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Research on psychological stress and mental health of medical staff in COVID-19 prevention and control

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ABSTRACT

Background: The characteristics of COVID-19, such as the long incubation period, the fast transmission speed, the high demand for treatment, and the lack of prior treatment experience, have brought tremendous psychological stress to the medical staff involved in the epidemic prevention and control, seriously affecting the mental health of medical staff. Therefore, this paper conducts a discussion on the psychological stress and mental health of medical staff.

Methods: (1) Interview 28 medical staff fighting against COVID-19 from Wuhan Central Hospital and Hubei Provincial Hospital of Traditional Chinese medicine. They have worked as doctors in mental health departments, surgery departments and emergency departments, nurses and management staffs; (2) Based on interviews and literature, the questionnaire survey is conducted among 528 medical personnel from all over the country who have participated in the fight against COVID-19 in Wuhan; (3) Use the structural equation modeling to explore the influence mechanism of medical staff’s psychological stress and mental health in the prevention and control of COVID-19.

Results: The epidemic severity in hospital and the work intensity are the important psychological stressors for the front-line medical staff. Self-risk perception has a mediating effect on the severity of epidemic in hospitals and mental health of medical staff. Social identification has no moderating effect between the self-risk perception and the mental health.

1. Background

The COVID-19 outbreak around the world and was classified as a “public health emergency of global concern” by the World Health Organization (WHO) on January 30th, 2020. The outbreak of public health events bring great pressure to medical staff’s screening and treatment [1]. Studies have shown that the general practitioners in Italy are under great physical and psychological pressure while fighting against COVID-19, and the general practitioners with moderate or severe depression have reported more feelings of helplessness. The levels of their anxiety and insomnia have increased significantly due to inadequate personal protective equipment and the need to care for more COVID-19 patients [2]. When SARS broke out in 2003, the main stress of front-line medical staff mainly came from the pressure brought by the working environment and the self-vulnerability perception [3]. How feelings are processed is related to emotion, and both hypersensitivity and hyposensitivity can exaggerate negative emotions and thus increase depression [4]. The medical workers who had taken part in the fight against MERS in 2015 suffered from post-traumatic stress disorder long after the outbreak of the emergency [5]. All of these factors are likely to become psychological stressors for the medical personnel involved in the fight against COVID-19.

After outbreak of COVID-19 pandemic, the Chinese government immediately took direct and effective measures to stop the spread of the epidemic. To solve the shortage of medical resources in Hubei province, the approach of One Province For One City (OPFOC) was adopted to support Hubei province. Some information was sorted out about the OPFOC in Fig. 1.

In addition to the policy of OPFOC, some other countermeasures are also adopted to cut off transmission routes of the COVID-19 pandemic, such as the COVID-19 designated hospitals for sever patients in severe condition, cabin hospitals for patients with mild symptoms, designated hotels for quarantining the suspected patients and home quarantine for those with close contact with the suspected patients. Interviews with the health care workers at the designated hospitals have reported the high levels of physical and psychological stress that they have undergone in the fight against COVID-19. Some of the medical staff felt exhausted and lost their appetites. Some manifested anxiety and impatience. Some

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washed their hands repeatedly even when they returned to the hotel after work. Some even suffered from insomnia due to the great psychological stress. This paper, taking medical workers who have participated in the fight against COVID-19 pandemic as research objects, explores the process of psychological stressors affecting the physical and mental health of anti-epidemic medical staff. The research questions include:

1. What psychological stress do medical staff have to face in fighting the epidemic?
2. How does the psychological stress affect the physical and mental health of the medical staff?
3. What measures can the medical staff take to relieve their psychological stress in the fight against the epidemic?

2. Literature review

The research on stress can be traced back to Selye (Selye. H, 1956) in 1936. He considered stress as a general adaptation syndrome and put forward the concept of psychological stress, believing that psychological stress is an adaptive or coping response process that an individual makes when facing or perceiving environmental changes that threaten or challenge the organism [6]. The research on psychological stress is mainly divided into two schools: stress response theory and stress stimulus theory.

Stress response theory believes that when an individual, such as a human or an animal, encounters a threat or other stressors, their body is prepared to deal with the stress and restore their body to a stable state after the threat [7]. However, some researchers have confirmed that when an organism responds to this stressors, certain organs or systems in the body become less resistant to certain diseases, resulting in some devastating consequences. For example, when actively responding to stress, high cardiovascular response may make hypertension highly susceptible [8]. The risk of hypertension gradually increase with work pressure from low to high [9]. Recent studies have also shown that in addition to being susceptible to cardiovascular disease, people with previous experience of stress may also show slow response in the later stage [10].

The stress stimulus theory believes that external stimuli can cause the individual to produce physiological responses such as tension and fear, the representatives of which are Thomas Holmes and Richard Rahe (1967). Thomas Holmes and Richard Rahe believed that the nervous response of individual originates from the stimulus of external environment, namely the stressors. The stress stimulus theory emphasizes the impact of stress on people’s psychology, and thus affecting people’s physical and mental health. Relevant studies have shown that the chronic stressors of anything from a simple test taking to a major life event like the loss of a spouse and the caring for the unlived people are linked to increased inflammation marker [11,12]. More and more studies have further confirmed that elevated inflammatory markers can speed up the progression of diseases, such as AIDS and cancer [13,14].

Although many studies have explored the psychological impact of the epidemic on medical staff [2,15,16], how psychological stress affects the physical and mental health of medical staff is still unknown. This paper, using psychological stress as an intermediary variable and introducing a potential variable of self-risk perception to measure psychological stress, deeply analyzes the impact mechanism of psychological stress on physical and mental health of medical staff fighting against the epidemic.

3. Conceptual model

Occupational stress is recognized as a global phenomenon with significant impacts on economy and health [17]. Occupational stressors mainly include poor control ability, high job requirements, lack of information and other “bad” working background [18]. In public health emergencies, medical staff face not only physical and psychological pressure, but also pressure from the risk of close contact with infectious disease sources [19]. Following the COVID-19 outbreak, the number of medical staff in need increased dramatically. Even though the Chinese government mobilizes medical personnel and backbone teams from all over the country to provide assistance, the treatment needs of the local COVID-19 patients could not be met in a short time. The shortage of medical staff has brought a huge workload to the medical personnel involved in the fight against COVID-19 and also caused a lot of negative emotions and psychological distress to medical staff (Fig. 2).

![Fig. 1. Essential information of medical rescue team about OPFOC.](image-url)
3.1. Psychological stress

According to a study in India: the negative factors of anti-epidemic medical staff increase personal fears and concerns, such as whether they may become the source of infection, whether they are isolated/quarantined, whether they make their family members and other related staff at risk, whether they use the personal protective equipment improperly, whether the confinement and medical insurance of the epidemic cause family problems, and etc [20]. The Italian front-line general practitioners felt helpless at the lack of personal protective equipment to protect themselves from the new coronavirus [2]. Concerns for personal safety, family members and worry about the death of the patients are important triggers of stress for medical staff [21].

If the anti-epidemic medical staff changes from rescue workers to patients, such a sudden change of role may lead to frustration, helplessness, adaptation problems, stigma and fear of discrimination [22]. In order to further understand the difficulties and psychological pressures faced by medical staff in the fight against COVID-19, the study interviewed medical staff from two hospitals which are designated to treat patients with the epidemic, and found that their psychological stressors include:

1. The Insufficient protective materials in early stage and the fear of becoming a source of infection threatening life and the worries of the family members about the medical staff. With the adequate supply of protective materials in the later stage, the improvement of personal and public awareness of protection, and the increase of protection knowledge, the mental tension of the medical staff will not be as intense as it was at the beginning of the epidemic, although the pressure still exists.
2. The pressure formed due to the gap between the high expectation and fact that the professional level of medical staff cannot meet the requirements of patients due to lack of understanding of COVID-19 at the beginning of the epidemic. When the number of patients increases, the condition of patients get worse and the effect of medical assistance measures is not obvious, the mood of medical staff are extremely depressed. Some medical staff admitted that when they saw a patient being discharged from the hospital after recovery, they would experience a short-term emotional increase, but when they saw the patient’s condition worsening, irreversible scenes appearing repeatedly and more and more patients coming to the hospital for treatment but they could do nothing, their psychological endurance almost reached its limit and was on the verge of collapse. When this happens, colleagues would encourage each other, leaders would care about them, and family members would comfort them.
3. Stress caused by excessive workload. During the fight against the epidemic, not only the medical staff, but also the administrative staff and the logistics support staff admitted that their bodies were overloaded with work. According to the interview, it is rare for medical workers involved in the anti-epidemic rescue work to work less than 8 h a day, and the longest time is over 12 h. This kind of high-intensity workload poses a great challenge to the health of medical staff fighting the epidemic.
4. Pressure from other factors. Some medical staff participating in the interview said that they were under the pressure caused by conflicts with colleagues in the distribution of medical protective supplies, daily affairs other than professional work (such as filling in forms), and the incomprehension of the patient’s family members. These pressures were relatively light compared with the former pressures.

From the analysis above, it can be seen obviously that the main pressures of anti-epidemic medical personnel are the first three. To facilitate the study, variables measuring the first three factors were defined in this study as safety protection, epidemic severity in hospital and work intensity.

3.2. Self-risk perception and psychological health

Self-risk perception refers to people’s perception of the potential loss that they may encounter when pursuing the ideal results [23]. The three dimensions of risk perception are uncertainty, consequences and psychological panic [24]. And the undetected or uncontrollable risk is easily to be judged as high risk [25]. Self-risk perception is a process from external risk to people’s internal psychological cognition [26], through which the information of COVID-19 epidemic affects individuals’ coping behavior and mental health [27]. A report found that the higher the severity of anxiety and insomnia in general practitioners, the worse the mental and physical quality of their life [2]. Both sensory sensitivity and high levels of sensory avoidance are associated with depression and alexithymia [4]. Self-risk perception originates from the subjective judgment of individuals, when the probability of the occurrence of emergencies and the severity of the consequences are judged excessively, the self-risk perception is high, which trigger psychological reactions such as fear and anxiety, and thus have an impact on people’s mental health. Therefore, the first hypothesis is put forward:

**Hypothesis 1.** (H1). There is a significant negative effect between self-risk perception and mental health.

The formation and evolution of risk perception is a dynamic regulation process of continuous demand and retrieval of information. Different crisis events individual perceive different risks, which mainly depend on the source of crisis event information, communication subject and channel [28]. When the SARS broke out in 2003, the public’s perception of the epidemic risk was closely related to the public’s
familiarity with SARS, the severity of the epidemic situation and the influence of the surrounding population [29]. The severity of the epidemic affected people’s cognition and behavior. The degree of public concern was mainly related to the uncertainty and inevitability of the consequences of SARS. The data showed that people in the affected areas were significantly more affected by SARS than people in the non-affected areas [30]. When an individual is faced with an emergency, the scope, duration, various preventive measures and risk avoidance skills of the emergency affect the individual’s psychological reaction and behavior [31].

The latest research results show that in the case of COVID-19 outbreak, individual risk perception affects social distance between people, and the safety atmosphere is conducive to the mitigation of risk perception and the narrowing of social distance [32]. Information closely related to oneself, such as whether there are confirmed patients in the unit and region, whether there are confirmed patients among the people they know, are more likely to cause individual high-risk perception. Curative information and preventive measures in place can reduce the level of individual risk perception. Moreover, epidemic information affects individual mental health through risk perception [27]. From these findings, it can be seen that in emergencies, the impact of the epidemic and protective measures are important factors affecting the level of individual risk perception, which is consistent with the results of interviews with medical staff participating in the fight against COVID-19. The interview shows that safety protection and severity of the epidemic are important factors affecting the risk perception and behavior of medical staff. Some interviewees reported that when the number of patients increased and the healing effect was not obvious, they would feel very uncomfortable and suffer psychologically. This also indicates that the severity of the epidemic affects the mental health of individuals. Based on the above analysis, the following 4 hypotheses are proposed:

Hypothesis 2. (H2). There is a significant positive effect between the severity of in-hospital illness and self-risk perception.

Hypothesis 3. (H3). The severity of in-hospital illness negatively affects mental health through self-risk perception.

Hypothesis 4. (H4). There is a significant negative effect between the severity of in-hospital illness and mental health.

Hypothesis 5. (H5). The safety protection and self-risk perception of medical staff have significant negative effects.

3.3. Work intensity and psychological health

In addition to harmful biological, chemical and physical factors in the work environment, the work process can also lead to mental and psychological overload, which constitutes a serious potential adverse health factors, occupational stress [33]. A survey of Italian general practitioners showed that the caring for an increasing number of COVID-19 patients has caused moderate to severe depressive symptoms among them [2].

In the early stage of the outbreak of the epidemic, excessive workload caused different degrees of psychological pressure on medical staff [34]. During the interview, it was learned that the medical staff involved in the front-line fight against the epidemic not only had to maintain good communication with patients from different social groups, but also had to bear heavy labor intensity and long working hours due to the shortage of manpower. The number of patients and the number of days occupied in bed were more than usual. Therefore, it can be considered that excessive work intensity is also one of the important risk factors affecting health-related quality of life, and work intensity affects mental health through the occurrence of physical and mental diseases. Hence, the sixth hypothesis is proposed:

Hypothesis 6. (H6). There is a significant negative effect between work intensity and mental health of medical staff.

3.4. Social identity and mental health

The core principle of social identity is individual self-cognition, which comes not just from their personal identity, but also from the social categorization to which they belong to Ref. [35]. When an individual defines himself as a member of a specific group, he takes this social identity as a reference, thus influencing his own thinking and behavior [36]. Because social identity fundamentally shapes individual’s psychology and behavior, it has an important impact on his health. Studies have shown that strong social identity can better promote depression recovery [37], and interventions to increase social identity are more beneficial to physical and mental health than smoking cessation or regular exercise [38].

Experimental evidence also suggests that psychological resources provided by social identity, such as meaning, purpose and support, can buffer self-perceived health threats [39–41]. Positive factors can boost the morale of anti-epidemic medical staff. Social support, such as support from others, encouragement from colleagues, recognition and appreciation from peers/patients, can reduce anxiety and stress levels of medical staff and improve their self-efficacy [42]. During the fight against the epidemic, some medical staff participating in the interview believed that the high praise and affirmation for front-line medical workers from the society would make them proud and consider what they did as a thing of social value. However, some medical workers held a neutral attitude towards this view. Therefore, to some extent, we believe that social identity has a certain regulatory effect on people’s mental health, so we put forward the last hypothesis:

Hypothesis 7. (H7). Social identity plays a moderating role in the influence of self-risk perception on mental health.

Based on the above analysis, the conceptual framework model of this research is proposed.

4. Methodology

4.1. Study design and setting

This study is conducted by collecting empirical and survey data (using a mixed research methods).

The first step is to design an interview outline and conduct a preliminary survey, asking the medical staff involved in COVID-19 epidemic the following questions: Whether were they under great psychological stress while fighting the epidemic? How did the psychological stress affect their physical and mental health? What are the specific manifestations? How do they cope with it when their psychological stress arises?

Informal one-to-one interviews are conducted with a sample of about 30 medical staff from the designated COVID-19 hospitals to find out the psychological stress status of the anti-epidemic medical staff.

The second step is to design a set of questionnaires based on the literature review and the first step. The questionnaire is composed of two parts. One is the basic information of the respondents, which is used to understand the basic characteristics of population statistics. It is an objective multiple-choice question. The other part measures the variables of the conceptual model and measures them through a set of subjective questions, so as to obtain the dimensions of the impact on the physical and mental health of the anti-epidemic medical staff and the extent of the impact varying from strongly disagree to strongly agree. The dimensions of the impact on the physical and mental health of personnel and the extent of their impact are very subjective. The dependent variable of the questionnaire is physical and mental health, and the independent variables consists of work intensity, epidemic severity in hospital and safety protection. The variables were stated on a set of 5-point Likert scales, where “1” = “strongly disagree” and “5” =
"strongly agree". The score of a variable is the arithmetic mean of the sum of the dimensions under each variable.

The questionnaires is distributed to about 500 medical staff involved in the fight against COVID-19 pandemic. The data of the questionnaires is collected to find the evidence on whether they were under great psychological stress and how the psychological stress affected their physical and mental health.

The questionnaires are only for medical personnel who have participated in the fight against COVID-19.

4.2. Participants

The participants of the interview were 28 medical workers from two designated hospitals for COVID-19 patients, including 18 females, accounting for 64.3% of the total medical personnel, and 10 males, accounting for 35.7%. There were 9 doctors, accounting for 32.1% of the total medical personnel, 15 nurses, accounting for 53.6%, and 4 medical technicians, accounting for 14.3%. The first interview was conducted on June 12, 2020, and the last interview was on June 21, 2020.

The questionnaire is conducted online, with respondents including front-line doctors, nurses, hospital administrative staff, students or interns. Basic information on demographic characteristics includes gender, age, education level, type of occupation, severity of the epidemic in the place of residence, epidemic situation in the working hospital, and physical condition (with or without underlying diseases).

The questionnaire was released on July 2, 2020 and ended on July 20. A total of 569 questionnaires were collected. Through logical screening and eliminating the questionnaires with suspected untrue answers and the questionnaires with too short answering time, 528 valid questionnaires were received, the effective rate of the questionnaire was 92.79%, and the average response time of the valid questionnaires was 238 s.

In this survey, more than half (368) of the participants were female, accounting for 69.7% of the total participants, and the other 30.3% were male. Those aging between 31 and 45 accounted for 53.6%. And there were more doctors than nurses, 58.71% for doctors and 24.81% for nurses. The demographic characteristics of the respondents are shown in Table 1.

### Table 1. Demographic profile of the overall sample.

| Variables                      | N   | %    |
|-------------------------------|-----|------|
| Gender                        |     |      |
| Male                          | 160 | 30.3 |
| Female                        | 368 | 69.7 |
| Age                           |     |      |
| 18-25 years old               | 92  | 17.42|
| 26-30 years old               | 93  | 17.61|
| 31-45 years old               | 283 | 53.6 |
| More than 46 years old        | 60  | 11.36|
| Education level               |     |      |
| Bachelor’s degree             | 312 | 59.09|
| Master’s degree               | 130 | 24.62|
| PhD                           | 30  | 5.68 |
| Other degree                  | 56  | 10.61|
| Severity of epidemic in the place Where you live |     |      |
| Low risk areas                | 106 | 20.08|
| Medium risk areas             | 65  | 12.31|
| High risk areas               | 357 | 67.61|
| Severity of epidemic in your Hospital |     |      |
| The most severity             | 110 | 20.83|
| More severity                 | 163 | 30.87|
| Medium severity               | 108 | 20.45|
| lower severity                | 56  | 10.61|
| The lowest severity           | 91  | 17.23|
| Any underlying disease do you have |     |      |
| Yes                           | 50  | 9.47 |
| No                            | 478 | 90.53|

4.3. Measures

According to the set theoretical framework model, there are 6 variables to be measured, which are safety protection, epidemic severity in hospital, self-risk perception, social identity, work intensity and mental health.

The measurement of safety protection is based on the safety awareness scale developed by Wang and De Mao et al., and is measured from three dimensions of safety cognition, safety attitude and safety actions [43,44]. Description items, SP (1–2), SP (3–5) and SP (6–8), were respectively used to assess the safety cognition, safety attitude and safety actions of the anti-epidemic medical staff. The higher the score, the better the safety protection.

The epidemic severity in hospital was measured by referring to the latest situation of the national epidemic and the graphic description standard of Zhang Yan at that time, and the national regions were divided into five levels according to the severity of the epidemic: the most severe region, the more severe region, the intermediate region, the mild region and the milder region [47]. Epidemic severity in hospital was assessed through the description item of ESH (1–3). The higher the score, the more severe the epidemic in the hospital was.

The measurement of Self-risk perception refers to a paradigm of risk perception measurement proposed by Slovic from the perspective of psychology [46], and four dimensions of possibility, severity, impact and persistence of infection are selected in combination with the development of epidemic situation. The description item RP (1–3) was used to evaluate the self-risk perception of the anti-epidemic medical staff. The higher the score, the higher the self-perceived risk.

The measurement of social identity, based on the research of Frings and Gong Keyu [47,48] is carried out from five dimensions: professional value, professional remuneration, professional reputation, professional belonging and professional evaluation of medical staff. The description item SI (1–5) was used to assess the social identity of the anti-epidemic medical staff. The higher the score, the higher the social identity.

The measurement of work intensity, based on the research data of Jin Xiaoning and Sami [19–50], is conducted from five dimensions: the working hours, leisure time, the number of bed days, the number of patients and the physical condition of medical staff after work. The description item WI (1–5) was used to assess the work intensity of the anti-epidemic medical staff. The higher the score, the higher the work intensity.

The measurement of mental health is based on the research results of D1enerh and Vitterson, and the questions are designed from five dimensions of anxiety, depression, compulsion, impulsiveness and loneliness [51,52]. The description item PH (1–5) was used to measure the mental health level of the anti-epidemic medical workers. The higher the score, the greater the psychological stress they felt.

According to the measurement dimension of variables, a preliminary scale with 7 factors and 37 questions is compiled. Principal component analysis (PCA), orthogonal rotation method (Varimax method) and maximum variance method are used for exploratory factor analysis [53–55]. Questions with ambiguous meanings were deleted, and questions with similar meanings were merged to form a 28-question questionnaire. See Table 2 for details.

4.4. Data analysis procedure

The data analysis after questionnaire collection is divided into four steps:

Step 1: Descriptive statistical analysis. Descriptive statistical analysis is carried out on the collected data, including the mean value, standard deviation and correlation analysis of variables. This part is carried out with the help of SPSS21.0 statistical tools.

Step 2: EFA (Exploratory Factor Analysis) and CFA (Confirmatory
Table 2  
Overview of variables.

| Latent Variables          | Codes of observed variables | Survey instrument statements                                                                                           |
|---------------------------|-----------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Safe Protection           | SP1                         | You are familiar with the standard protocol for prevention and control of COVID-19.                                   |
|                           | SP2                         | You have a good understanding of the protective equipment and requirements for the prevention and control of COVID-19.|
|                           | SP3                         | You are satisfied with the work of relevant government departments or units on the prevention and control of COVID-19, such as safety promotion and protection, and guidance. |
|                           | SP4                         | You attach great importance to infection in the prevention and control of COVID-19.                                      |
|                           | SP5                         | You know how to take timely measures if you are at a risk of getting infected and exposed to COVID-19.                 |
|                           | SP6                         | You will actively participate in the operational training of epidemic prevention and control knowledge.                 |
|                           | SP7                         | You will tell your family how to strengthen the prevention and control of COVID-19.                                      |
|                           | SP8                         | You will investigate the potential transmission hazards of COVID-19 in the surrounding environment.                    |
| Epidemic severity in hospital | ESH1                     | You consider the intensity of exposure in hospital is relatively high.                                               |
|                           | ESH2                         | You think the probability of virus infection in hospital is relatively high.                                          |
|                           | ESH3                         | You think the rate of increase of confirmed cases in hospital is relatively fast.                                       |
| Self-risk perception      | RP1                         | You think it will have a greater impact on your life if you are infected with COVID-19.                                |
|                           | RP2                         | You will get scared if you are infected with COVID-19.                                                                |
|                           | RP3                         | You think it will take a long time to get back to your normal life if you are infected with COVID-19.                 |
| Social Identity           | SI1                         | You are satisfied with the remuneration of the medical workers involved in the epidemic prevention and control.       |
|                           | SI2                         | You can feel the social admiration for the medical staff involved in prevention and control of the epidemic.           |
|                           | SI3                         | You will continue to be a doctor if you have the opportunity to choose your career again.                              |
|                           | SI4                         | You will be very happy to hear the praise for the medical staff involved in prevention and control of the epidemic.    |
| Work Intensity            | WI1                         | You worked for a long time on average every day (over 8 h) during your participation in the epidemic prevention and control. |
|                           | WI2                         | You feel very tired after work every day when you participate in prevention and control of the epidemic.               |
|                           | WI3                         | You spend very little time on leisure activities during the epidemic prevention and control (less than 1 h per day on average). |
|                           | WI4                         | You have a large number of patients involved in the prevention and control of the epidemic.                            |
|                           | WI5                         | You have a lot of bed-occupied days in your participation in epidemic prevention and control.                           |

Table 2 (continued)  

| Latent Variables          | Codes of observed variables | Survey instrument statements                                                                                           |
|---------------------------|-----------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Psychological health      | PH2                         | You have difficulty falling asleep and sleeping peacefully during the anti-epidemic period.                          |
|                           | PH3                         | You are always afraid of something terrible will happen during the anti-epidemic period.                            |
|                           | PH4                         | You cannot feel the support of the society or the care of your family during the anti-epidemic period.             |
|                           | PH5                         | You can’t help washing your hands repeatedly during the anti-epidemic period.                                        |

Factor Analysis). Exploratory factor analysis is used to establish the construct validity of scale and questionnaire, and confirmatory factor analysis is used to test the appropriateness and authenticity of construct validity. This part is carried out with the help of SPSS21.0 and AMOS statistical tools.

Step 3: Structural equation modeling analysis. It includes the control of measurement errors and the prediction of the influence of psychological stress on mental health. This part is carried out with the help of AMOS.

Step 4: Regulation test. Use the method of stratified regression to test the moderating effect of social identity on mental health. This part is completed with the help of SPSS21.0 statistical tools.

5. Results

5.1. Preliminary analysis

The absolute values of all observed variables are $<2$ and kurtosis $<4$, which meet the normal distribution [56,57]. The mean value, standard deviation and mutual coefficient matrix of variables are shown in Table 3.

As shown in Table 3, the severity of COVID-19 in hospitals is significantly positively correlated with the self-perceived risk of medical staff ($r = 0.315, p < 0.01$), so the H2 hypothesis is verified. The relationship between risk perception and mental health among medical staff ($r = 0.435, p < 0.01$), that between the working intensity and mental health of medical staff ($r = 0.384, p < 0.01$) and that between epidemic severity in hospital and staff mental health ($r = 0.311, p < 0.01$) are all significant positive correlation, which means the higher the score level, the epidemic situation in hospital, and the greater the work intensity, the higher the score of mental health measurement index of medical staff. Combined with the questionnaire, it is known that the score of mental health measurement index and mental health value is a pair of reciprocal indicators,¹ So the H1, H4 and H6 are verified.

Reliability analysis is to test the consistency of the questionnaire. Cronbach $\alpha$ is used to test the homogeneity reliability of the questionnaire. Validity analysis is to test the accuracy of measurement tools, including content validity and structure validity analysis, which is completed by combining EFA and CFA. The reliability and efficiency analysis is completed with the help of SPSS21.0.

SPSS 21.0 software statistically analyzes the data collected from the questionnaire, checks the KMO value and Bartlett’s sphericity of the

¹ The higher the score of mental health in the scale, the worse the mental health of the participants. In this study, the data from the mental health questionnaire was analyzed without reverse processing, and the statistical result was interpreted in reverse.
questionnaire, and analyzes the validity of the questionnaire. The KMO value of the questionnaire is 0.84 (> 0.8); the Sig. Value of Bartlett’s spherical test was 0.000 (< 0.01), indicating that the scale is suitable for factor analysis.

Using principal component analysis, six principal factors are extracted based on the feature value greater than 1. Through factor analysis, the cumulative contribution rate of the six main factors is 68.03%, which manifests that the six main factors can reflect 68.03% of the original 28 variables. Thus it is believed that this questionnaire has a good validity. Cronbach α coefficient is used for reliability analysis, and the results show that the coefficient of each latent variable is between 0.853 and 0.901, indicating that the measurement of the scale has satisfactory reliability and the questionnaire has high reliability. The Cronbach α value of each latent variable and the specific information of variable factors are shown in Table 4.

5.2. SEM analysis

Regardless of the adjustment effect of social recognition, in order to verify the relationship between the mental health of medical staff and the influencing factors and their relative importance in the fight against COVID-19, this study import the data of 5 potential variables including safety protection, epidemic severity in hospitals, self-risk perception, work intensity and mental health as well as their 28 observation variables into the set model, which is run by AMOS, to obtain the model identification indicators (see Table 5) and recognition model (see Fig. 3) as follows.

According to Table 5, AGFI = 0.875, RMR = 0.088 and RMSEA = 0.059, these three indicators are reasonably adapted [58], and other

| Table 3 | Basic statistical information of variables. |
|---------|--------------------------------------------|
| Variables | MD  | SD   | SP  | SEH | RP   | SI  | WI  | PH    |
| SP       | 4.36| 0.53 | –   | –   | –    | –   | –   | –     |
| ESH      | 3.37| 0.94 | –0.02| –   | –    | –   | –   | –     |
| RP       | 3.84| 0.87 | 0.02| .315**| –    | –   | –   | –     |
| SI       | 3.85| 0.73 | .268**| –0.03| –.116**| –   | –   | –     |
| WI       | 3.5 | 0.78 | .999*| .382**| .204**| 0.01| –   | –     |
| PH       | 2.13| 0.77 | 0.02| .311**| .435**| –0.08| –.384**| –     |

| Table 4 | Results of reliability and validity analysis. |
|---------|-----------------------------------------------|
| Variables | Codes | Factors | α  | CR  | AVE  |
| Safe protection | SP1 | 0.81 | 0.901 | 0.903 | 0.543 |
|  | SP2 | 0.79 | –   | –   | –   |
|  | SP3 | 0.51 | –   | –   | –   |
|  | SP4 | 0.80 | –   | –   | –   |
|  | SP5 | 0.82 | –   | –   | –   |
|  | SP6 | 0.85 | –   | –   | –   |
|  | SP7 | 0.82 | –   | –   | –   |
|  | SP8 | 0.73 | –   | –   | –   |
| Epidemic severity in hospital | ESH1 | 0.86 | 0.855 | 0.866 | 0.686 |
|  | ESH2 | 0.87 | –   | –   | –   |
|  | ESH3 | 0.78 | –   | –   | –   |
| Self-risk perception | RP1 | 0.81 | 0.866 | 0.868 | 0.688 |
|  | RP2 | 0.81 | –   | –   | –   |
|  | RP3 | 0.84 | –   | –   | –   |
| Social Identity | SI1 | 0.75 | 0.721 | 0.735 | 0.411 |
|  | SI2 | 0.72 | –   | –   | –   |
|  | SI3 | 0.73 | –   | –   | –   |
|  | SI4 | 0.71 | –   | –   | –   |
| Work Intensity | WI1 | 0.77 | 0.853 | 0.876 | 0.5993 |
|  | WI2 | 0.75 | –   | –   | –   |
|  | WI3 | 0.81 | –   | –   | –   |
|  | WI4 | 0.76 | –   | –   | –   |
|  | WI5 | 0.73 | –   | –   | –   |
| Psychological health | PH1 | 0.89 | 0.895 | 0.890 | 0.623 |
|  | PH2 | 0.83 | –   | –   | –   |
|  | PH3 | 0.80 | –   | –   | –   |
|  | PH4 | 0.78 | –   | –   | –   |
|  | PH5 | 0.69 | –   | –   | –   |
| Eigenvalue | 6.11 | 1.84 | 2.04 | 1.46 | 2.42 | 5.18 |
| Proportion of Variance (%) | 21.83 | 6.56 | 7.28 | 5.2 | 8.66 | 18.50 |
| Cumulative of Variance (%) | 21.83 | 28.39 | 35.67 | 40.87 | 48.15 | 68.03 |

Note: $\chi^2 = 661.85; \text{df} = 231$. 

| Table 5 | Identification index of model. |
|---------|--------------------------------|
| Fit Indices | Baseline | Estimated value |
| $\chi^2$/df | <3.00 | 2.865 |
| GFI | >0.90 (good) | 0.903 |
| AGFI | >0.80 (reasonable) | 0.875 |
| RMR | <0.05 (good) | 0.088 |
| RMSEA | <0.05 (good) | 0.059 |
| CFI | >0.90 | 0.946 |
| NFI | >0.90 | 0.92 |
| TLI | >0.90 | 0.935 |
| PNFI | >0.50 | 0.77 |
| PGFI | >0.50 | 0.696 |
indicators are well adapted [59, 60], indicating that the model has a high fitting degree.

In Fig. 3, self-risk perception has a significant negative effect on mental health, and the standardized path coefficient is significant, \( \beta = 0.412, P < 0.01 \). The standardized coefficient between work intensity and mental health is \( \beta = 0.283, P < 0.01 \). The standardized path coefficient between the epidemic severity in hospital and the self-risk perception of medical staff is \( \beta = 0.353, p < 0.01 \); which are consistent with the assumptions of H1, H6 and H2 that have been proved earlier. The standardized path coefficient between safety protection and self-risk perception of medical staff is \( \beta = 0.042, P < 0.365 \), and it fails the significance test. Table 3 also shows that the negative correlation between safety protection and self-risk perception of medical staff is not obvious, which may be related to whether the supply of protective materials is sufficient. In the interview, the interviewees felt that the lack of protective materials in the early stage of the outbreak would increase the risk perception level of the medical staff, and they did not worry about being infected when the protective materials were fully supplied in the later stage, so the hypothesis of H5 is not supported by the data. Therefore, it is assumed that H5 is not supported by the data. The path coefficients of the structural equation modeling are shown in Table 6.

5.3. Mediating effect of self-risk perception on psychological health among medical staff during COVID-19

Fig. 3 shows that the standardized path coefficient between the epidemic severity in hospital and the self-risk perception of medical staff, and the standardized path coefficient between risk perception and the mental health of medical staff are significantly not 0. Therefore, it is inferred that self-risk perception plays an intermediary role in the impact of epidemic severity on mental health of medical staff. The Bootstrap method is used to test the mediating effect of the mediating model [61]. This study used 5000 samples to evaluate the mediating effect of the epidemic severity on mental health. The results are shown in Table 7.

Under the 95% confidence interval (CI), the bias correction confidence interval (BC) and percentile position confidence interval (PC) of the mediating utility are not 0. The significance test is passed, which indicates that the mediating effect of self-risk perception of medical staff is obvious during the anti-epidemic period. At the same time, since the direct effect of the epidemic severity on mental health of medical staff does not include 0, it manifests that the influence of self-risk perception on mental health of medical staff is part of the intermediary effect. Hence, H3 has been verified.

5.4. Moderation effect of social identity

In order to test H7: the moderating effect of social identity between self-risk perception and mental health of anti-epidemic medical staff, this study uses hierarchical moderated regression to examine the size of the moderating effect. Before the test, the interaction variables of social identity and self-risk perception were added and the results of the hierarchical regression obtained by running SPSS21.0 were shown in Table 7.

![Table 6](image)

| Path | Unstandardized path coefficients | Standardized path coefficients | S.E. | C.R. | p  |
|------|---------------------------------|--------------------------------|------|------|----|
| SP→RP | 0.065                           | 0.042                          | 0.072| 0.905| 0.365 |
| ESH→RP | 0.319                           | 0.353                          | 0.044| 7.169| ***  |
| RP→PH | 0.441                           | 0.412                          | 0.052| 8.439| ***  |
| ESH→PH | 0.08                            | 0.083                          | 0.045| 1.769| 0.077 |
| WI→PH | 0.263                           | 0.283                          | 0.041| 6.347| ***  |

![Table 7](image)

| Model Pathways | effects | Point estimation | Bootstrapping | |
|----------------|---------|------------------|---------------|---|
|                |         |                  | Bias-corrected| Percentile 95% |
|                |         |                  | Lower | Uper | Lower | Uper |
| ESH→PH | Total effects | 0.314 | 0.213 | 0.421 | 0.213 | 0.42 |
|         | Direct effects | 0.166 | 0.065 | 0.26 | 0.066 | 0.268 |
|         | Indirect effects | 0.148 | 0.099 | 0.212 | 0.096 | 0.209 |
The epidemic severity in hospital not only affects the mental health of the medical staff directly, but also affects their mental health indirectly through their self-risk perception level. When the mean level of the epidemic severity in hospital reached 3.375 points of the 5-point scale, the direct path utility coefficient from the epidemic severity in hospital to mental health is 0.166, and the indirect path utility coefficient is 0.148, which is similar to those of the previous studies [27, 29, 32]. The study has found that the mediating effect of self-risk perception is equivalent to the direct effect of the severity of the epidemic on mental health. The findings suggest that in addition to control the severity of the epidemic, reducing the level of risk perception among front-line health care workers should not be ignored, which provides a certain direction for both the relief the psychological pressure of medical staff and the focus and content of media coverage of the epidemic.

6.3. The moderating role of social identity and psychological health among medical staff

Many studies have shown that there is a correlation between social identity and mental health. It is believed that social identity spiritually guides people’s psychology and behavior, thus affecting people’s health [68, 69], and increasing social identity is more beneficial than other measures to the physical and mental health of medical staff [38, 42]. However, this study does not get similar results. When testing H7, the moderating effect of social identity on mental health is not significant (Table 8). One reason may be that this study is a retrospective study, and the questionnaire was conducted in July when the epidemic has been basically under control and the mental health of many medical staff has gradually improved or even returned to normal, so the survey results may be biased. Another reason may be that medical staff are underpaid. SI1 is a survey on the satisfaction of first-line medical staff with remuneration. The results show that 34.47% of medical staff think the remuneration is average, 8.71% are not satisfied with the remuneration and 6.63% are very dissatisfied with the remuneration. In other words, 49.81% of anti-epidemic health workers think that their work has not been properly paid.

7. Conclusions

In the fight against COVID-19, the results of this study demonstrate that safety protection, the severity of the epidemic situation and work intensity are important risk factors affecting front-line medical staff. Moreover, self-risk perception has an important intermediary effect on the mental health of medical staff. However, the absence of similar results in demonstrating the role of social identity in self-risk perception and mental health regulation suggests a need for flexibility while considering the role of social identity in the relationship between self-risk perception and mental health among COVID-19 medical staff.

Therefore, in addition to attaching great importance to the epidemic situation development, on the one hand, the government should take measures to reduce the self-risk perception level and the work intensity of the medical staff, increase their treatment, and develop more appropriate psychological interventions to build optimistic attitude in psychological impact of working hard. When front-line medical staff become the source of infection, they feel terrified and helpless [22]. According to the survey results, front-line medical staff are very afraid of being infected by COVID-19 (the average score for this problem is 3.84 out of 5). They believe that once infected, even recovery has a great impact on their life and it takes a long time to recover (the average score is 3.92 out of 5). The findings indicate that front-line health workers involved in the COVID-19 outbreak have a heavy psychological burden, which poses a serious threat to their mental health.

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Therefore, in addition to attaching great importance to the epidemic situation development, on the one hand, the government should take measures to reduce the self-risk perception level and the work intensity of the medical staff, increase their treatment, and develop more appropriate psychological interventions to build optimistic attitude in...
coping with the stress of work, thus promoting their mental health. On the other hand, as the results of the survey show the severity of the epidemic in hospital has a mediating effect on the mental health of medical staff through self-risk perception, the medical staff themselves should take active coping measures, such as strengthening the awareness of safety protection, participating in the study of safety knowledge and emergency skills, and improving the ability of risk prevention, to relieve their own psychological stress.

It is hoped that this study can not only provide a basis for the medical staff to apply good decompression measures to relieve their psychological stress, but also provide a directive reference for both the government to establish policies on the mental health of medical staff and the media news reports.

8. Limitations

The limitation of this study is that all the respondents were from the medical workers who have participated in the epidemic fighting in Hubei province, and no data were collected from the medical workers in other places. Therefore, geographical limitation may affect the representativeness of the samples, and the results of this study may not necessarily be applicable to all anti-epidemic medical workers.

In addition, although the questionnaire was designed with reference to the widely used scale applicable to the general population, it was not a scale exclusively for anti-epidemic medical personnel, thus its reliability and validity have not been verified. It is necessary for future research to develop an exclusive scale with good reliability and validity that can reflect the psychological state of the anti-epidemic medical staff, such as self-risk perception and lockdown [70], etc.

Author contributions

Several authors have contributed to this paper, as follows: Conceptualization, Yinggui QIU, and Qian WU methodology, Yinggui QIU software, SPSS 21.0 and AMOS; formal analysis, Yinggui QIU; investigation, Yinggui QIU and Qian WU; resources, Rui CHEN, Mei WU and Yan ZHOU; writing—original draft preparation, Yinggui QIU; Project administration Cuiling GUAN. All authors have read and agreed to the published version of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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