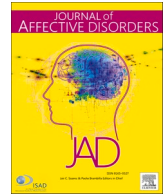




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The associations between COVID-19 vaccination and psychological disorders among healthcare workers in China

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ABSTRACT

Introduction: COVID-19 has caused an unprecedented psychological affection that might impact the nationwide vaccination program in China. This study was to explore the association between COVID-19 vaccination and psychological disorders among healthcare workers.

Methods: The study included 1571 healthcare workers from an anonymous online survey. Participants' socio-demographic characteristics, uptake data for the COVID-19 vaccine, and scores of the Depression, Anxiety, and Stress Scale (DASS-21) were collected. Nonparametric tests were conducted to compare the mean scores of DASS-21 between different subgroups. The potential factors related to psychological disorders of healthcare workers were analyzed using logistic regression.

Results: The vaccination rate was 69.6 %, the incidence of vaccine-related adverse events was 35.13 %, and the prevalence of depression, anxiety, and stress were 24.8 %, 32 %, and 33.4 % in this study, respectively. Compared to vaccinated participants (single-dose and double-dose vaccines), unvaccinated participants got significantly higher mean scores of DASS-21 ($p < 0.05$ for all). Vaccinated participants who suffered no adverse events scored significantly lower than those who suffered 1–2 or ≥ 3 adverse events ($p < 0.05$ for all). Vaccination was negatively associated with higher depression, anxiety, and stress, however, the number of vaccine-related adverse events was positively associated with them.

Limitations: As this is a cross-sectional study, we could only speculate on the causality.

Conclusions: An obvious impact of the psychological disorders on the COVID-19 vaccine coverage and related adverse events was detected in this study. Public health agencies should attach great importance to the psychological states of our citizens before getting vaccinated.

1. Introduction

The outbreak of the novel coronavirus disease 2019 (COVID-19) has caused unprecedented psychological, socio-economic, and health problems among the world's population (Ceylan et al., 2020; Fofana et al., 2020; French et al., 2020; Liu et al., 2021; Sher, 2020). Although China has effectively controlled the pandemic, the local clustered epidemic, caused by imported Delta and Omicron variants, was still reported frequently in many cities in China (Wang et al., 2021a; Yuan et al., 2022). This added more unpredictability and uncertainty to the spread of COVID-19. Hence, preventing transmission and addressing the

potential challenges are still crucial issues for the national healthcare system.

From a scientific perspective, widespread vaccination against COVID-19 with highly effective vaccines represents an important tool in efforts to control the pandemic (Izda et al., 2021; Sharma et al., 2020). Meanwhile, phase 3 trials should also be designed to assess individual-level efficacy and safety before the approval of the COVID-19 vaccine (Dutta, 2020; Lipsitch and Dean, 2020). However, most of the current studies typically focus on the final efficacy of the vaccine, regarding entirely preventing the virus infection for reducing transmission (Mehrotra et al., 2021). Also, even more unaware questions about the

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characteristics of the COVID-19 vaccine are likely to remain after the trials are completed (Kostoff et al., 2020; Patel et al., 2021). As a result, less attention has been placed on vaccine-related adverse events and influential factors.

Extensive research in public mental health has established that numerous psychological problems including stress, depression, anxiety, irritability, insomnia, and frustration were ubiquitous in the affected populations during the pandemic (Luo et al., 2020; Wu et al., 2020; Xiong et al., 2020). Additionally, psychological disorders including depression, anxiety, and stress were more common in healthcare workers who experienced high-stress work and had the risk of exposure to the COVID-19 virus (Gautam et al., 2020; Lasalvia et al., 2020; Mattila et al., 2021). According to the experience, the outbreak of pandemics as well as Severe Acute Respiratory Syndromes (SARS), Middle East Respiratory Syndrome (MERS), and the Ebola virus would have caused the burden of long-term psychological affection on the healthcare workers (Magnavita et al., 2021). Therefore, it is imperative to take notice of the continuous changes and the impacts of the psychological burden on healthcare workers, for those who were an essential part of the global frontline pandemic response.

China had conducted a nationwide COVID-19 vaccination program to consolidate the anti-epidemic intervention in early 2021. Healthcare workers were the first group to administer the COVID-19 vaccine as acquiring priority. But the uptake rate of the COVID-19 vaccine was unknown under the earlier stage of the policy on voluntary vaccination. In addition, clusters of anxiety-related events after COVID-19 vaccination were reported to the Centers for Disease Control (CDCs) in different countries (Hause et al., 2021; Madison et al., 2021; Palacios et al., 2020; Shimabukuro, 2021a, 2021b; Shimabukuro and Nair, 2021; Xia et al., 2020; Xia et al., 2021). Consistent with these reports, a lot of healthcare workers also stated suffering different levels of symptoms such as dizziness, lethargy, fever, and others after getting vaccinated. To our knowledge, several previous studies have demonstrated that stress, depression, and poor health behaviors can impair the immune system's response to vaccines (Madison et al., 2021). However, so far there has not been any statistical analysis conducted in attempting to identify if or how the COVID-19 vaccination decision and vaccine-related adverse events were influenced by the psychological disorders among healthcare workers.

Based on these considerations, the purpose of this study was to examine the relationships between COVID-19 vaccine coverage and related adverse events and psychological disorders (depression, anxiety, and stress) among healthcare workers in China. This study hypothesized that negative affective states might impact healthcare workers' vaccination decisions, and it might also be linked to a range of vaccine-related adverse events of them.

2. Methods

2.1. Study design and participants

This cross-sectional study was conducted from March to April 2021, while the first wave of the mass COVID-19 vaccination program was being implemented simultaneously. A web-based questionnaire (depending on the popular online platform: <https://www.wjx.cn>) was spread among the invited participants via professional and scientific associations, following a snowball strategy. The initial participants (seeds) were leaders of doctors, nurses, pharmacists, social workers, and administrators who had a certain degree of reputation in the healthcare systems (hospitals, public health agencies, and healthcare agencies) of China.

This study was approved by the Research Ethics Committee of Plastic Surgery Hospital of Chinese Academy of Medical Science (2021/21) and registered at the Chinese Clinical Trial Registry (Registration number: ChiCTR2100043832). Informed consent was obtained by all participants before completing the online questionnaire. Participation was voluntary

without any financial compensation and all data was collected anonymously.

2.2. Data collection and variables

Participants' information was collected by the questionnaire (Supplementary Material) consisting of sociodemographic characteristics, uptake data of COVID-19 vaccine, and DASS-21 (Depression, Anxiety, and Stress Scale). After reviewing a series of literature, the details of the questionnaire were well elaborated and were in accordant with relevant guidelines and regulations. Additionally, an anti-counterfeiting test question was embedded in the questionnaire to extract carelessness respondents on purpose. According to the branching logic that whether questions were applied to the relative individual participants, the number of the survey questions varied respectively.

2.2.1. Sociodemographic characteristics

Participants were asked to fill in their sociodemographic information in this part, which contained gender, age, ethnic group, religious belief, marital status, educational background, province, department, academic rank, monthly income, daily working time, and the number of chronic diseases.

The ethnic groups were divided into HAN and minorities. Marital status was coded into single, in love, married without children, and married with children. According to the Chinese standard classification of education codes, the educational background was categorized into college, bachelor, graduate, doctor, and post-doctor. Participants were also asked to report whether they lived in the capital city of China (Beijing). The department of the healthcare workers was collected as internal medicine, surgery, and others. Academic rank was coded into clinical practice, primary title, middle title, and high title. The monthly income (Chinese Yuan, CNY) was recorded into <5000, 5000–10,000, 10,000–15,000, and >15,000. The number of the chronic diseases was determined by a report that whether the following listed diseases (hypertension, glaucoma, diabetes, cataract, benign prostatic hyperplasia, chronic bronchitis, cardio-cerebrovascular disease, asthma, and others) were previously diagnosed by a doctor or not.

2.2.2. Uptake data of COVID-19 vaccine

Related information was collected by the following questions. 1. Have you ever taken part in supporting anti-epidemic for the severe areas? (yes/no). 2. Have you ever got vaccinated (single-dose or double-dose vaccines)? (yes/no). 3. Which of the following adverse events (none, dizziness, headache, fatigue, fever, hypersomnia, insomnia, chills, dryness-heat, excitement, hyperventilation, cough, asitia, nausea, vomiting, diarrhea, tickle, erythrina) occurred after vaccination? The number of adverse events that occurred to individuals was also summed up. The Chronbach's alpha of this part was 0.70 in this study.

2.2.3. DASS-21

To assess the psychological symptoms of the participants, DASS-21 (Osman et al., 2012) was used in this study. It was a standardized measurement scale that indicated different levels of agreement with the 21 items on a 4-point Likert scale (0 = Did not apply to me at all, 1 = Applied to me to some degree or some of the time, 2 = Applied to me a considerable degree or a good part of the time, 3 = Applied to me very much or most of the time). The 21 items were categorized into three subscales which measured depression, anxiety, and stress with the sum scores. The cutoff scores were used to indicate different levels of depressive, anxious, and stress symptoms, respectively. The Chronbach's alpha of the three subscales of DASS-21 were 0.90, 0.87 and 0.90, and 0.96 for the total DASS-21 in this study.

2.3. Statistical analysis

In this study, descriptive analysis was used to illustrate the

sociodemographic characteristics, uptake data of the COVID-19 vaccine, and different levels of depressive, anxious, and stress symptoms. Continuous variables were expressed as means (M) and standard deviation (SD), and percentages were used to describe the categorical variables.

The Wilcoxon rank test was used to compare the difference in DASS-21 scores (depression, anxiety, and stress scores) between the vaccinated and unvaccinated participants. According to the uptake data of the COVID-19 vaccine, all participants were divided into single-dose, double-dose, and unvaccinated groups, and vaccinated participants were divided into none, 1–2, and ≥3 adverse events groups. The comparisons of DASS-21 scores were carried out using the Kruskal-Wallis H (for 3 samples) test for these groups. Furthermore, the Student-Newman-Keuls (SNKs) test was also conducted for multiple comparisons when appropriate.

The logistic regression analyses were conducted to investigate the association between potential variables and psychological disorders in this study. Results were reported for the univariable (crude) and multivariable (adj = adjusted) analysis of variables (gender, age, ethnic group, religious belief, marital status, educational background, province, department, academic rank, monthly income, daily working time, the number of chronic diseases, supporting anti-epidemic, COVID-19 vaccination, number of vaccine-related adverse events) for predicting depression, anxiety, and stress separately. The estimates of the strengths of associations were demonstrated by the odds ratio (OR) with a 95 % confidence interval (CI). A two-tailed $p < 0.05$ was considered statistically significant. All statistical analyses were performed using Statistical Analysis Software 9.2 (SAS 9.2).

3. Results

In this study, 1572 out of 1578 total participants completed the questionnaire, giving a completion rate of 99.62 %. One questionnaire completed carelessly was excluded and so 1571 valid questionnaires were included in our analysis finally. Table 1 shows the descriptive statistics of participants' baseline information. The majority were female (66.8 %), married with children (69.4 %), well-educated (89.3 %, at least a bachelor's degree), and middle to high academic rank (75.6 %). The mean age of the participants was 34.74 (SD = 7.77) years old, and their daily working time was 9.20 (SD = 1.86) hours. Up to the deadline of this survey, 69.6 % of the participants got vaccinated. Among the 1093 healthcare workers who were administered COVID-19 vaccines, 35.13 % of them stated they had suffered from one or more vaccine-related adverse events. The prevalence of depression, anxiety, and stress (from mild to extremely severe) in this study were 24.8 %, 32 %, and 33.4 %, respectively.

3.1. Comparison of the DASS-21 scores between vaccinated and unvaccinated healthcare workers

As is shown in Table 2, the mean scores of DASS-21 were significantly higher in unvaccinated healthcare workers compared to vaccinated healthcare workers [depression: 6.44 (SD = 6.84) versus 5.15 (SD = 6.05), Wilcoxon rank test, $p = 0.0004$; anxiety: 6.36 (SD = 6.42) vs. 4.87 (SD = 5.25), Wilcoxon rank test, $p < 0.0001$; stress: 9.26 (SD = 8.31) vs. 7.56 (SD = 7.20), Wilcoxon rank test, $p = 0.0005$].

3.2. Comparison of DASS-21 scores among the single-dose, double-dose, and unvaccinated groups

Analysis of DASS-21 scores between the single-dose, double-dose, and unvaccinated groups are shown in Table 3. The Kruskal-Wallis H test revealed that unvaccinated healthcare workers got significantly higher scores comparatively overall (depression, $p = 0.0005$; anxiety, $p = 0.0002$; stress, $p = 0.0003$, respectively). However, the SNKs test showed that there were no significant differences in DASS-21 scores

Table 1
Descriptive statistics of participants' baseline information.

Variables	Total participants (n = 1571)
Sociodemographic characteristics	
Gender, n (%)	
Male	521 (33.2 %)
Female	1050 (66.8 %)
Age, years (Mean ± SD)	34.74 ± 7.77
Ethnic group, n (%)	
Han	1543 (98.2 %)
Minorities	28 (1.8 %)
Religious belief, n (%)	
Yes	90 (5.7 %)
No	1481 (94.3 %)
Marital status, n (%)	
Single	222 (14.1 %)
In love	106 (6.8 %)
Married without children	152 (9.7 %)
Married with children	1091 (69.4 %)
Educational background, n (%)	
College	168 (10.7 %)
Bachelor	1088 (69.3 %)
Graduate	227 (14.4 %)
Doctor	74 (4.7 %)
Post-doctor	14 (0.9 %)
Province, n (%)	
Beijing	41 (2.6 %)
Out of Beijing	1530 (97.4 %)
Department, n (%)	
Internal medicine	135 (8.6 %)
Surgery	240 (15.3 %)
Others	1196 (76.1 %)
Academic rank, n (%)	
Clinical Practice	81 (5.2 %)
Primary title	302 (19.2 %)
Middle title	935 (59.5 %)
High title	253 (16.1 %)
Monthly income (CNY), n (%)	
<5000	651 (41.4 %)
5000–10,000	719 (45.8 %)
10,000–15,000	160 (10.2 %)
>15,000	41 (2.6 %)
Daily working time, Hours (Mean ± SD)	9.20 ± 1.86
Number of Chronic diseases, n (%)	
0	1389 (88.4 %)
1	151 (9.6 %)
2	25 (1.6 %)
≥3	6 (0.4 %)
Uptake data of COVID-19 vaccine	
Supporting anti-epidemic in severe areas, n (%)	
Yes	74 (4.7 %)
No	1497 (94.1 %)
COVID-19 vaccination, n (%)	
Yes	1093 (69.6 %)
No	478 (30.4 %)
Number of vaccine-related adverse events, n (%)	
0	1187 (75.5 %)
1–2	309 (19.7 %)
≥3	75 (4.8 %)
Psychological symptoms	
Depression, n (%)	
Normal	1181 (75.2 %)
Mild	179 (11.4 %)
Moderate	173 (11.0 %)
Severe	28 (1.8 %)
Extremely severe	10 (0.6 %)
Anxiety, n (%)	
Normal	1068 (68.0 %)
Mild	144 (9.2 %)
Moderate	263 (16.7 %)
Severe	57 (3.6 %)
Extremely severe	39 (2.5 %)
Stress, n (%)	
Normal	1047 (66.6 %)
Mild	385 (24.5 %)
Moderate	117 (7.5 %)
Severe	16 (1.0 %)
Extremely severe	6 (0.4 %)

Abbreviations: SD, standard deviation; DASS-21, Depression, Anxiety and Stress Scale; COVID-19, Coronavirus disease 2019; CNY, Chinese Yuan.

Table 2
Comparison of DASS-21 scores between vaccinated and unvaccinated healthcare workers.

DASS-21 scores, mean (SD)	Vaccinated (n = 1093)	Unvaccinated (n = 478)	P*
Depression	5.15 (6.05)	6.44 (6.84)	0.0004
Anxiety	4.87 (5.25)	6.36 (6.42)	<0.0001
Stress	7.56 (7.20)	9.26 (8.31)	0.0005

Abbreviations: SD, standard deviation; DASS-21, Depression, Anxiety and Stress Scale.

* Indicates the Wilcoxon rank test. P < 0.05 indicates a significant difference.

Table 3
Comparison of DASS-21 scores among the single-dose, the double-dose, and unvaccinated groups.

DASS-21 scores, mean (SD)	Single-dose (n = 234)	Double-dose (n = 859)	Unvaccinated (n = 478)	P*
Depression	4.79 (6.39)	5.25 (5.96)**	6.44 (6.84)***	0.0005
Anxiety	4.64 (5.33)	4.93 (5.23)**	6.36 (6.42)***	0.0002
Stress	6.91 (7.38)	7.74 (7.15)**	9.26 (8.31)***	0.0003

Abbreviations: SD, standard deviation; DASS-21, Depression, Anxiety and Stress Scale.

Note: The vaccinated healthcare workers were divided into the single-dose group and the double-dose group.

The Student-Newman-Keuls (SNKs) test was also performed for multiple comparisons.

* Indicates the Kruskal-Wallis test. P < 0.05 indicates a significant difference.

** Indicates a significant difference between double-dose group and unvaccinated group.

*** Indicates a significant difference between single-dose group and unvaccinated group.

between the single-dose and double-dose groups.

3.3. Comparison of the DASS-21 scores among the vaccinated healthcare workers with different adverse events

As shown in Table 4. The Kruskal-Wallis H test was used to compare

Table 4
Comparison of DASS-21 scores among the vaccinated healthcare workers with different adverse events.

DASS-21 scores, mean (SD)	None adverse events (n = 709)	1–2 adverse events (n = 309)	≥3 adverse events (n = 75)	P*
Depression	4.67 (6.01)**	5.92 (5.98)	6.53 (6.27)	<0.0001
Anxiety	4.31 (5.06)**	5.68 (5.45)***	6.80 (5.37)****	<0.0001
Stress	6.97 (7.09)**	8.58 (7.26)***	8.99 (7.44)	0.0003

Abbreviations: SD, standard deviation; DASS-21, Depression, Anxiety and Stress Scale.

Note: According to the number of vaccine-related adverse events, the vaccinated healthcare workers were divided into three groups (none, 1–2, and ≥3 adverse events).

The Student-Newman-Keuls (SNKs) test was also performed for multiple comparisons.

* Indicates the Kruskal-Wallis test. P < 0.05 indicates a significant difference.

** Indicates a significant difference between none adverse events group and ≥3 adverse events group.

*** Indicates a significant difference between none adverse events group and 1–2 adverse events group.

**** Indicates a significant difference between 1 and 2 adverse events group and ≥3 adverse events group.

the mean scores of DASS-21 among different adverse event groups. Analysis indicated that the vaccinated healthcare workers who suffered no vaccine-related adverse events scored significantly lower than those who suffered 1–2 adverse events and those who suffered ≥3 adverse events (depression, p < 0.0001, anxiety, p < 0.0001, stress, p = 0.0003, respectively). Furthermore, the mean scores of DASS-21 were compared between every two groups using the SNKs test. Significant differences were found in scores of depression between ≥3 adverse events group and none adverse events group, scores of anxiety among ≥3 adverse events group, 1–2 adverse events group, and none adverse events group, and scores of stress between ≥3 adverse events group or 1–2 adverse events group and none adverse events group.

3.4. The logistic regression analysis of potential factors associated with depression, anxiety, and stress

Univariable (crude) and multivariable (adj = adjusted) logistic regression models were developed to analyze all potential factors that were tentatively associated with current depressive, anxious, and stress symptoms in healthcare workers (Table 5).

In both the crude and fully adjusted models, vaccination was negatively associated with higher depression (OR_{crude} = 0.62, 95 % confidence interval, or CI = [0.43–0.79], p < 0.0001; OR_{adj} = 0.53, 95%CI = [0.40–0.69], p < 0.0001), anxiety (OR_{crude} = 0.62, 95%CI = [0.50–0.77], p < 0.0001; OR_{adj} = 0.50, 95 % = [0.39–0.65], p < 0.0001), and stress (OR_{crude} = 0.65, 95%CI = [0.52–0.81], p < 0.0001; OR_{adj} = 0.56, 95%CI = [0.44–0.72], p < 0.0001). However, the number of vaccine-related adverse events was positively associated with higher anxiety (OR_{crude} = 1.29, 95%CI = [1.07–1.54], p = 0.0064; OR_{adj} = 1.59, 95%CI = [1.30–1.95], p < 0.0001). Additionally, the number of vaccine-related adverse events was also positively associated with higher depression (OR_{adj} = 1.41, 95%CI = [1.12–1.76], p = 0.0028) and stress (OR_{adj} = 1.37, 95%CI = [1.12–1.68], p = 0.0024) in the fully adjusted model.

Other relevant factors that have statistically significant associations with depression, anxiety, and stress were gender, age, marital status, religious belief, monthly income, daily working time, and chronic diseases. Religious belief, daily working time, and the number of chronic diseases were positively associated with higher depression, anxiety, and stress. Female gender, married status, and monthly income were negatively associated with higher depression. Age, married status, and monthly income were negatively associated with higher anxiety. Monthly income was negatively associated with higher stress.

4. Discussion

This survey was conducted at the first wave when the nationwide COVID-19 vaccination program was implemented in China. To the best of our knowledge, this was the first study that explored the association between COVID-19 vaccination and psychological disorders among healthcare workers in the country.

The prevalence of depression, anxiety, and stress in this study were 24.8 %, 32 %, and 33.4 %, respectively. Compared with the survey results during the COVID-19 outbreak in China (Bareeqa et al., 2021; Han et al., 2020; Liu et al., 2021), we did not find any significant reduction. As the mass COVID-19 vaccination program had been implemented for more than two months, the vaccination rate in this study only reached 69.6 %. It reminded us that the depression, anxiety, and stress symptoms might influence healthcare workers' vaccination decisions.

According to the comparison of the DASS-21 scores between vaccinated (single-dose and double-dose) and unvaccinated healthcare workers, our results indicated that unvaccinated healthcare workers had higher levels of perceived depression, anxiety, and stress than the vaccinated healthcare workers. In addition, both the univariable and multivariable analysis demonstrated that vaccination was negatively associated with higher depressive, anxious, and stress symptoms in

Table 5
The logistic regression analysis of potential factors associated with depression, anxiety, and stress.

Variables	Depression				Anxiety				Stress			
	Univariable analysis		Multivariable analysis		Univariable analysis		Multivariable analysis		Univariable analysis		Multivariable analysis	
	OR _{crude} (95%CI)	P	OR _{adj} (95%CI)	P	OR _{crude} (95%CI)	P	OR _{adj} (95%CI)	P	OR _{crude} (95%CI)	P	OR _{adj} (95%CI)	P
Gender (female)	0.74 (0.58–0.94)	0.0127	0.76 (0.58–0.99)	0.04	1.04 (0.84–1.30)	0.71	0.99 (0.77–1.27)	0.94	0.91 (0.74–1.14)	0.42	0.93 (0.73–1.19)	0.57
Age	0.10 (0.98–1.01)	0.65	1.00 (0.98–1.03)	0.75	0.98 (0.97–1.00)	0.02	0.99 (0.99–1.01)	0.29	1.00 (0.98–1.01)	0.72	1.00 (0.98–1.02)	0.90
Ethnic group	1.52 (0.70–3.31)	0.29	1.34 (0.58–3.06)	0.49	0.71 (0.30–1.66)	0.42	0.64 (0.26–1.56)	0.32	1.47 (0.70–3.06)	0.31	1.36 (0.62–2.95)	0.44
Religious belief	1.75 (1.13–2.71)	0.01	1.77 (1.12–2.78)	0.01	1.92 (1.27–2.88)	0.0018	2.11 (1.39–3.22)	0.0005	1.75 (1.16–2.64)	0.0081	1.77 (1.16–2.71)	0.0086
Marital status (married)	0.90 (0.81–0.99)	0.03	0.89 (0.77–0.98)	0.03	0.89 (0.82–0.98)	0.02	0.91 (0.81–1.02)	0.09	0.96 (0.87–1.05)	0.37	0.94 (0.84–1.06)	0.30
Education degree	1.14 (0.97–1.33)	0.11	1.17 (0.97–1.40)	0.11	1.00 (0.86–1.16)	0.98	1.13 (0.95–1.35)	0.17	1.00 (0.87–1.16)	0.98	1.05 (0.88–1.25)	0.59
Province (Beijing)	0.73 (0.34–1.58)	0.42	0.54 (0.23–1.24)	0.15	0.61 (0.30–1.28)	0.19	0.61 (0.28–1.36)	0.23	0.60 (0.29–1.24)	0.16	0.57 (0.26–1.24)	0.16
Department	0.88 (0.74–1.05)	0.16	0.85 (0.71–1.02)	0.08	0.98 (0.83–1.15)	0.78	0.95 (0.80–1.13)	0.53	0.93 (0.79–1.09)	0.36	0.88 (0.74–1.04)	0.13
Academic rank	0.95 (0.81–1.10)	0.48	1.04 (0.84–1.28)	0.73	0.90 (0.79–1.04)	0.16	1.11 (0.91–1.35)	0.30	0.98 (0.86–1.13)	0.81	1.08 (0.89–1.30)	0.46
Monthly income (CNY)	0.94 (0.81–1.10)	0.42	0.82 (0.68–1.00)	0.05	0.79 (0.68–0.92)	0.0016	0.75 (0.63–0.90)	0.0020	0.89 (0.77–1.03)	0.11	0.82 (0.68–0.98)	0.03
Daily working time (h)	1.13 (1.07–1.20)	<0.0001	1.11 (1.05–1.1)	0.0003	1.13 (1.07–1.19)	<0.0001	1.12 (1.06–1.18)	0.0001	1.16 (1.10–1.22)	<0.0001	1.15 (1.08–1.21)	<0.0001
Number of chronic diseases	1.59 (1.26–2.02)	0.0001	1.63 (1.26–2.11)	0.0002	1.55 (1.24–1.95)	0.0002	1.79 (1.39–2.29)	<0.0001	1.59 (1.26–1.99)	<0.0001	1.65 (1.29–2.11)	<0.0001
Supporting anti-epidemic	0.85 (0.51–1.42)	0.53	0.95 (0.55–1.62)	0.85	0.81 (0.50–1.29)	0.37	0.78 (0.48–1.28)	0.33	0.76 (0.48–1.21)	0.25	0.80 (0.49–1.29)	0.36
COVID-19 vaccination	0.62 (0.43–0.79)	<0.0001	0.53 (0.40–0.69)	<0.0001	0.62 (0.50–0.77)	<0.0001	0.50 (0.39–0.65)	<0.0001	0.65 (0.52–0.81)	<0.0001	0.56 (0.44–0.72)	<0.0001
Number of vaccine-related adverse events	1.16 (0.95–1.41)	0.16	1.41 (1.12–1.76)	0.0028	1.29 (1.07–1.54)	0.0064	1.59 (1.30–1.95)	<0.0001	1.18 (0.97–1.40)	0.10	1.37 (1.12–1.68)	0.0024

Abbreviations: adj, adjusted for all other variables in the model; crude, univariable model; OR, odds ratio; CI, confidence interval; DASS-21, Depression, Anxiety, and Stress Scale; CNY, Chinese Yuan; COVID-19, Coronavirus disease 2019. Note: $P < 0.05$ indicates a significant difference.

healthcare workers. These findings highlighted the association between COVID-19 vaccination and psychological health. Consistent with previous studies (Ansari et al., 2021; Corace et al., 2016; Karlsson et al., 2019; Miles et al., 2020; Pandey et al., 2021; Prematunge et al., 2012), we supposed that healthcare workers with good mental health would be more willing to get vaccinated. Moreover, we speculated that vaccination could in turn boost the confidence of healthcare workers and alleviate their depressive, anxious, and stress symptoms in the post-COVID-19 era. Therefore, considering this reciprocal impact of vaccine coverage on people's psychological health, we suggest public health authorities and healthcare providers take good mental health as a necessary element of preventive healthcare. Also, to accomplish the nationwide vaccination program success, it is urgent to enhance the psychological health of all potential subjects in the country. We would like to recommend several practical measures to the public, such as digital mental health interventions, physical activity, taking vitamins, getting out more, a special diet, and doing courses on relaxation, stress management or yoga (Abd-Alrazaq et al., 2020; Lattie et al., 2019; Kandola et al., 2019; Shahidi et al., 2020; MahdaviFar et al., 2021; Glabska et al., 2020; Hosker et al., 2019; Cramer et al., 2013). It could be convenient and beneficial to all the citizens.

Another important finding was that vaccinated healthcare workers with poor mental health might be prone to suffer vaccine-related adverse events. As the mean scores of DASS-21 were significantly higher in the 1–2 adverse events group and ≥ 3 adverse events group, the logistical regression also indicated that the number of vaccine-related adverse events was positively associated with the levels of depression, anxiety, and stress in this study. These results were consistent with previous studies which indicated that psychological factors could substantially affect the immune system's vaccine response (Brydon et al., 2009; Futterman et al., 1992). Notably, the incidence of vaccine-related adverse events was 35.13 % in this study, which further implied the importance of guaranteeing the efficacy and safety of the COVID-19 vaccines. Therefore, it reminds us that prioritizing COVID-19 vaccines for patients with severe mental illness and physical illnesses (including tumor, hypertension, coronary heart disease, and diabetes that were at risk for psychological disorders) should be offered robust strategies to avoid unexpected adverse events (The Lancet Psychiatry, 2021; Albus et al., 2014; Robinson et al., 2018; Solmi et al., 2020; Turana et al., 2021). Public health agencies could conduct a psychological assessment to identify persons with psychological disorders and make full preparation for them to prevent the probable vaccine-related adverse events. Healthcare providers should prolong the observational time and give them a standard indication after getting vaccinated.

Currently, other relevant and important factors of psychological health in healthcare workers are also found in this study. Same as previously published literature has mentioned (Gadi et al., 2020; Rozenberg et al., 2020; Wang et al., 2021b), the female and married healthcare workers have a lower risk to be depression in this sample. Furthermore, healthcare workers with lower monthly income have a higher risk of depression, anxiety, and stress, which is in agreement with former studies as well (Ettman et al., 2020; Zhou et al., 2020). We also found that the mental health of healthcare workers was susceptible to the longer daily working time and chronic diseases (Song et al., 2020; Wu et al., 2020). Besides, considering the number of participants who have a religious belief was very small in this study, such a rare feature cannot be considered a determinant. Thus, if we want to make a psychological evaluation of potential subjects before they get vaccinated, it is necessary to pay more attention to those with high-risk factors such as elder age, male gender, unmarried status, lower monthly income, longer daily working time, and concomitant chronic diseases.

4.1. Strengths and limitations

To reduce response bias, the high-quality data of our study was rigorously collected from the healthcare workers who could be vigilant

in recognizing and reporting adverse events after vaccination. Another strength of this study is that all the participants are voluntary without any financial compensation, which could avoid selection bias. Simultaneously, this survey was conducted at the beginning of the mass vaccination plan implementation in China, which could afford the first material on the efficacy and safety of the COVID-19 vaccine. Finally, it was supposed that our study could attract public attention and make the current COVID-19 vaccination programs to be more robust.

Nonetheless, this study has limitations. Although we evaluated many covariates and conducted multiple comparisons, residual confounding possibly exists, as there might be other psychological factors associated with vaccine-related adverse events which we did not investigate in this study. In addition, accounting for an absence of the baseline information about the psychological states of healthcare workers in this study, we could only speculate on the causality between COVID-19 vaccination and the psychological disorders of participants. The correlation between COVID-19 vaccination and psychological disorders should be confirmed in future rigorous randomized controlled trials (Parrino et al., 2021). More work is needed to see whether the COVID-19 pandemic and related stress promote poor health behaviors that in turn worsen mental health and vaccine-related adverse events in a vicious cycle.

4.2. Conclusions

An obvious impact of the psychological disorders on the COVID-19 vaccine coverage and related adverse events was detected in this study. Healthcare workers with good mental health might be quite willing to get vaccinated against COVID-19, but the occurrence or frequency of vaccine-related adverse events could be exacerbated by the poorer mental health of subjects. To make the current COVID-19 vaccination programs to be more robust, we strongly suggest public health agencies attach great importance to the psychological states of our citizens. This might play a vital role in fighting against the pandemic in terms of vaccine efficacy and safety.

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Ethical standards

This study did not involve human and/or animal experimentation.

CRediT authorship contribution statement

Fei Guo: Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Ruili Han:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Yiwei Sun:** Data curation, Writing – review & editing. **Li Sun:** Data curation, Writing – review & editing. **Ting Luo:** Data curation, Writing – review & editing. **Lanlan Zheng:** Data curation, Writing – review & editing. **Changjun Gao:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Supplementary material

Questionnaire on the association between COVID-19 vaccination and

psychological disorders among health care workers in China.

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