analysis. J Psychosom Res 2021;141:110343.
[8] Buysse DJ. Insomnia. Jama 2013;309(7):706–16.
[9] Ishak WW, et al. Quality of life in patients suffering from insomnia. Innov Clin Neurosci 2012;9(10):13.
[10] Deng J, et al. The prevalence of depressive symptoms, anxiety symptoms and sleep disturbance in higher education students during the COVID-19 pandemic: a systematic review and meta-analysis. Psychiatr Res 2021;301:113803.
[11] Deng J, et al. The prevalence of depression, anxiety, and sleep disturbances in COVID-19 patients: a meta-analysis. Ann N Y Acad Sci 2021;1486(1):90–111.
[12] Salari N, et al. The prevalence of sleep disturbances among physicians and nurses facing the COVID-19 patients: a systematic review and meta-analysis. Glob Health 2020;16(1):92.
[13] Marvaldi M, et al. Anxiety, depression, trauma-related, and sleep disorders among healthcare workers during the COVID-19 pandemic: a systematic review and meta-analysis. Neurosci Biobehav Rev 2021;126:252–64.
[14] Serrano-Ripoll MJ, et al. Insomnia and sleep quality in healthcare workers fighting against COVID-19: a systematic review of the literature and meta-analysis. Actas Esp Psiquiatr 2021;49(4):155–79.
[15] Xia L, et al. Prevalence of sleep disturbances and sleep quality in Chinese healthcare workers during the COVID-19 pandemic: a systematic review and meta-analysis. Front Psychiatr 2021;12:646342.
[16] da Silva FCT, Neto MLR. Psychiatric symptomatology associated with depression, anxiety, distress, and insomnia in health professionals working in patients affected by COVID-19: a systematic review with meta-analysis. Prog Neuro-Psychopharmacol Biol Psychiatry 2021;104:110057.
[17] Pappa S, et al. Prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic: a systematic review and meta-analysis. Brain Behav Immun 2020;88:901–7.
[18] Mulyadi M, et al. Prevalence of mental health problems and sleep disturbances in nursing students during the COVID-19 pandemic: a systematic review and meta-analysis. Nurse Educ Pract 2021;57:103223.
[19] Sharma M, et al. Impact of COVID-19 pandemic on sleep in children and adolescents: a systematic review and meta-analysis. Sleep Med 2021;84:259–67.
[20] Souza UFF, et al. The impact of COVID-19 pandemic in the quality of sleep by Pittsburgh Sleep Quality Index: a systematic review. Ciência Saúde Coletiva 2021;26(4):1457–66.
[21] Morin CM, et al. The Insomnia Severity Index: psychometric indicators to detect insomnia cases and evaluate treatment response. Sleep 2011;34(5):601–8.
[22] Chiu HY, et al. A meta-analysis of diagnostic accuracy of three screening tools for insomnia. J Psychosom Res 2016;87:85–92.
[23] Wang H, et al. The methodological quality of individual participant data meta-analysis on intervention effects: systematic review. BMJ 2021;373:n736.
[24] Mohler D, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 2009;151(4):264–9.
[25] Bastien CH, Vallières A, Morin CM. Validation of the Insomnia Severity Index as an outcome measure for insomnia research. Sleep Med 2000;1(2):297–307.
[26] Luchini C, et al. Assessing the quality of studies in meta-analyses: advantages and limitations of the Newcastle Ottawa scale. World J Meta-Anal 2017;5(4):80–4.
[27] Simmonds MC, et al. Meta-analysis of individual patient data from randomized trials: a review of methods used in practice. Clin Trials 2005;2(3):209–17.
[28] Debray TP, et al. Individual participant data meta-analysis for a binary outcome: one-stage or two-stage? PLoS One 2013;8(4):e50560.
| Reference                                                                 | Title                                                                 | Journal                                                                 |
|---------------------------------------------------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------|
| [30] Borenstein M, et al. | A basic introduction to fixed-effect and random-effects models for meta-analysis | Res Synth Methods 2010;1:2:97–111.                                      |
| [31] DerSimonian R, Laird N | Meta-analysis in clinical trials revisited. | Contemp Clin Trials 2015;45(Pt A):39–45.                              |
| [32] Cipper C, Pearson E | The use of confidence or fiducial limits illustrated in the case of the Bioterrorism. | Sleep Med 2001;21:111–115.                                            |
| [33] IntHout J, et al. | Plea for routinely presenting prediction intervals in meta-analysis. | BMJ Open 2016;6(7):e010247.                                            |
| [34] Higgins JP, Thompson SG | Quantifying heterogeneity in a meta-analysis. | Stat Med 2002;21:111–115.                                             |
| [35] Higgins JP, et al. | Measuring inconsistency in meta-analyses. | BMJ 2003;327(7414):55–60.                                             |
| [36] Hedges LV, Olkin I | Statistical methods for meta-analysis. | Academic press; 1985.                                                  |
| [37] Cochran WG | The combination of estimates from different experiments. | Biometrics 1954;10(1):101–29.                                          |
| [38] Higgins JP, et al. | Cochrane handbook for systematic reviews of interventions. | John Wiley & Sons; 2019.                                               |
| [39] Sterne JAC, et al. | Recommendations for examining and interpreting funnel plots. | J Stat Software 2010;36(3):1–8.                                       |
| [40] Beggs CB, Mazumdar M | Operating characteristics of a rank correlation test for publication bias. | Biometrics 1994:1088–101.                                             |
| [41] Gjerde M, Heuch I | Improving the error rates of the Beggs and Mazumdar test for publication bias in fixed effects meta-analysis. | BMC Med Res Methodol 2012;14(1):11.                                    |
| [42] Duval S, Tweedie R | A nonparametric “Trim and Fill” method of accounting for publication bias in meta-analysis. | J Am Stat Assoc 2000;95(459):89–98.                                   |
| [43] R: A.1.0. | Vienna R Foundation for Statistical Computing; 2020 05(05): 2020. p. 2021. Available from: | https://www.R-project.org/.                                             |
| [44] Balduzzi S, Rücker G, Schwarzer G | How to perform a meta-analysis with R: a comprehensive study. | BMJ Open 2011;1:559819.                                               |
| [45] Alimoradi Z, et al. | Gender-specific factors associated with mental health outcomes across healthcare settings in Oman during COVID-19: frontline versus non-frontline healthcare workers. | BMJ Open 2020;10:10.e026136.                                          |
| [46] Atac O, et al. | Anxiety and depression among healthcare workers during the covid-19 pandemic. | Turkish J Public Health 2020;18:47–57.                                |
| [47] Barutcu Atas D, et al. | The association between perceived stress with sleep quality, insomnia, anxiety and depression in kidney transplant recipients during Covid 19 pandemic. | PLoS One 2021;16(3):e0248117.                                        |
| [48] Bajaj S, et al. | Insomnia during COVID-19 pandemic and lockdown: a cross-sectional survey of hospital nursing staff in the Fangcang shelter hospital in China. | Int J Soc Isol 2020;76:16.                                              |
| [49] Giardino DL, et al. | The endless quarantine: the impact of the COVID-19 outbreak on healthcare workers after three months of mandatory social isolation in Argentina. | Sleep Med 2020;76:16–25.                                              |
| [50] Gu Y, Zhu Y, Xu G | Factors associated with mental health outcomes among healthcare personnel in the Fangcang shelter hospital in China. | Int J Soc Isol 2020;76:16.                                              |
| [51] Gualano MR, et al. | Effects of covid-19 lockdown on mental health and sleep disturbances in Italy. | Int J Environ Res Publ Health 2020;17(13).                             |
| [52] Hendrickson RC, et al. | The impact of working during the Covid-19 pandemic on mental health and sleep quality among people during the COVID-19 pandemic: a cross-sectional study. | Front Psychol 2020;11:559819.                                          |
| [53] Khoury JE, et al. | COVID-19 and mental health during pregnancy: the importance of cognitive appraisal and social support. | J Affect Disord 2021;281:95–104.                                      |
| [54] Kim K, et al. | Functional impairments in the mental health, depression and anxiety related to the COVID-19 pandemic, and disruption in healthcare service utilization among cancer patients in the COVID-19 pandemic Era. | Cancer Res Treat 2021.                                                  |
| [55] König J, et al. | The German translation of the stress and anxiety to viral epidemics-9 (SAVE-9) scale: results from healthcare workers during the second wave of COVID-19. | Int J Environ Res Publ Health 2021;18(17).                             |
| [56] Laih A, et al. | Correlates of insomnia among the adults during COVID19 pandemic: evidence from an online survey in India. | Sleep Med 2021;77:95–104.                                             |
| [57] Laukkala T, et al. | COVID-19 pandemic and Helsinki university hospital personnel psychological well-being: six-month follow-up results. | Int J Environ Res Publ Health 2021;18(5):2524.                         |
| [58] Marello S, et al. | COVID-19 lockdown on sleep quality in students and administration staff. | J Neurol 2020;281:1–8.                                               |
| [59] Marquis Q, Vine M, Morgan R | Mental health during the COVID-19 pandemic: effects of stay-at-home policies, social distancing behavior, and social resources. | Psychiatr Res 2020;293:113419.                                         |
