the Impact of COVID-19 on Nurses' Mental Healthcare and sustainability by data analysis

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ABSTRACT

COVID-19 has profoundly impacted everyone's lives with many publications investigating different aspects of this pandemic, yet limited literature focused on the mental health of frontline nurses with a small sample size. The published dataset in Hu et al.'s studies, with collected frontline nurses' mental health conditions and sociodemographic characteristics in Wuhan, February 13, 2020, were chosen to be the original dataset. In this paper, three responses-depression, anxiety, and fear-are selected, and 17 socio-demographic covariates are chosen. The results were obtained by applying linear regression, logistic regression, ordinal regression, corresponding model selection, and diagnostics in R. It revealed that Wuhan as origin, working wards changed, and willingness to participate in the frontline are the factors associated with anxiety; child-rearing, monthly household income, and etc. to participate in the frontline are the factors associated with depression; age, sex, education, average working hours/shift, Wuhan as origin, and etc. are the factors associated with fear.

CCS CONCEPTS

• Applied computing • Life and medical sciences • Bioinformatics

KEYWORDS

COVID-19 Pandemic, Sustainability science, Mental Healthcare, Frontline Nurses, big data analysis

1. Introduction

COVID-19 has profoundly changed the world in the past year; the pandemic has impacted every side of life, from medical care to businesses and schools. A lot of publications were posted after the pandemic concerning different aspects of this pandemic.

During this challenging time, those health workers, who would require hugely increased workload associated with unusual risk, are therefore needed to be concerned. This problem, however, is often overlooked as the major focus is always the patients rather than the health workers. In comparison to the vastly available literature on COVID-19, there are merely around 500 pieces of research on the mental health of frontline nurses on Pubmed.

One phenomenon is unique in China. As more patients arose in Wuhan, teams from other cities in China-such as Shanghai, Guangdong, and Tianjin-formed the Chinese Emergency Medical Teams to support hospitals in infected areas. The team had professional doctors, nurses, and paramedics from governments, charities, and international organizations. From January the 24th, approximately nineteen thousand nurses-respectively in 346 medical teams-arrived at Wuhan. Approximately 8000 medical workers also work in the square-cabin hospital built for all the positive covid patients to stay [1].

The final project takes to the research question of "to what extent does the pandemic, COVID-19, influence the mental health of frontline nurses?" and "any difference (in factors) between anxiety, depression, and fear?" The study population of this research is frontline nurses in Wuhan.

This research aims to call attention to the mental health of frontline nurses in China, especially the healthcare workers' mental health during the pandemic. As there are not many studies on the mental health of Chinese healthcare workers during the pandemic, this research would like to focus on the impact of COVID-19 on nurses' mental health. Once the factors that could cause the mental health problem the most are known, the government could intervene and prevent more serious mental health problems and decrease unnecessary mental consumption in nurses.

2. Background and Literature Review

Nurses remain at the forefront of patient care and are known to work in a psychologically and physically demanding work environment, which exposes them to a higher risk of developing negative mental states such as depression, anxiety, and stress. Many researchers have conducted surveys and studies revealed that nurses are generally susceptible to negative mental health states, which could worsen under pandemic situations.

Previous studies have suggested that medical workers are more likely to have depressive symptoms and mental health problems ($P<0.05$) due to higher job stresses and found that more than half of the Chinese nurses had depressive symptoms that adversely affected the quality of life and quality of care in 2009 [2,3]. Moreover, a meta-analysis of 244 papers indicated that the mental health level of Chinese nurses decreased steadily from 1998 to 2016 [4]. The mental health problems of nurses are prevalent throughout the world as well, and several studies found that depression, anxiety, and stress are also prevalent among Portugal, Australia, and England nurses [5-7].

In these studies, various covariates have been identified by multivariate logistic regression analysis as positively associated with depressive symptoms, including lower job rank, less sleeping hours, higher over-commitment, worse nurse-patient relationship, and higher education background, while social support, rewards, and skill discretion were negatively associated with mental health problems.

A global pandemic is likely to influence the mental health status of many people as research has demonstrated that individuals tend to be more depressed during a pandemic. Dr. Tzeng's team points out that the SARS cohort had a 2.8-fold increased risk of overall psychiatric disorders when compared to the control cohort, which means that SARS has a long-term mental health effect on people [8]. Dr. Ettman shows that the prevalence of depressive symptoms in the US was more than 3-fold higher during COVID-19 compared with before the COVID-19 pandemic [9]. Although SARS and COVID-19 are two different pandemics, they share some similarities: for instance, both of them are caused by two similar, but different, coronaviruses.

Further, as more studies are related to nurses' mental health in China and other countries during the pandemic, they demonstrated increases in mental health problems of nurses worldwide. For instance, Dr. Havaei found a rise in anxiety and depression among the nurses in BC, Canada [10]. Dr. Liu also noticed more mental health problems of nurses in China. [11]. Furthermore, some countries, like South Korea, Japan, and Canada, all had news about nurses striking and quitting their jobs because of pandemic stress and mental health problems [12-14]. However, there is no news about that in China. Oppositely, Dr. Hu detected that even if the nurses in Wuhan hospitals had some mental health problems, they still expressed their willingness to work [15].

Moreover, previous studies on mental health problems suggested some differences between China and other countries in the world. The awareness of mental health problems is still not enough in China. So, people with mental health problems would not seek professional help [16]. When Dr. Wong compared British and Hong Kong on identifying mental health problems, he found that the British had a higher level of awareness of mental problems than Hong Kong [17].

In China, much of the mental health studies are on teenagers, women, and teachers; relatively few studies are focused on nurses, unlike other countries that already had much research on nurses' mental health. And the reasons that caused the mental health problem for nurses are also different. Dr. Roelen discovered that other countries are mainly because of job demands [18], while Dr. Xin found that, besides job demands, Chinese nurses would also have mental health problems due to the patient-to-nurse ratio [4]. In general, nurses in China had a higher chance of getting mental health problems than in other countries.

This research improved the limitation of existing studies on the following points. Firstly, this research is more comprehensive with a large sample size of 2014 and considers more variables, while existing studies are generally on the small sample size of fewer than one thousand data. For instance, Dr. Kameg's research has only collected 151 cases. Secondly, previous studies focused on numerous different variables, which are blurred and difficult to understand by readers. Dr. Hu focused on a more general range, such as self-efficacy, burnout resilience, perceived social support, etc [15]. However, this research focused specifically on three response variables: anxiety, depression, and fear. Finally, this study is also more specifically focused on frontline workers in Wuhan when covid-19 just began, whereas most studies available right now focused on the general population or nurses in other places. For instance, Dr. Ettman's research focused on the general population in the US [9].

3. Methods

Data collection happened in two Wuhan's hospitals in China. The three divisions in three separated locations of one of the public tertiary hospitals all participated in the process of data collection. Two of the divisions only accept COVID-19 patients between January 13, 2020, and February 13, 2020, with around 1860 beds and 2000 nurses. The other hospital also only received COVID-19 patients from February 3, 2020, with approximately 1000 beds and 600 nurses [15]. All frontline nurses, except the head nurses and the directors of nursing, in these two hospitals taking care of COVID-19 patients are encouraged to take an online self-developed questionnaire survey that was sent to them in WeChat on February 13, 2020. This dataset was found online with the article, "Frontline nurses' burnout, anxiety, depression, and fear statuses and their associated factors during the COVID-19 outbreak in Wuhan, China: A large-scale cross-sectional study", by Deying Hu, Yue Kong, et al [15].

The sample size of the dataset is 2014 rows and 190 columns; for this research, 20 columns that are relevant to the research topic are used: 17 covariates and 3 responses [15].

Data screening has proceeded to accomplish the goal of this research. Initially, the sociodemographic covariates include identity background, working experience and background, personal confidence and beliefs, and willingness. This research selected all the numerical variables that correspond with this study, excluding covariates that are too diversified, such as the original and current clinical department. This will not bring inaccuracy to this research since whether there is a transfer between original and current department is recorded with binomial responses. Only completed cases are used.

In this research, the responses are anxiety, depression, and fear, categorized already by the publisher. Response variables include the following: Zung's Self-Rating Anxiety Scale (SAS) checked out for emotional and physical symptoms of anxiety ranging from 25 to 100, where 50–59 is mild, 60–69 is moderate, and ≥70 is severe anxiety [20]. Zung's Self-Rating Scale (SDS) checked out for emotional, psychomotor, psychological, and physiological imbalance also

Table 1: Description and parameters of the covariates [15]

Sociodemographic variables		Mean (SD)	n (%)
Age		30.99 (-6.17)	
Sex			
	Male		260 (12.9%)
	Female		1752 (87.1%)
Marital status			
	Married		1230 (61.1%)
	Other marital status		784 (38.9%)
Had one or more children			
	Yes		1100 (54.6%)
	No		914 (45.4%)
Education			
	Diploma or lower		441 (21.9%)
	Bachelor's degree or higher		1573 (78.1%)
Professional title			
	Junior		1495 (74.2%)
	Intermediate and senior		519 (25.8%)
Monthly household income (USD/month)			
	≤1440		1109 (55.1%)
	>1440		905 (44.9%)
Clinical experience (month)		107.76 (78.09)	
Working duration as frontline nurse during the COVID-19 outbreak (days)		20.72 (12.94)	
Average working hours/ shift		6.57 (1.90)	
Wuhan as origin working place	Yes		1324 (65.7%)
	No		690 (34.3%)
Original position			
	Bedside nurse		1818 (90.3%)
	Head nurse or nurse director (including vice-director)		196 (9.7%)
Position in Wuhan			
	Bedside nurse		1894 (94.0%)
	Head nurse or nurse director (including vice-director)		120 (6.0%)
Working wards changed			
	Yes		747 (37.1%)
	No		1267 (62.9%)
	Prior training about caring patients with infectious disease		
	Yes		1654 (82.1%)
	No		360 (17.9%)
	Prior experience about caring patients with infectious disease		
	Yes		785 (39.0%)
	No		1229 (61.0%)
	Willingness to participate in frontline during COVID-19 outbreak		
	Yes		1950 (96.8%)
	No		64 (3.2%)

arranged between 25 and 100, where 53–62 is mild, 63–72 is moderate, and ≥73 is severe depression [19]. Fear Scale for Healthcare Professionals (FS-HPs) checked out the fear for nurses and their family and friends to get infected and fear towards death. It ranged from 8 to 40, where ≤19 is mild, 20–29 is moderate, and 30–40 is severe fear. Table 1 showed the description of covariates from EDA.

For the analysis methods, first, EDA was used to find the mean, standard deviation of the covariates and responses (see table 1). Next, multiple linear regression was conducted, where covariates are used to predict the outcomes of the three responses. Then, this research used log transformation to fit a better model and make the response variables as normally disturbed as possible. Then, stepwise selection, AIC, and BIC were applied to find the best fit and most significant variables. For both AIC and BIC, the smaller, the better. Moreover, since anxiety, depression, and fear were a group of ordered variables ranging none, mild, moderate to severe mental health problems, ordinal logistic regression was performed to determine whether the relative ordering between the covariates is significant [19,20]. Lastly, this research also conducted model diagnostics for each full model with the residuals vs. fitted plot, normal QQ plot, and R-squared to see how well the model fitted. All codes of data analysis, tables, and graphs are finished in R software.

4. Results

As linear regression was conducted on the dataset, the result is displayed in Table 2 with its confidence interval and P-value. Applying the threshold of $p<0.05$, the p-value that fitted the range was highly significant. Among seventeen covariates, ten in anxiety, nine in

Table 2: Linear Regression Model

	anxiety			*depression*			*fear*		
Predictors	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*
Intercept	51.9	45.1 – 58.7	**<0.001**	51.8	44.9 – 58.6	**<0.001**	32.8	28.3 – 37.3	**<0.001**
Age (year)	0.1	-0.1 – 0.3	0.294	0.2	0.0 – 0.4	**0.046**	-0.2	-0.3 – -0.0	**0.030**
Sex	1.6	0.1 – 3.1	**0.031**	2.1	0.6 – 3.5	**0.007**	2.6	1.7 – 3.6	**<0.001**
Marital Status	-1.4	-3.1 – 0.3	0.114	-1.4	-3.1 – 0.3	0.099	1.1	-0.0 – 2.2	0.057
Child Rearing	2.4	0.7 – 4.1	**0.007**	2.4	0.7 – 4.2	**0.006**	-0.1	-1.3 – 1.0	0.828
Education	0.5	-0.8 – 1.7	0.450	0.1	-1.2 – 1.3	0.894	0.9	0.1 – 1.7	**0.034**
Professional Title	0.5	-1.0 – 1.9	0.545	1.1	-0.4 – 2.6	0.151	0.0	-1.0 – 1.0	0.962
Monthly Household Income	-1.7	-2.8 – -0.7	**0.001**	-2.4	-3.4 – -1.4	**<0.001**	0.2	-0.5 – 0.9	0.573
Clinical Experience	-0.0	-0.0 – 0.0	0.195	-0.0	-0.0 – 0.0	0.179	0.0	-0.0 – 0.0	0.180
Frontline Working Duration	0.0	0.0 – 0.1	**0.035**	0.0	-0.0 – 0.1	0.064	0.0	-0.0 – 0.0	0.235
Average Working Hours Shift	-0.0	-0.3 – 0.3	0.982	-0.1	-0.3 – 0.2	0.593	-0.3	-0.5 – -0.2	**<0.001**
Wuhan as Origin	3.4	2.3 – 4.5	**<0.001**	3.4	2.3 – 4.5	**<0.001**	3.3	2.6 – 4.1	**<0.001**
Original Position	-2.0	-4.5 – 0.5	0.110	-1.7	-4.2 – 0.8	0.187	-2.3	-4.0 – -0.7	**0.006**
Position in Wuhan	3.1	0.1 – 6.1	**0.041**	3.2	0.2 – 6.2	**0.038**	-0.5	-2.5 – 1.5	0.621
Working Wards Changed	1.3	0.2 – 2.3	**0.018**	1.6	0.5 – 2.6	**0.004**	-0.1	-0.8 – 0.6	0.856
Prior Traning	-2.2	-3.5 – -0.9	**0.001**	-2.4	-3.7 – -1.1	**<0.001**	-0.6	-1.5 – 0.2	0.150
Prior Experience	0.1	-0.9 – 1.2	0.848	0.2	-0.9 – 1.2	0.740	-1.2	-1.9 – -0.5	**0.001**
Willingness to Participate in Frontline	-10.8	-13.5 – -8.1	**<0.001**	-10.4	-13.1 – -7.7	**<0.001**	-2.1	-3.9 – -0.3	**0.024**
Observations		2014			2014			2014	
R^2 / R^2 adjusted		0.085 / 0.077			0.090 / 0.082			0.124 / 0.117	

depression, and eight in fear display high significance. The AIC BIC model selection results displayed high similarities between the three responses. Model diagnostics are then conducted. According to the outcomes of diagnostic, the model generally obeyed the four assumptions of linear regression: no outlier is found (residuals vs. leverage), residuals are normally distributed (Q-Q plot), Homoscedasticity of residuals is displayed (residuals vs. fitted).

For anxiety, the nine covariates are sex, child-rearing, monthly household income, frontline working duration, Wuhan as origin, position in Wuhan, working wards changed, prior training, willingness to participate in the frontline. The model after AIC selection left eleven covariates, while two covariates (whether Wuhan is the original working place and the willingness to participate in the frontline) were left after BIC selection.

For depression, the significant variables were age, child-rearing, monthly household income, Wuhan as origin, position in Wuhan, working wards changed, prior training, and willingness to participate in the frontline. Then, in AIC, thirteen covariates were left, and in BIC, the same two covariates as that in anxiety were left.

For fear, the eight significant covariates were age, sex, education, average working hours/shift, Wuhan as origin, original position, prior experience, and willingness to participate in the frontline. The models of fear after BIC (see table 3) and AIC (see table 4) selection displayed a relatively more different pattern from anxiety and depression. Among eleven covariates of the AIC model, only six overlapped with that of either anxiety or depression; among two covariates, Wuhan as origin and sex, sex stands out as a difference.

Table 3: Linear Regression BIC Model

	anxiety			*depression*			*fear*		
Predictors	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*
Intercept	55.77	52.97 – 58.58	**<0.001**	58.08	55.24 – 60.92	**<0.001**	25.06	24.10 – 26.02	**<0.001**
Wuhan as Origin	3.83	2.83 – 4.83	**<0.001**	3.69	2.67 – 4.71	**<0.001**	3.72	3.05 – 4.39	**<0.001**
Willingness to Participate in Frontline	-10.84	-13.55 – -8.12	**<0.001**	-10.34	-13.09 – -7.59	**<0.001**			
Sex							3.33	2.38 – 4.29	**<0.001**
Observations		2014			2014			2014	
R^2 / R^2 adjusted		0.060 / 0.059			0.054 / 0.053			0.082 / 0.081	

Table 4: Linear Regression AIC Model

	anxiety			*depression*			*fear*		
Predictors	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*
Intercept	55.7	52.4 – 59.0	**<0.001**	54.1	49.0 – 59.1	**<0.001**	33.3	29.0 – 37.5	**<0.001**
Sex	1.4	-0.0 – 2.9	0.052	1.9	0.4 – 3.3	**0.011**	2.6	1.7 – 3.6	**<0.001**
Marital Status	-1.4	-3.0 – 0.3	0.111	-1.4	-3.1 – 0.3	0.103	1.0	0.3 – 1.8	**0.010**
Child Rearing	2.2	0.6 – 3.8	**0.008**	2.4	0.7 – 4.2	**0.006**			
Monthly Household Income	-1.8	-2.8 – -0.7	**0.001**	-2.4	-3.5 – -1.4	**<0.001**			
Frontline Working Duration	0.0	0.0 – 0.1	**0.043**	0.0	-0.0 – 0.1	0.077			
Wuhan as Origin	3.6	2.5 – 4.6	**<0.001**	3.4	2.3 – 4.5	**<0.001**	3.3	2.7 – 4.0	**<0.001**
Original Position	-2.3	-4.7 – 0.1	0.055	-1.8	-4.3 – 0.7	0.154	-2.6	-3.7 – -1.4	**<0.001**
Position in Wuhan	3.1	0.2 – 6.1	**0.037**	3.2	0.2 – 6.2	**0.036**			
Working Wards Changed	1.2	0.2 – 2.2	**0.015**	1.5	0.5 – 2.5	**0.003**			
Prior Traning	-2.1	-3.4 – -0.9	**0.001**	-2.3	-3.6 – -1.1	**<0.001**	-0.7	-1.5 – 0.2	0.128
Willingness to Participate in Frontline	-10.9	-13.6 – -8.2	**<0.001**	-10.4	-13.1 – -7.7	**<0.001**	-2.1	-3.9 – -0.3	**0.023**
Age (year)				0.1	-0.0 – 0.2	0.106	-0.2	-0.3 – -0.0	**0.022**
Professional Title				1.3	-0.2 – 2.7	0.081			
Education							0.9	0.1 – 1.7	**0.023**
Clinical Experience							0.0	-0.0 – 0.0	0.139
Average Working Hours Shift							-0.3	-0.5 – -0.2	**<0.001**
Prior Experience							-1.2	-1.9 – -0.5	**0.001**
Observations		2014			2014			2014	

R^2 / R^2 adjusted	0.084 / 0.079	0.089 / 0.083	0.123 / 0.119

Since the R-square for linear regression is 0.0852, far from 1, which meant it is not the best fit, log transformation was applied to the response variables for the remedy diagnosed from the linear regression. Table 5 showed the association between the covariates and mental health problems when log transformation is conducted. In anxiety, 8 of the covariates were observed to have p-value < 0.05: sex, child-rearing, monthly household income, frontline working duration, Wuhan as origin, working wards changed, prior training, willingness to participate in the frontline. Since there were too many variables, stepwise selections were conducted to find the most significant factors related to anxiety. BIC (see table 6) and AIC (see table 7) showed only two covariates, Wuhan as origin and willingness to participate in the frontline that are the same and significant.

Table 5: Log Transformation Model

	anxiety			*depression*			*fear*		
Predictors	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*
Intercept	3.9	3.8 – 4.1	**<0.001**	3.9	3.8 – 4.1	**<0.001**	3.5	3.3 – 3.7	**<0.001**
Age (year)	0.0	-0.0 – 0.0	0.259	0.0	-0.0 – 0.0	0.051	-0.0	-0.0 – -0.0	**0.044**
Sex	0.0	0.0 – 0.1	**0.018**	0.0	0.0 – 0.1	**0.002**	0.1	0.1 – 0.2	**<0.001**
Marital Status	-0.0	-0.1 – 0.0	0.103	-0.0	-0.1 – 0.0	0.109	0.0	0.0 – 0.1	**0.049**
Child Rearing	0.1	0.0 – 0.1	**0.004**	0.0	0.0 – 0.1	**0.008**	-0.0	-0.1 – 0.0	0.648
Education	0.0	-0.0 – 0.0	0.514	0.0	-0.0 – 0.0	0.693	0.0	0.0 – 0.1	**0.026**
Professional Title	0.0	-0.0 – 0.0	0.486	0.0	-0.0 – 0.1	0.172	-0.0	-0.0 – 0.0	0.700
Monthly Household Income	-0.0	-0.1 – -0.0	**0.002**	-0.0	-0.1 – -0.0	**<0.001**	0.0	-0.0 – 0.0	0.725
Clinical Experience	-0.0	-0.0 – 0.0	0.152	-0.0	-0.0 – 0.0	0.186	0.0	-0.0 – 0.0	0.317
Frontline Working Duration	0.0	0.0 – 0.0	**0.044**	0.0	-0.0 – 0.0	0.127	0.0	-0.0 – 0.0	0.285
Average Working Hours Shift	-0.0	-0.0 – 0.0	0.857	-0.0	-0.0 – 0.0	0.529	-0.0	-0.0 – -0.0	**0.001**
Wuhan as Origin	0.1	0.0 – 0.1	**<0.001**	0.1	0.0 – 0.1	**<0.001**	0.1	0.1 – 0.2	**<0.001**
Original Position	-0.0	-0.1 – 0.0	0.096	-0.0	-0.1 – 0.0	0.119	-0.1	-0.2 – -0.0	**0.012**
Position in Wuhan	0.1	-0.0 – 0.1	0.070	0.1	0.0 – 0.1	**0.043**	-0.0	-0.1 – 0.1	0.571
Working Wards Changed	0.0	0.0 – 0.0	**0.012**	0.0	0.0 – 0.1	**0.004**	0.0	-0.0 – 0.0	0.924
Prior Traning	-0.0	-0.1 – -0.0	**0.002**	-0.0	-0.1 – -0.0	**<0.001**	-0.0	-0.1 – 0.0	0.329
Prior Experience	0.0	-0.0 – 0.0	0.740	0.0	-0.0 – 0.0	0.719	-0.1	-0.1 – -0.0	**<0.001**
Willingness to Participate in Frontline	-0.2	-0.3 – -0.1	**<0.001**	-0.2	-0.3 – -0.1	**<0.001**	-0.1	-0.1 – 0.0	0.162
Observations		2014			2014			2014	
R^2 / R^2 adjusted		0.081 / 0.073			0.083 / 0.075			0.110 / 0.102	

Table 6: Log Transformation BIC Model

	anxiety			*depression*			*fear*		
Predictors	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*
Intercept	4.0	3.9 – 4.1	**<0.001**	3.9	3.8 – 3.9	**<0.001**	3.2	3.2 – 3.2	**<0.001**
Wuhan as Origin	0.1	0.1 – 0.1	**<0.001**	0.1	0.1 – 0.1	**<0.001**	0.1	0.1 – 0.2	**<0.001**
Willingness to Participate in Frontline	-0.2	-0.3 – -0.1	**<0.001**						
Sex							0.1	0.1 – 0.2	**<0.001**
Observations		2014			2014			2014	
R^2 / R^2 adjusted		0.055 / 0.055			0.028 / 0.027			0.071 / 0.070	

Table 7: Log Transformation AIC Model

	anxiety			*depression*			*fear*		
Predictors	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*	*Estimates*	*CI (95%)*	*P-Value*
Intercept	4.0	3.9 – 4.1	**<0.001**	3.9	3.8 – 4.1	**<0.001**	3.3	3.2 – 3.4	**<0.001**
Sex	0.0	0.0 – 0.1	**0.035**	0.0	0.0 – 0.1	**0.002**	0.1	0.1 – 0.2	**<0.001**
Marital Status	-0.0	-0.1 – 0.0	0.098	-0.0	-0.1 – 0.0	0.119	0.0	0.0 – 0.1	**0.015**
Child Rearing	0.0	0.0 – 0.1	**0.006**	0.0	0.0 – 0.1	**0.010**			
Monthly Household Income	-0.0	-0.1 – -0.0	**0.001**	-0.0	-0.1 – -0.0	**<0.001**			
Frontline Working Duration	0.0	-0.0 – 0.0	0.055	0.0	-0.0 – 0.0	0.138			
Wuhan as Origin	0.1	0.1 – 0.1	**<0.001**	0.1	0.1 – 0.1	**<0.001**	0.1	0.1 – 0.1	**<0.001**
Original Position	-0.1	-0.1 – -0.0	**0.041**	-0.0	-0.1 – 0.0	0.085	-0.1	-0.1 – -0.0	**<0.001**
Position in Wuhan	0.1	-0.0 – 0.1	0.063	0.1	-0.0 – 0.1	0.052			
Working Wards Changed	0.0	0.0 – 0.0	**0.010**	0.0	0.0 – 0.1	**0.004**			
Prior Traning	-0.0	-0.1 – -0.0	**0.002**	-0.0	-0.1 – -0.0	**<0.001**			
Willingness to Participate in Frontline	-0.2	-0.3 – -0.1	**<0.001**	-0.2	-0.3 – -0.1	**<0.001**			
Age (year)				0.0	-0.0 – 0.0	0.059	-0.0	-0.0 – -0.0	**0.024**
Clinical Experience				-0.0	-0.0 – 0.0	0.102			
Education							0.0	0.0 – 0.1	**0.019**
Average Working Hours Shift							-0.0	-0.0 – -0.0	**<0.001**

Prior Experience				-0.1	-0.1 – -0.0	**<0.001**
Observations	2014	2014		2014		
R^2 / R^2 adjusted	0.079 / 0.074	0.082 / 0.076		0.107 / 0.103		

Depression also had eight covariates that were observed to be significant: sex, child-rearing, monthly household income, Wuhan as origin, position in Wuhan, working wards changed, prior training, and willingness to participate in the frontline. As there were too many variables, BIC and AIC were applied. In AIC, except for the position in Wuhan, other variables were the same as the full model. BIC only selected Wuhan as the origin.

For fear, age, sex, education, average working hours/shift, Wuhan as origin, original position, prior experience, and willingness to participate in the frontline were related to fear significantly. When AIC and BIC selections were used, AIC selected the same eight covariates, where BIC selected only two, and they were sex and Wuhan as the origin. All detailed AIC and BIC models and results can be found in the table 7 as the selections were supporting the full models.

When diagnosing the full log transformation model, the residuals vs. fitted plot for anxiety and depression seemed linear with no distinctive pattern and homoscedasticity. The normal QQ plot showed the models were mostly normal for anxiety and depression. However, the R-squared here for anxiety and depression were 0.0807 and 0.0830, respectively, which was far from 1, so these models were not a good fit. For fear, the plot was not linear and had some patterns. The normal QQ plot also still showed the model was not normally distributed and had some normal error as the plot showed light-tailed. More remedies were needed here.

Ordinal logistic regression was selected to fit a better model since anxiety, depression, and fear are categorical variables with an order. Table 8 showed the association between the covariates and mental health problems with ordinal logistic regression. Two of the covariates in anxiety were significant: Wuhan as origin, working wards changed. Depression also had six covariates that were observed to be significant: child-rearing, monthly household income, Wuhan as origin, working wards changed, prior training, and willingness to participate in the frontline. The covariates related to fear significantly were age, sex, education, average working hours/shift, Wuhan as origin, original position, and prior experience.

Table 8: Ordinal Logistic Regression Model

	anxiety			*depression*			*fear*		
Predictors	*Odds Ratios*	*CI (95%)*	*P-Value*	*Odds Ratios*	*CI (95%)*	*P-Value*	*Odds Ratios*	*CI (95%)*	*P-Value*
mild anxiety|moderate anxiety	0.5	0.5 – 0.5	0.317						
moderate anxiety|no anxiety	0.9	0.7 – 1.1	0.834						
no anxiety|severe anxiety	43.0	31.6 – 58.5	**<0.001**						
Age (year)	1.0	1.0 – 1.0	0.961	1.0	1.0 – 1.0	0.825	1.0	0.9 – 1.0	**0.048**
Sex	0.9	0.7 – 1.2	0.666	1.1	0.8 – 1.4	0.659	1.8	1.4 – 2.3	**<0.001**
Marital Status	1.0	0.7 – 1.4	0.951	1.1	0.8 – 1.5	0.574	1.4	1.0 – 1.9	0.066
Child Rearing	0.9	0.7 – 1.3	0.720	0.6	0.5 – 0.9	**0.006**	1.0	0.7 – 1.4	0.996
Education	1.2	0.9 – 1.5	0.200	1.0	0.8 – 1.2	0.806	1.3	1.1 – 1.7	**0.017**
Professional Title	1.2	1.0 – 1.6	0.105	1.0	0.8 – 1.3	0.846	1.1	0.8 – 1.5	0.441
Monthly Household Income	1.1	0.9 – 1.4	0.234	1.3	1.1 – 1.6	**0.007**	1.0	0.8 – 1.2	0.773
Clinical Experience	1.0	1.0 – 1.0	0.832	1.0	1.0 – 1.0	0.810	1.0	1.0 – 1.0	0.169

Frontline Working Duration	1.0	1.0 – 1.0	0.509	1.0	1.0 – 1.0	0.100	1.0	1.0 – 1.0	0.232
Average Working Hours Shift	1.0	1.0 – 1.1	0.381	1.0	0.9 – 1.0	0.445	0.9	0.9 – 1.0	**<0.001**
Wuhan as Origin	0.7	0.5 – 0.8	**<0.001**	0.6	0.5 – 0.7	**<0.001**	2.3	1.9 – 2.9	**<0.001**
Original Position	1.1	0.7 – 1.8	0.620	1.2	0.8 – 2.0	0.404	0.6	0.4 – 1.0	**0.045**
Position in Wuhan	1.1	0.6 – 1.9	0.792	0.6	0.4 – 1.1	0.121	0.9	0.5 – 1.5	0.689
Working Wards Changed	0.8	0.7 – 1.0	**0.026**	0.8	0.6 – 0.9	**0.008**	1.0	0.8 – 1.3	0.722
Prior Traning	1.0	0.8 – 1.3	0.760	1.3	1.0 – 1.7	**0.028**	0.9	0.7 – 1.2	0.488
Prior Experience	0.9	0.8 – 1.1	0.457	0.9	0.8 – 1.2	0.593	0.8	0.6 – 0.9	**0.009**
Willingness to Participate in Frontline	1.2	0.7 – 1.9	0.581	1.7	1.1 – 2.7	**0.023**	0.6	0.3 – 1.1	0.117
mild depression|moderate depression				0.7	0.7 – 0.7	0.584			
moderate depression|no depression				1.1	0.8 – 1.4	0.889			
no depression|severe depression				140.2	102.3 – 192.0	**<0.001**			
mild fear|moderate fear							0.0	0.0 – 0.1	**<0.001**
moderate fear|severe fear							0.3	0.3 – 0.5	0.123
Observations	2014			2014			2014		
R^2 Nagelkerke	0.017			0.043			0.115		

5. Discussion

In this study, we observed that Wuhan as origin, working wards changed, and willingness to participate in the frontline were the factors associated with anxiety as they appeared in all models. Wuhan as origin, change in working wards was positively associated with anxiety, whereas willingness to participate in the frontline was negatively associated with anxiety. Depression was dependent on the factors of child-rearing, monthly household income, Wuhan as origin, working wards changed, prior training, and willingness to participate in the frontline. Other than monthly household income, prior training, and willingness to participate in the frontline were negatively correlated to depression; other factors were positively related to depression. The covariates associated with fear were age, sex, education, average working hours/shift, Wuhan as origin, original position, and prior experience. All factors are positively correlated to fear, except for age, and prior experience were negatively related to fear.

When comparing the three mental health problems, Wuhan as origin appeared in all three mental health problems; other factors were all different. Anxiety and depression are all correlated to working wards changed. Other factors are not the same between depression and fear.

Our findings are consistent with previous studies. Ettman et al's study conducted in America (Prevalence of Depression Symptoms in US Adults Before and During the COVID-19 Pandemic) demonstrated that lower income, having less than $5000 in savings, and having exposure to more stressors were associated with greater risk of depression symptoms during COVID-19 [9]. While this study pointed out that income is negatively associated with the level of depression in general during the pandemic, we limit the range to nurses and demonstrate that nurses are more prone to have depression symptoms when they earn less. Another study conducted by Lai et al's team indicated that health care workers in Wuhan reported high rates of symptoms of depression [21]. Our study, based on its conclusion, primarily focused on identifying the factors that are related to this problem.

One of the strengths of our study is that our study uses a dataset that was collected in February, when the pandemic was severest in Wuhan. Hence, our conclusion could maximally reflect the correlation between depression and the pandemic on medical workers. Compared to previous studies, our study has a larger sample size with nurses not only from Wuhan but also from other cities of China. Therefore, our sample is less biased and could reflect a broader range of medical workers.

However, there are certain limitations of our study. For example, our study only focuses on the mental status of nurses in Wuhan in February 2020, and does not perform a time series analysis as the data is only collected once. Also, the data about mental health are self-evaluated and reported, hence the results may not be very precise. Moreover, we did not proceed further with subgroup analyses as that would entail too many details and blur our main results. Besides, we only specifically focus on the influence of COVID-19 on Chinese's

nurses' mental health, for there is no other dataset of this sample size and diverse response available from other countries, and it would be hard to compare data from different studies using different measuring standards of mental health. Hence, there are certain spatial and temporal limitations of our study.

6. Conclusion

Our results observed that Wuhan as origin, working wards changed, and willingness to participate in the frontline were associated with anxiety. Child-rearing, monthly household income, Wuhan as origin, working wards changed, prior training, and willingness to participate in the frontline are correlated to depression. Fear is depended on the factors of age, sex, education, average working hours/shift, Wuhan as origin, original position, and prior experience. The three mental health problems are all related to Wuhan as origin. Between anxiety and depression, there is one factor that is the same, working wards changed. These are the factors that could cause problems for nurses' mental health problems. The best part of our researches that made differences from other studies is that the population that we concentrated on are the frontline nurses during Covid-19, while other studies aim at general nurses. Also, the dataset we found includes the nurses from Wuhan and the nurses from other cities in China, a relatively large sample size for us to use. With the factors in our results, the Chinese government could watch out for these factors and find a way to change or avoid them in order for the nurses to stay healthy psychologically during the pandemic period. Most importantly, our research wants more attention to mental health problems in China, especially to the nurses, who have higher possibilities of mental diseases. Only when the nurses are mentally healthy, they could cure more patients. In the future, we would like to conduct similar research on the nurses at the hospital in other cities or even outside of China if the datasets are published. Moreover, it could be great to follow up on the nurses throughout the pandemic to see if the factors would change since it could be significant to observe the status of nurses' mental health all the time in order for them to work in their best condition.

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