The prevalence and risk factors for anxiety in frontline nurses under COVID-19 pandemic based on a large cross-sectional study using the propensity score-matched method

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ABSTRACT

Introduction: We determined the prevalence of anxiety and the associated risk factors in frontline nurses under COVID-19 pandemic.

Methods: This cross-sectional study was conducted from February 20, 2020, to March 20, 2020, and involved 562 frontline nurses. The effective response rate was 87.68%. After propensity score matched, there were 532 participants left. Extensive characteristics, including demographics, dietary habits, life-related factors, work-related factors, and psychological factors were collected based on a self-reported questionnaire. Specific scales measured the levels of sleep quality, physical activity, anxiety, perceived organization support and psychological capital. Adjusted odds ratios and 95% confidence intervals were determined by binary paired logistic regression.

Results: Of the nurses enrolled in the study, 33.60% had anxiety. Five independent risk factors were identified for anxiety: poor sleep quality (OR=1.235), experienced major events (OR=1.653), lower resilience and optimism of psychological capital (OR=0.906, and OR=0.909) and no visiting friend constantly (OR=0.629).

Conclusions: This study revealed a considerable high prevalence of anxiety in frontline nurses during the COVID-19 outbreak, and identified five risk factors, which were poor sleep quality, experienced major events, lower resilience and optimism of psychological capital, and no visiting friend constantly. Protecting mental health of nurses is important for COVID-19 pandemic control and their wellbeing. These findings enrich the existing theoretical model of anxiety and demonstrated a critical need for additional strategies that could address the mental health in frontline nurses for policymakers.

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Keywords: anxiety, nurse, psychological capital, sleep quality, risk factors

Abbreviations: PSQI: Pittsburgh Sleep Quality Index; PHQ-9: Patient Health Questionnaire-9; OR: Odds Ratio; CI: Confidence Interval; BMI: Body Mass Index; IPAQ: International Physical Activity Questionnaire; MET: Metabolic Equivalent.

Introduction

Coronavirus disease 2019 (COVID-19), with an epicentre in Wuhan of China, has spread globally [1]. The World Health Organization Emergency Committee declared COVID-19 is an international public health emergency and outbreak in late January 2020 [2]. By Dec 1, 2020, there were 22,537,634 confirmed COVID-19 cases, including 1,790,670 associated deaths [2]. Such large-scale international public health threat presented severe challenges for medical staff. For example, frontline medical staff are under both physical and psychological pressure, staff members who experienced symptoms of anxiety were at increased risk of making errors in patient care [3]. Maintaining good mental health among medical staff is essential to prevent infectious disease spread and ensuring long-term wellbeing of staff [4]. Therefore, mental health of frontline medical staff should be supported during the outbreak of COVID-19.

Anxiety is characterized by fear, anxiousness, distress, and perceived threats in the environment or internal to oneself in the absence of objective threat. The response is out of proportion to the actual danger posed. It has been associated with impairment of both personal and professional performance [5]. It also linked to poor health behaviors and problematical physiological indicators, such as inflammation. Anxiety tends to be chronic, with a waxing and waning pattern of recurrence across the lifetime [6]. As reported in the Global Burden of Disease study, the number of cases of anxiety worldwide was 272.2 million in 2012. Prevalence peaks between the ages of 20 and 34 years and is 5.0% in adults of working age [7]. In a systematic review across 44 countries, the global prevalence of anxiety disorders was estimated at 7.3% [8].

Nurses appear to be at an increased risk of developing mental disorders, which may reflect longer hours at work, separation from their families, and caring for a large number of patients [9]. Anxiety impairs both psychological and physical functions, which diminish professional performance, affects the quality of patient treatment outcomes, and provokes conflicts with patients, or colleagues [10]. Therefore, anxiety is a critical issue, not only for nurses themselves, but also for the health and safety of the patients they treat [11].

As a new an international public health emergency, COVID-19 has generated great research interest. However, data on the prevalence and risk factors of anxiety among frontline nurses during the COVID-19 outbreak are scarce. Therefore, we developed a survey to determine the prevalence of anxiety and its associated risk factors in this population.

Methods

Study design

This cross-sectional study was based on WeChat-based survey programme Questionnaire and was conducted in Shengjing Hospital of China Medical University. From February 20, 2020, to March 20, 2020, a total of 641 frontline nurses responding to the COVID-19 outbreak participated in the present study. Data from participants who did not provide information on any of the variables of interest were excluded (n=79). Overall, data from 562 participants were included in the final analyses. The effective response rate was 87.68%. After propensity score matched, there were 532 participants left. The average questionnaire spent 10 to 15 min.

Inclusion and exclusion criteria

The inclusion criteria were as follows: occupationally active nurses who were employed in our hospitals. The following exclusion criteria were used: nurses who had participated in work less than 3 months or refused to participate in this program. Nurses who did not provide complete psychological questionnaire or clinical data were excluded either. Finally, effective responses were obtained from 562 individuals (effective response rate: 87.68%). A flow chart illustrating the process is detailed in Figure. 1

Measurement of characteristics

In this study, demographic characteristics included age, gender, BMI (kg/m²). Dietary habits included smoking status (current vs. never plus former), alcohol habit (current vs. never plus former), coffee habit (current vs. never plus former); Life related factors included sleep quality (PSQI, Pittsburgh sleep quality index scores), physical activity (IPAQ, International Physical Activity Questionnaire, Mets×hour/week), have religions (yes vs. no),

marital status (single/ divorce/ separation/ widow vs. married / cohabitation), have siblings (yes vs. no), household income monthly (RMB, yuan) was categorized as ,< 5,000, ≧5,000, < 10,000 and ≧10,000, experienced major life events (yes vs. no), visiting friend constantly (yes vs. no). Smoking habit was categorized as current smoker (≧ 1 cigarette per day and last ≧ 6 months), former smoker (stop smoking ≧ 6 months), and never smoker. Alcohol habit and coffee habit as categorized as current drinker (≧ 1 time per day and last ≧ 6 months), former drinker (stop drinking ≧ 6 months), and never drinker.

Work related factors included years of service (≤ 5 years vs. 5 years < and ≤ 10 years vs. > 10 years), specialty (surgery vs. internal medicine vs. obstetrics and gynecology vs. pediatrics vs. others), working duration (< 40 hours/week vs. 40-60 hours/week vs. >60 hours/week), and night shifts (times/month).

Psychological characteristics included Perceived Organization Support (POS) scale, Psychological Capital Questionnaire (PsyCap), and Genaral anxiety disorder (GAD-7).

Physical activity (PA) in the most recent week was assessed using the short form of the International Physical Activity Questionnaire (IPAQ) [12]. The questionnaire asked whether subjects had performed any activities from the following categories during the previous week: walking; moderate activity (household activity or childcare); vigorous activity (running, swimming, or other sports activities). Metabolic equivalent (MET) hours per week were calculated using corresponding MET coefficients (3.3, 4.0, and 8.0, respectively) according to the following formula: MET coefficient of activity × duration (h) × frequency (days). Total PA levels were assessed by combining separate scores for different activities.

Sleep quality was measured by Pittsburgh sleep quality index (PSQI), which was developed by Buysse et al. [13]. It is a self-report on subjective sleep quality over the last 4 weeks with 18 questions. The first four questions enquire about times (bedtime, number of minutes it took for the participant to fall asleep, get up time, and hours of sleep per night). The next 10 questions ask how often the participant had trouble sleeping because of different reasons (e.g., woke up in the middle of the night, need to go to the bathroom, cough, and bad dreams). Each of these questions must be answered on a 4-point scale ranging from "never" to "three times or more a week."
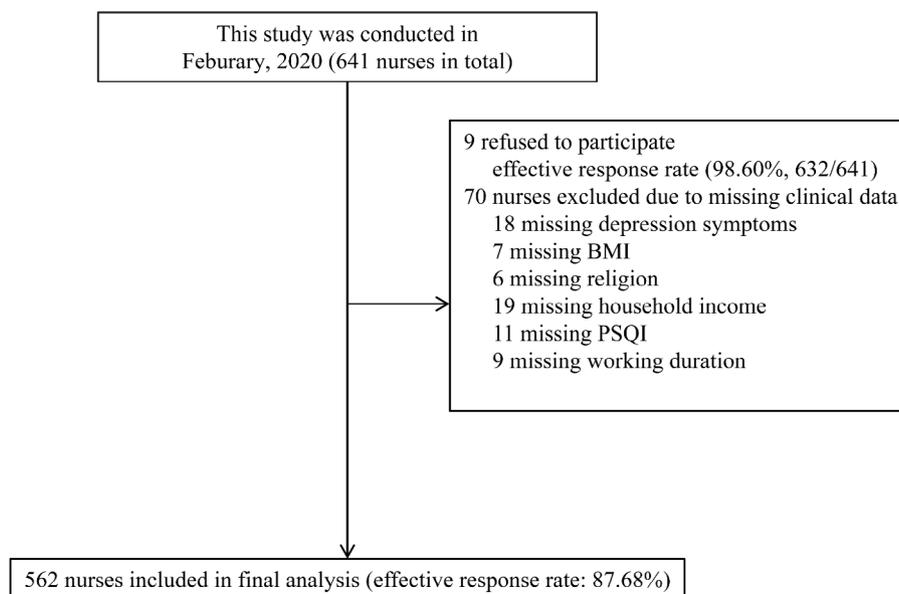
Figure 1. Flowchart of this study, Abbreviations: BMI: Body Mass Index; PSQI: Pittsburgh Sleep Quality Index.

Additional questions include a subjective rating of the participants' sleep quality (4-point scale from "very good" to "very bad"), the use of sleep medication, and trouble staying awake during the day (4-point scale ranging from "never" to "three times or more a week"). The final question asks if it has been a problem for the participant to keep up enough enthusiasm for getting things done (4-point scale ranging from "no problem at all" to "a very big problem"). The 18 items of the PSQI form seven-component score ranging from 0 to 3 (sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, sleep medication, and daytime dysfunction) that can be summed up to a general score. Higher scores represent worse sleep quality. Poor sleep quality is indicated by total score of 6 or greater.

Experienced major life events included separation/divorce, death or serious illness of closely family members, serious injury/traffic accident, violence, unemployment, natural disasters, death or serious illness of partner, serious conflict with family, medical disputes, or income decrease/debt.

Measurement of organization support

The Chinese version of the Perceived Organization Support Questionnaire (POS) was utilized to measure the level of organization support [14]. There were nine items, The score of each item is given on a 7-point Likert-type scale in accordance with the nurses' personal experiences, ranging from 1 (very strongly disagree) to 7 (very strongly agree). The total score ranges from 9 to 63, with a higher score indicating higher social support. The POS has good reliability and validity among various Chinese.

Measurement of psychological capital

PsyCap was evaluated by the Chinese version of the 24-item Psychological Capital Questionnaire (PCQ) [15]. The PCQ is comprised of four dimensions: self-efficacy (6 items), hope (6 items), resilience (6 items), and optimism (6 items). Each question is scored from 1 (strongly disagree) to 6 (strongly agree). Higher scores indicate higher levels of psychological capital. The PCQ has demonstrated adequate reliability and validity in multiple samples [16].

Measurement of anxiety symptoms

Anxiety symptoms were measured with the Chinese version of the Genaral anxiety disorder (GAD-7). The GAD-7 consists of 7 items, and each item is answered on a 4-point Likert-type scale responses ranging from 0 (never) to 3 (always). A higher score means more severe anxiety symptoms. Cut points of 5, 10, and 15 might be interpreted are presenting mild, moderate, and severe levels of anxiety on the GAD-7, The presence of major anxiety symptoms was defined as a GAD-7 standardized score $\geqq 10$ [17]. The Chinese GAD-7 has been extensively applied and validated among Chinese patients. In this study, the Cronbach's α coefficient was 0.923.

Propensity score-matching

We used the propensity score-matching (PSM) method to adjust baseline confounding variables between the anxiety and non-anxiety nurses in an effort to derive more accurate conclusions. Multivariate logistic regression analysis was used to determine propensity scores for each participant based on gender, age, body mass index, smoking status, alcohol habit, and drinking coffee habit, which were demographics or life habit. For assessing the calibration of the logistic regression model, the Hosmer–Lemeshow goodness-of-fit test (P=0.83) was performed for this logistic regression model [a high P value (>0.05) was interpreted as a good fit for the models]. anxiety and non-anxiety groups were matched 1:2 by using a caliper width 0.2 of the standard deviation of the logit of the propensity score through the nearest neighbor matching, as this value minimized the mean squared error of the estimated treatment

effect in several scenarios. After PSM, 498 nurses were left (Figure 2). The balance diagnostics completed for the propensity score method and showed no difference of covariates between two groups (|Standardized Difference| of all covariates was <0.1) [18].

Statistical analysis

Data were analyzed by SPSS 22.0 for Windows (SPSS Inc., Chicago, IL, USA). Continuous variables were presented as the median (interquartile range). Categorical variables were reported as the number (percentage). Univariate analysis was conducted by binary paired logistic regression model. Baseline variables that were considered clinically relevant or that had a p-value < 0.20 in the univariate analysis were included in a multivariate binary paired logistic regression model. Adjusted odds ratios and 95% confidence intervals (95% CI) were also determined after adjusting for potential confounders by binary paired logistic regression. Cutoff values and the area under the curve (AUC) for continuous variables which were independent risk factors for anxiety were calculated through receiver operating characteristic curve analysis. A p-value of less than 0.05 was considered statistically significant.

Results

There were 562 nurses included in this study finally (Figure 1). The demographic characteristics, dietary habits, life related factors, work related factors, and psychological characteristics were displayed in Table 1. Of these nurses, they reported 33.60% (189/562) with anxiety. The average age and BMI were 35.00 and 21.90 kg/m², respectively. The most nurses were female gender, drinking alcohol, drinking coffee, married status, and never smoker, had no religion, no experienced major life events, $\geqq$ 10,000 yuan/month household income, and 40-60 hours/week working duration. The ratio of visiting friends constantly, have siblings and years of service were balanced among each group. The average of PSQI, PA, night shifts, POS (self-efficacy, hope, resilience, and optimism), and PsyCap, were also presented in Table 1 specifically.

A balance of baseline confounding variables between the two groups (anxiety vs. non-anxiety) after PSM was achieved (Figure 2). There were 532 nurses left finally. In matched group, anxiety nurses had higher score of PSQI, and lower scores of POS and PsyCap. They also had higher ratio of experienced major life events and 40 to 60 hours working duration weekly. They had lower ratio of have siblings and visiting friends constantly. All above variables were statistical differences in univariate analysis and then included multivariate analysis, see details in Table 2.

Based on multivariate paired logistic regression, five independent risk factors for anxiety were identified, as follows: poor sleep quality (OR=1.235), experienced major events (OR=1.653), lower resilience and optimism of psychological capital (OR=0.906, and OR=0.909) and no visiting friend constantly (OR=0.629), see details in Table 3.

In addition, the optimal cutoff point of continuous risk factors were analyzed by the receiver operating characteristic curve. The cutoff value for PSQI, resilience and optimism of PsyCap were 7 scores, 26 scores and 23 scores, see Figure 3.

Discussion

Although transmission among medical staff was not the main route of transmission in the case of COVID-19, medical staff were in high-risk work environment. In addition, due to face a large number of intensive care and emergency patients affected by a new infectious disease, therefore, emotional supports and encouragement for overcoming COVID-19 were urgently required. This study revealed a considerable high prevalence of anxiety in this
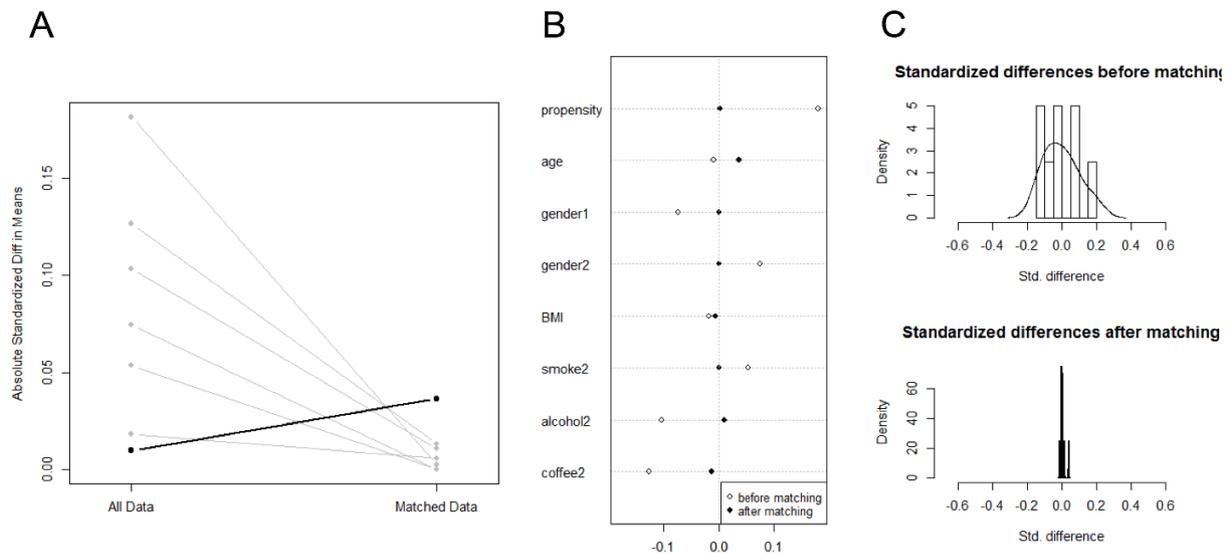
Figure 2. Plot of propensity score-matched in this study. A) line plot foe individual differences of anxiety. B) dot-plot for standardized mean differences of anxiety. C) histogram for standardized mean differences (before and after) of anxiety.
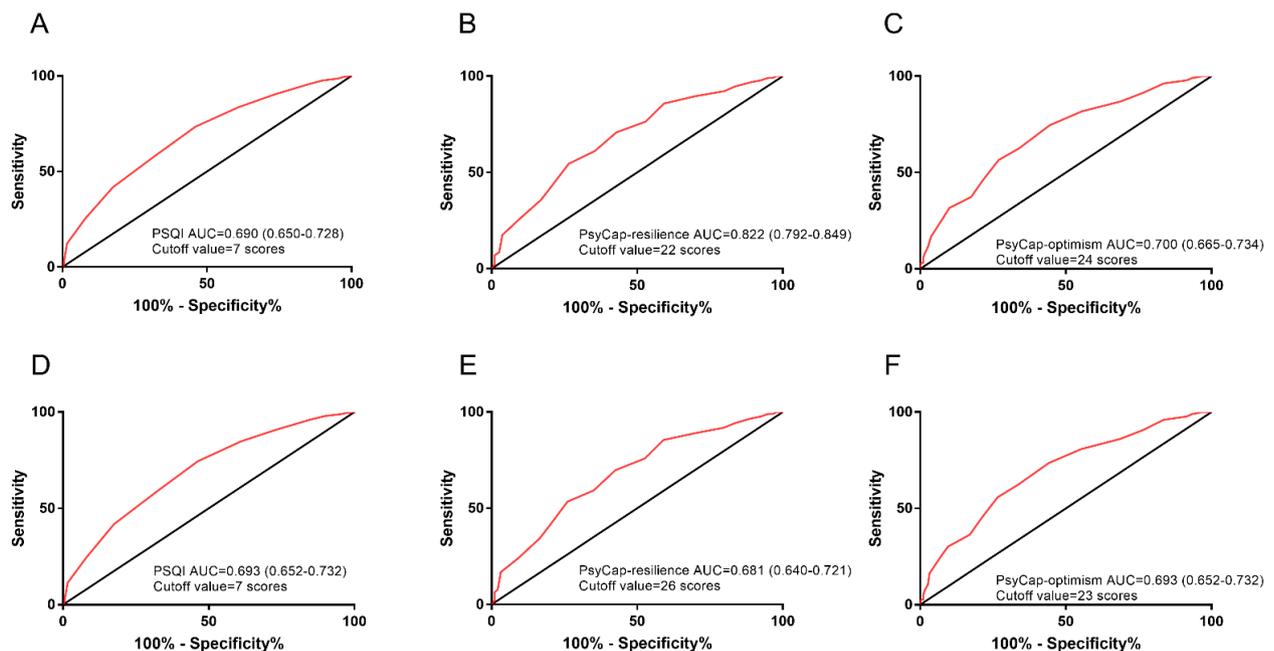
Figure 3. ROC curve and cutoff value for continuous independent risk factors of anxiety before and after PSM.

A) PSQI scores of anxiety before PSM. B) Optimism of PsyCap scores of anxiety before PSM. C) Resilesnce of PsyCap scores of anxiety before PSM. D) PSQI scores of anxiety after PSM. E) Optimism of PsyCap scores of anxiety after PSM. F) Resilesnce of PsyCap scores of anxiety after PSM. Abbreviations: ROC: Receiver Operating Characteristic Curve; AUC: Area Under The Curve; PSQI: Pittsburgh Sleep Quality Index; PsyCap: Psychological Capital; PSM: Propensity Score Matching.

population, and there were five risk factors for anxiety, which were poor sleep quality, experienced major life events, lower resilience, and optimism of psychological capital, and visiting friend rarely. In this study, 33.60% of nurses reported anxiety. These results show that frontline nurses responding to the COVID-19 outbreak are almost more than five times as likely to experience anxiety compared to the general population, as demonstrated in a nationally representative face-to-face household survey in Germany 2006 (n=5030, anxiety rate=5.1%) [19].

Loneliness, contrary to human nature due to the disposition toward social communication and unity is a negative situation occurring due to the insufficient quality and quantity of social relationship networks of an individual. Therefore, visiting friend constantly is usually a positive source of psychological supports. In line with this, visiting friend constantly was an independent factor for anxiety in frontline nurses. Maes et al. [20] also found that loneliness as a negative emotion was considered to be a predisposing factor in anxiety in a meta analysis, which included 3,995 individuals.

Table 1. Characteristics of nurses before and after PSM by anxiety in this study

Variables	Before PSM 562 (100%) nurses	After PSM 532 (100%)nurses
Anxiety (yes)	189 (33.60)	1:2 PSM
Demographic characteristics		
Age (years)	35.00 (34.00, 36.00)	35.00 (34.00, 36.00)
Sex (male vs.female)	118 (21.00)/444 (79.00)	105 (19.70)/427 (80.30)
BMI (kg/m²)	21.90 (19.80, 24.23)	21.80 (19.73, 24.00)
Dietary habits		
Smoking habit (current yes)	8 (1.40)	3 (0.60)
Alcohol habit (current yes)	293 (52.10)	285 (53.60)
Coffee habit (current yes)	430 (76.50)	417 (78.40)
Life related factors		
Sleep quality (PSQI scores)	6.00 (4.00, 7.00)	6.00 (4.00, 7.00)
Physical activity (IPAQ Mets×hour/week)	9.90 (6.60, 23.73)	9.90 (6.60, 23.78)
Have religions (yes)	25 (4.40)	21 (4.20)
Marital status		
Single/divorce/separation/widow	232 (41.30)	219 (41.20)
Married/cohabitation	330 (58.70)	313 (58.80)
Have siblings (yes)	268 (47.70)	252 (47.40)
Household income (Yuan/month)		
< 5,000	33 (5.90)	29 (5.50)
≧5,000, <10,000	121 (21.50)	115 (21.60)
≧10,000	408 (72.60)	388 (72.90)
Experienced major life events (yes)	180 (32.00)	173 (32.50)
Visiting friend constantly (yes)	259 (46.10)	244 (45.90)
Work related factors		
Years of service		
≤ 5 years	158 (28.10)	149 (28.00)
5 years < and ≤ 10 years	239 (42.50)	228 (42.90)
> 10 years	165 (29.40)	155 (29.10)
Speciality		
Surgery	68 (12.10)	61 (11.50)
Internal medicine	159 (28.20)	152 (28.60)
Obstetrics and Gynecology	61 (10.90)	61 (11.50)
Pediatrics	64 (11.40)	40 (11.30)
Others	210 (37.40)	198 (37.10)
Working duration (hours/week)		
40-60 hours	409 (72.80)	387 (72.70)
< 40 hours	18 (3.20)	16 (3.00)
> 60 hours	135 (24.00)	129 (24.20)
Night shifts (times/month)	1.00 (1.00, 4.00)	1.00 (1.00, 4.00)
Psychological characteristics		
POS (scores)	42.00 (36.00, 52.00)	42.00 (35.00, 52.00)
PsyCap-efficacy (scores)	25.00 (22.00, 29.00)	25.00 (22.00, 29.00)
PsyCap-hope (scores)	25.00 (22.00, 29.00)	25.00 (22.00, 29.00)
PsyCap-resilience (scores)	26.00 (23.00, 29.00)	26.00 (23.00, 29.00)
PsyCap-optimism (scores)	25.00 (22.00, 28.00)	25.00 (22.00, 28.00)

Continuous variables were reported median (interquartile range), categorical variables were reported as number (percentage).
Abbreviations: PSM: Propensity Score Matching; BMI: Body Mass Index; PSQI: Pittsburgh Sleep Quality Index; IPAQ: International Physical Activity Questionnaires; PGY: Post Graduation Year; POS: Perceived Organization Support; PsyCap: Psychological Capital.

Table 2. Univariate analysis of the risk factors for anxiety of nurses before and after PSM

Variables	PSM before 562 nurses			PSM after 498 nurses		
	Anxiety 189 nurses	Without anxiety 373 nurses	p	Anxiety 188 nurses	Without anxiety 344 nurses	p
Demographic characteristics						
Age (years)	35.00 (34.00, 36.00)	35.00 (34.00, 36.00)	0.905	35.00 (34.00, 36.00)	35.00 (34.00, 36.00)	0.341
Sex (male vs.female)	36 (19.00)/153 (81.00)	82 (22.00)/291 (78.00)	0.420	35 (18.60)/153 (81.40)	70 (20.30)/274 (79.70)	1.000
BMI (kg/m²)	22.05 (19.80, 24.30)	21.85 (19.73, 23.98)	0.841	21.80 (20.00, 24.18)	21.75 (19.70, 23.98)	0.601
Dietary habits						
Smoking habit (current yes)	2 (1.10)	6 (1.60)	0.605	1 (0.50)	2 (0.60)	0.942
Alcohol habit (current yes)	105 (55.60)	188 (50.40)	0.248	104 (55.30)	181 (52.60)	0.734
Coffee habit (current yes)	151 (79.90)	279 (74.80)	0.179	151 (80.30)	266 (77.30)	0.612
Life related factors						
Sleep quality (PSQI scores)	7.00 (5.00, 9.00)	4.00 (3.00, 6.00)	< 0.001	7.00 (5.00, 9.00)	5.00 (4.00, 7.00)	< 0.001
Physical activity (IPAQ Mets×hour/week)	8.96 (6.60, 22.73)	11.55 (6.60, 26.55)	0.705	8.96 (6.60, 20.96)	10.25 (6.60, 26.23)	0.608
Have religions (yes)	9 (4.80)	16 (4.30)	0.798	9 (4.80)	14 (4.10)	0.660
Marital status			0.714			0.763
Single/divorce/separation/widow	76 (40.20)	156 (41.80)		76 (40.40)	143 (41.60)	
Married/cohabitation	113 (59.80)	217 (58.20)		112 (59.60)	201 (58.40)	
Have siblings (yes)	82 (43.40)	186 (49.90)	0.147	81 (43.10)	171 (49.70)	0.173
Household income (Yuan/month)			0.634			0.468
< 5,000	12 (6.30)	21 (5.60)		12 (6.40)	17 (4.90)	
≧5,000, <10,000	42 (22.20)	79 (21.20)		41 (21.80)	74 (21.50)	
≧10,000	135 (71.50)	273 (73.20)		135 (71.80)	253 (73.50)	
Experienced major life events (yes)	78 (41.30)	102 (27.30)	0.001	78 (41.50)	95 (27.60)	0.001
Visiting friend constantly (yes)	68 (36.00)	191 (51.20)	0.001	67 (35.60)	177 (51.50)	0.002
Work related factors						
Years of service			0.846			0.904
≤ 5 years	51 (27.00)	107 (28.70)		51 (27.10)	98 (28.50)	
5 years < and ≤ 10 years	83 (43.90)	156 (41.80)		82 (43.60)	146 (42.40)	
> 10 years	55 (29.10)	110 (29.50)		55 (29.30)	100 (29.10)	
Speciality			0.879			0.776
Surgery	46 (12.30)	22 (11.60)		21 (11.20)	40 (11.60)	
Internal medicine	103 (27.60)	56 (29.60)		56 (29.80)	96 (27.90)	
Obstetrics and Gynecology	41 (11.00)	20 (10.60)		20 (10.60)	41 (11.90)	
Pediatrics	43 (11.50)	21 (11.10)		21 (11.20)	39 (11.30)	
Others	140 (37.60)	70 (37.10)		70 (37.20)	128 (37.30)	
Working duration (hours/week)			0.001			0.003
40-60 hours	121 (64.00)	288 (77.20)		120 (63.80)	267 (77.60)	
< 40 hours	8 (4.20)	10 (2.70)		8 (4.30)	8 (2.30)	
> 60 hours	60 (31.80)	75 (20.10)		60 (31.90)	69 (20.10)	
Night shifts (times/month)	1.00 (1.00. 4.00)	1.00 (1.00. 4.00)	0.215	1.00 (1.00. 5.00)	1.00 (1.00. 4.00)	0.320
Psychological characteristics						
POS (scores)	39.00 (33.00, 48.00)	46.00 (38.00, 54.00)	< 0.001	39.00 (33.00, 48.00)	44.00 (36.00, 53.00)	< 0.001
PsyCap-efficacy (scores)	24.00 (21.00, 27.00)	28.00 (24.00, 30.00)	< 0.001	24.00 (21.00, 27.00)	27.00 (23.00, 30.00)	< 0.001
PsyCap-hope (scores)	24.00 (20.00, 27.00)	28.00 (24.00, 30.00)	< 0.001	24.00 (20.00, 27.00)	27.00 (23.00, 30.00)	< 0.001
PsyCap-resilience (scores)	24.00 (21.00, 27.00)	27.00 (24.00, 30.00)	< 0.001	24.00 (21.00, 27.00)	27.00 (24.00, 29.00)	< 0.001
PsyCap-optimism (scores)	24.00 (21.00, 27.00)	27.00 (24.00, 30.00)	< 0.001	23.00 (21.00, 26.00)	26.00 (23.00, 30.00)	< 0.001

Continuous variables were expressed as median (interquartile range); categorical variables were reported as number (percentage). P value was analyzed by univariate paired conditional logistic regression.

Abbreviations: PSM: Propensity Score Matching; BMI: Body Mass Index; PSQI: Pittsburgh Sleep Quality Index; IPAQ: International Physical Activity Questionnaire; PGY: Post Graduation Year; IPAC: International Physical Activity Questionnaires; POS: Perceived Organization Support; PsyCap: Psychological Capital.

Table 3. Multivariate analysis of the risk factors for anxiety of nurses before and after PSM

Variables	PSM before		PSM after	
	OR (95% CI)	p	OR (95% CI)	p
Visiting friend constantly (yes vs. no)	N/A	N/A	0.629 (0.399, 0.992)	0.046
Sleep quality (PSQI scores)	1.245 (1.148, 1.351)	< 0.001	1.235 (1.130, 1.349)	< 0.001
Experienced major life events (yes vs. no)	1.710 (1.129, 2.591)	0.011	1.653 (1.059, 2.581)	0.027
PsyCap-resilience (scores)	0.911 (0.859, 0.967)	0.002	0.906 (0.845, 0.907)	0.005
PsyCap-optimism (scores)	0.905 (0.851, 0.961)	0.001	0.909 (0.849, 0.974)	0.007

The odds ratio and 95% confidence interval were analyzed by multivariate paired logistic regression.
Abbreviations: PSM: Propensity Score Matching; OR: Odds Ratio; CI: Confidence Interval; PSQI: Pittsburgh Sleep Quality Index; PsyCap: Psychological Capital.

This study demonstrated that poor sleep quality was positively associated with the prevalence of anxiety in nurses. Extensive previous studies have also found that poor sleep quality is associated with a higher prevalence of anxiety symptoms in different populations [21]. Poor sleep quality results in multiple downstream consequences that may confer a risk for anxiety symptoms, including epigenome changes [22], alterations in the hypothalamic–pituitary–adrenal axis [23], impaired cognitive function [24], impaired executive function [25], and immune system compromise [26]. Not only does sleep have an impact on anxiety, but anxiety is likely also to feed back to impair sleep. Anxiety symptoms, such as attentional bias and dysfunctional beliefs, likely contribute to poor sleep and insomnia. Likewise, anxiety symptoms such as rumination and worry have been shown to interfere with sleep onset latency and sleep quality [27]. Paralleling the findings of a prospective link between sleep quality and the onset of a subsequent anxiety disorder, a similar longitudinal effect has been found between anxiety and subsequent low sleep quality. Further, poor sleep predicts subsequent anxiety, which then predicts subsequent poor sleep [28]. Thus, there is likely a bidirectional relation between sleep and anxiety symptoms.

Psychological capital (PsyCap) is a higher-order core construct that fits within the positive organizational behavior approach and has been demonstrated as a positive resource for improving performance and psychological capacities [15]. PsyCap consists of the four-dimensional psychological resource capacities of self-efficacy, hope, optimism, and resilience. Resilience is the positive psychological capacity to bounce back from (and beyond) failure and adversity to attain success. Optimism includes not only the dispositional optimistic look towards the future, but also global positive expectations. It has been reported that individuals with higher levels of PsyCap are able to have more confidence and make greater efforts to pursue success, preserve the will to accomplish tasks or goals, bounce back from adversity or personal setbacks, and perceive positive expectations and attributes regarding consequences [29]. This study demonstrated that both lower resilience and optimism were significant risk factors for anxiety in nurses. In line with this, Zhou et al. [30] found that PsyCap could be a positive resource for combating anxiety in nurses, which included 1,354 nurses in a cross-sectional survey of China.

This study demonstrated that experienced major life events was positively associated with the prevalence of anxiety in nurses. The reason might be that adverse life events serve to increase vulnerability in one or more ways and are associated with increased risk of anxiety disorder onset. In line with this, Miloyan et al. [31] also found that adverse events are associated with increased risk of onset of anxiety disorders, which based on large longitudinal cohort.

There were several limitations in this study. First, this was a cross-sectional research that was unable to assess the causal relationships among study variables. Therefore, a longitudinal study should be carried out to verify our conclusions. Second, psycho-social variables were measured using self-report questionnaires, which might have recall and reporting bias. Third, anxiety was confirmed by GAD-7, not a clinical diagnosis, which may influence the estimates. Fourth, there were unmeasured confounding factors that contributed to the observed associations. Fifth, the participants of this study were recruited from one center, and there was participant bias due to not include overall frontline nurse population.

Conclusions

This study revealed a considerable high prevalence of anxiety in frontline nurses during the COVID-19 outbreak, and identified five risk factors, which were poor sleep quality, experienced major life events, lower resilience and optimism of psychological capital, and visiting friend rarely. Protecting mental health of nurses is important for COVID-19 pandemic control and their wellbeing. These findings enrich the existing theoretical model of anxiety and demonstrated a critical need for additional strategies that could address the mental health in frontline nurses for policymakers.

Ethical statement

Ethical approval was approved by the Institutional Research and Ethics Committee of the Shengjing Hospital Affiliated China Medical University in Shengyang, China. This study **were carried out in accordance with** STROCSS criteria and the Declaration of Helsinki. All participants provided written informed consent before participating in the study.

Author's Contribution

CP had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. CP was responsible for study concept and design. XD, QZ, JL, and CP were responsible for acquisition of data, analysis and interpretation of data. XD, QZ, and JL were responsible for drafting of the manuscript and critical revision of the manuscript. XD and QZ were responsible for statistical analysis. All authors critically reviewed the paper and approved the final version.

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