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Review article

Prevalence of stress, depression, anxiety and sleep disturbance among nurses during the COVID-19 pandemic: A systematic review and meta-analysis

Mohammed Al Maqbali a,b,*, Mohammed Al Sinani b, Badriya Al-Lenjawi c

a Ministry of Health – Oman, Oman  
b Reproductive and Developmental Biology Department of Surgery and Cancer, Faculty of Medicine, Imperial College London, London, UK  
c Hamad Medical Corporation, Doha, Qatar

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ABSTRACT

Background: The new coronavirus disease’s (COVID-19) high risk of infection can increase the workload of healthcare workers, especially nurses, as they are most of the healthcare workforce. These problems can lead to psychological problems. Therefore, the aim of this systematic review and meta-analysis is to ascertain the present impact of the COVID-19 outbreak on the prevalence of stress, anxiety, depression and sleep disturbance among nurses.

Methods: A systematic review and meta-analysis were conducted. The following databases were searched: PubMed, CHINAL, MEDLINE, EMBASE, PsycINFO, MedRxiv and Google Scholar, from January 2020 up to 26th October 2020. Prevalence rates were pooled with meta-analysis using a random-effects model. Heterogeneity was tested using I-squared ($I^2$) statistics.

Results: A total of 93 studies ($n = 93,112$), published between January 2020 and September 2020, met the inclusion criteria. The overall prevalence of stress was assessed in 40 studies which accounted for 43% (95% CI 37–49). The pooled prevalence of anxiety was 37% (95% CI 32–41) in 73 studies. Depression was assessed in 62 studies, with a pooled prevalence of 35% (95% CI 31–39). Finally, 18 studies assessed sleep disturbance and the pooled prevalence was 43% (95% CI 36–50).

Conclusion: This meta-analysis found that approximately one third of nurses working during the COVID-19 epidemic were suffering from psychological symptoms. This highlights the importance of providing comprehensive support strategies to reduce the psychological impact of the COVID-19 outbreak among nurses under pandemic conditions. Further longitudinal study is needed to distinguish psychological symptoms during and after the infectious disease outbreaks.

1. Introduction

At the end of December 2019, the new coronavirus disease (COVID-19) emerged in Wuhan City, Hubei province, China, and subsequently spread worldwide [1]. COVID-19 has seriously threatened human health. As of 30th January 2020, the World Health Organization (WHO) declared a public health emergency and considered COVID-19 a pandemic [2]. Globally, the WHO reported 65.6 million confirmed cases worldwide, with nearly 1.5 million deaths up until 6th December 2020 [3]. This increasing number of confirmed cases can overwhelm healthcare systems with thousands of patients needing urgent care.

This high risk of infection from COVID-19 increases the workload of healthcare workers who are involved directly in diagnoses, treatment and care of patients with COVID-19. This is particularly true of nurses, as they are most of the healthcare workforce, and they are in the closest proximity to patients with COVID-19. In June 2020, the International Council of Nurses (ICN) estimated that more than 600 nurses have died from COVID-19 worldwide [4]. In battling the sudden emergency by working at high risk of infection from patients, this can lead to mental health problems such as stress, anxiety and depression.

Previous research on the Severe Acute Respiratory Syndrome (SARS) or Middle East Respiratory Syndrome (MERS) epidemics indicates that nurses working at these times were under extraordinary amounts of pressure [5,6]. A systematic thematic review of 22 studies was
conducted by Brooks et al. [7] to identify the social and occupational factors associated with the psychological wellbeing of healthcare workers during the SARS outbreak. The review found that specialized training and preparedness, working at high risk of infection, quarantine, job stress, perceived risk, poor organizational support and stigmatization all impacted on nurses’ personal or professional life.

Two previous systematic reviews have been published which explore the prevalence of psychological outcomes among healthcare workers during infectious disease outbreaks [8,9]. However, to date, the psychological impact of the COVID-19 outbreak on nurses has not yet been systematically reported. Therefore, the aim of this study is to conduct a rapid systematic review and meta-analysis to ascertain the present impact of the COVID-19 outbreak on the prevalence of stress, anxiety, depression and sleep disturbance among nurses.

2. Methods

This systematic review and meta-analysis were undertaken according to the PRISMA standards. The review protocol was registered at PROSPERO (No. CRD42020193300).

2.1. Search strategy

A systematic literature search, between January 2020 and 26th October 2020, was conducted using the following databases: PubMed, CHINAL, MEDLINE, EMBASE, PsycINFO, MedRxiv and Google Scholar. Search terms used both free text words and medical subject headings, i.e. MeSH terms, to search papers in the review (Supplementary Appendix 1). In addition, reference lists were screened of the retrieved studies to identify any further studies.

2.2. Study selection

Two investigators (A.M; A.J) performed the search, scrutinizing all titles and abstracts for eligibility against the inclusion and exclusion criteria. Any disagreements were resolved through discussion with a third investigator (A. B). Studies were included in the review according to the following inclusion criteria: (1) reported prevalence of stress or anxiety or depression or sleep disturbance among nurses during COVID-19 outbreaks; (2) all types of setting; and (3), cross-sectional or cohort survey (only the baseline data were extracted). The exclusion criteria were: (1) protocol papers and conference abstracts; (2) if stress or anxiety or depression or sleep disturbance was assessed via an unvalidated scale; and (3), study did not report prevalence among nurses. For any additional information the study authors were contacted.

2.3. Quality assessment

Upon retrieval of the applicable studies, the quality assessment was completed using the Newcastle-Ottawa Scale (NOS) [10]. This scale consists of eight items that evaluate the non-randomized studies, which covered three criteria: the selection of the participants, comparability of
| Study | Preprint | Setting | Frontline | Country | Month | Measure | Events | Total Sample | Instrument Cut Off | NOS |
|-------|----------|---------|-----------|---------|-------|---------|--------|-------------|-------------------|-----|
| 1 Cai et al., (2020) | No NG NG China | February | Stress | 72 | 546 | SCL-90 | ≥160 | Moderate |
| 2 Z. Zhu et al., (2020) | No Hospital Frontline China | February | Anxiety | 863 | 3417 | IES-R | ≤33 | Low |
| 3 Choudhury et al., (2020) | No NG Mixed UK | April | Depression | 489 | 3417 | PHQ-9 | ≥10 | Low |
| 4 Lai et al., (2020) | No Hospital Mixed China | January | Stress | 569 | 764 | IES-R | ≥26 | Moderate |
| 5 Liu et al., (2020) | Yes Hospital Mixed China | February | Anxiety | 432 | 2826 | SRQ-20 | ≤7 | Low |
| 6 Yin et al., (2020) | No NG NG China | February | Anxiety | 110 | 246 | PCL-5 | ≥33 | Moderate |
| 7 J. Zhu et al., (2020) | No Hospital Frontline China | February | Anxiety | 34 | 86 | SAS | ≥50 | Moderate |
| 8 Guo et al., (2020) | Yes Hospital Mixed China | February | Anxiety | 1100 | 5900 | SAS | ≥50 | Moderate |
| 9 Xiao et al., (2020) | No Hospital Mixed China | January | Anxiety | 210 | 359 | HADS | ≤8 | Low |
| 10 Wang et al., (2020) | No Hospital Mixed China | February | Anxiety | 34 | 202 | PCL-5 | ≥50 | Moderate |
| 11 Wang et al., (2020) | No Hospital Mixed China | February | Anxiety | 29 | 75 | SAS | ≥50 | Moderate |
| 12 Zhang et al., (2020) | No Hospital Frontline China | February | Anxiety | 473 | 984 | GAD-7 | ≥10 | Moderate |
| 13 Mo et al., (2020) | No Hospital Frontline China | February | Anxiety | 526 | 984 | PHQ-9 | ≥10 | Moderate |
| 14 Huang et al., (2020) | No Hospital Frontline China | February | Anxiety | 59 | 180 | SAS | ≥50 | Moderate |
| 15 García-Fernández et al., (2020) | No NG NG Spain | March | Anxiety | 105 | 233 | ASDI | ≤7 | Moderate |
| 16 Zepkevicski et al., (2020) | No Hospital NG Poland | February | Anxiety | 13 | 62 | GAD-7 | ≤8 | Moderate |
| 17 Cui et al., (2020) | Yes Hospital Frontline China | February | Anxiety | 29 | 62 | PHQ-9 | ≤8 | Moderate |
| 18 Du et al., (2020) | No Hospital Frontline China | January | Anxiety | 34 | 164 | BDI-II | ≤7 | Moderate |
| 19 Zhou et al., (2020) | No Hospital Frontline China | February | Anxiety | 319 | 1569 | SAS | ≤8 | Moderate |
| 20 Jiang et al., (2020) | No Hospital Mixed China | February | Anxiety | 514 | 1569 | SAS | ≤8 | Moderate |
| 21 R. Zhang et al., (2020) | No Hospital Mixed China | February | Anxiety | 29 | 203 | IES-R | ≤33 | Moderate |
| 22 S. X. Zhang et al., (2020a) | No NG NG Peru, Ecuador, and Bolivia | April | Anxiety | 29 | 203 | IES-R | ≤33 | Moderate |
| 23 Anwar et al., (2020) | Yes Hospital Mixed China | April | Anxiety | 175 | 62 | GAD-7 | ≤33 | Moderate |
| 24 Taghizadeh et al., (2020) | Yes NG NG Iran | April | Anxiety | 175 | 62 | GAD-7 | ≤33 | Moderate |
| 25 S. X. Zhang et al., (2020a) | No NG NG Iran | February | Anxiety | 175 | 62 | GAD-7 | ≤33 | Moderate |
| 26 Salman et al., (2020) | Yes Hospital Mixed Pakistan | February | Anxiety | 35 | 133 | SAS | ≤8 | Moderate |
| 27 Zhpu et al., (2020) | Yes NG NG China | January | Anxiety | 133 | 147 | SAS | ≤8 | Moderate |
| 28 Pan et al., (2020) | No Hospital Frontline China | February | Anxiety | 44 | 148 | PHQ-9 | ≤5 | Moderate |

(continued on next page)
Table 1

| Study | Preprint | Setting  | Frontline | Country  | Month   | Measure | Events | Total Sample | Instrument | Cut Off | NOS |
|-------|----------|----------|-----------|----------|---------|---------|--------|--------------|------------|---------|-----|
|       |          |          |           |          |         |         |        |              |            |         |     |
| 29    | Ning et al., (2020) | No    | Hospital | Mixed    | China   | February | Insomnia | 129  | 148 | PHQ-15 | ≥10      |         |     |
|       |          |         |          |          |         |         | Anxiety | 60  | 295 | SAS    | ≥50  | Low   |     |
| 30    | Y. Liu et al., (2020) | Yes   | Hospital | Mixed    | China   | February | Stress   | 297  | 577 | PSS    | ≥14  | Moderate |     |
|       |          |         |          |          |         |         | Anxiety | 65  | 577 | GAD-7 | ≥15 | Moderate |     |
| 31    | Ongcmaater et al., (2020) | No    | Hospital | Mongolian | February | Stress   | 73  | 577 | PHQ-9 | ≥10 |         |     |
| 32    | Li et al., (2020) | No    | Hospital | Mixed    | China   | February | Anxiety  | 1127 | 3381 | IES-R | ≥25 | Moderate |     |
|       |          |         |          |          |         |         | Depression | 864  | 3381 | GAD-7 | ≥28 |         |     |
| 33    | Y. Liu et al., (2020) | Yes   | Hospital | Mixed    | China   | February | Stress   | 1280 | 3381 | PHQ-9 | ≥30 | Low    |     |
|       |          |         |          |          |         |         | Anxiety  | 1297 | 3381 | GAD-7 | ≥30 | Low    |     |
| 34    | Otgonbaatar et al., (2020) | No    | Hospital | Mixed    | Mongolia | February | Stress   | 83  | 577 | PSS    | ≥14  | Moderate |     |
|       |          |         |          |          |         |         | Anxiety  | 577  | 577 | GAD-7 | ≥15 | Moderate |     |
| 35    | Li et al., (2020) | No    | Hospital | Mixed    | China   | February | Stress   | 1127 | 3381 | IES-R | ≥25 | Moderate |     |
|       |          |         |          |          |         |         | Anxiety  | 864  | 3381 | GAD-7 | ≥28 |         |     |
| 36    | W. Zhang et al., (2020) | Yes   | Hospital | Mixed    | China   | February | Stress   | 100  | 313 | PHQ-9 | ≥10 | Moderate |     |
|       |          |         |          |          |         |         | Anxiety  | 39   | 197 | PHQ-4 | ≥3  |         |     |
| 37    | Weilenmann et al., (2020) | Yes   | Hospital | Mixed    | Switzerland | April | Stress   | 138  | 553 | PHQ-9 | ≥10 | Moderate |     |
| 38    | Sahin et al., (2020) | No    | Hospital | Mixed    | Turkey  | April    | Anxiety  | 226  | 301 | IES-R | ≥25 | Moderate |     |
| 39    | Rossi et al., (2020) | No    | Hospital | Mixed    | Italy   | March    | Stress   | 105  | 474 | PSS    | ≥3  | Low    |     |
| 40    | Kaveh et al., (2020) | No    | Hospital | Mixed    | Iran    | March    | Anxiety  | 225  | 577 | GAD-7 | ≥25 | Low    |     |
| 41    | Guixia and Hui, (2020) | No    | Hospital | Mixed    | China   | February | Stress   | 38   | 92  | SAS    | ≥50 | Moderate |     |
| 42    | Al Amer et al., (2020) | Yes   | Hospital | Mixed    | Jordan  | March    | Stress   | 208  | 405 | DASS  | ≥19 | Moderate |     |
| 43    | Shechter et al., (2020) | No    | Hospital | Mixed    | USA     | April    | Stress   | 200  | 313 | PSS    | ≥3  | Low    |     |
| 44    | Naser et al., (2020) | No    | Mixed    | NG       | Jordan  | March    | Anxiety  | 125  | 313 | GAD-2 | ≥3  |         |     |
| 45    | Que et al., (2020) | No    | Mixed    | Mixed    | China   | February | Stress   | 107  | 208 | PHQ-9 | ≥10 | Moderate |     |
| 46    | Jahrami et al., (2020) | No    | Mixed    | Mixed    | Bahrain | April    | Stress   | 95   | 119 | PSS    | ≥14 | Moderate |     |
| 47    | Koksal et al., (2020) | No    | Mixed    | Mixed    | Turkey  | April    | Anxiety  | 197  | 339 | HADS  | ≥10 | Moderate |     |
| 48    | Tu et al., (2020) | No    | Hospital | Frontline | China   | February | Stress   | 130  | 339 | HADS  | ≥7  | Moderate |     |
| 49    | Yang et al., (2020) | Yes   | Hospital | Mixed    | China   | March    | Anxiety  | 193  | 1017 | SAS    | ≥50 | Moderate |     |
| 50    | Chekole et al., (2020) | No    | Mixed    | Mixed    | Ethiopia | April    | Stress   | 335  | 1017 | PSS    | ≥20 | Moderate |     |
| 51    | Fang et al., (2020) | Yes   | NG       | Mixed    | China   | January  | Anxiety  | 117  | 293 | PSS    | ≥40  | Moderate |     |
| 52    | Jia et al., (2020) | No    | Hospital | Mixed    | Germany | April    | Anxiety  | 156  | 867 | SAS    | ≥50 | Moderate |     |
| 53    | Zerbini et al., (2020) | No    | Hospital | Mixed    | Germany | April    | Anxiety  | 34   | 75  | PHQ-9 | ≥5  | Moderate |     |
| 54    | Poulalizadeh et al., (2020) | No    | Hospital | Mixed    | Iran    | April    | Anxiety  | 165  | 441 | PHQ-9 | ≥10 | Moderate |     |
| 55    | Gallopeni et al., (2020) | No    | Hospital | Mixed    | Kosovo  | April    | Anxiety  | 137  | 304 | HADS  | ≥11 | Moderate |     |
| 56    | Li et al., (2020a) | No    | Hospital | Mixed    | China   | February | Anxiety  | 106  | 304 | HADS  | ≥11 | Moderate |     |
| 57    | Li et al., (2020b) | Yes   | Hospital | Mixed    | Malawi  | September | Anxiety  | 136  | 176 | HAM-A | ≥14 | Moderate |     |
Table 1 (continued)

| Study                          | Preprint | Setting | Frontline | Country | Month  | Measure | Events | Total Sample | Instrument | Cut Off | NOS |
|-------------------------------|----------|---------|-----------|---------|--------|---------|--------|--------------|------------|---------|-----|
| Chorwe-Sungani, (2020)        |          |         | Frontline | KSA     | April   | Anxiety | 57     | 123          | STA1       | ≥57     | Moderate |
| Saricam, (2020)               |          | No      | Hospital  | Turkey  | April   | Stress  | 55     | 103          | DASS       | ≥10     | Moderate |
| Arafa et al., (2020)          |          | No      | Hospital  | KSA & Egypt | April | Anxiety | 61     | 103          | DASS       | ≥8      | Moderate |
| Siliwal et al., (2020)        |          | No      | Hospital  | Nepal   | April   | Stress  | 24     | 152          | DASS       | ≥19     | Moderate |
| Li et al., (2020b)            |          | No      | Hospital  | China   | March   | Anxiety | 379    | 4692         | IES-R      | ≥10     | Moderate |
| Hong et al., (2020)           |          | No      | Hospital  | China   | February | Stress  | 220    | 356          | PCL-5      | ≥33     | Low |
| Hooei et al., (2020)          |          | Yes     | Mixed     | Austria | July    | Stress  | 1751   | 2602         | PSS        | ≥14     | Moderate |
| Xiaozei et al., (2020)        |          | No      | Hospital  | Frontline | China | March   | Stress  | 250    | 767          | PHQ-9      | ≥5      | Moderate |
| Zhan et al., (2020a)          |          | No      | Hospital  | Frontline | China | March   | Stress  | 789    | 1794         | AIS        | ≥25     | Low |
| AlAteeq et al., (2020)        |          | No      | Hospital  | Frontline | KSA    | March   | Anxiety | 44     | 132          | GAD-7      | ≥10     | Moderate |
| Khanal et al., (2020)         |          | No      | Hospital  | Nepal    | May     | Anxiety | 49     | 167          | HADS       | ≥7      | Moderate |
| Bachilo et al., (2020)        |          | Yes     | Mixed     | Russia   | May     | Anxiety | 55     | 193          | GAD-7      | ≥5      | Moderate |
| Waniagasaowriya et al., (2020) |          | Yes     | Hospital  | Frontline | UK     | July    | Stress  | 226    | 775          | IES-R      | ≥33     | Moderate |
| Leng et al., (2020)           |          | No      | Hospital  | Frontline | China  | February | Stress | 20     | 90           | PSS        | ≥25     | Moderate |
| Aksoy and Kocak, (2020)       |          | No      | Mixed     | Turkey   | April   | Anxiety | 264    | 726          | STA1       | ≥35     | Moderate |
| Hendy et al., (2020)          |          | No      | Hospital  | Egypt    | April   | Stress  | 293    | 374          | NIS        | ≥40     | Moderate |
| Zhan et al., (2020b)          |          | No      | Hospital  | China    | March   | Stress  | 1298   | 2667         | SAS        | ≥25     | Low |
| Prasad et al., (2020)         |          | No      | Hospital  | USA      | April   | Stress  | 208    | 248          | IES-R      | ≥26     | Moderate |
| Lee et al., (2020)            |          | No      | Hospital  | Singapore | June    | Stress  | 54     | 248          | PHQ-2      | ≥3      | Moderate |
| Azoulay et al., (2020)        |          | No      | Hospital  | France   | May     | Anxiety | 49     | 155          | HADS       | ≥11     | Moderate |
| Xiong et al., (2020)          |          | No      | Hospital  | Mixed    | China   | February | Anxiety | 94     | 231          | GAD-7      | ≥10     | Moderate |
| Sampsoa et al., (2020)        |          | No      | Mixed     | Portugal | April   | Stress  | 210    | 767          | DASS       | ≥10     | Moderate |
| Buselli et al., (2020)        |          | No      | Hospital  | Frontline | Italy  | May     | Anxiety | 20     | 133          | GAD-7      | ≥10     | Moderate |
| Salopek-Ziha et al., (2020)   |          | No      | Mixed     | Croatia  | April   | Stress  | 10     | 97           | DASS       | ≥10     | Moderate |
| Wasim et al., (2020)          |          | No      | Hospital  | Pakistan | June    | Stress  | 14     | 97           | DASS       | ≥6      | Moderate |
| Ahn et al., (2020)            |          | Yes     | Hospital  | Korea    | April   | Anxiety | 46     | 78           | ISI        | ≥8      | Moderate |
| Zheng et al., (2020)          |          | No      | Mixed     | Mixed    | China   | February | Anxiety | 248    | 1103         | PHQ-9      | ≥10     | Moderate |
| Gorini et al., (2020)         |          | No      | Hospital  | Frontline | Italy   | May     | Stress  | 125    | 214          | IES-R      | ≥26     | Moderate |
| An et al., (2020)             |          | No      | Hospital  | Frontline | China   | March   | Depression | 481  | 1103         | PHQ-9      | ≥10     | Moderate |
| Zhang et al., (2020)          |          | No      | Mixed     | Mixed    | China   | April   | Depression | 111  | 468          | PCL-5      | ≥50     | Moderate |

(continued on next page)
study groups and outcome assessment. The NOS uses a score system with the lowest possible score of zero and the highest possible score of nine. The total points awarded indicate the overall quality of the study. A study was determined to be of low risk of bias when the score was 7–9, of moderate risk of bias if the score was 5–6, and high risk of bias if the score was 0–4 [11].

### 2.4. Data analyses

To estimate the pooled prevalence, odds ratios (ORs) with 95% Confidence Interval (CI) were calculated as the effect size by using a random-effects model. Heterogeneity was tested using I-squared ($I^2$) statistics. A value of $I^2$ was considered to be low with 0–25%, 25–50% as moderate and 50–75% considered as high heterogeneity [12]. In addition, subgroup analyses to test the significant differences in the prevalence of stress, anxiety, depression and sleep disturbance between different groups (setting, frontline or second line; data collection month, NOS,) were performed when there were at least four studies per subgroup. A sensitivity analysis was performed by removing one study at a time to evaluate the impact of pooled prevalence of remining studies [13].

Funnel plots were found to be an inaccurate method for assessing publication bias in meta-analyses of proportion studies [14,15]. Therefore, publication bias was estimated using Egger’s linear regression test and funnel plot [16]. A p value of less than 0.05 was considered as statistically significant. Meta-analysis was conducted using Comprehensive Meta-Analysis software, version 2.2 (Englewood, New Jersey, USA). Forest plots were constructed using a Microsoft Excel spreadsheet constructed by Neyeloff et al. [17].

### 3. Results

The database search identified 3306 papers; of these, 3100 papers were excluded during title and abstract screening for the following reasons: 556 papers were not conducted during the COVID-19 period; 83 did not give information about nurses; 2430 were duplicated papers. A further, 113 papers were excluded during full text review. As such, 93 studies were identified as eligible for meta-analysis (Fig. 1 shows the PRISMA flow chart).

#### 3.1. General characteristics

Ninety-three studies, involving 93,112 nurses, were included in this meta-analysis. All studies were conducted between January 2020 and September 2020: eight in January, 36 in February, 13 in March, 13 in April, six in May, two in June, two in July and one in September. Twenty preprint studies [18–37] were included in the analyses. All studies included in this meta-analysis were of cross sectional design. The vast majority (n = 67 studies) were conducted in hospital settings; seventeen were mixed setting and only nine studies did not provide setting information. Thirty-four studies involved nurses who worked on the frontline in the fight against the COVID-19 epidemic; however, 49 studies involved mixed nurses, i.e. those working in the frontline and second line, whereas ten studies did not give this information. Forty-nine studies originated from China, four from each Turkey and Iran, three from Italy, two each from Germany, Jordan, Nepal, Pakistan, Spain, the USA and the UK, and one from each of the following: Austrian, Bahrain, Croatia, Egypt, Ethiopia, France, Greece, Korea, Kosovo, Malawi, Mongolian, Poland, Portugal, Russia, Singapore and Switzerland. Two study was conducted in more than one country [38,39]. (See Table 1 for a general characteristics of studies).

#### 3.2. Quality assessment

The studies were assessed using the NOS checklist. Nineteen studies were classified as having a low risk of bias and seventy-four as moderate. The detailed results of the quality assessment of the studies included in this meta-analysis are listed in Table 2.

#### 3.3. Prevalence of stress

Stress was estimated in 40 studies [18,20,25,27,29,33,35,36,39–70]. The overall pooled point estimates of prevalence for stress varied between 10% and 84% (Fig. 2: forest plots). All meta-analyses of prevalence estimates of stress reported by the 40 studies yielded a summary prevalence of 43% (11,139/27,034 participants, 95% CI 37–49). Sensitivity analysis by excluding one study each time demonstrated that no differences in the overall estimation by more or less than 1%. There was significant heterogeneity between studies to estimate the prevalence ($p < 0.000$, $I^2 = 98$).

The pooled prevalence according to the month of data collected was as follows: February: 32% (n = 14; 95% CI 25–41; $I^2 = 98$), March: 45% (n = 6; 95% CI 37–53; $I^2 = 96$) and April: 50% (n = 13; 95% CI 35–66; $I^2 = 98$). Seventeen studies [20,35,36,39,43,44,46,54,57–63,67,69] involving nurses who were working on the frontline showed stress prevalence at 46% (95% CI = 39–54; $I^2 = 97$), whereas 20 studies including mixed nurses working in the frontline and second line showed the stress prevalence was 42% (95% CI = 31–53; $I^2 = 99$). Thirteen studies that used the Perceived Stress Scale (PSS) showed a pooled prevalence of stress at 50% (95% CI = 41–59, $I^2 = 98$), whereas eight studies [35,45,54–56,63,64,67] using the Impact of Event Scale-Revised (IES-R) had a pooled prevalence of 50% (95% CI = 37–63, $I^2 = 99$). The other studies used different scales. In the subgroup analyses using the NOS, the pooled prevalence in studies (n = 9) with low risk of bias accounted for 41% (95% CI = 29–54, $I^2 = 99$), whereas those with a moderate risk of bias (n = 31) accounted for 43% (95% CI = 36–52, $I^2 = 98$).

#### 3.4. Prevalence of anxiety

The overall pooled point estimates of prevalence for anxiety varied between 8% and 91%, which was reported...
Table 2
Quality assessment result of observational studies (n = 93) using the Newcastle-Ottawa Scale:

| Study | Representativeness of the sample (One Point) | Sample Size (One Point) | Non-Respondents (One Point) | Ascertainment of the exposure (One Point) | Study controls for other variable (Two Point) | Assessment of Outcome (One Point) | Statistical Test (One Point) | Adequate Follow up time (One Point) | Score | Quality |
|-------|---------------------------------------------|-------------------------|-----------------------------|------------------------------------------|----------------------------------------------|----------------------------------|-------------------------------|----------------------------------|-------|---------|
| 1     | Cai et al., (2020)                          | 1                       | 1                           | 1                                        | 0                                            | 0                                | 0                             | 1                                | 1     | Moderate |
| 2     | Z. Zhu et al., (2020)                       | 1                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 0                                | 7     | Low     |
| 3     | Choudhury et al., (2020)                    | 0                       | 1                           | 0                                        | 1                                            | 2                                | 1                             | 1                                | 0     | Moderate |
| 4     | Lai et al., (2020)                          | 1                       | 1                           | 1                                        | 1                                            | 2                                | 1                             | 1                                | 0     | Low     |
| 5     | Liu et al., (2020)                          | 1                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 0                                | 7     | Low     |
| 6     | Yin et al., (2020)                          | 1                       | 1                           | 0                                        | 1                                            | 1                                | 1                             | 1                                | 0     | Moderate |
| 7     | J. Zhu et al., (2020)                       | 0                       | 1                           | 0                                        | 1                                            | 2                                | 1                             | 1                                | 0     | Moderate |
| 8     | Guo et al., (2020)                          | 1                       | 1                           | 1                                        | 1                                            | 2                                | 1                             | 1                                | 0     | Low     |
| 9     | Xiao et al., (2020)                         | 1                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 0                                | 7     | Low     |
| 10    | Wang et al., (2020)                         | 0                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 1                                | 0     | Low     |
| 11    | Wang et al., (2020)                         | 0                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 0                                | 5     | Moderate |
| 12    | Zhang et al., (2020)                        | 1                       | 1                           | 1                                        | 1                                            | 1                                | 0                             | 1                                | 0     | Moderate |
| 13    | Mo et al., (2020)                           | 0                       | 1                           | 1                                        | 1                                            | 0                                | 1                             | 1                                | 0     | Moderate |
| 14    | Huang et al., (2020)                        | 0                       | 1                           | 0                                        | 1                                            | 2                                | 1                             | 1                                | 0     | Moderate |
| 15    | García-Fernández et al., (2020)            | 0                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 1                                | 0     | Moderate |
| 16    | Szepietowski et al., (2020)                | 0                       | 1                           | 1                                        | 0                                            | 1                                | 1                             | 1                                | 0     | Moderate |
| 17    | Cai et al., (2020)                          | 0                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 1                                | 0     | Moderate |
| 18    | Du et al., (2020)                           | 0                       | 1                           | 1                                        | 1                                            | 1                                | 0                             | 1                                | 0     | Moderate |
| 19    | Zhou et al., (2020)                         | 0                       | 1                           | 1                                        | 1                                            | 1                                | 0                             | 1                                | 1     | Moderate |
| 20    | Jiang et al., (2020)                        | 0                       | 1                           | 0                                        | 1                                            | 2                                | 1                             | 1                                | 0     | Moderate |
| 21    | R. Zhang et al., (2020)                     | 0                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 1                                | 0     | Moderate |
| 22    | S. X. Zhang et al., (2020)                 | 0                       | 1                           | 1                                        | 0                                            | 1                                | 1                             | 1                                | 0     | Moderate |
| 23    | Wan et al., (2020)                          | 0                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 1                                | 0     | Moderate |
| 24    | Taghiadeh et al., (2020)                   | 0                       | 1                           | 1                                        | 1                                            | 1                                | 0                             | 1                                | 0     | Moderate |
| 25    | S. X. Zhang et al., (2020)                 | 0                       | 1                           | 1                                        | 1                                            | 1                                | 0                             | 1                                | 1     | Moderate |
| 26    | Salman et al., (2020)                       | 0                       | 1                           | 1                                        | 1                                            | 1                                | 0                             | 1                                | 0     | Moderate |
| 27    | Zhipu et al., (2020)                        | 0                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 1                                | 0     | Moderate |
| 28    | Pan et al., (2020)                          | 0                       | 1                           | 0                                        | 1                                            | 2                                | 1                             | 1                                | 0     | Moderate |
| 29    | Ning et al., (2020)                         | 1                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 1                                | 0     | Moderate |
| 30    | Y. Liu et al., (2020)                       | 0                       | 1                           | 1                                        | 1                                            | 1                                | 0                             | 1                                | 0     | Moderate |
| 31    | Otgonbaatar et al., (2020)                 | 0                       | 1                           | 1                                        | 1                                            | 1                                | 0                             | 1                                | 0     | Moderate |
| 32    | Li et al., (2020)                           | 0                       | 1                           | 0                                        | 1                                            | 2                                | 1                             | 1                                | 0     | Moderate |
| 33    | Lu et al., (2020)                           | 1                       | 1                           | 1                                        | 1                                            | 2                                | 1                             | 1                                | 0     | Moderate |
| 34    | Hu et al., (2020)                           | 1                       | 1                           | 1                                        | 1                                            | 2                                | 1                             | 1                                | 0     | Low     |
| 35    | B. Wang et al., (2020)                      | 0                       | 1                           | 1                                        | 1                                            | 1                                | 1                             | 1                                | 0     | Moderate |

(continued on next page)
| Study | Representativeness of the sample (One Point) | Sample Size (One Point) | Non-Respondents (One Point) | Ascertainment of the exposure (One Point) | Study controls for other variable (Two Point) | Assessment of Outcome (One Point) | Statistical Test (One Point) | Adequate Follow up time (One Point) | Score |
|-------|----------------------------------------------|------------------------|-----------------------------|------------------------------------------|---------------------------------------------|---------------------------------|-------------------------------|----------------------------------|--------|
| 36    | W. Zhang et al., (2020)                      | 0                      | 1                           | 1                                        | 1                                           | 1                               | 1                            | 0                                | 6      | Moderate |
| 37    | Weilenmann et al., (2020)                    | 0                      | 1                           | 0                                        | 1                                           | 2                               | 1                            | 1                                | 0      | 6        | Moderate |
| 38    | Sahin et al., (2020)                         | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 39    | Rossi et al., (2020)                         | 1                      | 1                           | 1                                        | 1                                           | 2                               | 1                            | 1                                | 0      | 8        | Low     |
| 40    | Kaveh et al., (2020)                         | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 41    | Guixia and Hui, (2020)                       | 0                      | 1                           | 0                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 42    | Al Amer et al., (2020)                       | 0                      | 1                           | 1                                        | 1                                           | 1                               | 1                            | 1                                | 0      | 6        | Moderate |
| 43    | Shechter et al., (2020)                     | 1                      | 1                           | 1                                        | 1                                           | 2                               | 1                            | 1                                | 0      | 8        | Low     |
| 44    | Naser et al., (2020)                         | 1                      | 1                           | 0                                        | 1                                           | 1                               | 1                            | 1                                | 0      | 6        | Moderate |
| 45    | Que et al., (2020)                           | 0                      | 1                           | 1                                        | 1                                           | 1                               | 1                            | 1                                | 0      | 6        | Moderate |
| 46    | Jahrami et al., (2020)                       | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 47    | Koksal et al., (2020)                        | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 48    | Tu et al., (2020)                            | 1                      | 1                           | 1                                        | 1                                           | 1                               | 1                            | 1                                | 0      | 7        | Low     |
| 49    | Yang et al., (2020)                          | 1                      | 1                           | 0                                        | 1                                           | 1                               | 1                            | 1                                | 0      | 6        | Moderate |
| 50    | Chekole et al., (2020)                       | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 51    | Fang et al., (2020)                          | 0                      | 1                           | 1                                        | 1                                           | 1                               | 1                            | 1                                | 0      | 6        | Moderate |
| 52    | Jia et al., (2020)                           | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 53    | Zerbini et al., (2020)                       | 0                      | 1                           | 0                                        | 1                                           | 2                               | 1                            | 1                                | 0      | 6        | Moderate |
| 54    | Pouralizadeh et al., (2020)                  | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 1      | 6        | Moderate |
| 55    | Gallopeni et al., (2020)                     | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 56    | Li et al., (2020)                            | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 57    | Chorwe Sungani, (2020)                       | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 58    | Saricam, (2020)                              | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 59    | Arafa et al., (2020)                         | 0                      | 1                           | 1                                        | 1                                           | 1                               | 1                            | 1                                | 0      | 6        | Moderate |
| 60    | Silwal et al., (2020)                        | 1                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 1      | 5        | Moderate |
| 61    | Li et al., (2020)                            | 1                      | 1                           | 1                                        | 1                                           | 1                               | 1                            | 1                                | 0      | 7        | Low     |
| 62    | Hong et al., (2020)                          | 1                      | 1                           | 1                                        | 1                                           | 2                               | 1                            | 1                                | 0      | 8        | Low     |
| 63    | Hoedl et al., (2020)                         | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 1      | 6        | Moderate |
| 64    | Xiaozheng et al., (2020)                     | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 65    | Zhan et al., (2020)                          | 1                      | 1                           | 1                                        | 1                                           | 1                               | 1                            | 1                                | 0      | 7        | Low     |
| 66    | AliAteeq et al., (2020)                      | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 1      | 6        | Moderate |
| 67    | Khanal et al., (2020)                        | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 0      | 5        | Moderate |
| 68    | Bachilo et al., (2020)                       | 0                      | 1                           | 1                                        | 0                                           | 1                               | 1                            | 1                                | 0      | 5        | Moderate |
| 69    | Wangasooriya et al., (2020)                  | 1                      | 1                           | 1                                        | 0                                           | 0                               | 0                            | 1                                | 1      | 5        | Moderate |
| 70    | Leng et al., (2020)                          | 0                      | 1                           | 1                                        | 1                                           | 1                               | 0                            | 1                                | 1      | 6        | Moderate |
| 71    | Aksoy and Kocak, (2020)                      | 0                      | 1                           | 1                                        | 0                                           | 1                               | 1                            | 1                                | 0      | 5        | Moderate |
| 72    | Hendy et al., (2020)                         | 0                      | 1                           | 0                                        | 1                                           | 2                               | 1                            | 1                                | 0      | 6        | Moderate |
| 73    |                                              | 1                      | 1                           | 1                                        | 1                                           | 2                               | 1                            | 1                                | 0      | 8        | Low     |

(continued on next page)
by 73 studies \[18–26,28–30,32,34,35,37–39,42–46,48,49,51,53–57,62,64–67,71–106\] (Fig. 3: forest plots). All meta-analyses of prevalence estimates of anxiety yielded a summary prevalence of 37\% (23,535/61,561 participants, 95\% CI 32–41). The pooled prevalence did not change in sensitivity analysis by excluding one study each time by less than 2\%. There was significant heterogeneity between studies to estimate the prevalence (p < 0.000, I² = 99).

The prevalence of anxiety among nurses who worked on the frontline (n = 24) was high at 39\% (95\% CI = 32–46, I² = 98) compared to mixed studies (n = 42), which was 32\% (95\% CI = 27–38, I² = 99). In the subgroup analyses by month, according to when the study was conducted, the pooled prevalence of anxiety was 45\% (n = 7; 95\% CI = 33–58, I² = 99), 32\% (n = 29; 95\% CI = 25–40, I² = 99), 38\% (n = 9; 95\% CI = 26–52, I² = 98), 40\% (n = 18; 95\% CI = 34–46, I² = 95) and 39\% (n = 5; 95\% CI = 28–51, I² = 93) for January, February, March, April and May, respectively. Thirty-two studies used the Generalized Anxiety Disorder-7 (GAD-7) scale, which showed the highest anxiety prevalence at 30\% (95\% CI = 25–35, I² = 98), whereas studies (n = 16) using the Zung Self-Rating Anxiety Scale (SAS) reported anxiety prevalence at 30\% (95\% CI = 22–39, I² = 99). The prevalence of anxiety in the low risk of bias studies (n = 16) was 32\% (95\% CI = 24–41, I² = 99); in studies (n = 57) with a moderate risk of bias, the pooled prevalence was 38\% (95\% CI = 33–43, I² = 97).

### 3.5. Prevalence of depression

The overall pooled point estimates of depression reported by the 62 studies \[19,22–31,34,35,37,39,42,43,45,48,49,51,53–57,62,64–67,71–74,77–88,90,91,94–96,99–103,105–108\] varied between 9\% and 89\% (Fig. 4: forest plots). The pooled point prevalence of depression was 35\% (25,769/76,992 participants, 95\% CI 31–39). In sensitivity analysis, no study had an implication for the prevalence by more or less than 1\%. There was significant heterogeneity between studies to estimate the prevalence (p < 0.000, I² = 99). The pooled prevalence according to the month of data collected was as follows: January: 49\% (n = 7; 95\% CI 42–56; I² = 95), February: 29\% (n = 24; 95\% CI 24–35; I² = 99), March: 50\% (n = 8; 95\% CI 27–45; I² = 97), April: 31\% (n = 14; 95\% CI 25–39; I² = 95) and May: 35.1\% (n = 5; 95\% CI 27–45; I² = 89). Nineteen studies involving nurses who were working on the frontline showed the depression prevalence at 33\% (95\% CI = 24–43, I² = 99), whereas 36 studies including nurses working on the frontline and second line showed the depression prevalence was 33\% (95\% CI = 29–37, I² = 98).

Twenty-nine studies used the Patient Health Questionare-9 (PHQ-9) scale had a pooled prevalence of 32\% (95\% CI = 25–40, I² = 99), whereas thirteen studies used the Zung Self-Rating Depression Scale (SDS) had a pooled prevalence of 39\% (95\% CI = 32–46, I² = 99). The

| Study | Representativeness of the sample (One Point) | Sample Size (One Point) | Non-Respondents (One Point) | Ascertainment of the exposure (One Point) | Study controls for other variable (Two Point) | Assessment of Outcome (One Point) | Statistical Test (One Point) | Adequate Follow up time (One Point) | Score |
|-------|---------------------------------|-----------------|-----------------------------|---------------------------------|---------------------------------|---------------------------------|------------------------|-------------------------------|-------|
| Zhan et al., (2020b) | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 6 | Moderate |
| Skoda et al., (2020) | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 5 | Moderate |
| Nie et al., (2020) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | Low |
| Zhou et al., (2020) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | Low |
| Chen et al., (2020) | 0 | 1 | 0 | 1 | 2 | 1 | 1 | 1 | 0 | 6 | Moderate |
| Tselelis et al., (2020) | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 5 | Moderate |
| Prasad et al., (2020) | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 6 | Moderate |
| Lee et al., (2020) | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 5 | Moderate |
| Azrael et al., (2020) | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 5 | Moderate |
| Xiong et al., (2020) | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 5 | Moderate |
| Sampaio et al., (2020) | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 6 | Moderate |
| Baselli et al., (2020) | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 5 | Moderate |
| Salopek-Zha et al., (2020) | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 6 | Moderate |
| Wasim et al., (2020) | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 6 | Moderate |
| Ahn et al., (2020) | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 6 | Moderate |
| Zheng et al., (2020) | 1 | 1 | 1 | 2 | 1 | 0 | 8 | Low |
| Gorini et al., (2020) | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 6 | Moderate |
| An et al., (2020) | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 6 | Moderate |
| Zhang et al., (2020) | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 6 | Moderate |
| Ruiz-Fernández et al., (2020) | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 5 | Moderate |
| Han et al., (2020) | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 0 | 8 | Low |
| Study                          | Rate (95% CI) |
|-------------------------------|--------------|
| Salopek-Ziha et al., (2020)  | 10 (6-18)    |
| Cai et al., (2020)            | 13 (11-16)   |
| R. Zhang et al., (2020)       | 14 (10-20)   |
| Liu et al., (2020)            | 15 (14-17)   |
| Silwal et al., (2020)         | 16 (11-23)   |
| Wang et al., (2020)           | 17 (12-23)   |
| B. Wang et al., (2020)        | 19 (15-24)   |
| Rossi et al., (2020)          | 22 (19-26)   |
| Leng et al., (2020)           | 22 (15-32)   |
| Zhang et al., (2020)          | 24 (20-28)   |
| Sampaio et al., (2020)        | 27 (24-31)   |
| Huang et al., (2020)          | 29 (22-36)   |
| Wanigasooriya et al., (2020) | 29 (26-33)   |
| Cui et al., (2020)            | 30 (26-35)   |
| Choudhury et al., (2020)      | 30 (15-52)   |
| Mo et al., (2020)             | 33 (26-40)   |
| Z. Zhu et al., (2020)         | 33 (32-35)   |
| Li et al., (2020)             | 33 (32-35)   |
| Zhan et al., (2020)           | 44 (42-46)   |
| Yin et al., (2020)            | 45 (39-51)   |
| Garcia-Fernandez et al., (2020)| 45 (39-52) |
| Zerbini et al., (2020)        | 45 (35-57)   |
| Zhan et al., (2020)           | 49 (47-51)   |
| Al Amer et al., (2020)        | 50 (45-55)   |
| Tsleebis et al., (2020)       | 50 (42-58)   |
| Y. Liu et al., (2020)         | 52 (47-56)   |
| Arafa et al., (2020)          | 53 (44-63)   |
| Du et al., (2020)             | 55 (41-67)   |
| Gorini et al., (2020)         | 58 (52-65)   |
| Li et al., (2020)             | 62 (57-67)   |
| Shechter et al., (2020)       | 64 (58-69)   |
| Otgonbaatar et al., (2020)    | 65 (61-70)   |
| Hoedl et al., (2020)          | 67 (66-69)   |
| Chekole et al., (2020)        | 68 (58-76)   |
| Nie et al., (2020)            | 74 (68-79)   |
| Lai et al., (2020)            | 75 (71-77)   |
| Ruiz Fernandez et al., (2020) | 76 (71-80)   |
| Hendy et al., (2020)          | 78 (74-82)   |
| Jahrami et al., (2020)        | 80 (72-86)   |
| Prasad et al., (2020)         | 84 (79-88)   |
|                               | 43 (37-49)   |

Heterogeneity: $I^2 = 98\%$, $p<0.000$

Fig. 2. Forest Plot of the Prevalence of Stress ($N=40$).
Fig. 3. Forest Plot of the Prevalence of Anxiety (N = 73).
Fig. 4. Forest Plot of the Prevalence of Depression (N = 62).
other studies used different scales. In the subgroup analyses using the NOS, the pooled prevalence in studies (n = 16) with low risk of bias was 39% (95% CI = 32–47, I² = 99), whereas the moderate risk of bias studies (n = 46) accounted for 34% (95% CI = 29–39, I² = 97).

### 3.6. Prevalence of sleep disturbance

The prevalence rate of sleep disturbance in 18 studies [24,26,36,48,52,55,56,59,72,79,82,84,86,88,96,104,109,110] ranged from 12% to 87% (Fig. 5: Forest plots) with pooled prevalence estimates of 43% (4082/10,697 participants, 95% CI 36–50). In sensitivity analysis, no study had an implication for the pooled prevalence by more or less than 2%. There was significant heterogeneity between studies to estimate the prevalence (p < 0.000, I² = 97). The studies (n = 9) including frontline nurses reported the prevalence of sleep disturbance at 47% (95% CI = 34–60.1, I² = 98), whereas the studies (n = 8) including mixed nurses reported the prevalence at 37% (95% CI = 28–46, I² = 96).

Eight studies used the Insomnia Severity Index (ISI) scale with a pooled prevalence of 36% (95% CI = 30–43, I² = 95), whereas five studies used the Pittsburgh Sleep Quality Index (PSQI) with a pooled prevalence of 41% (95% CI = 22–64, I² = 98). The other studies used different scales. In the subgroup analyses using the NOS, the pooled prevalence in studies (n = 5) with low risk of bias was 38% (95% CI = 27–50, I² = 98), whereas the moderate risk of bias studies (n = 13) accounted for 45% (95% CI = 35–57, I² = 97).

### 3.7. Publication bias

Funnel plots indicated evidence of publication bias using visual inspection (Fig. 6). However, Egger’s regression test in stress (n = 40) (p = 0.42), anxiety (n = 73) (p = 0.29), depression (n = 38) (p = 0.35) and sleep disturbance (n = 18) (p = 0.38) did not show presence of publication bias.

### 4. Discussion

The psychological health of nurses during the COVID-19 pandemic is important, as this can impact their performance and reduce the quality of care provided. Sadly, there have been several reports of suicides among healthcare professionals due to psychological pressures and the possible fear of dying [111,112].

This meta-analysis is the first to estimate the aggregate prevalence of stress, anxiety, depression and sleep disturbance among nurses during the COVID-19 pandemic. The review included 93 cross-sectional studies of a total of 93,112 nurses showing high proportions of those symptoms. The aggregate prevalence of stress, anxiety, depression and sleep disturbance (43%, 37%, 35% and 43%, respectively) among nurses during the COVID-19 outbreak suggests that at least one third of nurses have experienced stress, anxiety, depression and sleep disturbance. These results are higher than those reported in the general population during the same period. Shi et al. [113] reported that in the general population, 24% of people had stress, 32% had anxiety, 28% had depression and 29% had insomnia. This was because the nurses were more exposed to patients with COVID-19.

The results of current review are even higher when compared with the reported prevalence during the MERS and SARS epidemics among nurses: 11% for stress [114], 20% for depression [115], 30% for anxiety [116] and 10% for sleep disturbance [117]. This may be because COVID-19 is rapidly spread, is human-to-human transmissible [1], and is potentially fatal. These factors are exacerbated by the shortage of personal protective equipment, increased working hours and new or unfamiliar clinical guidelines for the management of COVID-19 patients [118]. Altogether, these factors can increase nurses’ experience of stress,
anxiety, depression and sleep disturbance.

This meta-analysis found that the pooled prevalence varied between studies; for example, ranging between 10% [66] - 84% [52,64] for stress, 8% [94] - 91% [51] for anxiety, 9% [94] - 89% [51] for depression and 12% [48] - 87% [72] for sleep disturbance. This could be explained by the diversity of the assessment scale, healthcare system, population characteristics and lifestyles. Another possible reasons of differences in prevalence the variation in cut-offs scores of elevated symptoms for same instrument. For example; as shown in Table 1, the cut-off score of IES-R scale in Zhu et al. [54] was ˃33, whereas Lai et al. [55] used ≥26. The GAD-7 cut off score was ≥8 in Zhang et al. [56] and ≥ 10 by Zhpu et al. [24]. In depression, Lv et al. [26] used ≥5, while Li et al. [45] used ≥10 as cut off score of PHQ-9. The ISI cut off score was ≥15 in Que. et al. [82], whereas ’8 in Zhang et al. [88].

The studies’ quality was assessed using the NOS; all studies fell into the medium-quality and low-quality categories. The bias mainly involved the selection and size of samples, and follow-up time. Therefore, the amount of heterogeneity between the studies in terms of pooled prevalence and moderate analyses were low. Most importantly the Egger’s test showed an absence of a publication bias.

The major strength of this meta-analysis is the large sample size of over 93,112 articles drawn from 93 studies, which estimated the psychological impacts on nurses during the COVID-19 outbreak. However, there are several potential limitations to this this meta-analysis. First, this review searched medRxiv’s preprint studies, which are still not peer reviewed, which may introduce publication bias. Second, the majority of the studies (n = 69) were conducted in Asia, the generalization of the finding may be limited. Third, there is a possibility that some studies were not included in this meta-analysis, although this analysis used different MeSH terms and several databases. In addition, only studies published, unpublished or translated into English were included in this analysis. Fourth, stress, anxiety, depression and sleep disturbance were assessed using various scales and measures; this led to variability between studies and could increase the errors of prevalence estimates. Fifth, there were insufficient data available on the demographic and clinical characteristics, so not all information could be eliminated thoroughly. Finally, all findings were derived from cross-sectional design, which can reduce the ability to draw conclusions about changes in the psychological symptoms and associated factor [119]. It is important for further research to conduct a longitudinal study to identify the prevalence of symptoms during and after the infectious disease outbreaks.

Altogether, stress, anxiety, depression and sleep disturbance are significant problems for nurses worldwide during an infection disease outbreaks. The results of this meta-analysis have a number of potential implications for interventions to improve the psychological wellbeing of nurses during crises. For example, organizations should provide counselling support services or online workshops and training material to enable them to come over any psychological problems [120].

In addition, they should improve the working conditions of nurses by increasing manpower and resource allocation. Nurse managers play a crucial role through effective communication, rotating nurses, implementing flexible schedules and encouraging nurses to use psychosocial and psychological support service [121].

5. Conclusions

This is the first systematic review and meta-analysis reporting pooled prevalence estimates for stress, anxiety, depression and sleep disturbance among nurses during the COVID-19 outbreak. The findings show...
that over one third of nurses have experienced stress, anxiety, depression and sleep disturbance during the COVID-19 outbreak, which is higher than the previous MERS and SARS epidemics. Furthermore, these results highlight the need for appropriate interventions that can reduce psychological impacts on nurses.

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Contributions
A.M and A.J designed the protocol, literature search, data synthesis interpreted the results, and wrote the manuscript and contributed to the conceptualization and design and the manuscript preparation.

Declaration of Competing Interest
The authors certify that there is no actual or potential conflict of interest in relation to this article.

Appendix A. Supplementary data
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