SSM - Population Health 25 (2024) 101588

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Global burden of sleep disturbances among older adults and the disparities by geographical regions and pandemic periods

Min Du [a], Min Liu [a], Yaping Wang [a], Chenyuan Qin [a], Jue Liu [a,b,c,d,e,*]

[a] Department of Epidemiology and Biostatistics, School of Public Health, Peking University, No.38, Xueyuan Road, Haidian District, Beijing, China
[b] Institute for Global Health and Development, Peking University, No.5, Yiheyuan Road, Haidian District, Beijing, 100871, China
[c] Global Center for Infectious Disease and Policy Research & Global Health and Infectious Diseases Group, Peking University, No.38, Xueyuan Road, Haidian District, Beijing, 100191, China
[d] Key Laboratory of Reproductive Health, National Health and Family Planning Commission of the People's Republic of China, No.38, Xueyuan Road, Haidian District, Beijing, 100191, China
[e] Department of Global Health and Population, Harvard TH Chan School of Public Health, 677 Huntington Avenue, Boston, MA, USA

ARTICLE INFO

Keywords:
Older
Sleep
COVID
Insomnia
Meta

ABSTRACT

Sleep disturbances are highly prevalent during the COVID-19 pandemic, especially among older adults. We aimed to evaluate sleep heath during COVID-19 pandemic and assess the differences among geographical regions and pandemic periods. We searched three databases (PubMed, Embase, Web of Science) to find articles up to March 12, 2023. We included observational studies that reported the prevalence of sleep disturbances among adults aged 60 years or older in any setting. Two researchers independently reviewed the literature and retrieved the data. We used Der Simonian-Laird random effects meta-analyses to pool the data, followed by subgroup analysis, sensitivity analysis, and meta-regression. A total of 64 studies with 181,224 older adults during the pandemic were included. The prevalence of poor sleep quality, short sleep duration, long sleep duration, and insomnia symptoms were 47.12% (95% CI: 25.97%, 68.27%), 40.81% (95% CI: 18.49%, 63.12%), 31.61% (95% CI: 24.83%, 38.38%), and 21.15% (95% CI: 15.30%, 27.00%), respectively. The prevalence of sleep problems reported by self-constructed items was 26.97% (95% CI: 20.73%, 33.22%). When compared to America (64.13%), Europe (20.23%) and the Western Pacific (21.31%) showed a lower prevalence of sleep problems (all $P < 0.0001$). The prevalence of worsened sleep problems was 27.88% (95% CI: 11.94%, 43.82%). Compared to 2020 (15.14%), it increased to 47.42% in 2021 ($P < 0.05$). Eight studies on sleep disturbances among 672 older COVID-19 patients were included. The prevalence of sleep problems and insomnia symptoms among older COVID-19 patients were 41.58% (95% CI: 21.97%, 61.20%) and 41.56% (95% CI: 28.11%, 58.02%), respectively. A significant burden related to poor sleep has been observed among older adults worldwide over the past three years, with variations across different regions and time periods. It is important to make more efforts in prevention and intervention to identify the risk factors, treatment, and rehabilitation of sleep disturbances for healthy aging.

2. Introduction

As of November 8, 2023, 771,820,937 confirmed cases and 6,978,175 deaths due to the Coronavirus disease 2019 (COVID-19) resulted in a significant disease burden and economic loss worldwide (World Health Organization, 2022). It has been more than three years since the COVID-19 pandemic was declared by the World Health Organization (WHO) on March 11, 2020. COVID-19 related experiences, such as quarantine, closure, low social support, workplace bullying, and burnout influence people's health, causing numerous psychological morbidities, including depression, anxiety, and sleep disturbances (Chowdhury et al., 2023; Chowdhury, Kabir, Akter, et al., 2023; Chowdhury et al., 2022; Farooq, Tunmore, Wajid Ali, & Ayub, 2021; Krishnamoorthy, Nagarajan, Saya, & Menon, 2020; Salanti et al., 2022).

Sleep disturbances as potential risk factors for morbidity and mortality, should given paid attention (Liu et al., 2021). Krishnamoorthy

* Corresponding author. Department of Epidemiology and Biostatistics, School of Public Health, Peking University; Institute for Global Health and Development, Peking University Beijing, 100191, China.
E-mail address: jueliu@bjmu.edu.cn (J. Liu).

https://doi.org/10.1016/j.ssmph.2023.101588
Received 11 October 2023; Received in revised form 23 November 2023; Accepted 18 December 2023
Available online 23 December 2023

et al.(Krishnamoorthy et al., 2020) reported that the pooled prevalence of poor sleep quality and insomnia among general populations during the COVID-19 pandemic was 40% and 30%, respectively. Several studies have reported that a higher prevalence of sleep problems among COVID-19 patients, followed by healthcare professionals and the general population (Alimoradi et al., 2021; Krishnamoorthy et al., 2020; Pappa et al., 2020; Zhang et al., 2021). 30.57% of healthcare workers experienced insomnia among the 422 Bangladeshi healthcare workers in 2021 (Hasan et al., 2021). Jahrami et al. (Jahrami et al., 2022) reported that the estimated prevalence of sleep problem was as follows: 52.39% among COVID-19 patients, 45.96% among children and adolescents, 42.47% among healthcare workers, 41.50% among special populations with healthcare needs, 41.16% among university students, and 36.73% among the general population. The COVID-19 pandemic has threatened the sleep health of all populations, including older adults.

Older adults are a vulnerable population, and the number and proportion of people aged 60 years and older are increasing. According to the WHO, the number of older adults was 1 billion in 2019 (World Health Organization, 2023). This number is projected to increase to 1.4 billion by 2030 and 2.1 billion by 2050 (World Health Organization, 2023). During the COVID-19 pandemic, studies focusing on the sleep of older adults were limited compared with the general population. Previous studies have reported a wide range in the prevalence of sleep disturbances among older adults, from 5.59% to 65.45% (Osiogo et al., 2021; Rodríguez-Gómez et al., 2022). Similarly, the prevalence of insomnia has been reported to range from 3.88% to 64.49% (Philip et al., 2020; Savci, Cil Akinci, Yildirim Usenmez, & Keles, 2021) in this population. Karaogullarindan et al. reported that 70.37% of older COVDI-19 patients in Turkey had poor sleep quality (Karaogullarindan, Erkan, Tuhanioglu, Kuran, & Gorgulu, 2021). The prevalence of sleep disturbances reported by different studies in the elderly varies greatly, which may be related to various factors such as the assessment methods used (including scale, self-constructed items, and medical diagnosis), the country where the study was conducted, and the study period.

Understanding the effect of the COVID-19 pandemic on the sleep health of older adults is beneficial in order to implement intervention measures that can improve sleep, reduce the risk of morbidity and mortality from other diseases, and promote healthy aging. However, there was a lack of meta-analysis to estimate the prevalence of sleep disturbances among adults aged 60 years or older. Therefore, we conducted a systematic review to determine the prevalence of sleep disturbances, such as insomnia symptoms, poor sleep quality, and short or long sleep duration, in terms of various assessment methods. In addition, we examined the variations in geographical region, income level, COVID-19 pandemic period, and SARS-CoV-2 infection period, taking into account that more than three years had passed since the COVID-19 pandemic.

3. Material and methods

3.1. Search strategy

We searched scientific databases, including PubMed, Embase, and Web of Science, to identify studies that reported the prevalence of sleep disturbances among older adults aged 60 years or older during the COVID-19 pandemic or among those infected with SARS-CoV-2. We included studies published from the inception of each database through March 12, 2023. We conducted a systematic review and meta-analysis in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (appendix p26-29)(Page et al., 2021). The protocol of this study was registered in PROSPERO (CRD42023466957). We included insomnia symptoms, poor sleep quality, short or long sleep duration, restless legs syndrome (RLS), sleep-disordered breathing (SDB), and obstructive sleep apnea (OSA) as the sleep disturbances for this analysis. We used the search terms to probe the title and abstract included ("SARS-CoV-2" or "COVID" or "coronavirus") and ("sleep" or "sleep disturbances" or "sleep quality" or "sleep duration" or "sleep-disordered breathing" or "obstructive sleep apnea" or "Willis Ekbom disease" or "insomnia" or "restless legs syndrome") and ("older" or "elder" or "aging")". The detailed search strategies are presented in Supplementary Table 1.

The following PI/ECO model was used to evaluate the eligibility of the study.

(P) Participants: adults aged 60 years or older during the COVID-19 pandemic or those infected with SARS-CoV-2;
(I) Intervention/Exposure: not applicable;
(C) Comparator: not applicable;
(O) Outcome measure: sleep disturbances assessed using various methods including self-constructed items, scales, and clinical criteria.

3.2. Inclusion and exclusion criteria

Two researchers (YW and CQ) independently assessed study the eligibility of studies for inclusion. The studies were screened using the following inclusion criteria: 1) observational studies including case-control studies, cross-sectional studies, and cohort studies; 2) participants were older adults aged 60 or older; 3) due to the demand for rapid and convenient research during the COVID-19 pandemic, sleep has been investigated using various methods. Sleep disturbances were reported using self-constructed items, scales, and clinical criteria. We further analyzed sleep disturbances in terms of different assessment methods; 4) studies which provided sufficient data to calculate prevalence with 95% confidence intervals (CIs).

We excluded studies if they were reviews, animal studies, or duplicate studies (studies with a smaller sample size were excluded), and studies involving older adults with special diseases at baseline (e.g., patients with chronic diseases, cancer and mental diseases, etc.).

3.3. Data extraction and quality assessment

The data was independently extracted by two researchers (YW and CQ), who subsequently cross-checked the data in a blinded fashion. Controversial areas were resolved through discussion and were reviewed by a third author (MD). The extracted information includes the basic details of the article (first author, published year, title, country, and type of study), sample characteristics (mean or median age, COVID-19 pandemic period or SARS-CoV-2 infection period), the assess methods and diagnostic criteria of sleep disturbances, number of older adults and those with sleep disturbances, the mean scores with standard deviation (SD) of sleep disturbances, as well as information about sleep disturbances type (cases or scores) by age and sex groups. The income level of each country was further classified into low, low-middle, upper-middle, or high-income according to the World Bank's country classification (The World Bank. income, 2023). The quality of the included studies was evaluated using a tool developed by Hoy and colleagues (Cao et al., 2022; Hoy et al., 2012). Each study was assessed based on 10 criteria, and a score of one (yes) or zero (no) was assigned for each item. Quality was assessed using a ten-point tool and classified as low (>eight), moderate (six−eight), and high (≤five) risk of bias.

3.4. Measurement of sleep disturbances

During the COVID-19 pandemic, previous studies utilized various methods such as medical diagnosis, self-constructed items, and standardized questionnaires to assess sleep disturbances due to convenience and rapid availability. We further analyzed sleep disturbances in terms of different assessment methods.

We included five different sleep disturbances: 1) sleep disorders (sleep problems in 19 studies using self-constructed items (Amerio et al., 2023; Collinge & Bath, 2023; Corley et al., 2021; Gokseven et al., 2022;

Gustavsson & Beckman, 2020; Ikeda et al., 2022; Kapusta et al., 2023; Makizako et al., 2021; Nakai et al., 2022; Okely et al., 2020; Osiogo et al., 2021; Paiva et al., 2021; Perelman, Xavier, & Barros, 2022; Rodríguez-Gómez et al., 2022; Sampaio Brito, de Lima, Mascarenhas, Mota, & Leite, 2021; Sapara et al., 2021; van der Velden, Marchand, Das, Muffels, & Bosmans, 2022; Yilmaz & Onal, 2023; Yurumez Korkmaz et al., 2021) and poor sleep quality in seven studies using Pittsburgh sleep quality index (PSQI) and the Patient-Reported Outcomes Information System (PROIS) (Amicucci, Salfi, D'Atri, Viselli, & Ferrara, 2021; Bhat, Mir, Hussain, & Shah, 2020; Garcia Carlini et al., 2023; Kantor, Kantor, Fortgang, & Pace-Schott, 2022; Kim et al., 2022; Udeh-Momoh et al., 2021; Wang et al., 2021); 2) short sleep duration <7 h (three studies) (Amerio et al., 2023; Mistry et al., 2021; Rodríguez-Gómez et al., 2022) and long sleep duration ≥9 h (two studies) (Mistry et al., 2021; Rodríguez-Gómez et al., 2022); 3) insomnia symptoms (three studies using self-constructed items (Savci et al., 2021; Schou-Bredal et al., 2021; Xu, Li, Zhu, & Zhong, 2022) and 11 studies using the insomnia severity index (ISI) or the Athens insomnia scale (AIS) (Al-Mutawa & Al-Mutairi, 2021; Amicucci et al., 2021; Christodoulou et al., 2023; Dale, Budimir, Probst, Stippl, & Pieh, 2021; Humer, Schaffler, Jesser, Probst, & Pieh, 2022; Li et al., 2022; Parlapani et al., 2020; Philip et al., 2020; Pieh et al., 2021; Pieh, Budimir, & Probst, 2020; Wang, Zhang, et al., 2021)); and 4) high nightmare frequency ≥ once a week (two studies) (Holzinger et al., 2022; Musse et al., 2020).

Then, we included four different sleep statuses: 1) mean sleep duration (eight studies) (Alqurashi et al., 2022; Ataka, Kimura, Eguchi, & Matsubara, 2022; Garcia Carlini et al., 2023; Ikeda et al., 2022; Kholghi et al., 2021; Makizako et al., 2021; Mistry et al., 2021; Wielgoszewska et al., 2022); 2) mean sleep efficiency (three studies) (Ataka et al., 2022; Garcia Carlini et al., 2023; Kholghi et al., 2021); 3) mean sleep quality scores (four studies) (Chin et al., 2022; Garcia Carlini et al., 2023; Hausman et al., 2022; Tracy et al., 2022); 4) mean ISI scores (three studies) (Dale et al., 2021; Gezgin Yazici & Ökten, 2022; Pieh et al., 2021).

We additionally included four shifted sleep patterns: 1) worsened sleep problems (seven studies using self-constructed items (Andras et al., 2022; De Pue et al., 2021; Galle et al., 2021; Kilibarda et al., 2022; S. Kim & Hwang, 2022; Siltanen, Ilmarinen, Luoma, Leppaaho, & Kehusmaa, 2022; Smail et al., 2022) and one study using standardized questionnaires (Yuan et al., 2020)); 2) sleeping more (five studies) (Emerson, 2020; Lee & Chu, 2022; Savci et al., 2021; Schrack, Corkum, & Freedman, 2022; Wielgoszewska et al., 2022); 3) sleeping less (eight studies) (Emerson et al., 2022; Emerson, 2020; Hong & Hee, 2022; Lee & Chu, 2022; Sampaio Brito et al., 2021; Savci et al., 2021; Triolo et al., 2022; Wielgoszewska et al., 2022); 4) worsened insomnia (two studies) (Kim & Hwang, 2022; Smail et al., 2022).

Considering SARS-CoV-2 infection also affects sleep, we conducted an additional analysis on sleep disturbances among older COVID-19 patients, including sleep problems (Karaogullarindan et al., 2021; Sârbu et al., 2022; Yadav, Yadav, Kumar, & Kumar, 2021) and insomnia symptoms (Aly & Saber, 2021; Izquierdo-Condoy et al., 2022; L. Li et al., 2021; Nejad, Allahyari, Hosseinzadeh, Heiat, & Ranjbar, 2021; Rego de Figueiredo et al., 2023) were included. The number of references reporting the age groups and sex groups for sleep disturbances was less than one, except sleep problems using self-constructed items (age groups (Collinge & Bath, 2023; Perelman et al., 2022) and sex groups (Gustavsson & Beckman, 2020; Ikeda et al., 2022)).

3.5. Statistical analysis

We performed DerSimonian-Laird random-effects meta-analyses (DerSimonian & Laird, 2015) to calculate the pooled prevalence and 95% CI of sleep disturbances among older adults. We conducted a univariable meta-regression to assess the association between sleep disturbances and study characteristics (study design, geographical region, World Bank income level, COVID-19 pandemic period, SARS-CoV-2 infection period, and the level of risk of bias). Additionally, the analysis examined the differences in sleep disturbances among different age and sex groups. We used the I^2 statistic to estimated statistical heterogeneity among the studies. We defined the degrees of heterogeneity as follows: very low (≤25%), low (25% to ≤50%), moderate (50% to ≤75%), and high (≥75%) (Higgins, Thompson, Deeks, & Altman, 2003). We assessed publication bias using funnel plots and Egger's test (Egger, Davey Smith, Schneider, & Minder, 1997). We used one-by-one elimination method to observe the robustness of results in sensitivity analyses. All analyses were performed using Stata software (version 12.0; Stata SE Corporation LP, College Station, TX, USA). A two-sided P-value of <0.05 was considered statistically significant.

4. Results

4.1. Characteristics of included studies

We finally included 72 studies (64 articles on sleep disturbances during the pandemic and eight articles on sleep disturbances among COVID-19 patients) (Fig. 1). Out of the 64 articles, 34 (53.12%) were from Europe, 13 (20.31%) were from the Western Pacific region, 12 studies (18.75%) were from America, two were from Eastern Mediterranean region, two were from the South-East Asia region, and one was from multiple regions. Additionally, 46 studies (73.44%) were from high-income countries, 14 (21.87%) were from upper-middle income countries, and two were from lower-middle income countries, and two were from countries at multiple income levels. Furthermore, 62 studies (96.87%) were cross-sectional studies, while two were cohort studies. In terms of risk of bias, 11 studies had a high risk of bias, 48 studies had a moderate risk of bias, and five had a low risk of bias (Supplementary Table 2). The Characteristics of the eight studies on sleep disturbances among COVID-19 patients can be found in Supplementary Table 3.

4.2. Sleep statuses and sleep disturbances among older adults during the COVID-19 pandemic

The mean sleep duration, mean sleep efficiency, mean PSQI scores and ISI scores were 7.00 h (95% CI: 6.85 h, 7.14 h), 91.69% (95% CI: 86.42%, 96.95%), 5.77 (95% CI: 2.29, 9.42), and 7.94 (95% CI: 1.72, 14.16) (Supplementary Fig. 1). There was no significant difference in mean sleep duration between 2020 (7.00 h; 95% CI: 6.85 h, 7.14 h)) and 2021 (6.97 h; 95% CI: 5.61 h, 8.32 h) ($P = 0.965$). There was no evidence of publication bias based on the funnel plots (Supplementary Fig. 2) and Egger's test (all $P > 0.05$). Sensitivity analyses were seen in Supplementary Fig. 3.

The prevalence of sleep problems and poor sleep quality was 26.97% (95% CI: 20.73%, 33.22%) and 47.12% (95% CI: 25.97%, 68.27%), respectively (Fig. 2 and Supplementary Fig. 4). For poor sleep quality (Egger's test: $P > 0.05$), there was no evidence of publication bias. However, for sleep problems (Egger's test: $P < 0.001$), the result was reversed (Supplementary Fig. 5). The prevalence of sleep problems was associated with the geographical region. Compared to America (980 older adults; 64.13%; 95% CI: 57.42%, 70.83%), the prevalence of sleep problems was lower in Europe (44,705 older adults; 20.23%; 95% CI: 13.70%, 26.77%) and the Western Pacific (738 older adults; 21.31%; 95% CI: 7.94%, 36.48%) (all $P < 0.0001$, Table 1). The prevalence of sleep problems among older adults aged ≥80 years or older was 21.7% (95% CI: −4.6%, 48.1%). It was 22.0% (95% CI: 8.86%, 35.15%) and 40.86% (95% CI: 11.92%, 69.79%) among males and females ($P = 0.378$), respectively. Sensitivity analyses for prevalence of sleep problems and poor sleep quality were seen in Supplementary Fig. 6.

The prevalence of short sleep duration and long sleep duration was 40.81% (95% CI: 18.49%, 63.12%) and 31.61% (95% CI: 24.83%, 38.38%), respectively (Supplementary Fig. 7). There was no evidence of publication bias based on the funnel plots (Supplementary Fig. 8) and Egger's test (all $P > 0.05$). The prevalence of high nightmares was

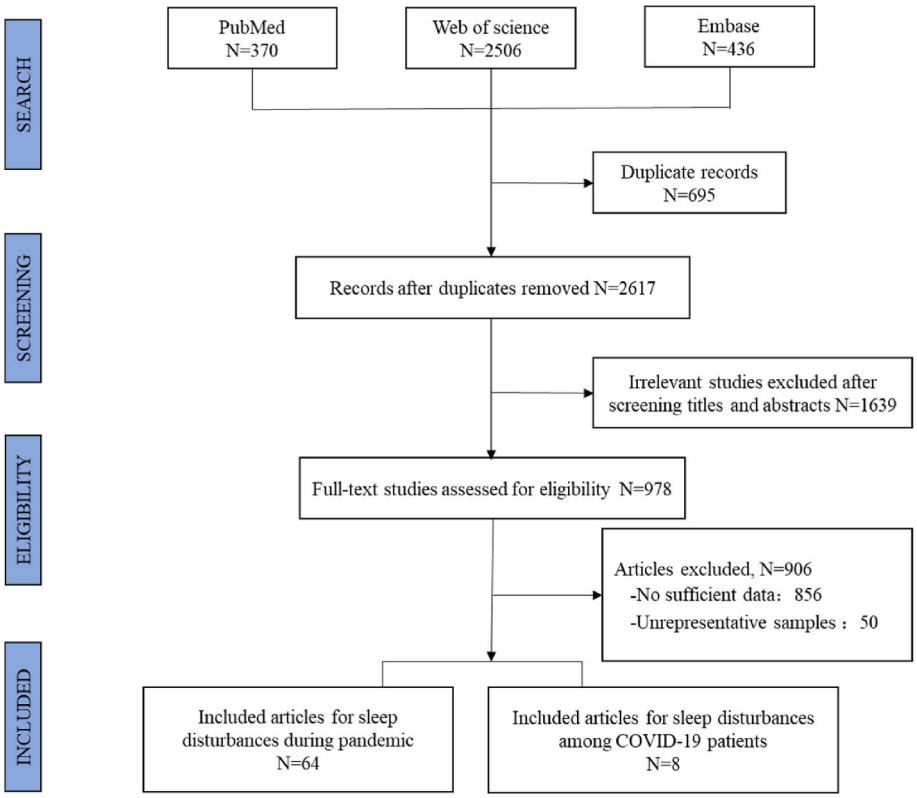
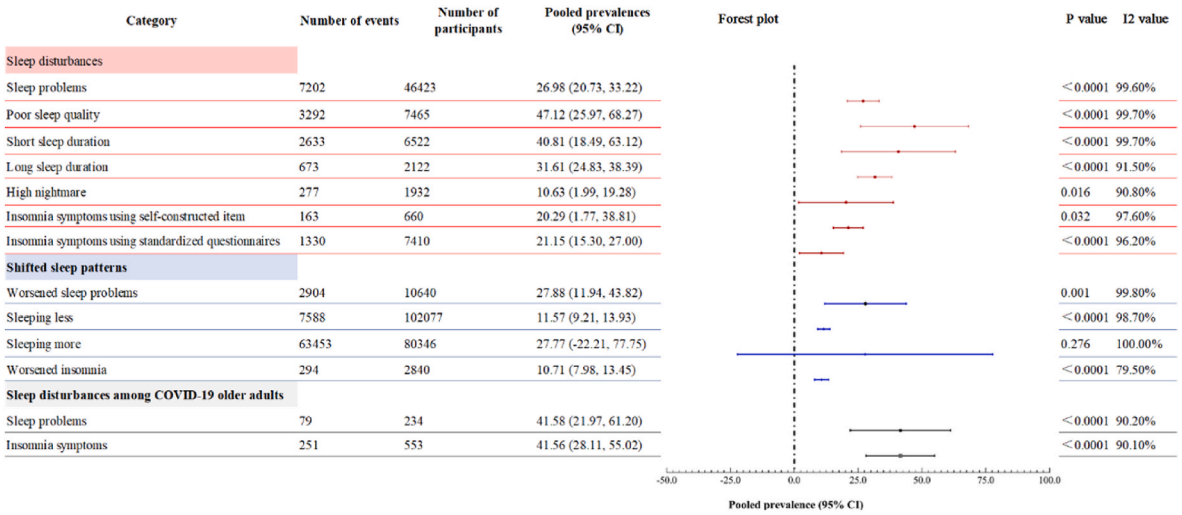


Fig. 1. Study flowchart.



Category	Number of events	Number of participants	Pooled prevalences (95% CI)	P value	I2 value
Sleep disturbances					
Sleep problems	7202	46423	26.98 (20.73, 33.22)	<0.0001	99.60%
Poor sleep quality	3292	7465	47.12 (25.97, 68.27)	<0.0001	99.70%
Short sleep duration	2633	6522	40.81 (18.49, 63.12)	<0.0001	99.70%
Long sleep duration	673	2122	31.61 (24.83, 38.39)	<0.0001	91.50%
High nightmare	277	1932	10.63 (1.99, 19.28)	0.016	90.80%
Insomnia symptoms using self-constructed item	163	660	20.29 (1.77, 38.81)	0.032	97.60%
Insomnia symptoms using standardized questionnaires	1330	7410	21.15 (15.30, 27.00)	<0.0001	96.20%
Shifted sleep patterns					
Worsened sleep problems	2904	10640	27.88 (11.94, 43.82)	0.001	99.80%
Sleeping less	7588	102077	11.57 (9.21, 13.93)	<0.0001	98.70%
Sleeping more	63453	80346	27.77 (-22.21, 77.75)	0.276	100.00%
Worsened insomnia	294	2840	10.71 (7.98, 13.45)	<0.0001	79.50%
Sleep disturbances among COVID-19 older adults					
Sleep problems	79	234	41.58 (21.97, 61.20)	<0.0001	90.20%
Insomnia symptoms	251	553	41.56 (28.11, 55.02)	<0.0001	90.10%

Fig. 2. Forest plots of sleep disturbances among older adults during COVID-19 pandemic. Note: CI = confidence interval.

10.63% (95% CI: 1.99%, 19.28%) among 1932 older adults. There was no evidence of publication bias based on the funnel plots and Egger's test ($P > 0.05$) (Supplementary Fig. 9). Sensitivity analyses for prevalence of short sleep duration, long sleep duration and high nightmares were seen in Supplementary Fig. 10.

The prevalence of insomnia symptoms was 20.29% (95% CI: 1.77%, 38.81%) and 21.15% (95% CI: 15.30%, 27.00%) when using self-constructed item and standardized questionnaires, respectively (Supplementary Fig. 11 and Fig. 2). For insomnia symptoms using self-constructed items (Egger's test: $P > 0.05$), there was no evidence of publication bias. However, for insomnia symptoms using standardized questionnaires (Egger's test: $P < 0.001$), the result was reversed (Supplementary Fig. 12). Sensitivity analyses were seen in Supplementary Fig. 13.

4.3. Shifted sleep patterns among older adults during the COVID-19 pandemic

The prevalence of worsened sleep problems, sleeping less, sleeping more, and worsened insomnia was 27.88% (95% CI: 11.94%, 43.82%), 11.57% (95% CI: 9.21%, 13.93%), 27.22% (95% CI: −22.21%, 77.75%), and 10.71% (95% CI: 7.98%, 13.45%), respectively (Supplementary Fig. 14). Except sleeping less (Egger's test: $P < 0.01$), there was no evidence of publication bias based on the funnel plots (Supplementary

Table 1
Univariable meta-regression of prevalence of sleep disturbances among older adults during COVID-19 pandemic.

Category	Number of studies	Pooled prevalence (95% CI)	I^2 value	Coefficient (95% CI)	P value
Sleep disturbances					
Sleep problems					
Geographic region					
America	3	64.13 (57.43, 70.83)	70.2%	Ref.	
Europe	13	20.24 (13.70, 26.77)	99.6%	0.64 (0.54, 0.74)	< 0.0001
Western Pacific	3	21.31 (7.94, 34.68)	95.3%	0.64 (0.53, 0.78)	< 0.0001
World Bank income level					
Multiple countries	1	7.76 (7.44, 8.08)	.%	Ref.	
Upper-middle-income	4	26.56 (15.75, 37.38)	95.0%	1.25 (0.78, 2.02)	0.335
High-income	14	28.00 (19.71, 36.29)	99.4%	1.22 (0.79, 1.90)	0.343
COVID-19 pandemic period					
2020	15	27.56 (20.25, 34.86)	99.6%	Ref.	
2021	3	21.07 (7.94, 34.20)	96.1%	0.94 (0.71, 1.23)	0.616
2022	1	36.44 (32.49, 40.40)	.%	1.09 (0.69, 1.70)	0.695
Level of risk of bias					
Moderate	12	26.97 (19.01, 34.94)	99.7%	Ref.	
High	7	25.99 (18.00, 33.97)	95.6%	1.01 (0.81, 1.20)	0.926
Poor sleep quality					
Geographic region					
America	2	28.37 (−10.78, 67.52)	99.3%	Ref.	
Europe	3	53.43 (30.97, 75.89)	97.4%	1.29 (0.70, 2.38)	0.282
Western Pacific	1	64.24 (62.46, 66.02)	.%	1.43 (0.64, 3.23)	0.254
South-East	1	50.00 (−19.30, 119.30)	.%	1.24 (0.31, 4.98)	0.652
World Bank income level					
Lower-middle-income	1	50.00 (−19.30, 119.30)	.%	Ref.	
Upper-middle-income	2	56.67 (41.24, 72.11)	95.3%	1.07 (0.30, 3.74)	0.894
High-income	4	41.74 (20.13, 63.35)	99.6%	0.92 (0.27, 3.10)	0.861
Level of risk of bias					
Low	2	64.20 (62.49, 65.91)	0.0%	Ref.	
Moderate	5	38.38 (18.95, 57.81)	99.3%	0.78 (0.54, 1.02)	0.163
Insomnia symptoms using standardized questionnaires					
Geographic region					
Western Pacific	2	15.12 (9.46, 20.79)	91.0%	Ref.	
Europe	8	22.17 (12.37, 31.96)	96.7%	1.08 (0.76, 1.54)	0.635
Eastern Mediterranean	1	33.33 (24.32, 42.35)	.%	1.20 (0.69, 2.10)	0.468
World Bank income level					
High-income	8	23.38 (13.94, 32.81)	96.6%	Ref.	
Upper-middle-income	2	15.12 (9.46, 20.79)	91.0%	0.92 (0.66, 1.27)	0.563
COVID-19 pandemic period					
2020	8	26.11 (17.78, 34.44)	96.8%	Ref.	
2021	2	11.77 (9.12, 14.41)	0.0%	0.86 (0.62, 1.20)	0.327
2022	1	6.51 (2.79, 10.23)	.%	0.82 (0.53, 1.27)	0.325
Level of risk of bias					
Moderate	7	23.47 (12.56, 34.38)	97.1%	Ref.	
Low	4	17.99 (11.45, 24.53)	91.6%	0.95 (0.73 1.17)	0.704
Shifted sleep patterns					
Worsened sleep problems					
Geographic region					
America	1	16.69 (14.28, 19.09)	.%	Ref.	
Europe	5	36.29 (20.53, 52.06)	99.3%	1.22 (0.73, 2.04)	0.373
Western Pacific	2	9.08 (−11.30, 29.45)	71.0%	0.94 (0.52, 1.70)	0.795
World Bank income level					
High-income	6	28.04 (7.06, 49.03)	99.8%	Ref.	
Upper-middle-income	2	30.66 (29.46, 31.87)	0.0%	0.99 (0.64, 1.55)	0.972
COVID-19 pandemic period					
2020	5	15.14 (4.38, 25.90)	98.6%	Ref.	
2021	3	47.20 (23.92, 70.47)	99.6%	1.38 (1.10, 1.72)	0.012
Level of risk of bias					
Moderate	7	25.06 (8.26, 41.85)	99.8%	Ref.	
High	1	47.10 (42.39, 51.81)	.%	1.25 (0.74, 1.76)	0.339
Sleeping less					
Geographic region					
America	2	28.33 (0.06, 56.60)	85.3%	Ref.	
Europe	4	12.66 (10.11, 15.22)	90.2%	0.95 (0.85, 1.06)	0.298
Western Pacific	2	6.95 (5.79, 8.12)	96.8%	0.90 (0.80, 1.01)	0.065
World Bank income level					
High-income	6	11.25 (8.79, 13.70)	99.1%	Ref.	
Upper-middle-income	2	26.17 (−7.30, 59.65)	88.7%	1.06 (0.89, 1.26)	0.462
Level of risk of bias					
Moderate	7	11.20 (8.85, 13.56)	98.9%	Ref.	
High	1	45.00 (23.20,66.80)	.%	1.40 (1.07, 1.73)	0.029
Sleeping more					
Geographic region					
America	2	14.20 (−11.06, 39.46)	99.6%	Ref.	

(*continued on next page*)

Table 1 (*continued*)

Category	Number of studies	Pooled prevalence (95% CI)	I^2 value	Coefficient (95% CI)	P value
Europe	2	12.17 (−7.81, 32.16)	99.5%	0.98 (0.48, 1.99)	0.913
Western Pacific	1	86.06 (85.80, 86.31)	.%	2.05 (0.86, 4.87)	0.07
Sleep disturbances among COVID-19 older adults					
Insomnia symptoms					
World Bank income level					
Lower-middle-income	2	38.71 (10.30, 67.11)	95.3%	Ref.	
Upper-middle-income	2	42.22 (15.96, 68.47)	86.1%	1.03 (0.44, 2.43)	0.881
High-income	1	45.35 (34.83, 55.87)	.%	1.07 (0.38, 3.01)	0.808
Level of risk of bias					
Moderate	2	53.94 (48.56, 59.32)	0.0%	Ref.	
High	3	32.57 (17.65, 47.50)	80.1%	0.81 (0.67, 0.95)	0.088

Note: CI = confidence interval.

Fig. 15) and Egger's test for the other three shifted sleep patterns (all $P > 0.05$). The prevalence of sleeping less was associated with the level of risk bias ($P = 0.029$, Table 1). The prevalence of worsened sleep problems was associated with COVID-19 pandemic period. Compared to 2020 (3592 older adults; 15.14%; 95% CI: 4.38%, 25.90%), the prevalence of worsened sleep problems was higher in 2021 (7048 older adults; 47.42%; 95% CI: 23.92%, 70.47%) ($P < 0.05$). Sensitivity analyses were seen in Supplementary Fig. 16.

4.4. Sleep disturbances among older adults infected with SARS-CoV-2

The prevalence of sleep problems and insomnia symptoms was 41.58% (95% CI: 21.97%, 61.20%) and 41.56% (95% CI: 28.11%, 58.02%), respectively (Supplementary Fig. 17 and Fig. 2). Except insomnia symptoms (Egger's test: $P > 0.05$), there was evidence of publication bias based on the funnel plots (Supplementary Fig. 18) and Egger's test of sleep problems ($P < 0.05$). Sensitivity analyses were seen in Supplementary Fig. 19.

5. Discussion

To the best of our knowledge, this current study is the first comprehensive systematic review and meta-analysis of the prevalence of sleep disturbances among older adults in terms of different assessment methods. This study considers the differences of sleep disturbances between geographical region, income level, COVID-19 pandemic period. Comprehensive assessment of sleep disturbances will provide the foundation for health management of older adults. Based on data from 64 observational studies covering 181,224 older adults, we have provided the estimates of poor sleep quality, short sleep duration, long sleep duration, and insomnia symptoms. We have also analyzed their differences in regional level and pandemic period.

Our findings integrated previously published evidence, and indicated that the prevalence of poor sleep quality and sleep problems among older adults was 47.12% and 26.97%, respectively. Two meta-analysis studies reported that the pooled prevalence of poor sleep quality or sleep problems was 40% and 36.73% among the general population, respectively (Jahrami et al., 2022; Krishnamoorthy et al., 2020). Kaur et al. (Kaur et al., 2021) reported that 11.27% of the general population in India had poor sleep quality. In addition, the significant prevalence of short sleep duration (40.81%) should not be overlooked. The prevalence short sleep duration was 55.82% among 593 Saudis during the COVID-19 home confinement in 2020 (Alqahtani, Banji, & Banji, 2021). Furthermore, the study conducted by Alqahtani et al. (Alqahtani et al., 2021) found that older subjects were more prone to experiencing insufficient sleep duration. Generally, among older adults, out of various different sleep assessments, our findings showed that the sleep quality and duration were particularly poor. During COVID-19 pandemic, depression, anxiety, and stress, compounded by factors such as fear of infection, limited medical resources, or confinement, may exacerbate sleep disturbances (Chowdhury et al., 2021; Spicuzza, Mancuso, Campisi, & Vancheri, 2022).

In addition, the prevalence of sleep problems was higher in America (64.13%) than in Europe (20.23%) and the Western Pacific (21.31%). This finding may be related to the severity of the COVID-19 epidemic. The majority of the included articles were published in 2020 and 2021. According to the WHO, as of July 5, 2021, the Region of the Americas had reported a significantly higher number of confirmed COVID-19 cases compared to the other two regions (World Health Organization, 2022). Similarly, as of October 4, 2021, the Region of the Americas had reported a larger number of deaths than the other two regions (World Health Organization, 2022). Given the higher possibility of infection and the potential for poor outcomes, older adults in America may be more prone to experiencing poor sleep. Furthermore, we reported that the prevalence of worsened sleep problems was higher in 2021 (47.42%) than in 2020 (15.14%). Spicuzza et al. (Spicuzza et al., 2022) reported that sleep quality during COVID-19 pandemic period was significantly worse compared to the pre-pandemic period. One study investigating 417 Brazilian rural adults found that subjective sleep quality declined (as indicated by higher PSQI scores) during the COVID-19 pandemic, especially among older adults (Taporoski et al., 2022). Compared to the time period before the pandemic, the percentage of older individuals reporting unsatisfactory sleep and insufficient sleep increased during the pandemic by 15% (from 12.3% to 14.1%) and 12% (from 35.2% to 39.5%) among 4400 Italian older adults, respectively (Amerio et al., 2023). During the early stage of the emerging infectious diseases, the longer it lasted, the more severely the life was affected, resulting in increased stress level and a higher proportion of elderly individuals experiencing sleep impairment (Amerio et al., 2023; Hampshire et al., 2022).

We also found that more than 40% of older adults infected with SARS-CoV-2 had sleep problems and insomnia symptoms. One meta-analysis reported that the estimated prevalence of sleep problems among COVID-19 patients was 52.39% (Jahrami et al., 2022). Cytokine storm, blood clots, direct damage by SARS-CoV-2, and/or molecular mimicry were important causes for increased insomnia and sleep disturbances (Fotuhi, Mian, Meysami, & Raji, 2020). After infection, the virus in the cerebrospinal fluid and brain tissue post-mortem could further induce the priming of neuro-immunological substrates, leading to an exacerbated immune response and autoimmunity targeting structures in the central nervous system (Tizenberg et al., 2021). This process may be induced or perpetuated by aging (Tizenberg et al., 2021). In addition, studies have reported that long COVID-19 patients exhibit bilateral hypometabolism in the right temporal lobe, the pons/medulla brainstem, and the cerebellum, compared with healthy subjects (Guedj et al., 2021). These regions may be associated with the occurrence of insomnia (Guedj et al., 2021). This finding indicated that the sleep disturbances were common among older COVID-19 patients, and should be considered in health management and rehabilitation.

This systematic review and meta-analysis included studies that in terms of different assessment methods among older adults, making the results relatively comparable and producing reliably pooled estimates.

However, there were some limitations in this study. Firstly, caution should be exercised when interpretating the results due to the high heterogeneity between the studies, which has reduced the precision of our pooled effect size estimates. Secondly, unmeasured or residual confounding in the source studies could not be addressed in this meta-analysis, as only published data used. Finally, sleep disturbances may vary significantly by demographic characteristics, such as gender and age. However, due to limited references, we only reported sleep problems by sex and age groups, as sleep disturbances by sex and age groups were not extensively studied among older adults. In the future, meta-analysis could include a greater number of studies and provide a detailed analysis of sleep health among older adults, taking into account demographic characteristics.

Our meta-analysis provided epidemiological estimates of various sleep disturbances to help healthcare professionals develop guidelines for diagnosis, treatment, prognosis, and linkage to care among older adults. These findings also suggested that in the later stage of the pandemic, attention should be paid to the recovery of the elderly. To address and improve the sleep problems experienced by the elderly in their daily lives, a multidisciplinary approach involving rehabilitation medicine, psychology, and nursing could be integrated in the primary healthcare system. Maintaining a healthy lifestyle, social contacts, family ties, and the ability to give or receive help may contribute to better sleep for older adults (Lebrasseur et al., 2021; Marcos-Pardo, Abelleira-Lamela, Vaquero-Cristobal, & González-Gálvez, 2022). More cohort studies or randomized controlled trials are still needed to identify appropriate intervention measures for sleep problems.

6. Conclusion

In conclusion, this systematic review and meta-analysis found that nearly half of the elderly had poor sleep quality and short sleep duration. Additionally, one in five individuals experienced excessive sleep, insomnia, and worsened sleep problems. Sleep problems were more prevalent in American region, and worsened sleep problems were severe in the later phase of COVID-19 pandemic. At the same time, sleep disturbances were equally severe in older SARS-CoV-2 infections. Thus, it is important to make more efforts in prevention and intervention to identify the risk factors, treatment, and rehabilitation of sleep disturbances for healthy aging.

Funding

This work was supported by the National Natural Science Foundation of China [grant numbers 72122001, 72211540398].

Financial disclosure statement

None to disclose.

Declaration of competing interest

The authors declare that they have no competing interests.

Ethics approval and consent to participate

Analysis for this systematic review is based on published journal articles, and does not constitute human subjects research. No ethics board approval was required.

CRediT authorship contribution statement

Min Du: Conceptualization, Data curation, Formal analysis, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Min Liu:** Conceptualization, Supervision, Validation, Writing – review & editing. **Yaping Wang:** Data curation, Investigation, Writing – review & editing. **Chenyuan Qin:** Conceptualization, Data curation, Writing – review & editing. **Jue Liu:** Conceptualization, Funding acquisition, Validation, Writing – review & editing.

Data availability

Data will be made available on request.

Acknowledgments

We appreciate the works by all authors for original data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2023.101588.

References

Al-Mutawa, N., & Al-Mutairi, N. (2021). Impact of COVID-19 pandemic and lockdown measures on the mental health of the general population in the gulf cooperation council states: A cross-sectional study. *Frontiers in Psychiatry, 12*. https://doi.org/10.3389/fpsyt.2021.801002

Alimoradi, Z., Broström, A., Tsang, H. W. H., Griffiths, M. D., Haghayegh, S., Ohayon, M. M., … Pakpour, A. H. (2021). Sleep problems during COVID-19 pandemic and its' association to psychological distress: A systematic review and meta-analysis. *EClinicalMedicine, 36*, Article 100916. https://doi.org/10.1016/j.eclinm.2021.100916

Alqahtani, S. S., Banji, D., & Banji, O. J. F. (2021). A survey assessing sleep efficiency among Saudis during COVID-19 home confinement using the Pittsburgh sleep quality index: A call for health education. *Saudi Pharmaceutical Journal, 29*(7), 692–698. https://doi.org/10.1016/j.jsps.2021.04.031

Alqurashi, Y. D., AlHarkan, K., Aldhawyan, A., Bahamdan, A., Alabdulkader, A., Alotaibi, R., … Ghamdi, K. A. (2022). Association between nap duration and cognitive functions among Saudi older adults. *Frontiers in Neuroscience, 16*, Article 917987. https://doi.org/10.3389/fnins.2022.917987

Aly, M. A. E. G., & Saber, H. G. (2021). Long COVID and chronic fatigue syndrome: A survey of elderly female survivors in Egypt. *International Journal of Clinical Practice, 75*(12). https://doi.org/10.1111/ijcp.14886

Amerio, A., Stival, C., Lugo, A., Fanucchi, T., d'Oro, L. C., Iacoviello, L., … Gallus, S. (2023). COVID-19 pandemic impact on mental health in a large representative sample of older adults from the Lombardy region, Italy. *Journal of Affective Disorders, 325*, 282–288. https://doi.org/10.1016/j.jad.2023.01.006

Amicucci, G., Salfi, F., D'Atri, A., Viselli, L., & Ferrara, M. (2021). The differential impact of COVID-19 lockdown on sleep quality, insomnia, depression, stress, and anxiety among late adolescents and elderly in Italy. *Brain Sciences, 11*(10). https://doi.org/10.3390/brainsci11101336

Andras, Z. J., Vanda, K., Borbala, B. D., Zsolt, B., Sandor, K., Anita, K., … Attila, H. A. (2022). Impact of the third wave of the COVID-19 pandemic on the lifestyle, mental and physical health of the Hungarian population over 60. *Orvosi Hetilap, 163*(31), 1215–1223. https://doi.org/10.1556/650.2022.32572

Ataka, T., Kimura, N., Eguchi, A., & Matsubara, E. (2022). Changes in objectively measured lifestyle factors during the COVID-19 pandemic in community-dwelling older adults. *BMC Geriatrics, 22*(1), 326. https://doi.org/10.1186/s12877-022-03043-1

Bhat, B. A., Mir, R. A., Hussain, A., & Shah, I. R. (2020). Depressive and anxiety symptoms, quality of sleep, and coping during the 2019 coronavirus disease pandemic in general population in Kashmir. *Middle East Current Psychiatry-Mecpsych, 27*(1). https://doi.org/10.1186/s43045-020-00069-2

Cao, G., Wang, Y., Wu, Y., Jing, W., Liu, J., & Liu, M. (2022). Prevalence of anemia among people living with HIV: A systematic review and meta-analysis. *EClinicalMedicine, 44*, Article 101283. https://doi.org/10.1016/j.eclinm.2022.101283

Chin, B. N., Tracy, E. L., Lehrer, H. M., Carroll, L. W., Lacey, P. N., Kimutis, S. K., … Hall, M. H. (2022). Social integration and sleep quality during the COVID-19 pandemic: Prospective evidence from a study of retired older adults. *Behavioral Sleep Medicine, 20*(3), 337–342. https://doi.org/10.1080/15402002.2021.2021203

Chowdhury, S. R., Kabir, H., Akter, N., Iktidar, M. A., Roy, A. K., Chowdhury, M. R., et al. (2023). Impact of workplace bullying and burnout on job satisfaction among Bangladeshi nurses: A cross-sectional study. *Heliyon, 9*(2), Article e13162. https://doi.org/10.1016/j.heliyon.2023.e13162

Chowdhury, S. R., Kabir, H., Das, D. C., Chowdhury, M. R., Chowdhury, M. R., & Hossain, A. (2023). Workplace violence against Bangladeshi registered nurses: A survey following a year of the COVID-19 pandemic. *International Nursing Review, 70*(2), 219–228. https://doi.org/10.1111/inr.12802

Chowdhury, S. R., Kabir, H., Mazumder, S., Akter, N., Chowdhury, M. R., & Hossain, A. (2022). Workplace violence, bullying, burnout, job satisfaction and their correlation with depression among Bangladeshi nurses: A cross-sectional survey during the COVID-19 pandemic. *PLoS One, 17*(9), Article e0274965. https://doi.org/10.1371/journal.pone.0274965

Chowdhury, S. R., Sunna, T. C., Das, D. C., Kabir, H., Hossain, A., Mahmud, S., et al. (2021). Mental health symptoms among the nurses of Bangladesh during the COVID-19 pandemic. *Middle East Current Psychiatry, 28*(1), 23. https://doi.org/10.1186/s43045-021-00103-x

Christodoulou, N., Bertrand, L., Palagini, L., Frija-Masson, J., d'Ortho, M.-P., Lejoyeux, M. L., … Geoffroy, P. A. (2023). Factors associated with insomnia symptoms: A cross-sectional study during a covid-19 fully restrictive lockdown. *Journal of Sleep Research, 32*(1). https://doi.org/10.1111/jsr.13752

Collinge, A. N., & Bath, P. A. (2023). Socioeconomic background and self-reported sleep quality in older adults during the COVID-19 pandemic: An analysis of the English longitudinal study of ageing (ELSA). *International Journal of Environmental Research and Public Health, 20*(5). https://doi.org/10.3390/ijerph20054534

Corley, J., Okely, J. A., Taylor, A. M., Page, D., Welstead, M., Skarabela, B., … Russ, T. C. (2021). Home garden use during COVID-19: Associations with physical and mental wellbeing in older adults. *Journal of Environmental Psychology, 73*, Article 101545. https://doi.org/10.1016/j.jenvp.2020.101545

Dale, R., Budimir, S., Probst, T., Stippl, P., & Pieh, C. (2021). Mental health during the COVID-19 lockdown over the christmas period in Austria and the effects of sociodemographic and lifestyle factors. *International Journal of Environmental Research and Public Health, 18*(7). https://doi.org/10.3390/ijerph18073679

De Pue, S., Gillebert, C., Dierckx, E., Vanderhasselt, M. A., De Raedt, R., & Van den Bussche, E. (2021). The impact of the COVID-19 pandemic on wellbeing and cognitive functioning of older adults. *Scientific Reports, 11*(1), 4636. https://doi.org/10.1038/s41598-021-84127-7

DerSimonian, R., & Laird, N. (2015). Meta-analysis in clinical trials revisited. *Contemporary Clinical Trials, 45*(Pt A), 139–145. https://doi.org/10.1016/j.cct.2015.09.002

Egger, M., Davey Smith, G., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *BMJ, 315*(7109), 629–634. https://doi.org/10.1136/bmj.315.7109.629

Emerson, K. G. (2020). Coping with being cooped up: Social distancing during COVID-19 among 60+in the United States. *Revista Panamericana De Salud Publica-Pan American Journal of Public Health, 44*. https://doi.org/10.26633/rpsp.2020.81

Emerson, E., Aitken, Z., Totsika, V., King, T., Stancliffe, R. J., Hatton, C., … Kavanagh, A. (2022). The impact of the COVID pandemic on working age adults with disability: Meta-analysis of evidence from four national surveys. *Health and Social Care in the Community, 30*(6), e4758–e4769. https://doi.org/10.1111/hsc.13882

Farooq, S., Tunmore, J., Wajid Ali, M., & Ayub, M. (2021). Suicide, self-harm and suicidal ideation during COVID-19: A systematic review. *Psychiatry Research, 306*, Article 114228. https://doi.org/10.1016/j.psychres.2021.114228

Fotuhi, M., Mian, A., Meysami, S., & Raji, C. A. (2020). Neurobiology of COVID-19. *J Alzheimers Dis, 76*(1), 3–19. https://doi.org/10.3233/jad-200581

Galle, F., Sabella, E. A., Roma, P., Ferracuti, S., Da Molin, G., Diella, G., … Napoli, C. (2021). Knowledge and lifestyle behaviors related to COVID-19 pandemic in people over 65 Years old from southern Italy. *International Journal of Environmental Research and Public Health, 18*(20). https://doi.org/10.3390/ijerph182010872

Garcia Carlini, G. C., Silva Ribas, C. M., Maluf di Lernia, R., Lima, R. D. S., Gaspari da Silva, R., & Dos Santos Quaresma, M. V. L. (2023). Physical exercise practice was positively associated with better dietary practices of aged people during COVID-19 social distance: A cross-sectional study. *Clin Nutr ESPEN, 54*, 98–105. https://doi.org/10.1016/j.clnesp.2023.01.015

Gezgin Yazici, H., & Ökten, Ç. (2022). The insomnia and loneliness of elderly individuals and affecting factors during the COVID-19 pandemic in Turkey. *Social Work in Public Health, 37*(7), 601–608. https://doi.org/10.1080/19371918.2022.2053630

Gokseven, Y., Ozturk, G. Z., Karadeniz, E., Sarı, E., Tas, B. G., & Ozdemir, H. M. (2022). The fear of COVID-19 infection in older people. *Journal of Geriatric Psychiatry and Neurology, 35*(3), 460–466. https://doi.org/10.1177/08919887211002651

Guedj, E., Campion, J. Y., Dudouet, P., Kaphan, E., Bregeon, F., Tissot-Dupont, H., … Eldin, C. (2021). F-18-FDG brain PET hypometabolism in patients with long COVID. *European Journal of Nuclear Medicine and Molecular Imaging, 48*(9), 2823–2833. https://doi.org/10.1007/s00259-021-05215-4

Gustavsson, J., & Beckman, L. (2020). Compliance to recommendations and mental health consequences among elderly in Sweden during the initial phase of the COVID-19 pandemic-A cross sectional online survey. *International Journal of Environmental Research and Public Health, 17*(15). https://doi.org/10.3390/ijerph17155380

Hampshire, A., Trender, W., Grant, J. E., Mirza, M. B., Moran, R., Hellyer, P. J., et al. (2022). Item-level analysis of mental health symptom trajectories during the COVID-19 pandemic in the UK: Associations with age, sex and pre-existing psychiatric conditions. *Comprehensive Psychiatry, 114*, Article 152298. https://doi.org/10.1016/j.comppsych.2022.152298

Hasan, M. K., Kabir, H., Rahman, M., Roy, A. K., Akter, S., & Mitra, D. K. (2021). Association between insomnia and mucormycosis fear among the Bangladeshi healthcare workers: A cross-sectional study. *J Affect Disord Rep, 6*, Article 100262. https://doi.org/10.1016/j.jadr.2021.100262

Hausman, H. K., Dai, Y., O'Shea, A., Dominguez, V., Fillingim, M., Calfee, K., … Woods, A. J. (2022). The longitudinal impact of the COVID-19 pandemic on health behaviors, psychosocial factors, and cognitive functioning in older adults. *Frontiers in Aging Neuroscience, 14*, Article 999107. https://doi.org/10.3389/fnagi.2022.999107

Higgins, J. P., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *BMJ, 327*(7414), 557–560. https://doi.org/10.1136/bmj.327.7414.557

Holzinger, B., Nierwetberg, F., Chung, F., Bolstad, C. J., Bjorvatn, B., Chan, N. Y., … De Gennaro, L. (2022). Has the COVID-19 pandemic traumatized us collectively? The impact of the COVID-19 pandemic on mental health and sleep factors via traumatization: A multinational survey. *Nature and Science of Sleep, 14*, 1469–1483. https://doi.org/10.2147/nss.s368147

Hong, E., & Hee, L. K. (2022). Factors associated with depression in older adults living alone during the COVID-19 pandemic. *Journal of Korean Academy of Community Health Nursing, 33*(4), 418–431.

Hoy, D., Brooks, P., Woolf, A., Blyth, F., March, L., Bain, C., … Buchbinder, R. (2012). Assessing risk of bias in prevalence studies: Modification of an existing tool and evidence of interrater agreement. *Journal of Clinical Epidemiology, 65*(9), 934–939. https://doi.org/10.1016/j.jclinepi.2011.11.014

Humer, E., Schaffler, Y., Jesser, A., Probst, T., & Pieh, C. (2022). Mental health in the Austrian general population during COVID-19: Cross-sectional study on the association with sociodemographic factors. *Frontiers in Psychiatry, 13*. https://doi.org/10.3389/fpsyt.2022.943303

Ikeda, Y., Tabira, T., Ohshige, T., Masumitsu, T., Makizako, H., & Ku-Ohl Project, M. (2022). Association between sleep onset problem and subjective cognitive complaints among Japanese older adults during the coronavirus disease 2019 pandemic. *International Journal of Environmental Research and Public Health, 20*(1). https://doi.org/10.3390/ijerph20010156

Izquierdo-Condoy, J. S., Fernandez-Naranjo, R., Vasconez-González, E., Cordovez, S., Tello-De-la-Torre, A., Paz, C., … Ortiz-Prado, E. (2022). Long COVID at different altitudes: A countrywide epidemiological analysis. *International Journal of Environmental Research and Public Health, 19*(22). https://doi.org/10.3390/ijerph192214673

Jahrami, H. A., Alhaj, O. A., Humood, A. M., Alenezi, A. F., Fekih-Romdhane, F., AlRasheed, M. M., … Vitiello, M. V. (2022). Sleep disturbances during the COVID-19 pandemic: A systematic review, meta-analysis, and meta-regression. *Sleep Medicine Reviews, 62*, Article 101591. https://doi.org/10.1016/j.smrv.2022.101591

Kantor, J., Kantor, B. N., Fortgang, R. G., & Pace-Schott, E. F. (2022). Sleep quality impairment is associated with pandemic attitudes during the coronavirus disease 2019 (COVID-19) circuit breaker lockdown in england: A cross-sectional study. *Frontiers in Public Health, 10*. https://doi.org/10.3389/fpubh.2022.819231

Kapusta, J., Chudzik, M., Kałuzińska-Kołat, Ż., Kołat, D., Burzyńska, M., Jankowski, P., et al. (2023). Do selected lifestyle parameters affect the severity and symptoms of COVID-19 among elderly patients? The retrospective evaluation of individuals from the STOP-COVID registry of the PoLoCOV study. *J Infect Public Health, 16*(1), 143–153. https://doi.org/10.1016/j.jiph.2022.12.008

Karaogullarindan, A., Erkan, S. O., Tuhanioglu, B., Kuran, G., & Gorgulu, O. (2021). Sleep quality in patients over 65 years of age in the COVID-19 pandemic. *Turkish Journal of Geriatrics-Turk Geriatri Dergisi, 24*(3), 381–390. https://doi.org/10.31086/tjgeri.2021.235

Kaur, T., Ranjan, P., Chakrawarty, A., Kasi, K., Berry, P., Suryansh, S., … Prasad, V. B. (2021). Association of sociodemographic parameters with depression, anxiety, stress, sleep quality, psychological trauma, mental well-being, and resilience during the second wave of COVID-19 pandemic: A cross-sectional survey from India. *Cureus Journal of Medical Science, 13*(7). https://doi.org/10.7759/cureus.16420

Kholghi, M., Ellender, C. M., Zhang, Q., Gao, Y., Higgins, L., & Karunanithi, M. (2021). Home-based sleep sensor measurements in an older Australian population: Before and during a pandemic. *Sensors, 21*(18). https://doi.org/10.3390/s21185993

Kilibarda, T., Sinanovic, S., Bubanj, S., Trgovcevic, S., Ivanovic, S., & Milutinovic, S. (2022). Protective personality factors for stress in the elderly during COVID-19 pandemic: A cross-sectional study. *Acta Facultatis Medicae Naissensis, 39*(1), 95–105. https://doi.org/10.5937/afmnai39-35292

Kim, S., & Hwang, J. (2022). Examining risk factors for mental health during the COVID-19 pandemic-focusing on older adults in South Korea. *International Journal of Public Health, 67*, Article 1604487. https://doi.org/10.3389/ijph.2022.1604487

Kim, M., Opsasnick, L., Batio, S., Benavente, J. Y., Zheng, P., Lovett, R. M., … Wolf, M. S. (2022). Prevalence and risk factors of sleep disturbance in adults with underlying health conditions during the ongoing COVID-19 pandemic. *Medicine (Baltimore)*, (37), 101. https://doi.org/10.1097/md.0000000000030637

Krishnamoorthy, Y., Nagarajan, R., Saya, G. K., & Menon, V. (2020). Prevalence of psychological morbidities among general population, healthcare workers and COVID-19 patients amidst the COVID-19 pandemic: A systematic review and meta-analysis. *Psychiatry Research, 293*, Article 113382. https://doi.org/10.1016/j.psychres.2020.113382

Lebrasseur, A., Fortin-Bédard, N., Lettre, J., Raymond, E., Bussières, E. L., Lapierre, N., … Routhier, F. (2021). Impact of the COVID-19 pandemic on older adults: Rapid review. *JMIR Aging, 4*(2), Article e26474. https://doi.org/10.2196/26474

Lee, H., & Chu, H. S. (2022). The effects of changes in daily life due to the COVID-19 pandemic on the depressive symptoms among community-dwelling older adults in Korea. *International Journal of Mental Health Nursing, 31*(4), 974–984. https://doi.org/10.1111/inm.13008

Li, S., Guo, B., Lu, X., Yang, Q., Zhu, H., Ji, Y., et al. (2022). Investigation of mental health literacy and status of residents during the Re-outbreak of COVID-19 in China. *Frontiers in Public Health, 10*. https://doi.org/10.3389/fpubh.2022.895553

Liu, L., Ni, S. Y., Yan, W., Lu, Q. D., Zhao, Y. M., Xu, Y. Y., … Lu, L. (2021). Mental and neurological disorders and risk of COVID-19 susceptibility, illness severity and mortality: A systematic review, meta-analysis and call for action. *EClinicalMedicine, 40*, Article 101111. https://doi.org/10.1016/j.eclinm.2021.101111

Li, L., Wu, M. S., Tao, J., Wang, W., He, J., Liu, R., … Han, B. (2021). A follow-up investigation of mental health among discharged COVID-19 patients in wuhan, China. *Frontiers in Public Health, 9*. https://doi.org/10.3389/fpubh.2021.640352

Makizako, H., Kiyama, R., Nishimoto, D., Nishio, I., Masumitsu, T., Ikeda, Y., … Ku-Ohl Project, T. (2021). Association between regular exercise and self-rated health and sleep quality among adults in Japan during the COVID-19 pandemic. *International Journal of Environmental Research and Public Health, 18*(19). https://doi.org/10.3390/ijerph181910515

Marcos-Pardo, P. J., Abelleira-Lamela, T., Vaquero-Cristobal, R., & González-Gálvez, N. (2022). Changes in life satisfaction, depression, general health and sleep quality of

Spanish older women during COVID-19 lockdown and their relationship with lifestyle: An observational follow-up study. *BMJ Open, 12*(8), Article e061993. https://doi.org/10.1136/bmjopen-2022-061993

Mistry, S. K., Ali, A. M., Ahmed, M. S., Yadav, U. N., Khan, M. S., Hossain, M. B., et al. (2021). Prevalence and correlates of total sleep time among the older adults during COVID-19 pandemic in Bangladesh. *Sleep Epidemiol, 1*, Article 100008. https://doi.org/10.1016/j.sleepe.2021.100008

Musse, F. C. C., Castro, L.d. S., Sousa, K. M. M., Mestre, T. F., Teixeira, C. D. M., Pelloso, S. M., … Carvalho, M. D.d. B. (2020). Mental violence: The COVID-19 nightmare. *Frontiers in Psychiatry, 11*. https://doi.org/10.3389/fpsyt.2020.579289

Nakai, Y., Makizako, H., Shiratsuchi, D., Taniguchi, Y., Akaida, S., Tateishi, M., … Yokoyama, K. (2022). Association of sleep quality status with worsening low back or knee pain during the COVID-19 state of emergency among old-old adults. *Pain Management Nursing, 23*(4), 473–477. https://doi.org/10.1016/j.pmn.2022.01.001

Nejad, J. H., Allahyari, F., Hosseinzadeh, R., Heiat, M., & Ranjbar, R. (2021). Neurological symptoms of COVID-19 infection; a cross-sectional study on hospitalized COVID-19 patients in Iran. *Clinical Neurology and Neurosurgery, 210*. https://doi.org/10.1016/j.clineuro.2021.106985

Okely, J. A., Corley, J., Welstead, M., Taylor, A. M., Page, D., Skarabela, B., … Russ, T. C. (2020). Change in physical activity, sleep quality, and psychosocial variables during COVID-19 lockdown: Evidence from the lothian birth cohort 1936. *International Journal of Environmental Research and Public Health, 18*(1). https://doi.org/10.3390/ijerph18010210

Osiogo, F., Shalaby, R., Adegboyega, S., Hrabok, M., Gusnowski, A., Vuong, W., … Agyapong, V. I. O. (2021). COVID-19 pandemic: Demographic and clinical correlates of disturbed sleep among 6,041 Canadians. *International Journal of Psychiatry in Clinical Practice, 25*(2), 164–171. https://doi.org/10.1080/13651501.2021.1881127

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*. https://doi.org/10.1136/bmj.n71. n71.

Paiva, T., Reis, C., Feliciano, A., Canas-Simiao, H., Machado, M. A., Gaspar, T., … Matos, M. G. (2021). Sleep and awakening quality during COVID-19 confinement: Complexity and relevance for health and behavior. *International Journal of Environmental Research and Public Health, 18*(7). https://doi.org/10.3390/ijerph18073506

Pappa, S., Ntella, V., Giannakas, T., Giannakoulis, V. G., Papoutsi, E., & Katsaounou, P. (2020). Prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic: A systematic review and meta-analysis. *Brain, Behavior, and Immunity, 88*, 901–907. https://doi.org/10.1016/j.bbi.2020.05.026

Parlapani, E., Holeva, V., Nikopoulou, V. A., Sereslis, K., Athanasiadou, M., Godosidis, A., … Diakogiannis, I. (2020). Intolerance of uncertainty and loneliness in older adults during the COVID-19 pandemic. *Frontiers in Psychiatry, 11*, 842. https://doi.org/10.3389/fpsyt.2020.00842

Perelman, J., Xavier, M., & Barros, P. P. (2022). How do European mature adults and elderly perceive SARS-COV-2 and associated control measures? A cross-country analysis of mental health symptoms in june and july 2020. *International Journal of Public Health, 67*. https://doi.org/10.3389/ijph.2022.1604218

Philip, P., Dupuy, L., Morin, C. M., de Sevin, E., Bioulac, S., Taillard, J., … Micoulaud-Franchi, J.-A. (2020). Smartphone-based virtual agents to help individuals with sleep concerns during COVID-19 confinement: Feasibility study. *Journal of Medical Internet Research, 22*(12). https://doi.org/10.2196/24268

Pieh, C., Budimir, S., Delgadillo, J., Barkham, M., Fontaine, J. R. J., & Probst, T. (2021). Mental health during COVID-19 lockdown in the United Kingdom. *Psychosomatic Medicine, 83*(4), 328–337. https://doi.org/10.1097/psy.0000000000000871

Pieh, C., Budimir, S., & Probst, T. (2020). The effect of age, gender, income, work, and physical activity on mental health during coronavirus disease (COVID-19) lockdown in Austria. *Journal of Psychosomatic Research, 136*. https://doi.org/10.1016/j.jpsychores.2020.110186

Rego de Figueiredo, I., Branco Ferrao, J., Dias, S., Drummond Borges, D., Fernandes, J., Bernardino, V., … Panarra, A. (2023). The prevalence of COVID-19 fog and the impact on quality of life after SARS-CoV-2 infection (QoL-COVID): A cross sectional study. *Acta Med Port*. https://doi.org/10.20344/amp.18784

Rodríguez-Gómez, I., Sánchez-Martín, C., García-García, F. J., García-Esquinas, E., Miret, M., Vicente-Rodriguez, G., … Ara, I. (2022). The medium-term consequences of a COVID-19 lockdown on lifestyle among Spanish older people with hypertension, pulmonary disease, cardiovascular disease, musculoskeletal disease, depression, and cancer. *Epidemiol Health, 44*, Article e2022026. https://doi.org/10.4178/epih.e2022026

Salanti, G., Peter, N., Tonia, T., Holloway, A., White, I. R., Darwish, L., … Honda, Y. (2022). The impact of the COVID-19 pandemic and associated control measures on the mental health of the general population : A systematic review and dose-response meta-analysis. *Annals of Internal Medicine, 175*(11), 1560–1571. https://doi.org/10.7326/m22-1507

Sampaio Brito, L. M., de Lima, V. A., Mascarenhas, L. P., Mota, J., & Leite, N. (2021). Physical activity, eating habits and sleep during social isolation: From young adult to elderly. *Revista Brasileira de Medicina do Esporte, 27*(1), 21–25. https://doi.org/10.1590/1517-8692202127012020_0061

Sapara, A., Shalaby, R., Osiogo, F., Hrabok, M., Gusnowski, A., Vuong, W., … Agyapong, V. I. O. (2021). COVID-19 pandemic: Demographic and clinical correlates of passive death wish and thoughts of self-harm among Canadians. *Journal of Mental Health, 30*(2), 170–178. https://doi.org/10.1080/09638237.2021.1875417

Sârbu, F., Oprea, V. D., Tatu, A. L., Drima, E. P., Ştefănescu, C., Nechita, A., … Romila, A. (2022). COVID-19-related psychiatric manifestations requiring hospitalization: Analysis in older vs. younger patients. *Experimental and Therapeutic Medicine, 24*(2), 497. https://doi.org/10.3892/etm.2022.11424

Savci, C., Cil Akinci, A., Yildirim Usenmez, S., & Keles, F. (2021). The effects of fear of COVID-19, loneliness, and resilience on the quality of life in older adults living in a nursing home. *Geriatric Nursing, 42*(6), 1422–1428. https://doi.org/10.1016/j.gerinurse.2021.09.012

Schou-Bredal, I., Grimholt, T. K., Bonsaksen, T., Skogstad, L., Heir, T., & Ekeberg, Ø. (2021). Psychological responses and associated factors during the initial lockdown due to the corona disease epidemic (COVID-19) among Norwegian citizens. *Journal of Mental Health*, 1–8. https://doi.org/10.1080/09638237.2021.1952949

Schrack, J. A., Corkum, A. E., & Freedman, V. A. (2022). COVID-19 pandemic experiences of older adults with dementia in community and residential care settings: Results from a US national survey. *Alzheimer's and Dementia: Diagnosis, Assessment & Disease Monitoring, 14*(1). https://doi.org/10.1002/dad2.12382

Siltanen, S., Ilmarinen, K., Luoma, M.-L., Leppaaho, S., & Kehusmaa, S. (2022). Changes in older people's quality of life in the COVID-19 era: A population-based study in Finland. *Quality of Life Research, 31*(11), 3177–3187. https://doi.org/10.1007/s11136-022-03210-2

Smail, E. J., Kaufmann, C. N., Riehm, K. E., Mardini, M. T., Cenko, E., Bai, C., et al. (2022). Worsening sleep predicts lower life space mobility during the onset of the COVID-19 pandemic. *Journal of the American Geriatrics Society, 70*(7), 1931–1938. https://doi.org/10.1111/jgs.17896

Spicuzza, L., Mancuso, S., Campisi, R., & Vancheri, C. (2022). Sleep quality and mental health during the COVID-19 pandemic in patients with severe obstructive sleep apnea. *Journal of Patient-Reported Outcomes, 6*(1). https://doi.org/10.1186/s41687-022-00454-x

Taporoski, T. P., Beijamini, F., Gómez, L. M., Ruiz, F. S., Ahmed, S. S., von Schantz, M., … Knutson, K. L. (2022). Subjective sleep quality before and during the COVID-19 pandemic in a Brazilian rural population. *Sleep Health, 8*(2), 167–174. https://doi.org/10.1016/j.sleh.2021.11.007

The World Bank. (2023). *income*. Retrieved from https://datahelpdesk.worldbank.org/knowledgebase/. (Accessed 17 November 2023).

Tizenberg, B. N., Brenner, L. A., Lowry, C. A., Okusaga, O. O., Benavides, D. R., Hoisington, A. J., … Postolache, T. T. (2021). Biological and psychological factors determining neuropsychiatric outcomes in COVID-19. *Current Psychiatry Reports, 23*(10), 68. https://doi.org/10.1007/s11920-021-01275-3

Tracy, E. L., Chin, B., Lehrer, H. M., Carroll, L. W., Buysse, D. J., & Hall, M. H. (2022). Coping strategies moderate the effect of perceived stress on sleep and health in older adults during the COVID-19 pandemic. *Stress and Health, 38*(4), 708–721. https://doi.org/10.1002/smi.3124

Triolo, F., Saadeh, M., Sjöberg, L., Fratiglioni, L., Welmer, A. K., Calderón-Larrañaga, A., et al. (2022). Pre-pandemic physical function and social network in relation to COVID-19-associated depressive burden in older adults in Sweden. *Innov Aging, 6*(5), Article igac041. https://doi.org/10.1093/geroni/igac041

Udeh-Momoh, C. T., Watermeyer, T., Sindi, S., Giannakopoulou, P., Robb, C. E., Ahmadi-Abhari, S., … Middleton, L. T. (2021). Health, lifestyle, and psycho-social determinants of poor sleep quality during the early phase of the COVID-19 pandemic: A focus on UK older adults deemed clinically extremely vulnerable. *Frontiers in Public Health, 9*, Article 753964. https://doi.org/10.3389/fpubh.2021.753964

van der Velden, P. G., Marchand, M., Das, M., Muffels, R., & Bosmans, M. (2022). The prevalence, incidence, and risk factors of mental health problems and mental health service use before and 9 months after the COVID-19 outbreak among the general Dutch population. A 3-wave prospective study. *PLoS One, 17*(11), Article e0276834. https://doi.org/10.1371/journal.pone.0276834

Wang, Y., Fu, P., Li, J., Jing, Z., Wang, Q., Zhao, D., et al. (2021). Changes in psychological distress before and during the COVID-19 pandemic among older adults: The contribution of frailty transitions and multimorbidity. *Age and Ageing, 50*(4), 1011–1018. https://doi.org/10.1093/ageing/afab061

Wang, S., Zhang, Y., Guan, Y., Ding, W., Meng, Y., Hu, H., … Wang, M. (2021). A nationwide evaluation of the prevalence of and risk factors associated with anxiety, depression and insomnia symptoms during the return-to-work period of coronavirus disease 2019 in China. *Social Psychiatry and Psychiatric Epidemiology, 56*(12), 2275–2286. https://doi.org/10.1007/s00127-021-02046-4

Wielgoszewska, B., Maddock, J., Green, M. J., Di Gessa, G., Parsons, S., Griffith, G. J., … Ploubidis, G. B. (2022). The UK coronavirus job retention scheme and diet, physical activity, and sleep during the COVID-19 pandemic: Evidence from eight longitudinal population surveys. *BMC Medicine, 20*(1). https://doi.org/10.1186/s12916-022-02343-y

World Health Organization. (2022). *Coronavirus (COVID-19) dashboard* (2023) Retrieved from https://covid19.who.int/. (Accessed 17 November 2023).

World Health Organization. (2023). *Ageing*. Retrieved from https://www.who.int/health-topics/ageing#tab=tab_1. (Accessed 17 November 2023).

Xu, Y. M., Li, C., Zhu, R., & Zhong, B. L. (2022). Prevalence and correlates of insomnia symptoms in older Chinese adults during the COVID-19 outbreak: A classification tree analysis. *Journal of Geriatric Psychiatry and Neurology, 35*(2), 223–228. https://doi.org/10.1177/08919887221078561

Yadav, R., Yadav, P., Kumar, S. S., & Kumar, R. (2021). Assessment of depression, anxiety, and sleep disturbance in COVID-19 patients at tertiary care centre of north India. *Journal of Neurosciences in Rural Practice, 12*(2), 316–322. https://doi.org/10.1055/s-0040-1722811

Yilmaz, B. A., & Onal, O. (2023). Effect of loneliness and sociodemographic, health, COVID-19 pandemic-related factors on depression among older adults. *Educational Gerontology, 49*(1), 12–26. https://doi.org/10.1080/03601277.2022.2065440

Yuan, S., Liao, Z., Huang, H., Jiang, B., Zhang, X., Wang, Y., et al. (2020). Comparison of the indicators of psychological stress in the population of hubei province and non-endemic provinces in China during two weeks during the coronavirus disease 2019

(COVID-19) outbreak in february 2020. *Medical Science Monitor, 26*. https://doi.org/10.12659/msm.923767

Yurumez Korkmaz, B., Gemci, E., Cosardereliogl u, C., Yigit, S., Atmis, V., Yalcin, A., … Aras, S. (2021). Attitudes of a geriatric population towards risks about COVID-19 pandemic: In the context of anxiety and depression. *Psychogeriatrics, 21*(5), 730–737. https://doi.org/10.1111/psyg.12731

Zhang, H., Li, W., Li, H., Zhang, C., Luo, J., Zhu, Y., … Li, C. (2021). Prevalence and dynamic features of psychological issues among Chinese healthcare workers during the COVID-19 pandemic: A systematic review and cumulative meta-analysis. *Gen Psychiatr, 34*(3), Article e100344. https://doi.org/10.1136/gpsych-2020-100344

Glossary

AIS: Athens insomnia scale
CIs: confidence intervals
COVID-19: coronavirus disease 2019
ISI: insomnia severity index
OSA: obstructive sleep apnea
PROIS: patient-reported outcomes information system
PSG: objective polysomnography
PSQI: Pittsburgh sleep quality index
RLS: restless legs syndrome
SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2
SD: standard deviation
SDB: sleep-disordered breathing
WHO: World Health Organization