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ORIGINAL RESEARCH

# Understanding the Mediating Role of Anxiety and Depression on the Relationship Between Perceived Stress and Sleep Quality Among Health Care Workers in the COVID-19 Response

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**Objective:** There is an increasing amount of evidence exploring the adverse effects of perceived stress or anxiety and depression independently on sleep quality during the COVID-19 outbreak, although the underlying mechanisms are unclear. The aim of the current study was to explore the role of anxiety and depression as a potential mediator between perceived stress and sleep quality among health care workers.

**Methods:** Data were collected through an online survey using the snowball sampling method and comprised 588 current health care workers in Zhejiang and Hubei provinces, China, from February to March 2020. We administered the Sleep Quality Questionnaire (SQQ), the Perceived Stress Scale (PSS-10), the Patient Health Questionnaire (PHQ-4) and the sociodemographic characteristics and COVID-19-related characteristics questionnaire. Structural equation modelling (SEM) was used to examine the direct and indirect relationships between perceived stress, anxiety and depression, and sleep quality.

**Results:** The average scores for sleep quality and perceived stress were 16.01 (95% CI [15.40, 16.57]) and 15.46 (95% CI [15.05, 15.87]), respectively. The positive rates of anxiety and depression symptom tests were 9.86% and 10.37%, respectively. The SEM results indicated that the original relationship between perceived stress and sleep quality was beta = 0.52 ($P < 0.001$) and reduced to beta = 0.25 ($P = 0.045$) while introducing anxiety and depression as mediating variables. Perceived stress was positively associated with anxiety and depression (beta = 0.78, $P = 0.014$), and anxiety and depression were positively associated with sleep quality (beta = 0.42, $P < 0.001$).

**Conclusion:** Poor sleep quality and high perceived stress were common during the COVID-19 crisis. Reducing perceived stress could help reduce anxiety and depression symptoms, thereby improving sleep quality among health care workers. In an attempt to promote psychological resources, we should perhaps take multiple measures, including personal tailored intervention and organizational humanistic concern.

**Keywords:** health care workers, sleep quality, anxiety, depression, perceived stress, COVID-19

## Introduction

Globally, to date (10 September 2021), there have been 223,022,538 confirmed cases of COVID-19, including 4,602,882 deaths, reported to the World Health Organization (WHO).[1] The rapid spread of COVID-19 poses a grave health threat and has serious socioeconomic implications for all.[2] In response to this global outbreak, many countries have adopted a variety of measures, such as social

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distancing, self-isolation and travel restrictions, or even forced lockdown. The COVID-19 crisis has almost certainly placed a significant strain on health systems across the globe and has exposed health care workers to an unprecedented threat.[3,4] Not surprisingly, health care workers are not only placed at the core of the pandemic but are in a particularly vulnerable position.[4] They are predisposed to a number of risks: heavy workloads, unpredictable work patterns, and a higher risk of infection, which might have consequences on their health and well-being.[5,6] Moreover, in comparison to the general population, health care workers are facing increased professional and personal responsibilities during the pandemic, which may lead to an additional psychological burden.[7]

Multiple work stressors increase the risk of adverse mental health outcomes, including but not limited to psychological distress (fear, stress, anxiety, depression, exhaustion, post-traumatic stress disorder (PTSD)) and sleep dysfunction (poor sleep quality, sleep debt, insomnia). Indeed, during a crisis such as the current COVID-19 pandemic, the quality of sleep of health care workers becomes essential.[4] However, there is no single perfectly reliable criterion for defining sleep or even sleep quality because it is generally defined as a complex state.[8] Ample sleep, a balanced diet, and physical activity are three fundamental needs.[9] Ample sleep is summarized by at least three aspects: adequate sleep quantity (quantity), good sleep quality (quality), and regular sleep patterns (circadian rhythm).[10] Good sleep is vital to good health.[11] Subjective sleep quality complaints may be a consequence of disease.[12] Sleep quality is an important signal and sign of the transition between health and disease. Poor sleep quality, sleep debt, acute/chronic stress, and other mental health problems could impair cognitive functioning and weaken decision-making ability, thereby reducing clinical work efficiency and increasing the risk of medical errors, which may hinder the fight against COVID-19 and could result in a lasting effect on overall well-being.[13–18] Hence, the toll of the crisis has been heavy on health care workers.

Health care services are widely recognized as a challenging occupation; health care workers, who receive rigorous training to prepare themselves for this occupation, report a higher level of sleep disturbance during the COVID-19 pandemic. For instance, a 2021 meta-analysis reported that worldwide, the prevalence of sleep disturbance has been estimated to be between 18.4 and 84.7% in health care workers and 17.65–81% in the general population.[19] Exposure to the COVID-19 pandemic in the workplace could act as a precipitating factor of a hyperarousal state, which could lead to a higher incidence of sleep disturbance and other sleep disorders when compared with the general population.[3] Sleep dysfunction is often accompanied by psychological distress symptoms among health care workers during the COVID-19 pandemic.[20–22] Studies have shown that work stressors from COVID-19 can induce mild to severe levels of anxiety, depression, exhaustion, PTSD and sleep dysfunction.[15,23–26] Alternatively, another argument for there is still little evidence of an increase in sleep disturbances in health care workers during the outbreak;[27] health care workers had poor sleep status, even before COVID-19. Work stressors can have on sleep, but lack or poor quality of sleep has on resilience and stress, which is cyclical relationship.[28] In the long term, we are addressing the urgent needs of protecting the sleep health, mental health and well-being of health care workers.[29,30] However, evidence is limited regarding the impact of the current pandemic on sleep dysfunction in health care workers derived from coronavirus stress, particularly the underlying mechanism of both variables.

Despite the strong relationship between psychological health and sleep, little is known about the mechanism of the relationship between COVID-19 stress, anxiety and depression, and sleep quality. Based on the current literature, a priori hypotheses are that high stress in health care workers will reduce sleep quality, mainly indirectly through anxiety and depression during the COVID-19 epidemic. Considering the available evidence that anxiety and depression could act as a risk factor to intensify the negative consequences of perceived stress on health care workers, the aim of this study was to explore the mediating role of anxiety and depression in the relationship between perceived stress and sleep quality. Meanwhile, the current study revealed influencing factors on the mental health of health care workers during the COVID-19 crisis. The findings will help to better understand factors associated with perceived stress, anxiety and depression, and sleep quality, specifically the influencing mechanism of anxiety and depression on both variables of health care workers. These findings might have significant implications for effective interventions designed to improve sleep quality and well-being of health care workers.

# Methods

## Participants and Procedure

From February 25 to March 3, 2020, for approximately a week, we recruited health care workers from across

Zhejiang and Hubei provinces to complete the online survey. At the beginning of the COVID-19 outbreak, a snowball sampling method was used to recruit participants anonymously.[31] The self-selection survey was distributed through a dozen department heads, and the respondents chose to participate by clicking on a link or scanning a quick response (QR) code. Each respondent and her or his department head knew each other. Inclusion criteria: (1) health care workers, (2) agreed to participate in the survey, and (3) could read a Chinese questionnaire. Exclusion criteria: (1) would not be allowed to submit survey responses using the same IP address, (2) who were not in position at the time of the survey due to any leave of absence and (3) invalid response such as short response time and longstring. Participants included medical doctors, registered nurses, medical technicians (eg, pharmacists, therapists, laboratory technicians) and administrators (eg, department directors, nursing supervisors). Prior to data analyses, we excluded 2 (0.3%) of the initial respondents because they were identified as invalid responses. Our final sample contained 588 submitted surveys with no missing data.

## Measures

### Sociodemographic Characteristics and COVID-19-Related Characteristics Questionnaire

The sociodemographic characteristics included gender (male and female), province (Zhejiang, Hubei, and others), marital status (single, married, divorced, widowed), occupational categories (medical doctor, registered nurse, medical technician, administrator), professional title (unknown, junior, intermediate, vice-senior or senior), and educational level (technical secondary school or below, college degree, bachelor's degree, master's degree or above).

The COVID-19-related characteristics include departmental function (designated hospitals, community health centre, other medical institutions), if work affairs were the same as before (identical, basically consistent, inconsistent), job category (direct contact with confirmed patients and/or body fluid, possible contact with confirmed patients and/or body fluid, direct contact with suspected patients and/or body fluid, possible contact with suspected patients and/or body fluid, have no contact with any confirmed and suspected patients and/or body fluid), adequate protection (No or Yes), quarantined status currently (No or Yes), the burden of family care (No and Yes), and work experience in response to outbreaks (No or Yes).

### Sleep Quality Questionnaire (SQQ)

The Sleep Quality Questionnaire (SQQ) was used to assess sleep quality.[32] Participants responded to ten items about their subjective experience of sleep in the past month. They rated the extent of agreement with each 5-point Likert scale item, ranging from 0 (strongly disagree) to 4 (strongly agree). Individual scores on the SQQ can range from 0 to 40, with higher composite scores indicating poorer sleep quality. The Chinese version of the SQQ (SQQ-C) was adapted and validated for the first time by a doctoral program of the corresponding author and exhibited satisfactory psychometric properties using a large sample survey among university students, medical workers, and general patients.[33,34] Cronbach's α coefficient for the SQQ-C was 0.901 (95% CI [0.889, 0.913]), suggesting optimal internal consistency.

### Perceived Stress Scale (PSS-10)

The Perceived Stress Scale (PSS) is a brief scale of stress perceptions and measures the degree to which one perceives three aspects: uncontrollable, unpredictable, and overloading.[35] There were three forms: fourteen items (PSS-14), ten items (PSS-10) and four items (PSS-4).[36] Respondents were required to respond to each item on a 5-point Likert scale, ranging from 0 (never) to 4 (very often), with higher composite scores indicative of greater levels of perceived stress within the past month. The current study used the PSS-10, and thus, individual scores on the PSS can range from 0 to 40. The Chinese version of the PSS-10 (PSS-10-C) established adequate reliability and validity statistics when used in a sample of Chinese policewomen.[37] Cronbach's α coefficient for the PSS-10-C was 0.815 (95% CI [0.792, 0.837]), suggesting satisfactory internal consistency.

### Patient Health Questionnaire (PHQ-4)

A self-report version of the Primary Care Evaluation of Mental Disorders (PRIME-MD) called the Patient Health Questionnaire (PHQ) was developed and validated in two large studies.[38] The Generalized Anxiety Disorder scale (GAD) is derived from the original PHQ. The GAD-2 and PHQ-2 altogether consist of the PHQ-4 for detecting probable generalized anxiety disorder and major depressive disorder, respectively. Each scale rates the severity of each item over the preceding 2 weeks on a four-point Likert scale (0–3; 0 = not at all, 3 = nearly

every day).[39] A score of each scale ranges from 0 to 6. When screening for anxiety disorders or depressive disorders, a recommended cut-off point for further evaluation is a score of 3 or greater. The Chinese version of the PHQ-4 (PHQ-4-C) and its instruction manual are now publicly available from the Patient Health Questionnaire (PHQ) Screeners (Retrieved from: https://www.phqscreeners.com). Cronbach's α coefficient for the PHQ-4-C was 0.870 (95% CI [0.852, 0.886]), suggesting satisfactory internal consistency.

## Data Analyses

The authors managed the data with EXCEL (version 2010; Microsoft Corporation, Redmond, WA, USA) software. SPSS plus Amos (version 18.0; SPSS Inc., Chicago, IL, USA) and JASP (version 0.12.2; JASP Team, University of Amsterdam, Amsterdam, The Netherlands) were adopted to analyse the data. Frequencies were used to describe the sociodemographic characteristics and COVID-19-related characteristics. The mean (95% confidence interval, 95% CI) represented the mean value; analysis of variances or chi-square test was used to compare values among groups. We estimated the strength of the pathways between perceived stress, anxiety and depression, and sleep quality using structural equation modelling (SEM) with maximum likelihood estimation (MLE). An acceptable goodness-of-fit (GOF) model was indicated by the root mean square error of approximation (RMSEA, 90% CI) < 0.08, standardized root mean residual (SRMR) < 0.08, goodness of fit index (GFI) > 0.90, normed chi-square (NC) < 2.0–3.0, Tucker–Lewis index (TLI) > 0.90, comparative fit index (CFI) > 0.90, parsimony goodness-of-fit index (PGFI) > 0.50, and parsimony normed fit index (PNFI) > 0.50.[40–42]

## Ethics Statement

Participation in the study was voluntary and anonymous, and participants could opt out at any time while responding to these survey questions to ensure full respect and protection of individual privacy throughout this process. Do not allow the data to be associated with a specific person. Informed consent was obtained from all participants enrolled in the study. This study meets the relevant requirements of the Declaration of Helsinki and its revised version.[43] The Ethics Committee of Ningbo College of Health Sciences reviewed and approved the protocol.

# Results

## Sociodemographic Characteristics and COVID-19-Related Characteristics

Sociodemographic characteristics and COVID-19-related characteristics are described in Table 1. Regarding sociodemographic characteristics, 75.68% of respondents were female. Of the respondents, 60.37% worked in Zhejiang Province, 32.31% worked in Hubei Province, and 7.31% worked in other provinces. A total of 17.69% of participants surveyed were single, 80.95% were married, and 1.36% were divorced. Among all participants, 40.65% were medical doctors, 45.24% were registered nurses, 10.71% were medical technicians, and 3.40% were administrators. A total of 3.57% had unknown titles, 31.29% had junior titles, 48.30% had intermediate titles, and 16.84% had vice-senior or senior titles. Participants reported their education level, including technical secondary school (1.19%), college degree (10.03%), bachelor's degree (77.72%), and master's degree or above (11.05%).

Regarding COVID-19-related characteristics, 45.24% of respondents worked in the designated hospitals, 24.49% worked in the community health centre, and 30.27% worked in other medical institutions. Of the respondents, for 22.79% the work affairs were identical to the work affairs before the pandemic, for 50.51% the work affairs were basically consistent with the previous work affairs, and for 26.70% the work affairs were inconsistent with the previous work affairs. A total of 12.76% of the participants had direct contact with confirmed patients and/or body fluid, 14.29% had possible contact with confirmed patients and/or body fluid, 6.12% had direct contact with suspected patients and/or body fluid, 40.48% had possible contact with suspected patients and/or body fluid, and 26.36% had no contact with any confirmed and suspected patients and/or body fluid. Among all participants, 82.65% had adequate protection with standard precautions, and 17.35% had inadequate protection with standard precautions. A total of 9.35% of participants currently reported a state of quarantined status, 50.51% had a burden to take care of the family, and 16.50% had work experience in response to outbreaks.

## Outcome Characteristics – SQQ, PSS-10 and PHQ-4

The total mean of the SQQ score was 16.01 (95% CI [15.40, 16.57]). The SQQ scores were significantly

**Table 1** Sociodemographic Characteristics and COVID-19-Related Characteristics (N = 588)

| Characteristics | | N (%) |
|---|---|---|
| Gender | | |
| | Male | 143 (24.32) |
| | Female | 445 (75.68) |
| Province | | |
| | Zhejiang | 355 (60.37) |
| | Hubei | 190 (32.31) |
| | Others | 43 (7.31) |
| Marital status | | |
| | Single | 104 (17.69) |
| | Married | 476 (80.95) |
| | Divorced | 8 (1.36) |
| | Widowed | 0 (0) |
| Occupational categories | | |
| | Medical doctor | 239 (40.65) |
| | Registered nurse | 266 (45.24) |
| | Medical technician | 63 (10.71) |
| | Administrator | 20 (3.40) |
| Professional title | | |
| | Unknown | 21 (3.57) |
| | Junior | 184 (31.29) |
| | Intermediate | 284 (48.30) |
| | Vice-senior or senior | 99 (16.84) |
| Educational level | | |
| | Technical secondary school or below | 7 (1.19) |
| | College degree | 59 (10.03) |
| | Bachelor's degree | 457 (77.72) |
| | Master's degree or above | 65 (11.05) |
| Departmental function | | |
| | Designated hospitals | 266 (45.24) |
| | Community health centre | 144 (24.49) |
| | Other medical institutions | 178 (30.27) |
| If work affairs were the same as before | | |
| | Identical | 134 (22.79) |
| | Basically consistent | 297 (50.51) |
| | Inconsistent | 157 (26.70) |
| Job category | | |
| | Direct contact confirmed patients | 75 (12.76) |
| | Possible contact confirmed patients | 84 (14.29) |
| | Direct contact suspected patients | 36 (6.12) |
| | Possible contact suspected patients | 238 (40.48) |
| | Non-contact | 155 (26.36) |
| Adequate protection | | |
| | No | 102 (17.35) |
| | Yes | 486 (82.65) |
| Quarantined status currently | | |
| | No | 533 (90.65) |
| | Yes | 55 (9.35) |
| Have family care burden | | |
| | No | 291 (49.49) |
| | Yes | 297 (50.51) |
| Work experience in response to outbreaks | | |
| | No | 491 (83.50) |
| | Yes | 97 (16.50) |

different by departmental function (F = 3.73, $P$ = 0.024), job category (F = 4.02, $P$ = 0.003), and burden of family care (F = 13.86, $P$ < 0.001). No significant difference was found by gender, province, marital status, occupational categories, professional title, educational level, whether work affairs were the same as before, adequate protection, quarantined status, and work experience in response to outbreaks (all $P$ > 0.05) (Table 2).

The total mean PSS score was 15.46 (95% CI [15.05, 15.87]). The PSS scores were significantly different by province (F = 7.05, $P$ = 0.001), occupational categories (F = 3.14, $P$ = 0.025), if work affairs were the same as before (F = 4.31, $P$ = 0.014), job category (F = 3.51, $P$ = 0.008), adequate protection (F = 14.26, $P$ < 0.001), and burden of family care (F = 10.36, $P$ = 0.001). No significant difference was found by gender, marital status, professional title, educational level, quarantined status, or work experience in response to outbreaks (all $P$ > 0.05) (Table 2).

The PHQ-4 (GAD-2 and PHQ-2) scores are described separately in Table 3. In the GAD-2, the quantities of scores from 0 to 6 were 132, 123, 275, 22, 22, 6, and 8, accounting for 22.45%, 20.92%, 46.77%, 3.74%, 3.74%, 1.02%, and 1.36%, respectively. The positive rate of the anxiety symptoms test was 9.86% (58/588). In the PHQ-2, the quantities of scores from 0 to 6 were 154, 108, 265, 32, 16, 6, and 7, accounting for 26.19%, 18.37%, 45.07%, 5.44%, 2.72%,

**Table 2** Differences Between Groups on Sleep Quality and Perceived Stress

| Characteristics | Mean [95% CI] | *F* | *P* |
|---|---|---|---|
| **Sleep Quality** | | | |
| **Departmental function** | | 3.73 | 0.024 |
| Designated hospitals | 17.06 [16.19, 17.92] | | |
| Community health centre | 16.24 [15.09, 17.38] | | |
| Other medical institutions | 14.25 [13.08, 15.43] | | |
| **Job category** | | 4.02 | 0.024 |
| Direct contact confirmed patients | 18.64 [17.03, 20.25] | | |
| Possible contact confirmed patients | 18.70 [16.98, 20.43] | | |
| Direct contact suspected patients | 18.06 [15.77, 20.34] | | |
| Possible contact suspected patients | 15.13 [14.22, 16.04] | | |
| Non-contact | 14.14 [13.07, 15.21] | | |
| **Have family care burden** | | 13.86 | < 0.001 |
| No | 14.72 [13.91, 15.54] | | |
| Yes | 17.27 [16.42, 18.11] | | |
| **Perceived Stress** | | | |
| **Province** | | 7.05 | 0.001 |
| Zhejiang | 14.29 [13.77, 14.81] | | |
| Hubei | 17.14 [16.43, 17.84] | | |
| Others | 17.77 [16.04, 19.50] | | |
| **Occupational categories** | | 3.14 | 0.025 |
| Medical doctor | 15.45 [14.76, 16.14] | | |
| Registered nurse | 15.78 [15.17, 16.39] | | |
| Medical technician | 13.75 [12.50, 14.99] | | |
| Administrator | 16.85 [14.63, 19.07] | | |
| **If work affairs were the same as before** | | 4.31 | 0.014 |
| Identical | 13.95 [13.12, 14.78] | | |
| Basically consistent | 15.49 [14.91, 16.07] | | |
| Inconsistent | 16.71 [15.85, 17.56] | | |
| **Job category** | | 3.51 | 0.008 |
| Direct contact confirmed patients | 16.93 [15.73, 18.14] | | |
| Possible contact confirmed patients | 17.64 [16.53, 18.75] | | |
| Direct contact suspected patients | 15.39 [13.57, 17.21] | | |
| Possible contact suspected patients | 14.71 [14.08, 15.34] | | |
| Non-contact | 14.75 [13.92, 15.57] | | |
| **Adequate protection** | | 14.26 | < 0.001 |
| No | 14.92 [14.47, 15.36] | | |
| Yes | 18.06 [17.00, 19.12] | | |
| **Have family care burden** | | 10.36 | 0.001 |
| No | 14.57 [13.95, 15.19] | | |
| Yes | 16.33 [15.77, 16.89] | | |

1.02%, and 1.19%, respectively. The positive rate of depression symptoms test was 10.37% (61/588).

The anxiety and non-anxiety symptom individuals were significantly different by province ($\chi^2 = 11.640$, $P = 0.003$), if work affairs were the same as before ($\chi^2 = 8.818$, $P = 0.012$), job category ($\chi^2 = 15.300$, $P = 0.004$), and adequate protection ($\chi^2 = 8.408$, $P = 0.004$). The depression and non-depression symptom individuals were

**Table 3** Frequency of Each Score on the GAD-2 and the PHQ-2 (N = 588)

| Score | Frequency | Percent (%) | Cumulative Percent (%) |
|---|---|---|---|
| GAD-2 | | | |
| 0 | 132 | 22.45 | 22.45 |
| 1 | 123 | 20.92 | 43.37 |
| 2 | 275 | 46.77 | 90.14 |
| **3** | 22 | 3.74 | 93.88 |
| **4** | 22 | 3.74 | 97.62 |
| **5** | 6 | 1.02 | 98.64 |
| **6** | 8 | 1.36 | 100.0 |
| PHQ-2 | | | |
| 0 | 154 | 26.19 | 26.19 |
| 1 | 108 | 18.37 | 44.56 |
| 2 | 265 | 45.07 | 89.63 |
| **3** | 32 | 5.44 | 95.07 |
| **4** | 16 | 2.72 | 97.79 |
| **5** | 6 | 1.02 | 98.81 |
| **6** | 7 | 1.19 | 100.0 |

**Note:** Scores ≥ 3 in bold.

significantly different by province ($\chi^2$ = 17.807, $P$ < 0.001), professional title ($\chi^2$ = 9.904, $P$ = 0.019), if work affairs were the same as before ($\chi^2$ = 10.486, $P$ = 0.005), job category ($\chi^2$ = 11.477, $P$ = 0.022), and adequate protection ($\chi^2$ = 16.633, $P$ < 0.001) (Table 4).

## Correlational Analysis and Structural Equation Modelling

Correlational analysis showed that there were significant correlations between perceived stress and sleep quality (r = 0.52, $P$ < 0.001), anxiety and depression and sleep quality (r = 0.57, $P$ < 0.001), and perceived stress and anxiety and depression (r = –0.64, $P$ < 0.001). Good sleep quality usually indicated lower stress and fewer anxiety and depression symptoms during the COVID-19 pandemic.

Based on a priori hypotheses for building a model, perceived stress was associated with sleep quality (beta = 0.25, $P$ = 0.045), perceived stress was associated with anxiety and depression (beta = 0.78, $P$ = 0.014), and

**Table 4** Comparisons Between Anxiety and Non-Anxiety Symptom as Well as Depression and Non-Depression Symptom Individuals

| Characteristics | GAD-2 | | $\chi^2$ | P | PHQ-2 | | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|---|
| | < 3 (%) | ≥ 3 (%) | | | < 3 (%) | ≥ 3 (%) | | |
| **Province** | | | 11.640 | 0.003 | | | 17.807 | < 0.001 |
| Zhejiang | 332 (93.52) | 23 (6.48) | | | 333 (93.80) | 22 (6.20) | | |
| Hubei | 162 (85.26) | 28 (14.74) | | | 160 (84.21) | 30 (15.79) | | |
| Others | 36 (83.72) | 7 (16.28) | | | 34 (79.07) | 9 (20.93) | | |
| **Professional title** | | | | | | | 9.904 | 0.019 |
| Unknown | | | | | 17 (80.95) | 4 (19.05) | | |
| Junior | | | | | 156 (84.78) | 28 (15.22) | | |
| Intermediate | | | | | 261 (91.90) | 23 (8.10) | | |
| Vice-senior or senior | | | | | 93 (93.94) | 6 (6.06) | | |
| **If work affairs were the same as before** | | | 8.818 | 0.012 | | | 10.486 | 0.005 |
| Identical | 129 (96.27) | 5 (3.73) | | | 129 (96.27) | 5 (3.73) | | |
| Basically consistent | 266 (89.56) | 31 (10.44) | | | 265 (89.23) | 32 (10.77) | | |
| Inconsistent | 135 (85.99) | 22 (14.01) | | | 133 (84.71) | 24 (15.29) | | |
| **Job category** | | | 15.300 | 0.004 | | | 11.477 | 0.022 |
| Direct contact confirmed patients | 64 (85.33) | 11 (14.67) | | | 63 (84.00) | 12 (16.00) | | |
| Possible contact confirmed patients | 68 (80.95) | 16 (19.05) | | | 70 (83.33) | 14 (16.67) | | |
| Direct contact suspected patients | 31 (86.11) | 5 (13.89) | | | 30 (83.33) | 6 (16.67) | | |
| Possible contact suspected patients | 223 (93.70) | 15 (6.30) | | | 220 (92.44) | 18 (7.56) | | |
| Non-contact | 144 (92.90) | 11 (7.10) | | | 144 (92.90) | 11 (7.10) | | |
| **Adequate protection** | | | 8.408 | 0.004 | | | 16.633 | < 0.001 |
| No | 84 (82.35) | 18 (17.65) | | | 80 (78.43) | 22 (21.57) | | |
| Yes | 446 (91.77) | 40 (8.23) | | | 447 (91.98) | 39 (8.02) | | |

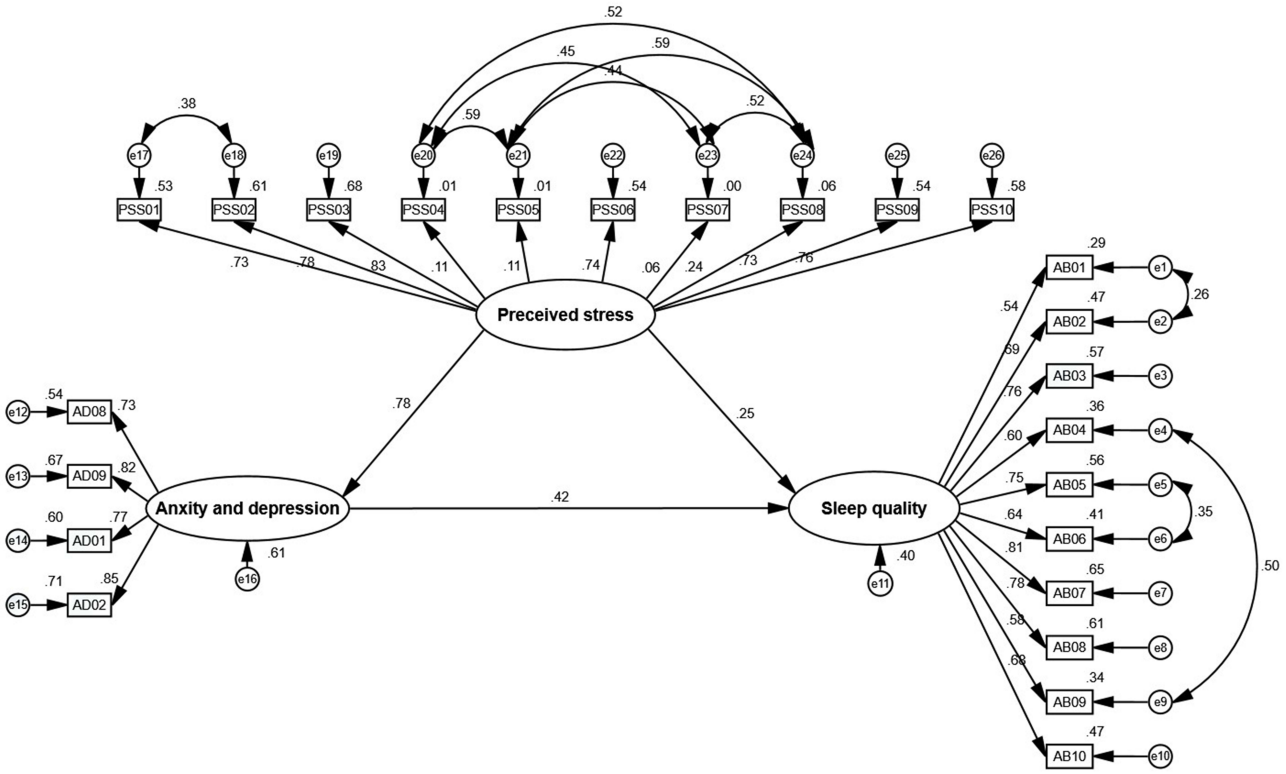


**Figure 1** Final structural model (N = 588).

anxiety and depression were associated with sleep quality (beta = 0.42, $P < 0.001$). The results are shown in Figure 1. All path coefficients in the model had $P < 0.05$. The results of the tests and the goodness-of-fit of the model are presented in Table 5.

**Table 5** Evaluation of the Goodness-of-Fit of the Model (N = 588)

| GOF Index | Test Result | Recommended Value | Model Fit |
|---|---|---|---|
| **Absolute measures** | | | |
| RMSEA (90% CI) | 0.057 (0.052, 0.062) | < 0.08 | Yes |
| SRMR | 0.056 | < 0.08 | Yes |
| GFI | 0.907 | > 0.90 | Yes |
| NC | 2.886 | < 2.0–3.0 | Yes |
| **Incremental fit measures** | | | |
| TLI | 0.933 | > 0.90 | Yes |
| CFI | 0.942 | > 0.90 | Yes |
| **Parsimony measures** | | | |
| PGFI | 0.723 | > 0.50 | Yes |
| PNFI | 0.791 | > 0.50 | Yes |

**Abbreviations:** GOF, goodness-of-fit; RMSEA, root mean square error of approximation; CI, confidence interval; SRMR, standardized root mean residual; GFI, goodness-of-fit index; NC, normed chi-square; TLI, Tucker-Lewis index; CFI, comparative fit index; PGFI, parsimony goodness-of-fit index; PNFI, parsimony normed fit index.

## Discussion

This trend is worrisome, as studies suggest that health care workers suffered from sleep dysfunction and psychological distress during the outbreak of COVID-19, especially poor sleep quality in frontline health care workers.[3,15,21,44–48] This study shows that sleep quality was related to departmental function, job category, and burden of family care among health care workers. Health care workers who work in designated hospitals had poorer sleep quality than those in community health centres and other medical institutions. Health care workers who worked in relatively safe places had better sleep quality because they might not have contact with the COVID-19 patients or their body fluid. COVID-19 outbreak-associated events, such as exposure to risk factors, correlate with decreased sleep quality in relationship with an increase in negative mood.[23] Health care workers who had the burden of taking care of the family had significantly worse sleep quality. In this study, we did not explore the difference between the outbreak and non-outbreak times on sleep quality among health care workers. However, another study from us found that the quality of sleep among health care workers during the outbreak was better than that during non-outbreaks,[33] and whether this finding was real and its cause needs follow-up evidence.

Studies indicate that health care workers fighting against COVID-19 are generally under stress worldwide.[24,49–53] Our study shows that the perceived stress of health care workers in this outbreak was related to province, occupational categories, whether work affairs were the same as before, job category, adequate protection and burden of family care. Health care workers in Zhejiang had lower perceived stress levels than health care workers in Hubei and others, probably because Wuhan (the capital of Hubei Province) and Hubei were in the epicentre during the early stage of the epidemic. Health care workers in Wuhan were faced with various stressors, such as a shortage of medical professionals, a lack of supplies of personal protective equipment and medical devices, and a high possibility of occupational exposure; thus, their perceived stress was relatively high. Due to the large amount of coordination and management, the perceived stress of administrators was higher than that of registered nurses, medical doctors and medical technicians. Many health care workers left their original positions and stationed at the frontline during the COVID-19 outbreak, which increased their perceived stress. Health care workers who had possible contact with patients or body fluids had the highest stress, which may be due to uncertainty and inadequate protection, compared with health care workers who directly contacted confirmed patients with COVID-19. Health care workers without adequate protection had significantly higher perceived stress than those with adequate protection, and health care workers with a burden of family care had significantly higher perceived stress.

This study shows that 9.86% of health care workers in the COVID-19 response may have anxiety symptoms, and 10.37% of health care workers may have depression symptoms. Additionally, a multinational and multicentre study on the psychological outcomes among health care workers during the COVID-19 outbreak exhibited 8.7% moderate to extremely severe anxiety, and 5.3% screened positive for moderate to very severe depression.[54] Preliminary evidence in a recent review suggests that the incidence rate of anxiety and depression was 16–28%.[55] The positive rate of anxiety and depression symptoms in our survey was fairly low, which could be because the surveyed respondents consisted of health care workers working in the confirmed ward and community health care workers and other health care workers who were relatively less affected by the outbreak. The anxiety and non-anxiety symptom individuals as well as depression and non-depression symptom individuals were significantly different by province, if work affairs were the same as before, job category, and adequate protection. Moreover, the depression and non-depression symptom individuals were significantly different by professional title.

Confronting an unforeseen global event due to the COVID-19 outbreak, most individuals are exposed to an unprecedented stressful situation of unknown duration, which might not only increase stress, anxiety and depression symptom levels but also decrease sleep quality.[56] The final SEM model in the current study provides us with further evidence that mitigating stress and increasing coping could help reduce anxiety and depression symptoms, thereby improving the level of sleep quality among health care workers. Many health care workers from a qualitative study mentioned that they did not need a psychologist but needed more rest without interruption and enough protective supplies.[57] In addition to developing targeted strategies to mitigate key stressors, the urgent need for better sleep health management strategies should be emphasized during the COVID-19 crisis. Moreover, managing sleep problems as best as possible during the COVID-19 crisis could limit perceived stress and possibly prevent disruptions of social relationships.[56] The current wave of COVID-19 outbreaks, which began more than a year ago around the world, is still ongoing. To promote the mental health of health care workers, we should first put their actual needs through a stress reduction program, thereby fundamentally decreasing their anxiety and depression symptoms and improving sleep quality level. There are currently three available interventions for consideration: work interventions, psychosocial interventions, and pharmacotherapies.[58] Additionally, our organizations should intensify the efforts to improve humanistic concern in case health care workers may have become overexcited in clinical work and refused reasonable rest to ensure their health.[59] In addition, it is equally crucial for health care workers to maintain a balance between their needs and others' needs.[60] Briefly, we highlight the role of perceived stress or work stressors and tailored interventions to mitigate poor sleep quality and prevent long-term physical and psychological implications. Nevertheless, be sure to keep in mind that the current situation during the COVID-19 outbreak will not disappear overnight and the focus should be on longer-term occupational capacity rather than repeated short-term crisis responses, based on the WHO strong recommendations.[61,62] Future studies should aim to provide high-quality information on the long-term consequences and the effectiveness of applied interventions coping with COVID-19.

There are valuable strengths and key limitations. First, this study assessed sleep quality and perceived stress and anxiety and depression symptoms among health care workers during the COVID-19 crisis and explored associated factors and their interactions, which could provide clues to help precise interventions of sleep quality and other mental health problems for health care workers. Second, the inclusion of multidisciplinary health care workers allowed for comparison between different backgrounds. Nevertheless, some limitations should be noted. First, the snowball sampling in this study generally might mean poor representativeness due to constraints on resources and conditions. Second, the sample size is comparably small to other studies in this field, and no large-scale study was carried out on severe pandemic situations at the initial stage of outbreaks. This nonrandom sampling method with small samples could limit the generalizability of these findings. Third, a cross-sectional study design based on a rapid online survey cannot make valid causal inferences about the relationship between the study variables, and no follow-up data from different stages of the pandemic stages were collected, which does not allow us to analyse sleep quality and perceived stress over some time. Finally, to keep the survey time and the response rate acceptable, the sampled questions did not include some mediating and moderating variables (eg, psychological resilience, psychological capital, social support, self-compassion, self-care, and optimism) and potential confounders[15] (eg, work shifts, work schedule, sleeping accommodations, caffeine/nicotine intake, diets, and coexisting sleep disorders).

## Conclusions

Poor sleep quality and high perceived stress were common in Chinese health care workers during the COVID-19 pandemic. Reducing perceived stress could help reduce anxiety and depression symptoms, thereby improving sleep quality among health care workers. Moreover, in an attempt to promote psychological resources, we should perhaps take multiple measures, including personal tailored intervention and organizational humanistic concern.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors declare no conflicts of interest.

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