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# Evaluating the Prevalence of Psychological Outcomes in Chinese Healthcare Workers During the COVID-19 Pandemic

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## Abstract

The aim of this systematic review and meta-analysis is to evaluate the prevalence of depression, anxiety, insomnia, stress, PTSD, and distress in Chinese healthcare workers (HCWs) and the changes in prevalence before and after the peak incidence of COVID-19 in China. 20 cross-sectional studies assessing the aforementioned psychological outcomes were included. Eligible studies were searched from the following databases: PubMed, Scopus, and Web of Science. Comparative analysis based on the time period of the included studies was conducted to assess changes in prevalence before and after peak incidence. Additionally, subgroup analyses based on study quality, province, survey tools, gender and healthcare profession, frontline or non-frontline working status, and severity of psychological outcomes were conducted to evaluate the prevalence of outcomes across various study methods, geographic regions, and professions. The findings of this study suggest that the overall prevalence of depression, anxiety, insomnia, stress, PTSD, and distress before peak incidence were 36.2%, 34.2%, 22.4%, 31.3%, 9.8%, and 56.7% as opposed to 31.8%, 24.1%, 34.4%, 59.0%, 20.9%, and 40.7% after the peak. The higher prevalence of depression, anxiety, and distress prior to the peak incidence of COVID-19 in China and of insomnia, stress, and PTSD thereafter serve as evidence that the mental health decline of HCWs is dynamic and should be addressed with adaptive approaches that provide tailored treatments.

## Keywords

COVID-19; Mental Health; Prevalence; Depression; Anxiety; Insomnia; Stress; PTSD; Distress

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## List of abbreviations

| | |
|---|---|
| BAI | Beck anxiety inventory |
| BDI | Beck depression inventory |
| CES-D | Center for Epidemiology Scale for Depression |
| COVID-19 | Coronavirus disease 2019 |
| DASS-21 | Depression, anxiety, and stress scales |
| DSM | Diagnostic and Statistical Manual of Mental Disorders |
| GAD | Generalized anxiety disorder scale |
| GPS | Global psychotrauma screen |
| HAD | Hospital anxiety depression scale |
| IES-R | Impact of event scale-revised |
| ISI | Insomnia severity index |
| K6 | Kessler psychological distress scale |
| MeSH | Medical Subject Headings |
| PC-PTSD | Primary care PTSD screen |
| PCL-C | PTSD Checklist-Civilian Version |
| PHQ | Patient health questionnaire |
| PSQI | Pittsburgh sleep quality index |
| PSS | Perceived stress scale |
| SARS-CoV-2 | Severe acute respiratory syndrome coronavirus 2 |
| SAS | Self-rating anxiety scale |
| SDS | Self-rating depression scale |
| ZSAS | Zung self-rating anxiety scale |
| ZSDS | Zung self-rating depression scale |

## 1. Introduction

In December 2019, cases of "pneumonia of an unknown etiology" were first reported in the city of Wuhan, Hubei province, China[21]. The International Committee on Taxonomy of Viruses (ICTV) later identified SARS-CoV-2 as the causative agent, deeming the cases as coronavirus-related pneumonia[22]. The World Health Organization declared coronavirus disease 2019 (COVID-19) as a pandemic on 11 March 2020[23]. As of 31 March 2021, COVID-19 has spread to 219 countries and territories, with 128,776,135cases and 2,814,038 deaths globally[24]. Undoubtedly, the pandemic has led to overwhelming demands on healthcare workers (HCWs), which has significantly impacted their mental health. Stressors including isolation, staff shortages, and fear of infection and transmission may be associated with the high prevalence of psychological outcomes among HCWs.

On 12 February 2020, the peak incidence of COVID-19 in China occurred with 14,108 cases[25]. This meta-analysis evaluates the prevalence of psychological outcomes in Chinese HCWs before and after the peak incidence of COVID-19 in China. Additionally, prevalence data based on study quality, province, assessment tools, gender, profession, frontline versus non-frontline responsibilities, and severity of outcome were also collected. Each of the 20 included studies are of cross-sectional design and used a variety of validated survey tools to measure the prevalence of outcomes. This study seeks to address the following questions: Is the prevalence of psychological outcomes in Chinese HCWs different before versus after the peak incidence of COVID-19 in China? Are there groups of HCWs that are particularly vulnerable to such outcomes?

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### 1.1 Populations of interest

Chinese physicians, nurses, and auxiliary HCWs who provided healthcare services in China during the COVID-19 pandemic comprised the populations of interest for this study. Healthcare professionals working in close proximity to COVID-19 patients or other exposed HCWs were considered frontline workers. Additional inclusion criteria were as follows: 1) Chinese-speaking residents of China and 2) age 18 to 80 years old.

### 1.2 Case definitions

In this study, the prevalence of depression, anxiety, insomnia, stress, PTSD, and distress were evaluated and defined according to their respective DSM criteria. Depression will be defined as a mood disorder that is present for at least two weeks, which may cause persistent feelings of sadness, hopelessness, or worthlessness, loss of interest, or self-harm ideations[26]. Anxiety will be defined as excessive fear, anticipation, or concern with a future idea or circumstance that hinders the ability to function normally[27]. Insomnia will be defined as dissatisfaction with sleep quantity or quality, associated with frequent awakenings, problems returning to sleep after awakenings, or difficulty initiating or maintaining sleep[28]. Stress and PTSD are both defined according to DSM criteria for Trauma- and Stressor-Related disorders as intense or prolonged psychological distress or physiological reactions in response to internal or external cues that resemble an aspect of a traumatic event and recurrent, involuntary, and intrusive distressing memories[29]. Lastly, distress is defined as a symptom for fears that hinders the ability to function normally[30].

### 1.3 Meaningful measure of disease frequency

In this study, prevalence is expressed as a percentage of participants who score above a specified threshold for a particular outcome. Designation into outcome groups is based on the type of validated tool used and its specific severity cutoff values. Studies that use the same measurement tool but have different cutoff values are detailed in Table 4.

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# 2. Methods

## 2.1 Databases and search strategy

Systematic search methods were performed using Web of Science, PubMed, and Scopus and with MeSH terms as appropriate. Prior to finalizing a search methodology, pilot examination of studies was carried out to identify key MeSH terms used in relevant literature. Search filters were not used when selecting studies to avoid the exclusion of potentially admissible studies. Terms utilized in literature searches are as follows:

**Table 1. Search terms and respective databases used for literature search.**

| |
|---|
| **Web of Science**<br>(psychologic* OR depression OR anxiety OR insomnia OR stress OR PTSD OR distress) AND (healthcare OR health) AND (physician OR doctor OR nurse OR worker OR allied) AND (COVID-19 OR pandemic) AND (frontline line OR exposed) AND (peak OR "peak incidence" OR epidemiolog* OR aetiolog OR prevalence OR cross-section*) AND ("People's Republic of China" OR China) |
| **PubMed**<br>((psychologic* OR depression [MeSH]) OR anxiety[MeSH]) OR insomnia[MeSH])OR stress[MeSH]) OR PTSD[MeSH]) OR distress[MeSH]) AND (healthcare OR health) AND (physician OR doctor OR nurse OR worker OR allied) AND (COVID-19 OR pandemic) AND (frontline line OR exposed) AND (peak OR "peak incidence" OR epidemiolog* OR aetiolog OR prevalence OR cross-section*) AND ("People's Republic of China" [MeSH]) OR China)) |
| **Scopus**<br>(psychologic* OR depression OR anxiety OR insomnia OR stress OR PTSD OR distress) AND (healthcare OR health) AND (physician OR doctor OR nurse OR worker OR allied) AND (COVID-19 OR pandemic) AND (frontline line OR exposed) AND (peak OR "peak incidence" OR epidemiolog* OR aetiolog OR prevalence OR cross-section*) AND ("People's Republic of China" OR China) |

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## 2.2 Selection of studies

773 studies were initially gathered using the aforementioned search terms in their designated databases. The studies were imported to Mendeley and duplicate literature was discarded, leaving 589 records for assessment. The remaining records were screened by title-abstract review according to the inclusion and exclusion outlined in Table 2. 42 titles and abstracts were chosen for full-text evaluation. Following full-text evaluation and further consideration of inclusion-exclusion criteria, 20 studies were deemed eligible for this study. Figure 1 illustrates the methodology used for the identification, screening, and eligibility-determination of included literature.

**Table 2. Inclusion and exclusion criteria used to screen preliminary publications collected from literature search.**

| Inclusion Criteria |
| --- |
| Study is relevant to COVID-19 and its psychological impact on healthcare workers |
| Study's cohort population includes healthcare workers |
| Study population consists of Chinese-speaking residents of China |
| Study used validated survey tools to measure psychological outcomes |
| Study provides prevalence data for psychological outcomes |
| Study uses a cross-sectional design and original data |
| Duration of study is specified |
| Study provides cutoff scores for validated survey tools |
| Study was non-interventional |
| Study is in English or a translated English version is available |
| Study was conducted after December 1, 2019 |
| Study population consists of more than 100 healthcare workers |

| Exclusion Criteria |
| --- |
| Study is irrelevant to COVID-19 and its psychological impact on healthcare workers |
| Study's cohort population excludes healthcare workers |
| Study population does not consist of Chinese-speaking residents of China |
| Study did not use validated survey tools to measure psychological outcomes |
| Study does not provide prevalence data for psychological outcomes |
| Study does not use a cross-sectional design |
| Duration of study was not specified |
| Study does not provide cutoff scores for validated survey tools |
| Study was interventional |
| Study is not in English or a translated English version is unavailable |
| Study was conducted before December 1, 2019 |
| Publication is a case report, editorial, review, abstract-only record, or biochemical study |
| Study population consists of less than 100 healthcare workers |

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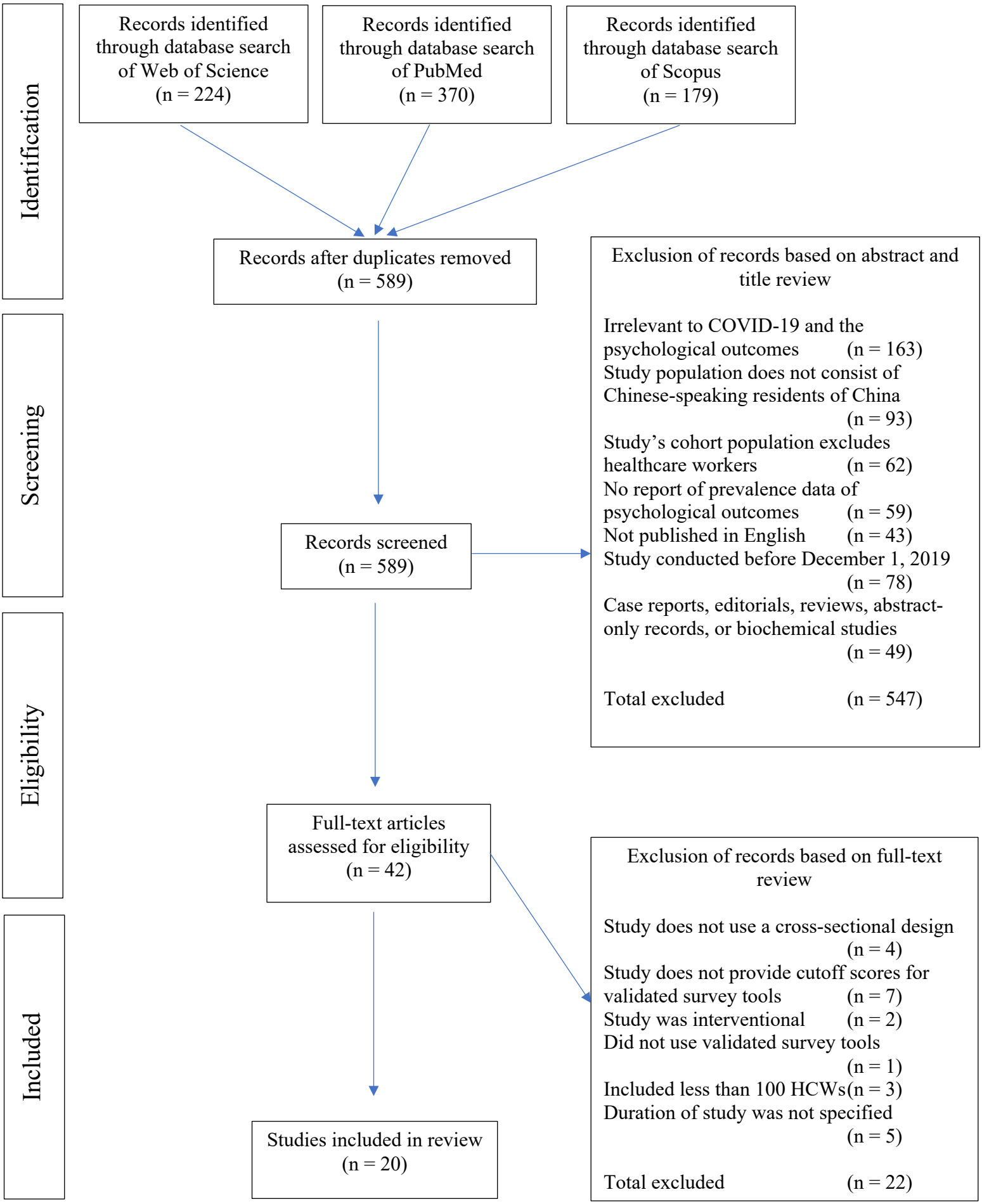
**Figure 1. Screening method used for selection of studies.**



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# 3. Results

## 3.1 Study quality

Quality assessment of the included studies was performed using the National Institutes of Health (NIH) quality assessment tool. The guidelines of the tool were used to provide a number score out of 14 and an overall rating for each study. The guidelines used for scoring consist of 14 "yes" or "no" questions regarding the clarity, validity, design, methods, and sample populations of the included studies. Of the 20 included studies, 13 were designated as "Good", seven as "Medium", and none as "Poor" quality. "Yes" and "no" determinations were made to the best of the reviewer's ability with consideration of all aspects of every study in order to decrease the likelihood of subjective errors. Assessments for each study are detailed in Table 3.

**Table 3. Quality assessment of included studies using the National Institutes of Health (NIH) tool.**

| Author | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Final Quality Score | Rating |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chen, J. 2020 (1) | Y | Y | Y | Y | N | N | Y | Y | Y | N | Y | NA | NA | N | 8 | Good |
| Hu 2020 (2) | Y | Y | Y | Y | Y | N | Y | N | Y | N | Y | NA | NA | Y | 9 | Good |
| Huang 2020 (3) | Y | Y | N | N | N | Y | N | Y | Y | N | Y | NA | NA | N | 6 | Medium |
| Juan 2020 (4) | Y | Y | Y | N | N | Y | N | Y | N | N | Y | NA | NA | N | 6 | Medium |
| Kang 2020 (5) | Y | Y | Y | N | Y | N | Y | Y | Y | N | Y | NA | NA | Y | 9 | Good |
| Lai 2020 (6) | Y | Y | N | N | N | Y | Y | N | Y | N | Y | NA | NA | N | 6 | Medium |
| Li 2020 (7) | Y | Y | N | N | N | Y | Y | N | Y | N | Y | NA | NA | N | 6 | Medium |
| Ning 2020 (8) | Y | Y | N | N | N | N | Y | N | Y | N | Y | NA | NA | N | 5 | Medium |
| Wang 2020 (9) | Y | Y | N | Y | Y | N | Y | Y | Y | N | Y | NA | NA | Y | 9 | Good |
| Xiao 2020 (10) | Y | Y | Y | Y | N | N | Y | N | Y | N | Y | NA | NA | N | 7 | Good |
| Zhao 2020 (11) | Y | Y | N | N | N | Y | Y | N | Y | N | Y | NA | NA | N | 6 | Medium |
| Zhu 2020 (12) | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | NA | NA | N | 10 | Good |
| Cai 2020 (13) | Y | Y | Y | Y | Y | N | Y | Y | Y | N | Y | NA | NA | N | 10 | Good |
| Chen, Y. 2020 (14) | Y | Y | Y | Y | Y | Y | Y | N | Y | N | Y | NA | NA | N | 9 | Good |
| Du 2020 (15) | Y | Y | N | Y | N | Y | Y | Y | Y | N | Y | NA | NA | N | 8 | Good |

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| Author | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Final Quality Score | Rating |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Guo 2020 (16) | Y | Y | N | Y | N | Y | Y | N | Y | N | Y | NA | NA | Y | 8 | Good |
| Pan 2020 (17) | Y | Y | Y | Y | Y | N | Y | Y | Y | N | Y | NA | NA | Y | 10 | Good |
| Que 2020 (18) | Y | Y | N | N | N | Y | Y | N | Y | N | Y | NA | NA | N | 6 | Medium |
| Xiaoming 2020 (19) | Y | Y | Y | Y | Y | Y | Y | N | Y | N | Y | NA | NA | N | 9 | Good |
| Zhang 2020 (20) | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | NA | NA | N | 10 | Good |

Y: Yes, N: No, NA: Not applicable. (Q1. Was the research question or objective in this paper clearly stated? Q2. Was the study population clearly specified and defined? Q3. Was the participation rate of eligible persons at least 50%? Q4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants? Q5. Was a sample size justification, power description, or variance and effect estimates provided? Q6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? Q7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? Q8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)? Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? Q10. Was the exposure(s) assessed more than once over time? Q11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? Q12. Were the outcome assessors blinded to the exposure status of participants? Q13. Was loss to follow-up (response rate) after baseline 20% or less? Q14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)? Rating—(Good, Medium or Poor), Good = 7–14 yes; Medium = 4–6 yes; Poor = 0-3.

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### 3.2 Study characteristics

All 20 studies used a cross-sectional design to quantify the outcome(s) of their respective sample populations. Each study used a sample size greater than 100 HCWs, 16 of which provide the percentages of enrolled physicians and nurses. The 12 studies that were initiated prior to 12 February 2020 (day of peak COVID-19 incidence) were designated as “pre-peak” studies, while the eight that commenced thereafter were deemed “post-peak” studies. 18 studies reported gender breakdowns of participants, all of which had over 60% female participation. Five different survey tools (PHQ-9, ZSDS, CES-D, HAD, and BDI-II) were used across all 20 studies to determine the prevalence of depression. Four different tools (GAD-7, ZSAS, HAD, and BAI) were used across 19 studies to ascertain the prevalence of anxiety. Four different tools (PSQI, ISI, IES-R, and PSS) were incorporated across 10 studies to demonstrate the prevalence of insomnia, stress, PTSD, and distress. Cutoff values were specific to each study and may differ for identical survey tools used by different research groups measuring the same outcome. The prevalence of outcomes reported by each study and all of the aforementioned details are outlined in Table 4.

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**Table 4. Characteristics of included studies.**

| Author/Year | Healthcare Worker Sample Size of Cross-sectional Study | Duration (pre- or post-peak specified) | Healthcare Workers | | Female (%) | Survey Tool | Cut-off | Outcomes (%) (n) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Physicians (%) | Nurses (%) | | | | Depression | Anxiety | Insomnia | Stress | PTSD | Distress |
| **Chen, J. 2020 (1)** | 902 | Feb. 9 to Feb. 11, 2020 (pre-peak) | 60.2 | 34.5 | 68.6 | PHQ-9 | ≥ 10 | 18.3 (165) | 16.6 (150) | NA | NA | NA | NA |
| | | | | | | GAD-7 | ≥ 10 | | | | | | |
| **Hu 2020 (2)** | 2,101 | Jan. 13 to Feb. 13, 2020 (pre-peak) | NA | 100.0 | 87.6 | ZSDS | ≥ 60 | 42.0 (878) | 40.0 (833) | NA | NA | NA | 41.5 (872) |
| | | | | | | ZSAS | ≥ 50 | | | | | | |
| **Huang 2020 (3)** | 7,236 | Feb. 3 to Feb. 17, 2020 (pre-peak) | NA | NA | NA | CES-D | > 28 | 20.1 (1,454) | 35.1 (2,540) | 18.2 (1,317) | NA | NA | NA |
| | | | | | | GAD-7 | ≥ 9 | | | | | | |
| | | | | | | PSQI | > 7 | | | | | | |
| **Juan 2020 (4)** | 456 | Feb. 1 to Feb. 14, 2020 (pre-peak) | 42.8 | 57.2 | 70.6 | PHQ-9 | ≥ 10 | 29.6 (135) | 31.6 (144) | NA | 43.2 (197) | NA | NA |
| | | | | | | GAD-7 | ≥ 10 | | | | | | |
| | | | | | | IES-R | ≥ 24 | | | | | | |
| **Kang 2020 (5)** | 994 | Jan. 29 to Feb. 4, 2020 (pre-peak) | 18.4 | 81.6 | 85.5 | PHQ-9 | ≥ 5 | 63.0 (627) | NA | NA | NA | NA | NA |
| | | | | | | ISI | ≥ 8 | | | | | | |
| | | | | | | IES-R | ≥ 9 | | | | | | |

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| Author/Year | Healthcare Worker Sample Size of Cross-sectional Study | Duration (pre- or post-peak specified) | Healthcare Workers | | Female (%) | Survey Tool | Cut-off | Outcomes (%) (n) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Physicians (%) | Nurses (%) | | | | Depression | Anxiety | Insomnia | Stress | PTSD | Distress |
| **Lai 2020 (6)** | 1,257 | Jan. 29 to Feb. 3, 2020 (pre-peak) | 39.2 | 60.8 | 76.7 | PHQ-9<br>GAD-7<br>ISI<br>IES-R | ≥ 5<br>≥ 5<br>≥ 15<br>≥ 9 | 50.4 (634) | 44.6 (560) | 34 (427) | NA | NA | 71.5 (899) |
| **Li 2020 (7)** | 908 | Feb. 3 to Feb. 24 (pre-peak) | 40.6 | 43.4 | 75.6 | ZSDS<br>ZSAS | ≥ 60<br>≥ 50 | 32.9 (299) | 24.3 (221) | NA | NA | NA | NA |
| **Ning 2020 (8)** | 612 | Early Feb., 2020 (pre-peak) | 51.8 | 48.2 | 72.9 | ZSDS<br>ZSAS | ≥ 53<br>≥ 50 | 25.0 (153) | 16.3 (100) | NA | NA | NA | NA |
| **Wang 2020 (9)** | 1,897 | Jan. 29 to Feb. 7, 2020 (pre-peak) | 29.7 | 70.3 | 82.5 | PHQ-9<br>GAD-7<br>IES-R | ≥ 10<br>≥ 10<br>≥ 9 | 15.0 (285) | 27.1 (515) | NA | NA | 9.8 (185) | NA |
| **Xiao 2020 (10)** | 958 | Jan. 28, 2020 (pre-peak) | 39.5 | 37.5 | 67.2 | HAD<br>PSS-14 | ≥ 8<br>≥ 8 | 58.0 (556) | 54.2 (519) | NA | NR | NA | NA |

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| Author/Year | Healthcare Worker Sample Size of Cross-sectional Study | Duration (pre- or post-peak specified) | Healthcare Workers | | Female (%) | Survey Tool | Cut-off | Outcomes (%) (n) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Physicians (%) | Nurses (%) | | | | Depression | Anxiety | Insomnia | Stress | PTSD | Distress |
| **Zhao 2020 (11)** | 2,250 | Feb. 3 to Feb. 17, 2020 (pre-peak) | NA | NA | NA | CES-D<br>GAD-7<br>PSQI | > 28<br>≥ 9<br>> 7 | 19.8 (446) | 35.6 (802) | 23.6 (531) | NA | NA | NA |
| **Zhu 2020 (12)** | 5,062 | Feb. 8 to Feb. 10, 2020 (pre-peak) | 19.8 | 67.5 | 85.0 | PHQ-9<br>GAD-7<br>IES-R | ≥ 10<br>≥ 8<br>≥ 33 | 13.5 (683) | 24.1 (1,220) | NA | 29.8 (1,508) | NA | NA |
| **Cai 2020 (13)** | 2,346 | Feb. 11 to Feb. 26, 2020 (post-peak) | NA | NA | 70.1 | PHQ-9<br>BAI<br>ISI | ≥ 10<br>≥ 15<br>≥ 9 | 12.2 (287) | 11.6 (271) | 38.4 (902) | NA | NA | NA |
| **Chen, Y. 2020 (14)** | 105 | March 29, 2020 (post-peak) | NA | NA | 90.5 | ZSDS<br>ZSAS | ≥ 50<br>≥ 50 | 29.5 (31) | 18.1 (19) | NA | NA | NA | NA |
| **Du 2020 (15)** | 134 | Feb. 13 to Feb. 17, 2020 (post-peak) | 35.1 | 41.0 | 60.4 | BDI-II<br>BAI<br>PSS | ≥ 14<br>≥ 8<br>≥ 14 | 12.7 (17) | 20.1 (28) | NA | 59.0 (79) | NA | NA |

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| Author/Year | Healthcare Worker Sample Size of Cross-sectional Study | Duration (pre- or post-peak specified) | Healthcare Workers | | Female (%) | Survey Tool | Cut-off | Outcomes (%) (n) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Physicians (%) | Nurses (%) | | | | Depression | Anxiety | Insomnia | Stress | PTSD | Distress |
| **Guo 2020 (16)** | 11,118 | Feb. 18 to Feb. 20, 2020 (post-peak) | 30.3 | 53.1 | 74.8 | ZSDS<br>ZSAS | ≥ 50<br>≥ 50 | 31.5 (3,497) | 17.5 (1,940) | NA | NA | NA | 40.7 (4,530) |
| **Pan 2020 (17)** | 194 | Feb., 2020 (post-peak) | 21.6 | 76.3 | 81.4 | PHQ-9<br>GAD-7 | ≥ 10<br>≥ 10 | 37.6 (73) | 32.5 (63) | NA | NA | NA | NA |
| **Que 2020 (18)** | 2,285 | Feb., 2020 (post-peak) | 77.6 | 9.10 | 69.1 | PHQ-9<br>GAD-7<br>ISI | ≥ 10<br>≥ 10<br>≥ 8 | 44.4 (1,015) | 46.0 (1,051) | 28.8 (658) | NA | NA | NA |
| **Xiaoming 2020 (19)** | 8,817 | Feb. 14 to Feb 23, 2020 (post-peak) | 36.4 | 53.1 | 78.0 | PHQ-9<br>PHQ-15<br>GAD-7 | ≥ 10<br>≥ 10<br>≥ 10 | 30.2 (2,663) | 20.7 (1,825) | NA | NA | NA | NA |
| **Zhang 2020 (20)** | 642 | June 6-13, 2020 (post-peak) | 27.1 | 72.9 | 85.1 | HAD<br>ISI<br>PCL-C | ≥ 8<br>≥ 8<br>≥ 50 | 17.1 (110) | 18.5 (119) | NA | NA | 20.9 (134) | NA |

NA: not available, DASS-21: Depression, anxiety, stress scales, ISI: Insomnia severity index, PHQ: Patient health questionnaire, BAI: Beck anxiety inventory, IES-R: Impact of event scale-revised, GAD: Generalized anxiety disorder scale, HAD: Hospital anxiety depression scale, BDI: Beck depression inventory, PSS: Perceived stress scale, GPS: Global psychotrauma screen, PC-PTSD: Primary care PTSD screen, K6: Kessler psychological distress scale, ZSDS: Zung self-rating depression scale, ZSAS: Zung self-rating anxiety scale, CES-D: The Center for Epidemiology Scale for Depression, PSQI: Pittsburgh sleep quality index, PCL-C: PTSD Checklist-Civilian Version.

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## 3.3 Meta-Analysis

### 3.3.1 Depression prevalence

The pooled prevalence of depression in a sample size of 50,274 HCWs was 33.7% (95% CI: 26.6-40.8, $I^2 = 43.3\%$, $p < 0.05$). Data provided by all 20 included studies[1-20] allowed for the calculation of pooled and subgroup prevalence values, which are detailed in Table __. The prevalence of depression among good quality studies[1,2,5,9,10,12-17,19,20] was 32.9%, which was lower than that of medium quality studies[3,4,6-8,11,18] at 35.9%. The pooled prevalence of depression prior to the peak incidence of COVID-19 in China was 36.2%[1-12] as opposed to 31.8%[13-20] after the peak. Five of the 20 studies were conducted in the Hubei province[2,12,15,17,20] and had a pooled prevalence of 28.9% compared to 34.3% in the 15 remaining studies conducted in other provinces[1,3-11,13,14,16,18,19]. The pooled prevalence for the 10 studies that used the Patient Health Questionnaire was 36.9%[1,4-6,9,12,13,17-19] compared to 32.3% for the other 10 studies[2,3,7,8,10,11,14-16,20], which used a different tool. Eight studies[1,3,6-8,13,15,18] provided gender data, with a pooled prevalence of 44.5% in females and 41.2% in males. Six studies[1,6,10,12,16,18] provided prevalence data for physicians and nurses, for which the pooled prevalence was higher in nurses (41.4%) compares to physicians (38.7%). Prevalence data on frontline versus non-frontline occupations was provided by six studies[1,2,8,11,13,16] with pooled prevalence values of 25.3% and 20.1% for frontline and non-frontline HCWs, respectively. The severity of depression was detailed in 16 studies[1-9,12,14,15,17-20] with the highest pooled prevalence relating to mild (59.6%), followed by moderate (28.6%), then severe (12.3%) depressive symptoms.

### 3.3.2 Anxiety prevalence

The pooled prevalence of anxiety in a sample size of 49,280 HCWs was 27.2% (95% CI: 22.0-32.4 $I^2 = 28.9\%$, $p < 0.05$). Data provided by 19 studies[1-4,6-20] allowed for the calculation of pooled and subgroup prevalence values, which are detailed in Table __. The prevalence of anxiety amongst good quality studies[1,2,9,10,12-17,19,20] was 24.9%, which was lower than that of medium quality studies[3,4,6-8,11,18] at 38.5%. The pooled prevalence of anxiety prior to the peak incidence of COVID-19 in China was 34.2%[1-4,6-12] as opposed to 24.1%[13-20] after the peak. Five studies were conducted in the Hubei province[2,12,15,17,20] and had a pooled prevalence of 29.8% compared to 27.8% in the remaining 14 studies[1,3,4,6-11,13,14,16,18,19] conducted in other provinces. The pooled prevalence for the nine studies[1,4,6,9,11,12,17-19] that used the Generalized Anxiety Disorder scale was 30.3% compared to 28.2% for the other 10 studies[2,3,7,8,10,13-16,20], which used a different tool. Eight studies[1,3,6-8,13,15,18] provided gender data, with a pooled prevalence of 43.7% in females and 40.9% in males. Six studies[1,6,10,12,16,18] provided prevalence data for physicians and nurses, for which the pooled prevalence was higher in nurses (36.7%) compares to physicians (31.8%). Prevalence based on frontline versus non-frontline occupations was provided by six studies[1,2,8,11,13,16] with pooled prevalence values of 37.0% and 27.3% for frontline and non-frontline HCWs, respectively. The severity of anxiety was detailed in 15 studies[1-4,6-9,12,14,15,17-20] with the highest pooled prevalence relating to mild (56.3%), followed by moderate (29.2%), then severe (13.5%) anxiety symptoms.

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### 3.3.3 Insomnia prevalence

The pooled prevalence of insomnia in a sample size of 15,374 was 24.9% (95% CI: 18.6-31.2, $I^2 = 59.2\%$, $p < 0.05$). Data provided by five studies[3,6,11,13,18] allowed for the calculation of pooled and subgroup prevalence values, which are detailed in Table __. The prevalence of insomnia in the good quality study[13] was 38.4%, which was greater than that in the medium quality studies[3,6,11,18] at 23.9%. Insomnia prevalence prior to the peak incidence of COVID-19 was 22.4%[3,6,11] as opposed to 34.4%[13,18] after the peak. All five studies[3,6,11,13,18] were conducted in provinces other than Hubei, the pooled insomnia prevalence for them was 24.9%. For the three studies[6,13,18] that used the Insomnia Severity Index (ISI), the prevalence was 34.4% compared to 22.3% for the other two studies,[3,11] which used a different survey tool.

### 3.3.4 Stress prevalence

The pooled prevalence of stress in a sample size of 5,652 was 32.6% (95% CI: 19.1-46.1, $I^2 = 74.4\%$, $p < 0.05$). Data provided by three studies[4,12,15] allowed for the calculation of pooled and subgroup prevalence values, which are detailed in Table __. The prevalence of stress among good quality studies[12,15] was 31.3%, which was less than that of the medium quality study[4] at 43.2%. Stress prevalence prior to the peak incidence of COVID-19 was 31.3%[4,12] as opposed to 59.0%[15] after the peak. Two of the studies[12,15] were conducted in provinces other than Hubei, with the pooled stress prevalence being 31.3% compared to 43.2% in the study[4] conducted in Hubei. For the two studies[4,12] that used the Impact of Even Scale-Revised (IES-R), the prevalence was 31.3% compared to 59.0% for the other study,[15] which used a different survey tool.

### 3.3.5 PTSD prevalence

The pooled prevalence of PTSD in a sample size of 2,539 was 14.5% (95% CI: 6.8-22.2, $I^2 = 77.8\%$, $p < 0.05$). Data provided by two studies[9,20] allowed for the calculation of pooled and subgroup prevalence values, which are detailed in Table __. The prevalence of PTSD amongst good quality studies[9,20] was 14.5%. PTSD data for medium quality studies was unavailable. PTSD prevalence prior to the peak incidence of COVID-19 was 9.8%[9] as opposed to 20.9%[20] after the peak. One study[20] was conducted in a province other than Hubei, the PTSD prevalence for which was 20.9% compared to 9.8% for the study[9] conducted in Hubei. For the study[9] that used the IES-R, the prevalence was 9.8% compared to 20.9% for the other study[15], which used a different survey tool.

### 3.3.6 Distress Prevalence

The pooled prevalence of distress in a sample size of 14,476 was 45.2% (95% CI: 29.0-61.4, $I^2 = 49.2\%$, $p < 0.05$). Data provided by three studies[2,6,16] allowed for the calculation of pooled and subgroup prevalence values, which are detailed in Table __. The prevalence of distress among good quality studies[2,16] was 35.0%, which was less than that of the medium quality study[6] at 71.5%. Distress prevalence prior to the peak incidence of COVID-19 was 56.7%[2,6] as opposed to 40.7%[16] after the peak. Two of the studies[12,15] were conducted in provinces other than Hubei, the pooled distress prevalence for which was 45.8% compared to 41.5% in the study[4] conducted in Hubei. For the study[6] that used the IES-R, the distress prevalence was 71.5% compared to 35.0% for the other two studies[2,16], which used a different survey tool.

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**Table 5. Subgroup analyses of depression prevalence.**

| Overall | Number of Studies | Proportion (%) | 95% CI | $I^2$ (%) | p value | References |
|---|---|---|---|---|---|---|
| **Depression prevalence** | 20 | 33.7 | 23.0-37.2 | 43.3 | <0.05 | [1-20] |

| Categories | Subgroups | Number of Studies | Proportion (%) | 95% CI | References |
|---|---|---|---|---|---|
| **Quality** | Good | 13 | 32.9 | 18.9-39.6 | [1,2,5,9,10,12-17,19,20] |
| | Medium | 7 | 35.9 | 20.7-42.7 | [3,4,6-8,11,18] |
| **Time period** | Pre-peak COVID-19 incidence | 12 | 36.2 | 21.4-43.2 | [1-12] |
| | Post-peak COVID-19 incidence | 8 | 31.8 | 17.0-36.8 | [13-20] |
| **Province** | Hubei | 5 | 28.9 | 7.1-42.1 | [2,12,15,17,20] |
| | Other | 15 | 34.3 | 23.4-40.6 | [1,3-11,13,14,16,18,19] |
| **Assessment** | PHQ-9 | 10 | 36.9 | 17.4-45.7 | [1,4-6,9,12,13,17-19] |
| | Other | 10 | 32.3 | 20.4-37.5 | [2,3,7,8,10,11,14-16,20] |
| **Gender** | Female | 8 | 44.5 | 35.1-51.9 | [1,3,6-8,13,15,18] |
| | Male | 8 | 41.2 | 30.6-50.3 | [1,3,6-8,13,15,18] |
| **Healthcare Professions** | Physicians | 6 | 38.7 | 26.4-51.8 | [1,6,10,12,16,18] |
| | Nurses | 6 | 41.4 | 29.6-54.3 | [1,6,10,12,16,18] |
| **Healthcare Workers** | Frontline | 6 | 25.3 | 16.9-35.2 | [1,2,8,11,13,16] |
| | Non-frontline | 6 | 20.1 | 13.7-33.5 | [1,2,8,11,13,16] |
| **Level of Depression** | Mild | 16 | 59.6 | 52.3-66.4 | [1-9,12,14,15,17-20] |
| | Moderate | 16 | 28.6 | 23.1-35.9 | [1-9,12,14,15,17-20] |
| | Severe | 16 | 12.3 | 8.7-16.3 | [1-9,12,14,15,17-20] |

Good quality score = 7+, Medium Quality score = 4–6, PHQ = Patient Health Questionnaire, CI = Confidence Interval, $I^2$ indicates heterogeneity.

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**Table 6. Subgroup analyses of anxiety prevalence.**

| Overall | Number of Studies | Proportion (%) | 95% CI | $I^2$ (%) | p value | References |
|---|---|---|---|---|---|---|
| **Anxiety prevalence** | 19 | 27.2 | 22.0-32.4 | 28.9 | <0.05 | [1-4,6-20] |

| Categories | Subgroups | Number of Studies | Proportion (%) | 95% CI | References |
|---|---|---|---|---|---|
| **Quality** | Good | 12 | 24.9 | 18.4-31.4 | [1,2,9,10,12-17,19,20] |
| | Medium | 7 | 38.5 | 23.6-43.2 | [3,4,6-8,11,19] |
| **Time period** | Pre-peak COVID-19 incidence | 11 | 34.2 | 23.9-39.7 | [1-4,6-12] |
| | Post-peak COVID-19 incidence | 8 | 24.1 | 13.9-32.3 | [13-20] |
| **Province** | Hubei | 5 | 29.8 | 15.8-38.3 | [2,12,15,17,20] |
| | Other | 14 | 27.8 | 21.0-36.1 | [1,3,4,6-11,13,14,16,18,19] |
| **Assessment** | GAD | 9 | 30.3 | 23.2-38.7 | [1,4,6,9,11,12,17-19] |
| | Other | 10 | 28.2 | 16.0-35.2 | [2,3,7,8,10,13-16,20] |
| **Gender** | Female | 8 | 43.7 | 35.9-52.4 | [1,3,6-8,13,15,18] |
| | Male | 8 | 40.9 | 32.1-48.6 | [1,3,6-8,13,15,18] |
| **Healthcare Professions** | Physicians | 6 | 31.8 | 22.6-40.5 | [1,6,10,12,16,18] |
| | Nurses | 6 | 36.7 | 26.9-44.3 | [1,6,10,12,16,18] |
| **Healthcare Workers** | Frontline | 6 | 37.0 | 25.4-45.6 | [1,2,8,11,13,16] |
| | Non-frontline | 6 | 27.3 | 20.2-36.3 | [1,2,8,11,13,16] |
| **Level of Anxiety** | Mild | 15 | 56.3 | 43.2-67.3 | [1-4,6-9,12,14,15,17-20] |
| | Moderate | 15 | 29.2 | 18.9-35.8 | [1-4,6-9,12,14,15,17-20] |
| | Severe | 15 | 13.5 | 7.6-19.7 | [1-4,6-9,12,14,15,17-20] |

Good quality score = 7+, Medium Quality score = 4–6, GAD = Generalized Anxiety Disorder, CI = Confidence Interval, $I^2$ indicates heterogeneity.

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**Table 7. Subgroup analyses of insomnia prevalence.**

| Overall | Number of Studies | Proportion (%) | 95% CI | $I^2$ (%) | p value | References |
|---|---|---|---|---|---|---|
| **Insomnia prevalence** | 5 | 24.9 | 22.3-34.9 | 59.2 | <0.05 | [3,6,11,13,18] |

| Categories | Subgroups | Number of Studies | Proportion (%) | 95% CI | References |
|---|---|---|---|---|---|
| **Quality** | Good | 1 | 38.4 | NR | [13] |
| | Medium | 4 | 23.9 | 20.4-31.9 | [3,6,11,18] |
| **Time period** | Pre-peak COVID-19 incidence | 3 | 22.4 | 17.8-32.7 | [3,6,11] |
| | Post-peak COVID-19 incidence | 2 | 34.4 | 26.9-40.3 | [13,18] |
| **Province** | Hubei | 0 | NA | NA | NA |
| | Other | 5 | 24.9 | 22.3-34.9 | [3,6,11,13,18] |
| **Assessment** | ISI | 3 | 34.4 | 29.3-38.2 | [6,13,18] |
| | Other | 2 | 22.3 | 17.2-24.6 | [3,11] |

NR = Not reported, Good quality score = 7+, Medium Quality score = 4–6, ISI = Insomnia severity index, CI = Confidence Interval, $I^2$ indicates heterogeneity.

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**Table 8. Subgroup analyses of stress prevalence.**

| Overall | Number of Studies | Proportion (%) | 95% CI | $I^2$ (%) | p value | References |
|---|---|---|---|---|---|---|
| **Stress prevalence** | 3 | 32.6 | 19.1-46.1 | 74.4 | <0.05 | [4,12,15] |

| Categories | Subgroups | Number of Studies | Proportion (%) | 95% CI | References |
|---|---|---|---|---|---|
| **Quality** | Good | 2 | 31.3 | 11.1-51.5 | [12,15] |
| | Medium | 1 | 43.2 | NR | [4] |
| **Time period** | Pre-peak COVID-19 incidence | 2 | 31.3 | 22.0-40.6 | [4,12] |
| | Post-peak COVID-19 incidence | 1 | 59.0 | NR | [15] |
| **Province** | Hubei | 2 | 31.3 | 11.1-51.5 | [12,15] |
| | Other | 1 | 43.2 | NR | [4] |
| **Assessment** | IES-R | 2 | 31.3 | 22.0-40.6 | [4,12] |
| | PSS | 1 | 59.0 | NR | [15] |

NR = not reported, Good quality score = 7+, Medium Quality score = 4–6, IES-R = Impact of event scale-revised, PSS = Perceived stress scale, CI = Confidence Interval, $I^2$ indicates heterogeneity.

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**Table 9. Subgroup analyses of PTSD prevalence.**

| Overall | Number of Studies | Proportion (%) | 95% CI | $I^2$ (%) | p value | References |
|---|---|---|---|---|---|---|
| **PTSD prevalence** | 2 | 14.5 | 6.8-22.2 | 77.8 | <0.05 | [9,20] |

| Categories | Subgroups | Number of Studies | Proportion (%) | 95% CI | References |
|---|---|---|---|---|---|
| **Quality** | Good | 2 | 14.5 | 6.8-22.2 | [9,20] |
| | Medium | 0 | NA | NA | NA |
| **Time period** | Pre-peak COVID-19 incidence | 1 | 9.8 | NR | [9] |
| | Post-peak COVID-19 incidence | 1 | 20.9 | NR | [20] |
| **Province** | Hubei | 1 | 20.9 | NR | [20] |
| | Other | 1 | 9.8 | NR | [9] |
| **Assessment** | IES-R | 1 | 9.8 | NR | [9] |
| | PCL-C | 1 | 20.9 | NR | [20] |

NR = Not reported, NA = Not applicable, Good quality score = 7+, Medium Quality score = 4–6, IES-R = Impact of event scale-revised, PCL-C = PTSD checklist-civilian version, CI = Confidence Interval, $I^2$ indicates heterogeneity.

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**Table 10. Subgroup analyses of distress prevalence.**

| Overall | Number of Studies | Proportion (%) | 95% CI | $I^2$ (%) | p value | References |
|---|---|---|---|---|---|---|
| **Distress prevalence** | 3 | 45.2 | 29.0-61.4 | 49.2 | <0.05 | [2,6,16] |

| Categories | Subgroups | Number of Studies | Proportion (%) | 95% CI | References |
|---|---|---|---|---|---|
| **Quality** | Good | 2 | 35.0 | 34.4-35.6 | [2,16] |
| | Medium | 1 | 71.5 | NR | [6] |
| **Time period** | Pre-peak COVID-19 incidence | 2 | 56.7 | 35.9-77.5 | [2,6] |
| | Post-peak COVID-19 incidence | 1 | 40.7 | NR | [16] |
| **Province** | Hubei | 1 | 41.5 | NR | [2] |
| | Other | 2 | 45.8 | 24.5-67.1 | [6,16] |
| **Assessment** | IES-R | 1 | 71.5 | NR | [6] |
| | Other | 2 | 35.0 | 34.4-35.6 | [2,16] |

NR = Not reported, NA = Not applicable, Good quality score = 7+, Medium Quality score = 4–6, IES-R = Impact of event scale-revised, CI = Confidence Interval, $I^2$ indicates heterogeneity.

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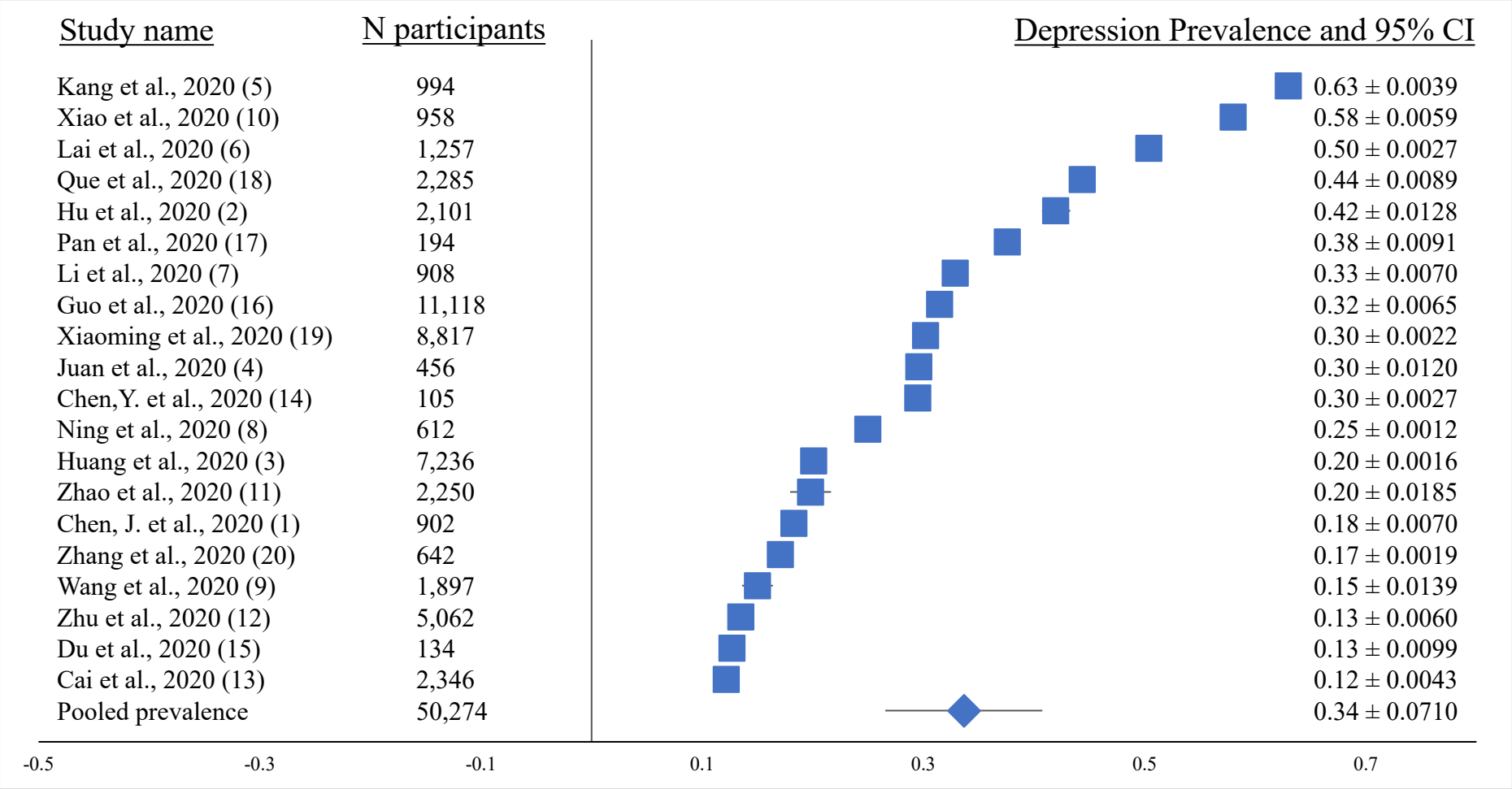
**Figure 2. Forest plot for the studies that provided estimates of the prevalence of depression among healthcare workers.**




The squares and horizontal lines correspond to the study-specific psychological outcome (depression) prevalence proportion and 95% confidence intervals (CIs). The diamond represents the pooled prevalence and 95% CIs from all 20 included studies. (fix the 95% CI for all graphs, make it compiled CIs of individual studies). The overall pooled prevalence of depression was 33.7% (95% CI 26.6-40.8).

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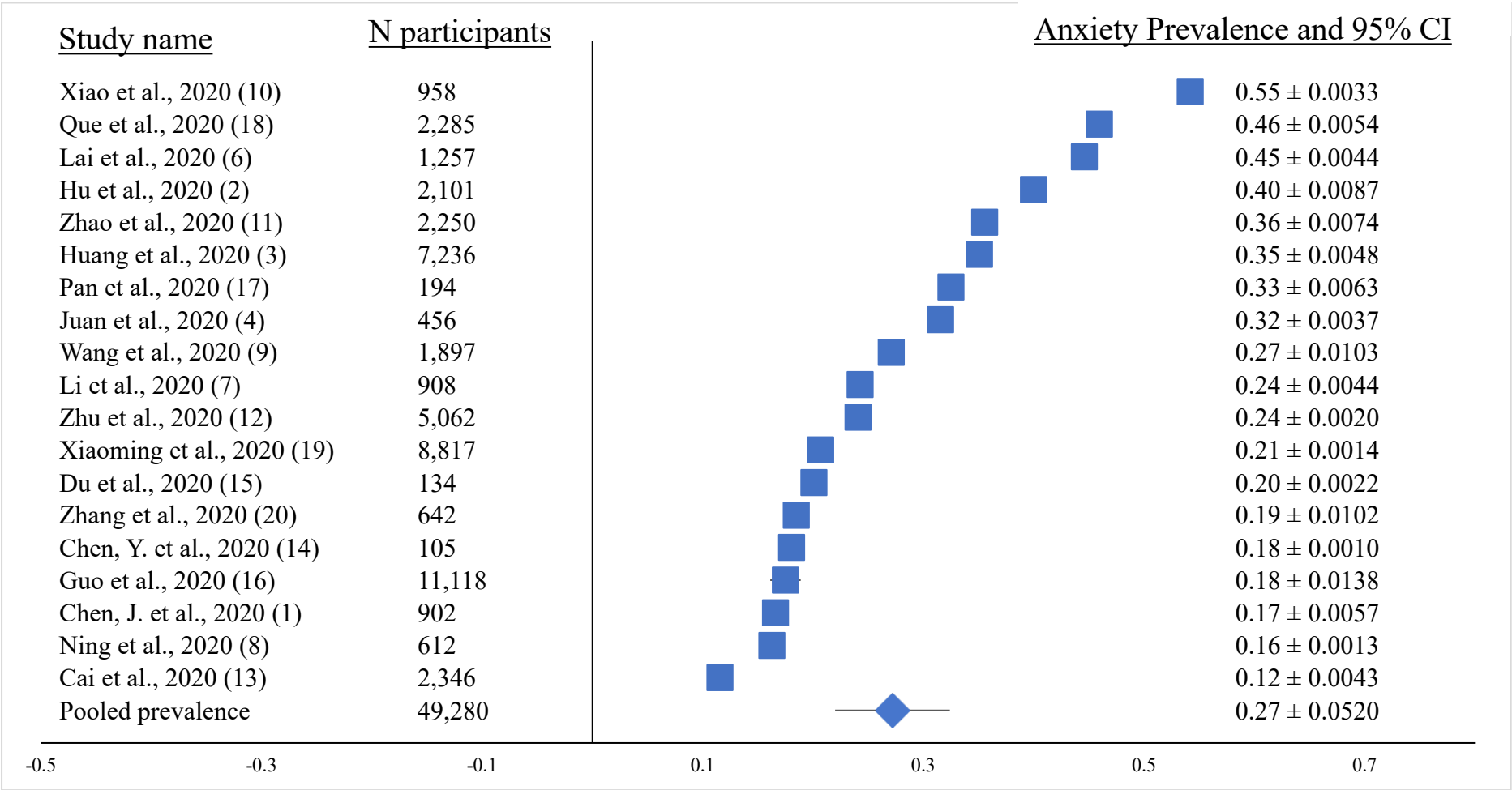
**Figure 3. Forest plot for the studies that provided estimates of the prevalence of anxiety among healthcare workers.**




The squares and horizontal lines correspond to the study-specific psychological outcome (anxiety) prevalence proportion and 95% confidence intervals (CIs). The diamond represents the pooled prevalence and 95% CIs from 19 of the included studies. (fix the 95% CI for all graphs, make it compiled CIs of individual studies). The overall pooled prevalence of anxiety was 27.2% (95% CI 22.0-32.4).

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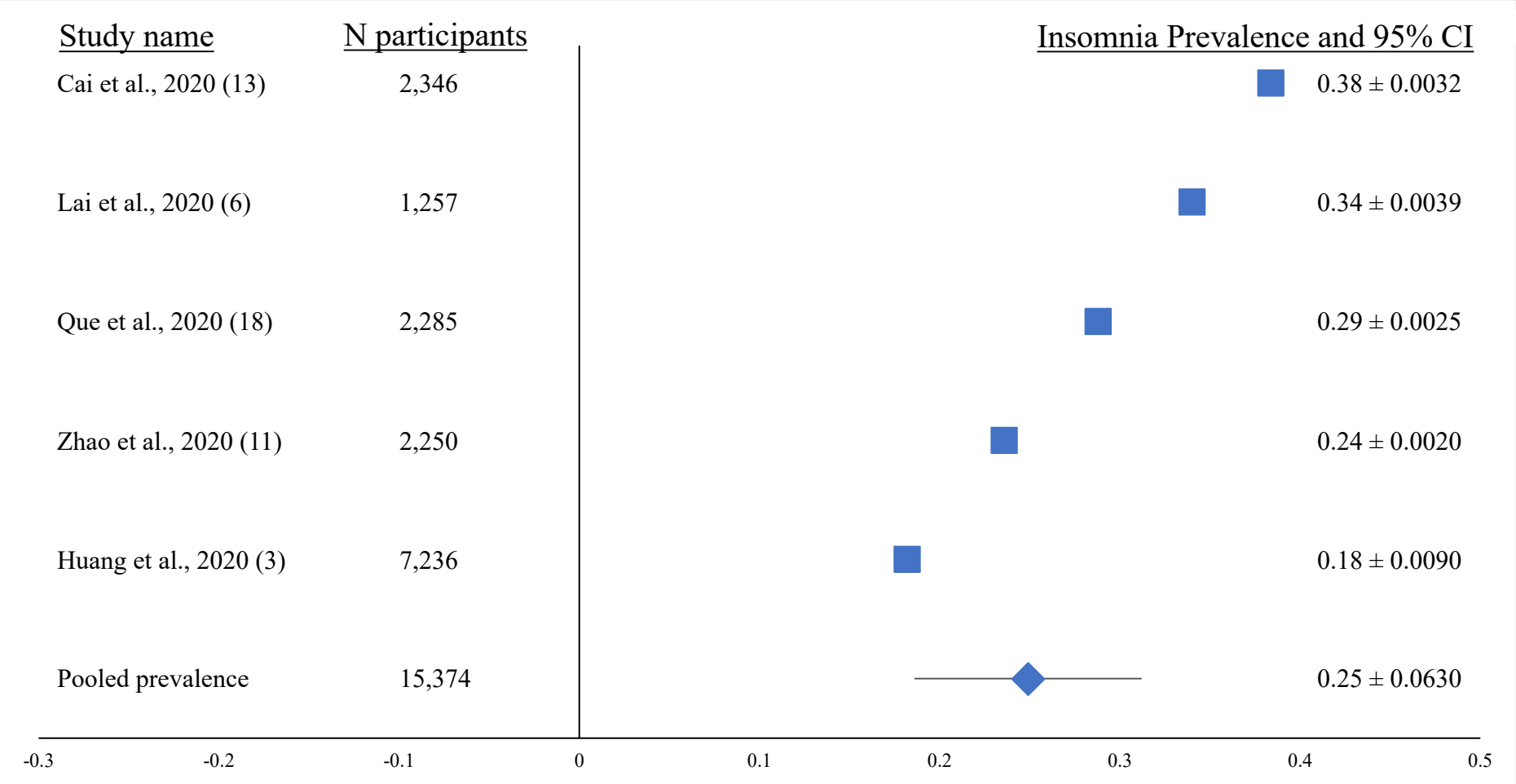
**Figure 4. Forest plot for the studies that provided estimates of the prevalence of insomnia among healthcare workers.**




The squares and horizontal lines correspond to the study-specific psychological outcome (insomnia) prevalence proportion and 95% confidence intervals (CIs). The diamond represents the pooled prevalence and 95% CIs from five of the included studies. (fix the 95% CI for all graphs, make it compiled CIs of individual studies). The overall pooled prevalence of insomnia was 24.9% (95% CI 18.6-31.2).

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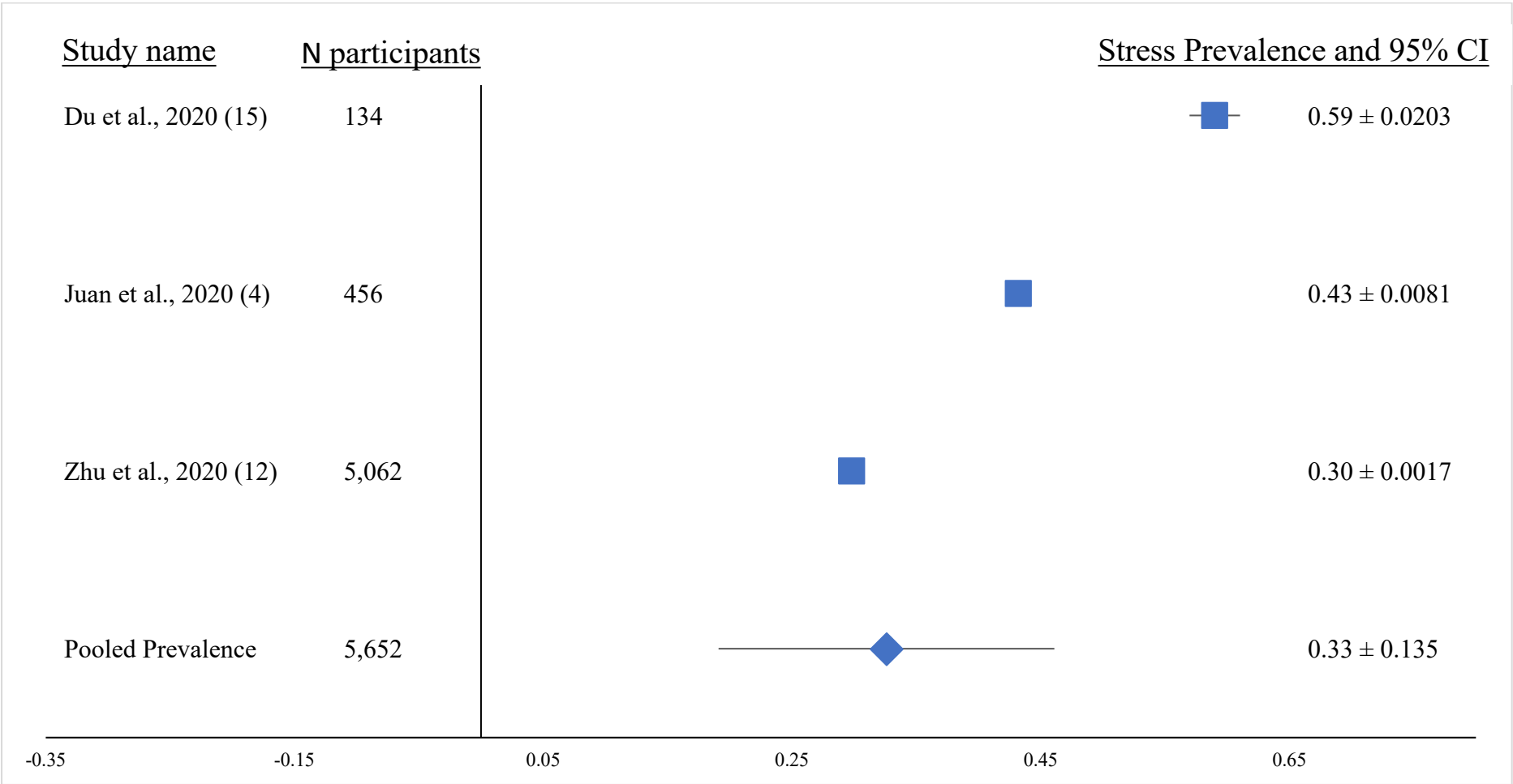
**Figure 5. Forest plot for the studies that provided estimates of the prevalence of stress among healthcare workers.**




The squares and horizontal lines correspond to the study-specific psychological outcome (stress) prevalence proportion and 95% confidence intervals (CIs). The diamond represents the pooled prevalence and 95% CIs from three of the included studies. (fix the 95% CI for all graphs, make it compiled CIs of individual studies). The overall pooled prevalence of stress was 32.6% (95% CI 19.1-46.1).

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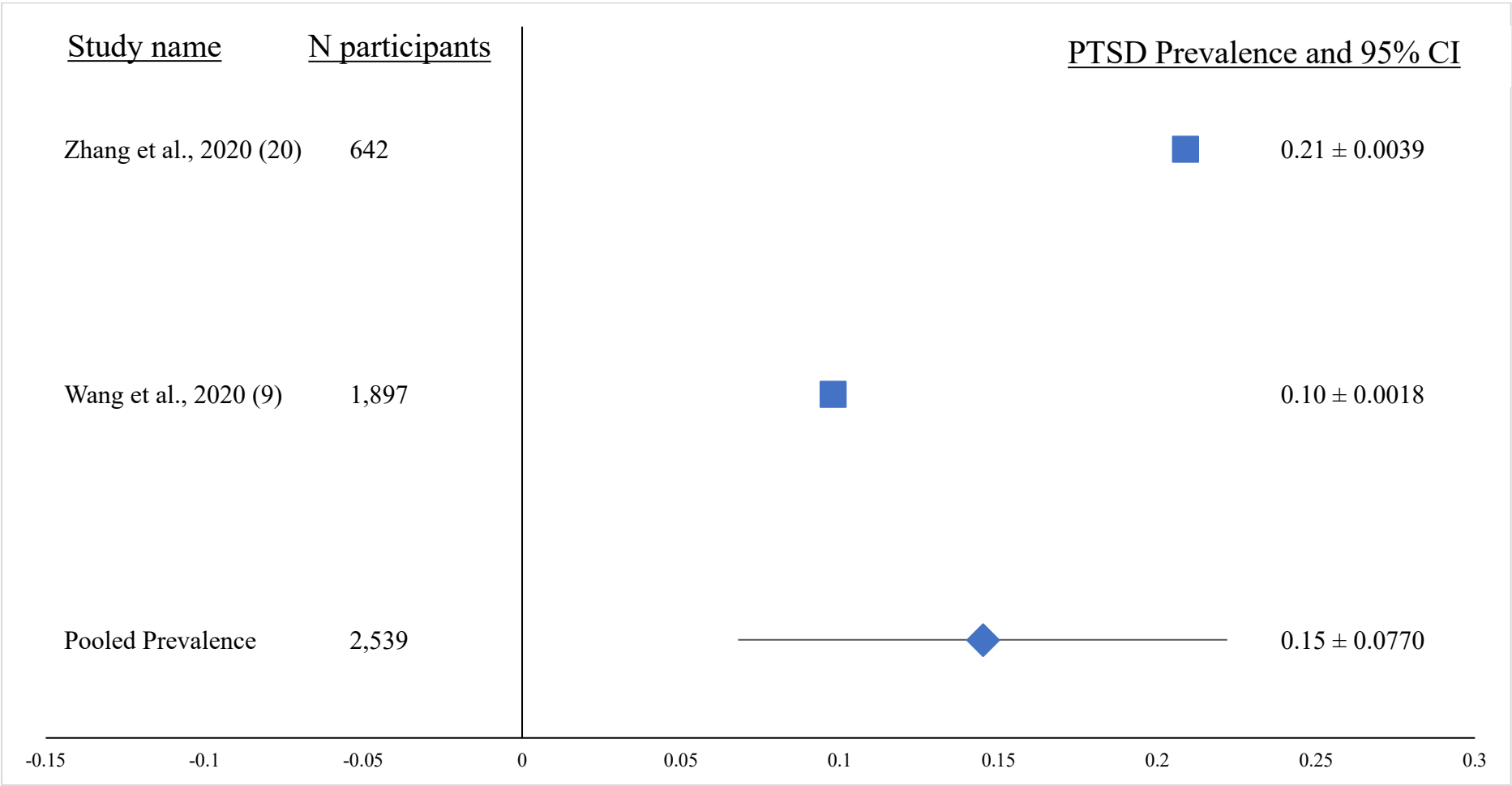
**Figure 6. Forest plot for the studies that provided estimates of the prevalence of PTSD among healthcare workers.**




The squares and horizontal lines correspond to the study-specific psychological outcome (PTSD) prevalence proportion and 95% confidence intervals (CIs). The diamond represents the pooled prevalence and 95% CIs from two of the included studies. (fix the 95% CI for all graphs, make it compiled CIs of individual studies). The overall pooled prevalence of PTSD was 14.5% (95% CI 6.8-22.2).

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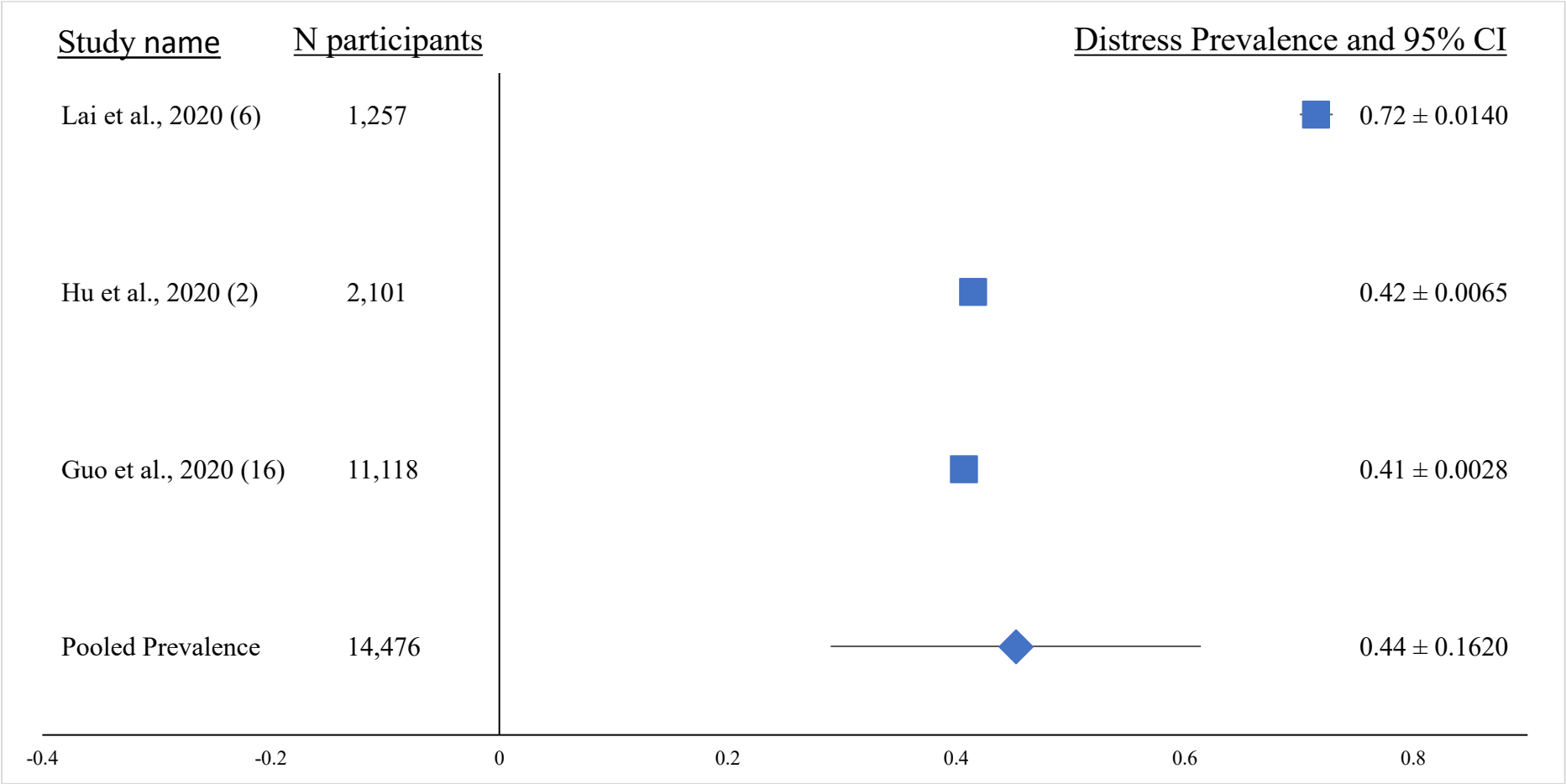
**Figure 7. Forest plot for the studies that provided estimates of the prevalence of distress among healthcare workers.**




The squares and horizontal lines correspond to the study-specific psychological outcome (distress) prevalence proportion and 95% confidence intervals (CIs). The diamond represents the pooled prevalence and 95% CIs from three of the included studies. (fix the 95% CI for all graphs, make it compiled CIs of individual studies). The overall pooled prevalence of distress was 43.5% (95% CI 29.0-61.4).

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## 4. Discussion

This meta-analysis included 20 studies with 50,274 participating Chinese HCWs, compared to a previous meta-analysis that included 12 studies[31]. Unlike prior meta-analyses, this study compared the prevalence of a wide range of psychological outcomes before and after a critical benchmark in the COVID-19 pandemic, the peak incidence of cases in China. The findings of this study suggest that the overall prevalence of depression, anxiety, insomnia, stress, PTSD, and distress before peak incidence were 36.2%, 34.2%, 22.4%, 31.3%, 9.8%, and 56.7% as opposed to 31.8%, 24.1%, 34.4%, 59.0%, 20.9%, and 40.7% after the peak. The higher prevalence of depression, anxiety, and distress prior to the peak may be attributable to the absence of effective prophylactic and treatment measures, overwhelmed staff, fear of infection or transmission, and lack of social support. According to Chen, J. *et al*., whose report consisted of 902 Chinese HCWs and was conducted before peak incidence, depression and anxiety were common in frontline HCWs due to increased workload, job burnout, and negative coping factors. The higher prevalence of PTSD and stress after the peak incidence may be explained by the accumulation traumatic experiences and prolonged exposure to stressors[32]. This study found a lower prevalence of insomnia both before (22.4%) and after (34.4%) peak incidence compared to a previous meta-analysis, which found the prevalence of insomnia in Chinese HCWs to be 38.9%[33]. This difference may be due to variable cutoff values for the ISI used in recent reports. The increase in insomnia prevalence after peak incidence may be explained by the presence of anxiety in HCWs early on in the pandemic. One study found that among people with comorbid disorders, anxiety disorders anteceded insomnia 73% of the time[34]. Thus, it is likely that prior anxiety disorders in HCWs is associated with an increased risk of insomnia. Additionally, this study found higher levels of depression and anxiety among nurses and frontline HCWs compared to physicians and non-frontline HCWs. This may be related to their longer periods of contact with COVID-19 patients compared to those of physicians and non-frontline HCWs. This study's findings may be confounded by the fact that the majority of frontline HCWs are nurses, who work with COVID-19 patient samples and are often female. Based on the cumulative findings of this meta-analysis, the group most vulnerable to psychological outcomes from the pandemic are female frontline nurses. Furthermore, no definitive reasons can be provided for the findings of higher anxiety and PTSD prevalence in Hubei compared to other provinces as such results may be influenced by how each province directs its COVID-19 protocols and availability of psychological services for HCWs.

The increasing prevalence of insomnia, stress, and PTSD throughout the duration of the pandemic and high relative prevalence of depression, anxiety, and distress both before and after the peak incidence of COVID-19 in China are indications of the need for greater preparedness, more interventions, and further research regarding the protection of the mental health of HCWs during public health crises. In terms of preparedness, the provision of psychological support, on-going surveillance of psychological ramifications associated with the pandemic, updating and strengthening training in disease information, and having adequate protective equipment have been advocated in the literature[3,4,7,17]. Interventions such as reducing the intensity of work, building self-efficacy and resilience through the introduction of social support, ensuring frontline work willingness, and access to mental healthcare services have been recognized by the literature as effective strategies to stabilize the mental state of HCWs[1,2,7]. Further research on cognitive and behavioral consequences during and after public health emergencies are necessary to inform policy makers and healthcare authorities on how preparedness and intervention-availability can be improved[19].

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### 4.1 Quality of evidence

This meta-analysis provides extensive evidence of psychological outcomes from a large sample of 50,274 participants. All 20 of the included cross-sectional studies were of good and medium quality. Subgroup analyses were conducted to quantify the heterogeneity among the studies using the Higgins-Thompson $I^2$ statistic and to account for further vulnerabilities.

### 4.2 Study limitations

This study has several noteworthy limitations. First, the results reported by the included studies are based on self-reports of psychological outcomes. Consequently, there may be uncertainty as to the appraisal of psychological symptoms and diagnoses. Second is the heterogeneity among the studies related to survey tools, cutoff scores, duration of study, sample sizes, and varying compositions of HCWs. Furthermore, the categorization of outcome severity differed between studies and thus may have affected the subgroup analyses. Although most studies used mild, moderate, and severe designations, some implemented mild, moderate, moderate-severe, and severe categorizations. Third, sampling bias for the province-specific subgroup analyses may have affected the results as 75% (15/20) of the studies were conducted in provinces other than Hubei. Thus, the external validity of the results may be limited. Fourth, the cross-sectional design of all 20 included studies provided only a snapshot of outcome prevalence at a specific point in time. Additionally, only prevalence data up until June 13$^{th}$, 2020 was considered without exploration into more recent developments. Lastly, language bias is likely as only studies published in English were included.

### 4.3 Research and Clinical Implications

The results of this study highlight the need for additional preventative and interventional measures to address the psychological outcomes of HCWs during public health emergencies. The higher prevalence of depression, anxiety, and distress prior to the peak incidence of COVID-19 in China and of insomnia, stress, and PTSD thereafter serve as evidence that the mental health decline of HCWs is dynamic and should be addressed with adaptive approaches that provide personalized treatments. Ensuring that HCWs are receiving substantial social support, are assured that all measures are being taken to protect their health, and have access to psychological services are vital for the protection of their mental health.

## 5. Conclusions

This meta-analysis provides extensive evidence for the psychological impact of COVID-19 on Chinese HCWs. Furthermore, it strengthens already existing evidence that female frontline nurses are among the most vulnerable groups to be psychologically impacted. Lastly, to our knowledge, this meta-analysis introduces novel evidence on the difference in psychological outcome prevalence before and after peak incidence of COVID-19 in China.

## 6. References


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