

# A Nomogram-Based Study: A Way Forward to Predict the Anxiety Status in Medical Staff During the COVID-19 Pandemic

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**Background and Objective:** Anxiety influences job burnout and health. This study aimed to establish a nomogram to predict the anxiety status of medical staff during the coronavirus disease (COVID-19) pandemic.

**Methods:** A total of 600 medical members were randomized 7:3 and divided into training and validation sets. The data was collected using a questionnaire. Logistic regression analysis and Akaike information criterion (AIC) were applied to investigate the risk factors for anxiety. Odds ratio (OR) and 95% confidence interval (95% CI) were calculated to establish a nomogram.

**Results:** Participation time (OR=44.28, 95% CI=13.13~149.32), rest time (OR=38.50, 95% CI=10.43~142.19), epidemic prevention area (OR=10.16, 95% CI=3.51~29.40), epidemic prevention equipment (OR=15.24, 95% CI=5.73~40.55), family support (OR=9.63, 95% CI=3.55~26.11), colleague infection (OR=6.25, 95% CI=2.18~19.11), and gender (OR=3.30, 95% CI=1.15~9.47) were the independent risk factors ( $P<0.05$ ) for anxiety in medical staff. The areas under the receiver operating characteristic (ROC) curves of the training and validation sets were 0.987 and 0.946, respectively. The decision curve's net benefit shows the nomogram's clinical utility.

**Conclusion:** The nomogram established in this study exhibited an excellent ability to predict anxiety status with sufficient discriminatory power and calibration. Our findings provide a protocol for predicting and identifying anxiety status in medical staff during the COVID-19 pandemic.

**Keywords:** nomogram, anxiety, COVID-19, medical staff

## Introduction

The COVID-19 outbreak has caused widespread psychological distress among the public. The unexpected nature of the illness, home isolation and confinement, a lack of clarity from authorities about the severity of the risk, or individual emotional spillover are all risk factors for this rise.<sup>1,2</sup> The psychological burden is exceptionally high among medical personnel, who face additional group-specific demands.<sup>3</sup> Long work hours, strict instructions and safety procedures, a constant need for focus and alertness, restricted social connection, and participation in tasks for which they may not be trained are all examples of exceptionally high job-related stressors.<sup>4,5</sup> These stressors have been linked to medical personnel's emotional distress during the COVID-19 pandemic, which may have become a source of anxiety.<sup>6,7</sup> According to recent research, medical professionals may be experiencing the highest levels of anxiety<sup>8</sup> because they are often responsible for treating COVID-19 patients and are more psychologically stressed. The fear of getting sick of an increasing virus load, and—most importantly—all types of discourses and approaches that undervalue the work of

healthcare professionals who put their health at risk are main contributors to burnout during epidemic periods like COVID-19. People who work in fields like “health”, which directly benefit people and place a premium on interpersonal relationships, are more likely to experience burnout.<sup>9,10</sup> Anxiety is a risk factor for job burnout.<sup>11–13</sup> In addition, medical staffs are prone to anxiety when encountering emergencies.<sup>10,14–16</sup> Since December 2019, novel coronavirus pneumonia (COVID-19) has broken and swept worldwide.<sup>17</sup>

Physicians, nurses, and other healthcare professionals who have frequent contact with patients may experience stress, anxiety, and burnout, which may impair their ability to perform their jobs, deteriorate their health and lower their quality of life. When it comes to healthcare workers, the anxiety that develops during or after a crisis intervention may affect their capacity for abstract thought, mental reasoning, and coordination. Their ability to solve problems can be impacted by various emotions, including fear and anxiety. Reduced problem-solving skills could result in less effective services being offered to safeguard public health, improve living conditions, and protect individual health.<sup>7,18,19</sup>

Therefore, it is significantly necessary to identify and predict anxiety in medical staff early, which contributes to reasonable and optimized medical staff configuration during COVID-19 pandemic. Herein, a cross-sectional study was conducted to identify anxiety in medical staff during epidemic prevention and mediating risk factors. Study employed a questionnaire collecting the data of participants, which included basic information (age, gender, marital status, occupation, professional title, hospital level, educational background), information relevant to work against COVID-19 (workplace, participation time, convenience of traffic, case of colleague infection, family supports as well as sufficient or insufficient mask, isolation clothes and salary) and Hamilton anxiety scale. Following data generated from respondents, a nomogram was established and validated internally and externally. Results in this study showed that the nomogram exhibits an excellent ability to predict anxiety status with sufficient discriminatory power and calibration. Therefore, in line with the preceding points, our proposed model may provide a protocol for anticipating and detecting anxiety in medical personnel during the COVID-19 pandemic.

## Materials and Methods

### Study Subjects

600 medical staff participating in battle against COVID-19 epidemic in China from February 1st, 2020, to May 30th, 2020, were enrolled in this study. The inclusion criteria were as follows: (1) medical personnels were on duty, and they were working in the fever clinics, isolation wards and quarantine hotels, and engaging in pre-inspection and quarantine; (2) the time for medical staff to engage themselves in epidemic prevention and control was no less than two weeks.

Exclusion Criteria: medical staff who were not involved in the battle against the COVID-19 epidemic and those who did not cooperate with the questionnaire.

### Data Collection

The basic information and relevant data of included medical staff who participated in the epidemic prevention of the COVID-19 pandemic in China from February 1st, 2020, to May 30th, 2020, were collected through a questionnaire. Questionnaires were distributed randomly to included medical staff by two investigators. The recording and collation of obtained data were in charge of a specially-assigned person. The quality control of the entered data was supervised by two investigators each other to ensure integrity and authenticity.

### Nomogram Establishment and Validation

Included cases were randomized 7:3 and divided into a training set of 420 and a validation set of 180 cases. Logistic regression analysis was applied to investigate the risk factors for anxiety. Next, the independent risk factors for anxiety were identified based on the Akaike information criterion (AIC). The odds ratio (OR) and 95% confidence interval (95% CI) were calculated and a nomogram model was established. The established nomogram was assessed by discrimination and calibration and validated internally and externally using the training and validation sets. The area evaluated the discrimination ability of the nomogram under the receiver operating characteristic (ROC) curve. The area under the ROC curve ranges from 0.5 to 1.0, with 0.5 ~ 0.7, 0.7 ~ 0.85 and 0.85 ~ 0.95 indicating low, fair

and high predictive value, respectively. The accuracy of the constructed nomogram was assessed by a calibration plot (ie, the comparison of nomogram-predicted probabilities and actual anxiety in medical staff). The close value of predicted probabilities to standard curve indicated positive predictive value and high accuracy. The decision curve analysis (DCA) was used to analyze the net benefit of the nomogram and assess the clinical utility.

## Statistical Analysis

Enumeration data were expressed as the number of cases and constituent ratio, and the chi-square test and Fisher's exact test were used to compare groups. All statistical analyses were conducted using Stata15 software, and the nomogram was constructed using R software. All reported P values were two-sided and P-value <0.05 was statistically considered significant.

## Results

### Basic Information

The demographic characteristics and baseline data of the study sample are shown in Table 1. A total of 258 cases were identified as anxious according to the criteria of Anxiety (Hamilton Anxiety Scale scored > 14), and the incidence rate of anxiety was 43%. This high incidence rate of anxiety indicates excessive perceived stress of a person.

**Table 1** Demographic Characteristics and Baseline Data of the Study Sample

Characteristic	Category	Cases of Anxiety	Cases of Un-Anxiety	$\chi^2$ value	P value
Gender	Males	7	81	7.223	0.007
	Females	58	226		
Age, years	20~29	20	87	6.144	0.15
	30~39	35	143		
	40~49	5	62		
	50~59	5	15		
Marital status	Not married	5	60	10.892	0.004
	Married	60	227		
	Divorced	0	20		
Occupation	Physician	31	138	0.162	0.687
	Nurse	34	169		
Professional title	No title	5	30	7.953	0.047
	Primary	10	82		
	Intermediate	33	152		
	Senior	17	43		
Educational background	Specialist Education	14	51	1.339	0.512
	Bachelor degree	40	211		
	Master degree	11	45		
Work place	Intersection quarantine point	32	148	28.072	<0.001
	Follow-up for pre-inspection	0	60		
	Fever clinics	26	94		
	Isolation wards	7	5		
Case of colleague infection	Uninfected	37	301	108.941	<0.001
	Infected	28	6		
Family supports	Supported	30	188	53.229	<0.001
	Not care	19	114		
	Not supported	16	5		
Mask	Very sufficient	0	15	11.857	0.018
	Relatively sufficient	5	36		
	Generally sufficient	23	132		
	Relatively inadequate	20	47		
	Inadequate	17	77		

(Continued)

**Table 1** (Continued).

Characteristic	Category	Cases of Anxiety	Cases of Un-Anxiety	X <sup>2</sup> value	P value
Isolation clothes	Very sufficient	5	15	12.675	0.013
	Relatively sufficient	22	57		
	Generally sufficient	11	105		
	Relatively inadequate	17	94		
	Inadequate	10	36		
Salary	Very reasonable	5	12	17.368	0.002
	Relatively reasonable	18	88		
	Generally reasonable	25	136		
	Relatively unreasonable	17	36		
	Irreasonable	0	35		
Convenience of traffic	Very convenient	5	42	12.5	0.014
	Relatively convenient	17	105		
	Generally convenient	17	88		
	Relatively inconvenient	16	57		
	Inconvenient	10	15		
Participation time	<1 week	0	5	23.995	<0.001
	1~2 weeks	0	5		
	2~3 weeks	5	42		
	3~4 weeks	0	63		
	>4 weeks	60	192		
Break time	One day a week	37	205	45.923	<0.001
	One day every two weeks	12	17		
	One day every three weeks	6	0		
	One day every four weeks	5	20		
	No time to rest	5	65		
Epidemic prevention area	In Hubei Province	21	11	56.144	<0.001
	Outside Hubei Province	44	296		

## Logistic Regression Analysis

Anxiety or non-anxiety was the outcome and logistic regression analysis was performed. The variance inflation factors (less than 5) indicated the collinearity between the various variables and the eligibility for logistic regression analysis. Univariate logistic regression analysis on the training set showed that participation time, rest time, epidemic prevention area, epidemic prevention equipment, family support, colleague infection, gender and years of work were risk factors for Anxiety ( $P < 0.05$ ) (Table 2). Multivariate logistic regression analysis demonstrated that participation time (OR=44.28, 95% CI=13.13~149.32), rest time (OR=38.50, 95% CI=10.43~142.19), epidemic prevention area (OR=10.16, 95% CI=3.51~29.40), epidemic prevention equipment (OR=15.24, 95% CI=5.73~40.55), family support (OR=9.63, 95% CI=3.55~26.11), colleague infection (OR=6.25, 95% CI=2.18~19.11), gender (OR=3.30, 95% CI=1.15~9.47) were the independent risk factors for anxiety ( $P < 0.05$ , minimized AIC=137.39) (Table 3).

**Table 2** Results from Univariate Logistic Regression Analysis

Variables	OR	95% CI	P value
Work place for epidemic prevention	1.32	1.01~1.74	<0.05
Participation time	2.72	1.54~4.82	<0.05
Isolation clothes	0.86	0.67~1.10	>0.05
Mask	1.30	1.01~1.67	<0.05
Break time	0.93	0.78~1.10	>0.05
Salary	0.86	0.65~1.13	>0.05

(Continued)

**Table 2** (Continued).

Variables	OR	95% CI	P value
Convenience of traffic	1.46	1.15~1.86	<0.05
Personnel cooperation	2.13	1.51~3.01	<0.05
Family supports	2.62	1.71~4.00	<0.05
Case of colleague infection	37.96	14.75~97.73	<0.05
Hospital level	0.92	0.72~1.17	>0.05
Epidemic prevention area	12.84	5.80~28.45	<0.05
Age	0.87	0.62~1.21	>0.05
Marital status	1.24	0.88~1.76	>0.05
Gender	2.97	1.30~6.77	<0.05
Educational background	0.92	0.58~1.47	>0.05
Professional title	1.51	1.08~2.13	<0.05

**Abbreviations:** OR, odds ratio; CI, confidence interval.

**Table 3** Results from Multivariate Logistic Regression Analysis

Contributing Factors	OR	95% CI	P value
Participation time	7.35	3.10~17.45	<0.05
Convenience of traffic	1.78	1.26~2.52	<0.05
Case of colleague infection	32.51	10.51~100.59	<0.05
Work place for epidemic prevention	10.29	3.21~33.03	<0.05
Gender	4.31	1.40~13.24	<0.05
Professional title	2.06	1.26~3.36	<0.05

**Abbreviations:** OR, odds ratio; CI, confidence interval.

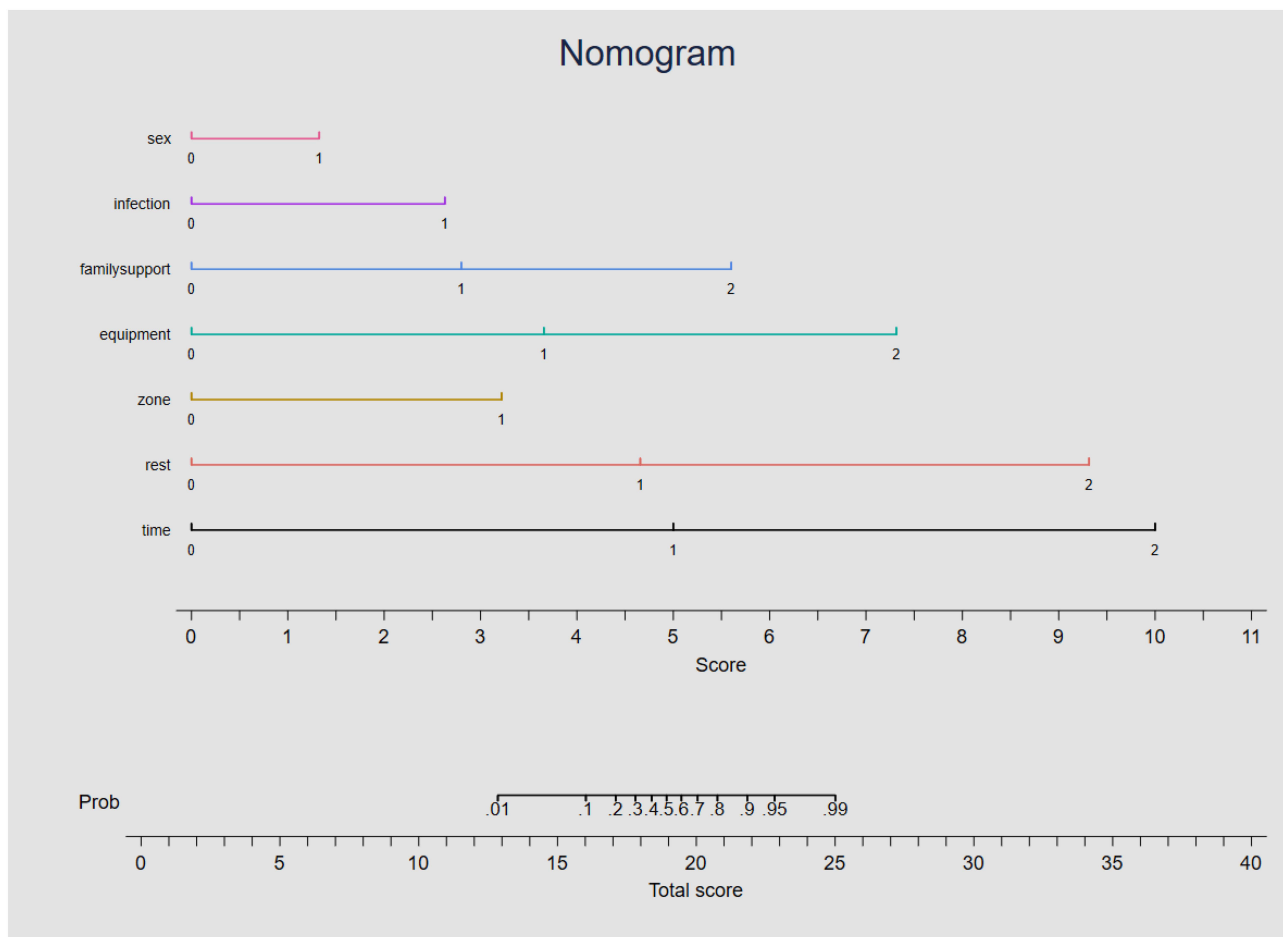
## Establishment and Evaluation of a Nomogram

Based on the independent risk factors screened, a nomogram was established (Figure 1) and validated internally in the training set and externally in the validation set. The area under the ROC curve in the training set was 0.987, indicating the constructed nomogram's good predictive accuracy and discriminative ability (Figure 2A). The calibration plot (Figure 2B) almost coincides with the idealized reference line, suggesting the well-calibrated nomogram. Results from the Hosmer-Lemeshow goodness of fit test ( $\chi^2=104.88$ ,  $P=0.99$ ) also suggest good calibration of the nomogram. Similarly, the area under the ROC curve in the validation set was 0.946, indicating good predictive accuracy and discriminative ability of the nomogram (Figure 3A). The calibration plot (Figure 3B) almost coincides with the idealized reference line, suggesting that the nomogram was well calibrated. Results from the Hosmer-Lemeshow goodness of fit test ( $\chi^2=80.35$ ,  $P=0.98$ ) also suggest good calibration of the nomogram. DCA demonstrated good net benefit when the threshold probability was 0.04~0.99 (Figure 4).

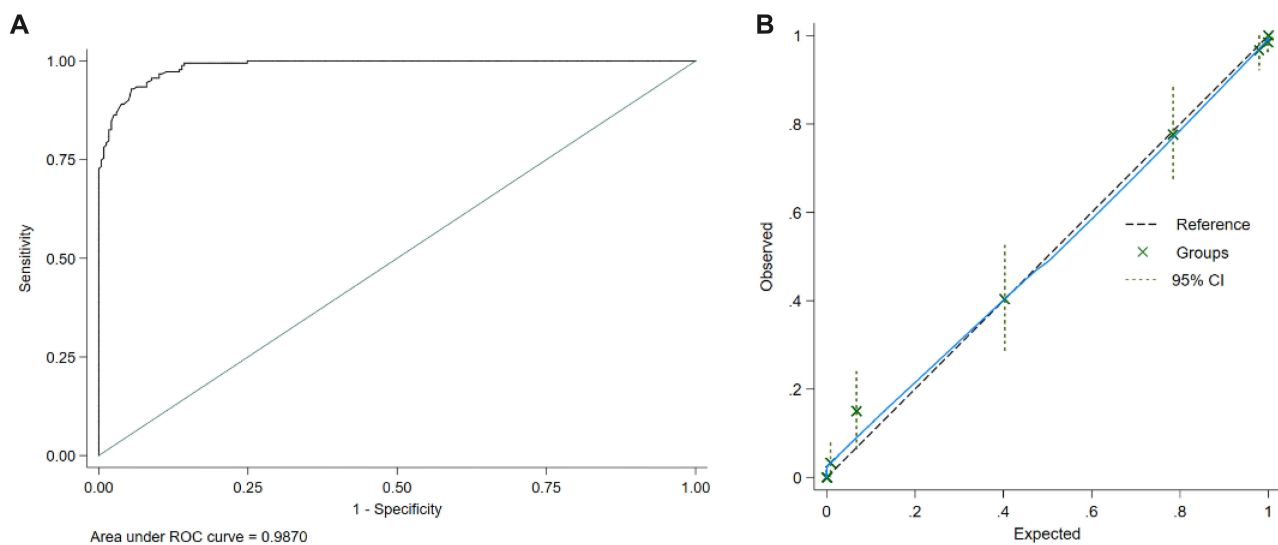
## Discussion

Emergencies have been shown to make people more prone to anxiety,<sup>20–22</sup> so medical personnel and places that prevent epidemics are recognized as independent risk factors for anxiety.<sup>23–26</sup> For example, the coronavirus pandemic, which has significantly impacted the world and resulted in thousands of fatalities, has forced healthcare experts to labor at a frenetic pace.

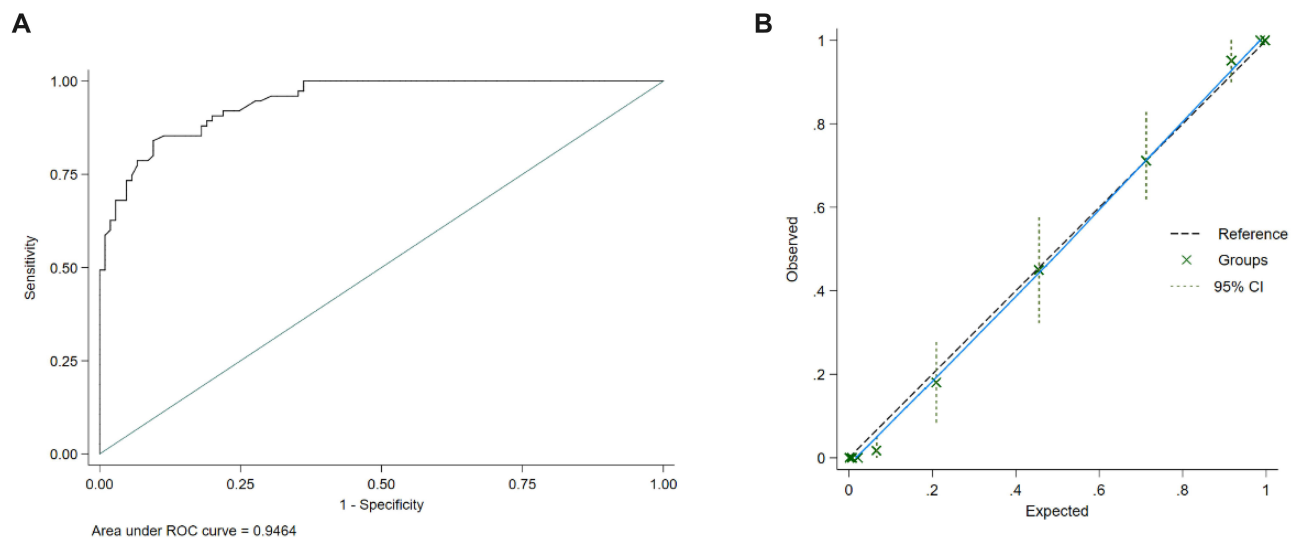
Our current study has examined how the COVID-19 epidemic affected their quality of life. To meet the hypothesis and scope of the study, we went through the measuring of participation time, epidemic prevention area and epidemic prevention equipment utilized to identify the risk factors for anxiety in medical staff during the period of the COVID-19 pandemic in their workplaces. To find how medical staff involved in treating COVID-19 patients could be dealing with serious mental health issues that can be a root cause of anxiety, we determine the prevalence rates of anxiety in medical workers. Furthermore, our research contains data on the increase in insufficient rest time, unsupported family, and



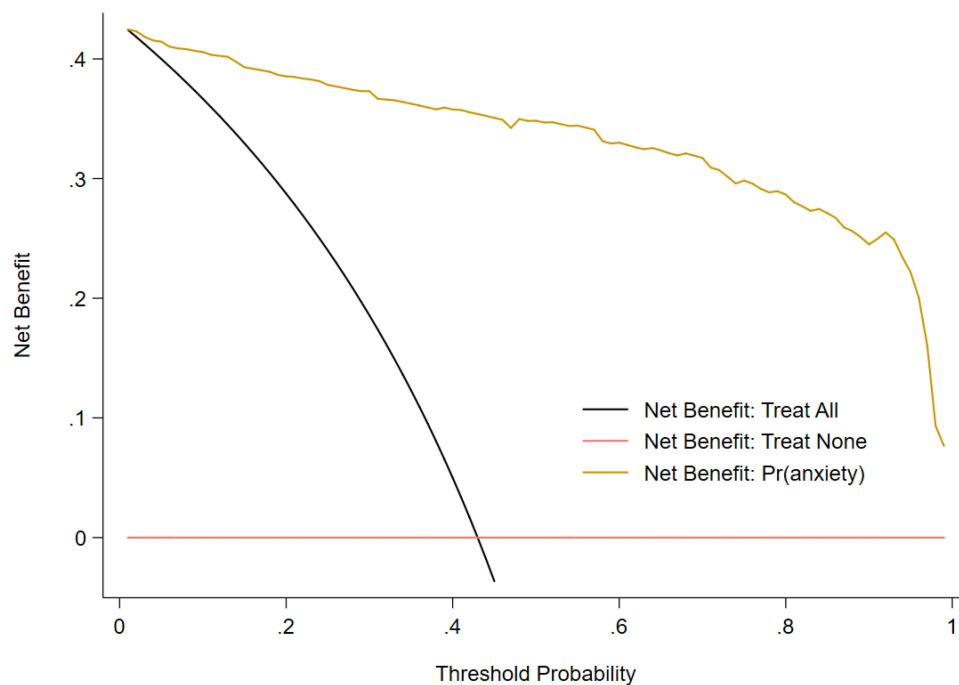
**Figure 1** The nomogram to predict the anxiety in medical staff during the period of epidemic prevention and control. “Time” indicates the participation time, “rest” indicates rest time, “zone” indicates the epidemic prevention area, “equipment” indicates epidemic prevention equipment, “infection” indicates the colleague infection.



**Figure 2** Internal validation of the nomogram. (A) The ROC curve in the training set. (B) The calibration plot in the training set.



**Figure 3** External validation of the nomogram. **(A)** The ROC curve in the validation set. **(B)** The calibration plot in the validation set.



**Figure 4** Decision curve analyses. “Treat All” indicates the positive control that all subjects experienced treatment. “Treat None” indicates the negative control that all subjects experienced no treatment. “Pr(anxiety)” indicates the net benefit increment for the anxiety risk prediction using the constructed nomogram.

infected colleagues related to the overall anxiety prevalence. Our findings supplemented the rest time (OR = 38.50, 95% CI = 10.43 ~ 142.19), family support (OR = 9.63, 95% CI = 3.55 ~ 26.11), and colleague infection (OR = 6.25, 95% CI = 2.18 ~ 19.11) as independent risk factors for anxiety in medical staff. Our studies also showed the effect of insufficient rest time on anxiety more than that of unsupported family and colleague infection on anxiety.

There is a correlation between anxiety and burnout and anxious medical staff are prone to job burnout.<sup>27–29</sup> The reasonable and optimized medical staff configuration during the COVID-19 pandemic, therefore, requires the prediction and identification of anxiety in the medical staff at an early stage. Our findings significantly link with previous studies.<sup>30,31</sup> For example, a multicenter online survey conducted in China to assess the mental health of healthcare



professionals revealed that 44.7% had signs of anxiety.<sup>32–34</sup> On the other hand, only 15.7% of the respondents in global research carried out in Singapore and India displayed anxiety symptoms.<sup>35,36</sup> Internal and external validation of the constructed nomogram in the present study demonstrated its accuracy in calculating the probability of anxiety in medical staff, with excellent discrimination and acceptable calibration.

There are still some limitations in this study. Firstly, there is a difference in the area under the ROC curve between the training and validation sets. Therefore, a more optimal prediction model can be constructed by increasing the sample size in a cross-sectional survey. Secondly, the established nomogram is limited to predicting the anxiety status of Chinese medical staff, because the data collected in this study are from within the territory of China.

## Conclusions

In conclusion, the study reveals high stress, anxiety, and burnout among healthcare professionals working during the COVID-19 pandemic. In particular, the constructed nomogram can predict anxiety status with sufficient discriminatory power and calibration. The study provides a baseline protocol for predicting and identifying anxiety status in medical staff during the COVID-19 pandemic. Considering the advantage of simplicity, intuitiveness and practicability over the traditional methods, we believe that established nomogram has specific auxiliary value in the clinical application of identifying anxiety in medical staff.

## Ethical Statement

The “Branch approved the study for Biomedicine Study, Henan University ethics committee”, and participants obtained consent. Moreover, the study has adopted all the guidelines outlined in the declaration of Helsinki’s ethical principles.

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## Disclosure

The authors declare no competing interest in this work.

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