

BMJ Open Estimation of sleep problems among pregnant women during COVID-19 pandemic: a systematic review and meta-analysis

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ABSTRACT

Objective To estimate the sleep problems among pregnant women during the COVID-19 pandemic.

Eligibility criteria English, peer-reviewed, observational studies published between December 2019 and July 2021 which assessed and reported sleep problem prevalence using a valid and reliable measure were included.

Information sources Scopus, Medline/PubMed Central, ProQuest, ISI Web of Knowledge and Embase.

Risk of bias assessment tool The Newcastle-Ottawa Scale checklist.

Synthesis of results Prevalence of sleep problems was synthesised using STATA software V.14 using a random effects model. To assess moderator analysis, meta-regression was carried out. Funnel plot and Egger's test were used to assess publication bias. Meta-trim was used to correct probable publication bias. The jackknife method was used for sensitivity analysis.

Included studies A total of seven cross-sectional studies with 2808 participants from four countries were included.

Synthesis of results The pooled estimated prevalence of sleep problems was 56% (95% CI 23% to 88%, $I^2=99.81%$, $\text{Tau}^2=0.19$). Due to the probability of publication bias, the fill-and-trim method was used to correct the estimated pooled measure, which imputed four studies. The corrected results based on this method showed that pooled prevalence of sleep problems was 13% (95% CI 0% to 45%; $p<0.001$). Based on meta-regression, age was the only significant predictor of prevalence of sleep problems among pregnant women.

Limitations of evidence All studies were cross-sectional absence of assessment of sleep problems prior to COVID-19, and the outcomes of the pregnancies among those with and without sleep problems in a consistent manner are among the limitation of the current review.

Interpretation Pregnant women have experienced significant declines in sleep quality when faced with the COVID-19 pandemic. The short-term and long-term implications of such alterations in sleep on gestational and offspring outcomes are unclear and warrant further studies.

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INTRODUCTION

Pregnant women are exposed to additional psychological stress due to the indirect

Strengths and limitations of this study

- Preferred Reporting Items for Systematic Reviews and Meta-Analyses guideline was used to report the findings.
- Newcastle-Ottawa Scale checklist was used to assess the methodological quality of included studies.
- Five academic databases were systematically searched to increase the comprehensiveness of search.
- All retrieved studies were cross-sectional.
- The outcomes of the pregnancies among those with and without sleep problems were not assessed in included studies.

adverse effects of COVID-19 pandemic.^{1 2} The unintended consequences of COVID-19 can negatively impact the health of pregnant women and raise substantial concerns for this population.³

Among these, mental health and psychological consequences, as well as sleep problems have become ubiquitously manifest across the world.⁴⁻⁷ On the other hand, people who have a good quality of sleep have fewer post-traumatic stress disorder symptoms associated with the COVID-19 outbreak.^{8 9} The United Nations has reported the COVID-19 pandemic as 'the seeds of a major mental health crisis around the globe'.¹⁰ In this context, pregnant women may often develop psychiatric symptoms, reduced sleep quality, which may enhance their vulnerability relative to others to the pandemic and its consequences and may be more at risk of COVID-19 infection and worse outcomes.^{11 12} Outbreaks of infectious diseases when combined with pregnancy are associated with major psychological distress and significant symptoms, including poor sleep quality.¹³

It is now well established that pregnancy in general is fraught with a higher risk of developing insomnia complaints, emergence

of excessive daytime sleepiness and reports of decreased subjective sleep quality.^{14 15} Available studies estimated the prevalence of sleep problems such as insomnia and frequent awakenings in pregnant women at 46%–78%, with the quality of sleep declining towards the third trimester.⁶ Sleep disorders are associated with various adverse pregnancy-related health outcomes, including poorer fetal outcomes, specifically birth weight, growth, preterm birth and stillbirth.¹⁶ Additionally, the occurrence of insomnia during pregnancy may increase the risk of postpartum depression.¹⁷ The result of a meta-analysis showed that the prevalence of anxiety and depression in pregnant women during COVID-19 pandemic was 15.8% and 25.8%, respectively.¹

Pregnant women may be more likely to develop anxiety, the latter being powerfully linked with poor sleep, particularly during the COVID-19 pandemic.¹⁸ The apparent associations between pregnancy and sleep disturbances, as well as the aforementioned adverse outcomes of COVID-19 in pregnant women, raise the strong possibility that the changes in lifestyle and many other environmental circumstances imposed by the COVID-19 crisis may translate into enhanced repercussions on sleep during pregnancy. As such, we would anticipate that the prevalence of insomnia, a disorder associated with increased risk of chronic illnesses, poor mental health and functional limitations, might be further enhanced.¹⁹ It would be reasonable to assume that pregnant women may experience incremental sleep problems due to the social distancing and isolation required during the COVID-19 pandemic.²⁰ Thus, early diagnosis and timely treatment of such sleep problems may mitigate the risk for adverse gestational and perinatal outcomes.²¹

Despite the impact of the COVID-19 on sleep quality and quantity,^{22–26} no systematic review or meta-analysis has yet been conducted to examine the impact of the pandemic on the prevalence of sleep problems during pregnancy. Therefore, this systematic review and meta-analysis was conducted to estimate the sleep problems among pregnant women during the COVID-19 pandemic.

METHODS

A systematic review was conducted through five academic databases. Relevant studies were extracted and their methodological quality was assessed using the Newcastle-Ottawa Scale (NOS) checklist. Findings were synthesised using a meta-analysis approach. The report of the present systematic review is part of a larger project registered in the International Prospective Register of Systematic Reviews.²⁷ Other related paper to this project is published elsewhere.^{25 26} This paper is prepared in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.²⁸

Search strategy

The five academic databases included Scopus, Medline/PubMed Central, ProQuest, ISI Web of Knowledge

and Embase which were searched systematically from December 2019 to July 2021. The search terms were extracted from PubMed Medical Subject Headings. The main search terms were ‘sleep’, ‘COVID-19’ and ‘pregnancy’. The Boolean search method (AND/OR/NOT) was used to develop the search query. Search syntax was customised based on the advanced search attributes of each database. Key search components were selected based on PECO search strategy (ie, Patient/Problem, Exposure, Comparison and Outcome)²⁹ to answer the research question. In the present study, key elements of exposure (COVID-19) and outcome (sleep problem) were selected.

Inclusion criteria

Observational studies were included if data on frequency or prevalence of sleep problems among pregnant women were reported. English, peer-reviewed papers published between December 2019 and July 2021 were included. There were no limitations regarding participant characteristics.

Outcomes

Primary outcome

Estimates of sleep problem frequency were the primary outcome. Sleep problems required assessments using valid and reliable psychometric scales, or confirmed with defined cut-off points. For instance, a global score of 5 or more in the Pittsburgh Sleep Quality Index (PSQI) or a total score of 8 or more in the Insomnia Severity Index (ISI) indicates poor sleep quality.^{30 31}

Secondary outcomes

Assessing the possible sources of heterogeneity and predictor variables of sleep problem prevalence among pregnant individuals.

Study screening and selection

Screening of title and abstract was done independently by two researchers based on the inclusion criteria and any disagreements were resolved by consensus. The full texts of potentially relevant studies were further examined based on the aforementioned criteria. In this process, relevant studies were selected.

Quality assessment

The NOS was used to evaluate the methodological quality of the studies in observational studies. Three characteristics (ie, selection, comparability and outcome) are examined with the NOS checklist. The checklist evaluates the methodological quality of cross-sectional studies based on seven items. The maximum quality score is 9 points and studies with less than 5 points are classified as having a high risk of bias.³² No studies were excluded based on the quality rating. However, the impact of quality on pooled effect size was assessed via meta-regression.

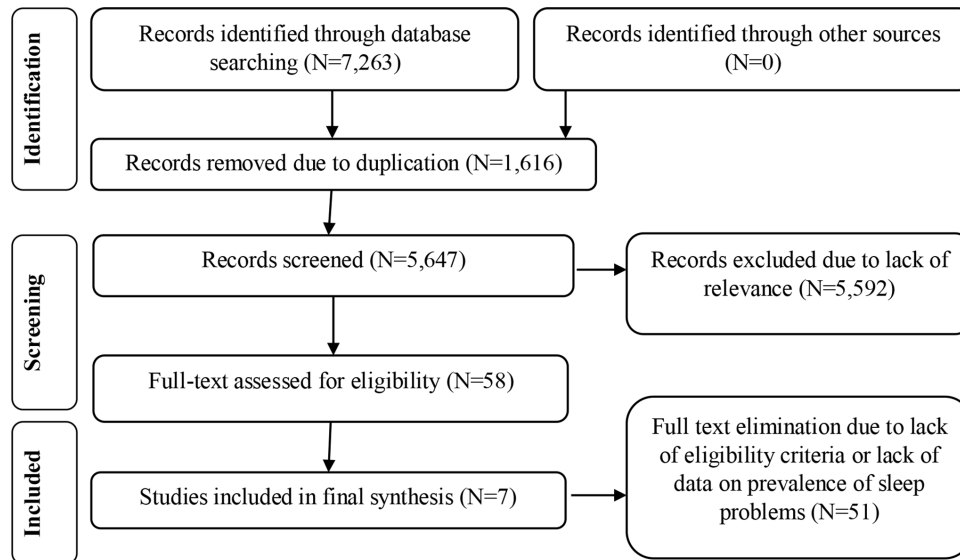


Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart of selected studies.

Data extraction

A predesigned form was prepared to extract data from the studies included. The following items were extracted: first author's name, data collection dates, study design, country, number of participants, mean age, scales used to assess sleep problems and numerical results regarding the frequency of sleep problems. It should also be noted that study selection, quality assessment and data extraction were processes performed independently by two reviewers. Disagreements were resolved through discussion.

Data synthesis

A quantitative synthesis using STATA software V.14 was conducted. Meta-analysis was run using a random effects model because included studies were taken from different populations, and both within-study and between-study variances should be accounted for.³³ Severity of heterogeneity was estimated using the I^2 index. Heterogeneity is interpreted as (1) mild when I^2 is less than 25%, (2) moderate when I^2 is 25%–50%, (3) severe when I^2 is 50%–75%, and (4) highly severe when I^2 is greater than 75%.³⁴ The key measure selected for the present study was prevalence of sleep problems. The

numerical findings regarding prevalence of sleep problems were reported consistently in six studies, and are reported along with 95% CIs. To assess moderator analysis, meta-regression was carried out. Funnel plot and Egger's test were used to assess publication bias.³⁵ Meta-trim with fill-and-trim method was used to correct probable publication bias.³⁶ Failure to correct the results in the presence of publication bias can lead to incorrect conclusions about the research question. Therefore, if the presence of publication bias is identified, the systematic reviewer should use the available methods to correct the results and present a more realistically justifiable conclusion. Although there are some methods recommended to correct the publication bias,³⁷ fill-and-trim method as a more conservative method was chosen and implemented. The jackknife method was used for sensitivity analysis.³⁸

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Table 1 Summary of the characteristics of included studies

Authors	Year	Country	Collection date	Sample size	Mean age (years)	NOS	Sleep Problem Scale
Li ¹¹	2020	China	25 April to 9 May 2020	398		9	ISI
Khoury <i>et al</i> ⁴¹	2021	Canada	3 June and 31 July 2020	303	32.13	7	ISI
Xie <i>et al</i> ³⁹	2021	China	–	689	29.03	6	PSQI
Zhang <i>et al</i> ⁴²	2021	China	January to February 2020	456		6	PSQI
Zhou <i>et al</i> ¹¹	2020	China	28 February to 12 March 2020	859	33.25	9	ISI
Ahorsu <i>et al</i> ⁴³	2020	Iran	7 March and 21 April 2020	290	29.24	9	ISI
Alan <i>et al</i> ⁴⁴	2020	Turkey	25–30 April 2020	166	29.65	10	PSQI

ISI, Insomnia Severity Index; NOS, Newcastle-Ottawa Scale; PSQI, Pittsburgh Sleep Quality Index.

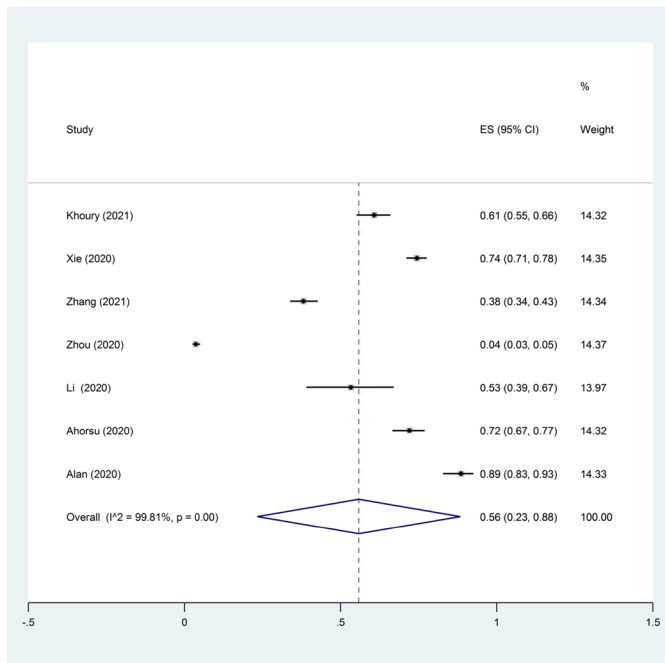


Figure 2 Forest plot regarding the pooled prevalence of sleep problems among pregnant women.

RESULTS

Study screening and selection process

The initial search in five databases resulted in 7263 studies: Scopus (n=2518), WOS (n=474), PubMed (n=338), Embase (n=1426) and ProQuest (n=2507). After removing the duplicates, 5647 papers were retained based on title and abstract. Finally, 58 papers appeared to be potentially eligible and their full texts were reviewed. In this process, seven studies met the eligibility criteria

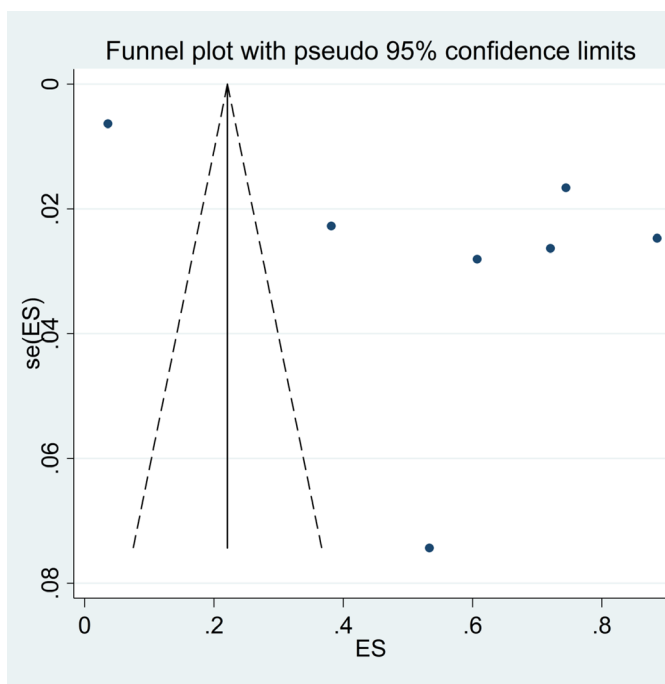


Figure 3 Funnel plot assessing the publication bias among included studies.

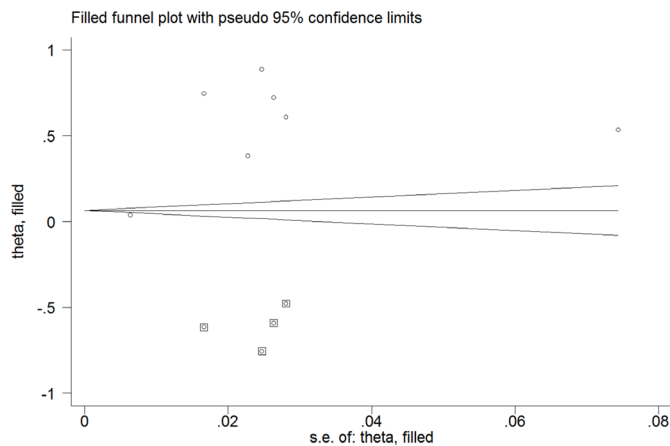


Figure 4 Corrected funnel plot based on fill-and-trim method.

and were pooled in the meta-analysis. **Figure 1** shows the search process based on the PRISMA flow chart.

Study description

A total of seven papers with 2808 participants from four different countries (Canada, Iran and Turkey (each one paper) and China (four papers) were included). None of these papers gathered the data during the national lockdown period in their respective countries. The smallest sample size was 45, and the largest sample size was 689, both from China. The mean age of participants was 30.66 years. All of the papers had cross-sectional design. Insomnia Severity Scale (ISI; n=4) and PSQI (n=3) were used to assess sleep problems. **Table 1** provides the summary characteristics of all included studies.

Quality assessment

All of the studies were categorised as being high-quality studies. Recruitment of participants via online sampling and absence of estimate or justification regarding sample size were the most common problems encountered in the quality assessments.

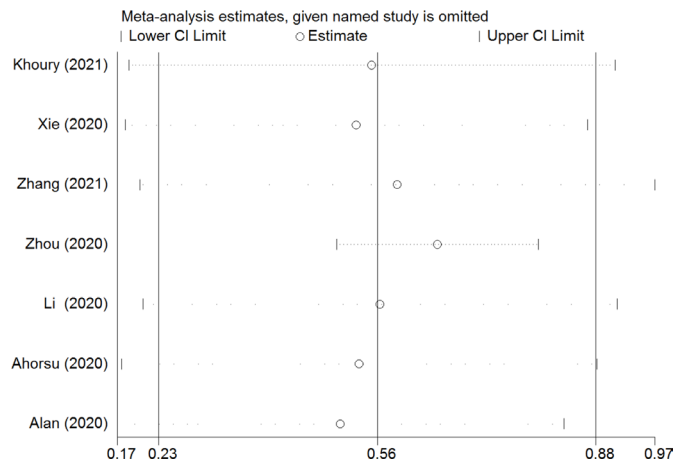


Figure 5 Assessment of small-study effect based on jackknife method.

Table 2 Results of meta-regression regarding estimated pooled prevalence

Variable	Coefficient	SE	P value	I ² res (%)	Adj R ² (%)	Tau ²
Univariable meta-regression						
Country	0.15	0.08	0.11	99.72	32.23	0.05
Age	-0.15	0.05	0.07	98.76	64.01	0.04
NOS score	0.02	0.06	0.74	99.82	-17.10	0.09
Measure of sleep	0.20	0.22	0.41	99.61	-3.06	0.09
Multivariable meta-regression						
Country	0.08	0.09	0.42	98.61	63.91	0.04
Age	-0.12	0.06	0.17			

NOS, Newcastle-Ottawa Scale.

Outcome measures

The pooled estimated prevalence of sleep problems was 56% (95% CI 23% to 88%, I²=99.81%, Tau²=0.19). [Figure 2](#) provides the forest plot regarding the pooled prevalence.

The probability of publication bias was assessed using Egger's test and funnel plot. Based on Egger's test (p=0.03) and funnel plot ([figure 3](#)), publication bias emerged as probable.

Due to the probability of publication bias, the fill-and-trim method was used to correct the estimated pooled measure. In this method, four studies were imputed, and the corrected results based on this method showed that the pooled prevalence of sleep problems was 13% (95% CI 0% to 45%; p<0.001). The resultant funnel plot after trimming is provided in [figure 4](#).

Furthermore, sensitivity analysis based on the jack-knife method showed that the pooled effect size was not affected by a single study effect ([figure 5](#)).

Meta-regression ([table 2](#)) showed that none of the examined variables explained the observed heterogeneity. Age was the only significant predictor of prevalence of sleep problems among pregnant women, and accounted for 64% of the variance. Each year, increase in participants' age was associated with a 12% decrease in the prevalence of sleep problems during pregnancy.

DISCUSSION

The main objective of this systematic review and meta-analysis was to examine the prevalence of sleep problems among pregnant women during the COVID-19 pandemic, and explore the potential predictors of such sleep problems. To the best of our knowledge, the present study is the first to summarise the available evidence on sleep problems, the latter being exclusively determined using validated instruments. We found that the overall prevalence of sleep problems during pregnancy in COVID-19 pandemic was nominally 56%, and after bias estimate corrections, 13%. In a recent systematic review, the pooled prevalence of sleep problems in the general population during the COVID-19 pandemic was estimated at 18%

(95% CI 15% to 21%).²⁵ In addition, Zhou *et al* found that the prevalence of insomnia symptoms in pregnancy during the COVID-19 pandemic was 2.6% compared with 5.4% among non-pregnant women.¹¹ Interestingly, Xie *et al* reported that sleep problems among pregnant women were 74.5% during the COVID-19 pandemic versus 69.1% before COVID-19 pandemic.³⁹ There may be possible reasons for this discrepancy. The study of Xie *et al* was conducted at the beginning of the pandemic, while the study of Zhou *et al* was pursued later. Numerous studies have shown that fear and mental health problems were more prominent at the beginning of the pandemic. Since these studies employed different tools to evaluate sleep problems, it is also likely that the differences in findings may be explained by such fact. In a current systematic review and meta-analysis, the corrected pooled estimated prevalence of sleep problems was 24% (95% CI 19% to 29%) for female participants.²⁶ Thus, sleep problems are prevalent among pregnant women during the COVID-19 pandemic, but not more than the prevalence found in the general population. Some factors may account for such observations, namely a decision to become pregnant is usually taken during a period of better mental health and more secure financial situation. Therefore, pregnant women may have improved and more stable mental health condition than non-pregnant women. Second, pregnant women receive the focus of family attention at all times, and such unique support mechanisms may be especially implemented by family members during the COVID-19 epidemic. Third, increased contact with medical workers for their prenatal care can provide support and decrease stress symptoms.⁴⁰ Therefore, these factors might lead to less insomnia in the pregnant women group.

Limitations

Among the limitations of the study, we should point out that all studies were cross-sectional absence of COVID-19-related assessments at the time of data collection, and the outcomes of the pregnancies among those with and without sleep problems in a consistent manner. Also, data regarding which trimester might be more susceptible to develop sleep disorders were not reported within the

included studies. Consequently, we could not compare the prevalence of sleep problems according to the pregnancy trimester. However, these results support the need for targeted studies in cohorts of pregnant women aimed at early detection of vulnerable subgroups along with initial behavioural interventions aimed at mitigating the potential negative consequences of living through a pandemic on sleep during pregnancy and downstream outcomes.

CONCLUSION

Pregnant women are likely to experience poor sleep quality when facing a pandemic such as COVID-19. Thus, special attention should be paid to pregnant women, and tools to identify those at risk for sleep problems along with effective interventions to prevent or mitigate the consequences of sleep problems during gestation are needed.

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Contributors ZA and AHP contributed to conception, design of the study and data collection. ZA and AHP contributed to data analysis and interpretation of data. ZA and FA drafted the manuscript. AHP and DG provided contributions to the literature review and discussion and substantially edited the primary manuscript and prepared the final version of the manuscript. All authors revised the manuscript, agreed to be fully accountable for ensuring the integrity and accuracy of the study and read and approved the final version of the manuscript to be published. AHP is the guarantor of this study.

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Competing interests None declared.

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Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement The Excel data is available from the corresponding author on request. No additional unpublished data are available.

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REFERENCES

- Ghazanfarpour M, Bahrami F, Rashidi Fakari F, et al. Prevalence of anxiety and depression among pregnant women during the COVID-19 pandemic: a meta-analysis. *J Psychosom Obstet Gynaecol* 2021;1:1–12.
- Rajabimajid N, Alimoradi Z, Griffiths M. Impact of COVID-19-related fear and anxiety on job attributes: a systematic review. *Asian Journal of Social Health and Behavior* 2021;4:51–5.
- Abdi F, Amirian A. Diagnosis of SARS-CoV-2 vertical transmission using the amniotic fluid test. *Journal Mil Med* 2020;22:670–1.
- Mandelkorn U, Genzer S, Choshen-Hillel S, et al. Escalation of sleep disturbances amid the COVID-19 pandemic: a cross-sectional international study. *J Clin Sleep Med* 2021;17:45–53.
- Fan S, Guan J, Cao L, et al. Psychological effects caused by COVID-19 pandemic on pregnant women: a systematic review with meta-analysis. *Asian J Psychiatr* 2021;56:102533.
- Smyka M, Kosińska-Kaczyńska K, Sochacki-Wójcicka N, et al. Sleep problems in Pregnancy—A cross-sectional study in over 7000 pregnant women in Poland. *Int J Environ Res Public Health* 2020;17:5306.
- Olashore A, Akanni O, Fela-Thomas A. The psychological impact of COVID-19 on health-care workers in African countries: a systematic review. *Asian Journal of Social Health and Behavior* 2021;4:85–97.
- Forte G, Favieri F, Tambelli R, et al. COVID-19 pandemic in the Italian population: validation of a post-traumatic stress disorder questionnaire and prevalence of PTSD symptomatology. *Int J Environ Res Public Health* 2020;17:4151.
- Seo WS. Review of sleep problems related to social distancing and home confinement during the COVID-19 pandemic. *Chronobiology in Medicine* 2021;3:87–91.
- Imbriano G, Larsen EM, Mackin DM, et al. Online survey of the impact of COVID-19 risk and cost estimates on worry and health behavior compliance in young adults. *Front Public Health* 2021;9:612725.
- Li X, Lu P, Hu L, et al. Factors associated with mental health results among workers with income losses exposed to COVID-19 in China. *Int J Environ Res Public Health* 2020;17:5627.
- Subbaraman N. Pregnancy and COVID: what the data say. *Nature* 2021;591:193–5.
- Jahrami H, BaHammam AS, Bragazzi NL, et al. Sleep problems during the COVID-19 pandemic by population: a systematic review and meta-analysis. *J Clin Sleep Med* 2021;17:299–313.
- Umeno S, Kato C, Nagaura Y, et al. Characteristics of sleep/wake problems and delivery outcomes among pregnant Japanese women without gestational complications. *BMC Pregnancy Childbirth* 2020;20:179.
- Sedov ID, Cameron EE, Madigan S, et al. Sleep quality during pregnancy: a meta-analysis. *Sleep Med Rev* 2018;38:168–76.
- Warland J, Dorrian J, Morrison JL, et al. Maternal sleep during pregnancy and poor fetal outcomes: a scoping review of the literature with meta-analysis. *Sleep Med Rev* 2018;41:197–219.
- Liu L, Su G, Wang S, et al. The prevalence of obstructive sleep apnea and its association with pregnancy-related health outcomes: a systematic review and meta-analysis. *Sleep Breath* 2019;23:399–412.
- Lin W, Wu B, Chen B, et al. Sleep conditions associate with anxiety and depression symptoms among pregnant women during the epidemic of COVID-19 in Shenzhen. *J Affect Disord* 2021;281:567–73.
- Zreik G, Asraf K, Haimov I, et al. Maternal perceptions of sleep problems among children and mothers during the coronavirus disease 2019 (COVID-19) pandemic in Israel. *J Sleep Res* 2021;30:e13201.
- Grossman ES, Hoffman YSG, Palgi Y, et al. COVID-19 related loneliness and sleep problems in older adults: worries and resilience as potential moderators. *Pers Individ Dif* 2021;168:110371.
- Abdi F, Navidpour F, And Dolatian M. A literature review of pregnancy worries and stress scales. *Iranian Journal of Psychiatry and Behavioral Sciences* 2018;12.
- Kunzler AM, Röhke N, Günthner L, et al. Mental burden and its risk and protective factors during the early phase of the SARS-CoV-2 pandemic: systematic review and meta-analyses. *Global Health* 2021;17:34.
- Datta K, Tripathi M. Sleep and Covid-19. *Neurol India* 2021;69:26.
- Altana E, Baglioni C, Espie CA, et al. Dealing with sleep problems during home confinement due to the COVID-19 outbreak: practical recommendations from a task force of the European CBT-I Academy. *J Sleep Res* 2020;29:e13052.
- Alimoradi Z, Broström A, Tsang HWH, et al. Sleep problems during COVID-19 pandemic and its' association to psychological distress: a systematic review and meta-analysis. *EClinicalMedicine* 2021;36:100916.
- Alimoradi Z, Gozal D, Tsang HWH, et al. Gender-Specific estimates of sleep problems during the COVID-19 pandemic: systematic review and meta-analysis. *J Sleep Res* 2022;31:e13432.
- Alimoradi Z, Pakpour A. Sleep and Covid-19 related psychological distress. *prospero* 2020 CRD42020181644 2020.
- Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med* 2009;151:264–9.
- Morgan RL, Whaley P, Thayer KA, et al. Identifying the PECO: a framework for formulating good questions to explore the association of environmental and other exposures with health outcomes. *Environ Int* 2018;121:1027–31.

- 30 Buysse DJ, Reynolds CF, Monk TH, *et al.* The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. *Psychiatry Res* 1989;28:193–213.
- 31 Morin CM, Belleville G, Bélanger L, *et al.* The insomnia severity index: psychometric indicators to detect insomnia cases and evaluate treatment response. *Sleep* 2011;34:601–8.
- 32 Luchini C, Stubbs B, Solmi M, *et al.* Assessing the quality of studies in meta-analyses: advantages and limitations of the Newcastle Ottawa scale. *World J Metaanal* 2017;5:80–4.
- 33 Hox JJ, EDD L. *Multilevel models for meta-analysis*, 2003.
- 34 Huedo-Medina TB, Sánchez-Meca J, Marín-Martínez F, *et al.* Assessing heterogeneity in meta-analysis: Q statistic or I² index? *Psychol Methods* 2006;11:193–206.
- 35 Rothstein HR, Sutton AJ, Borenstein M. *Publication bias in meta-analysis. Publication bias in meta-analysis: Prevention, assessment and adjustments*, 2005: 1–7.
- 36 Duval S, Tweedie R. Trim and fill: a simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics* 2000;56:455–63.
- 37 Sterne JAC, Sutton AJ, Ioannidis JPA, *et al.* Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. *BMJ* 2011;343:d4002.
- 38 Hedges L, Olkin I. *Statistical methods for meta-analysis*. Academic press, 2014.
- 39 Xie M, Wang X, Zhang J, *et al.* Alteration in the psychologic status and family environment of pregnant women before and during the COVID-19 pandemic. *Int J Gynaecol Obstet* 2021;153:71–5.
- 40 Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. *JAMA* 2020;323:1239–42.
- 41 Khoury JE, Atkinson L, Bennett T, *et al.* COVID-19 and mental health during pregnancy: the importance of cognitive appraisal and social support. *J Affect Disord* 2021;282:1161–9.
- 42 Zhang X, Liu J, Han N, *et al.* Social media use, unhealthy lifestyles, and the risk of miscarriage among pregnant women during the COVID-19 pandemic: prospective observational study. *JMIR Public Health Surveill* 2021;7:e25241.
- 43 Ahorsu DK, Lin C-Y, Pakpour AH. The association between health status and insomnia, mental health, and preventive behaviors: the mediating role of fear of COVID-19. *Gerontol Geriatr Med* 2020;6:233372142096608.
- 44 Alan S, Vurğec BA, Cevik A, *et al.* The effects of COVID-19 pandemic on pregnant women: perceived stress, social support and sleep quality. *Yonago Acta Med* 2020;63:360–7.