Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Research paper

The physical and mental health of the medical staff in Wuhan Huoshenshan Hospital during COVID-19 epidemic: A Structural Equation Modeling approach

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ABSTRACT

Introduction: Early in the epidemic of coronavirus disease 2019, the Chinese government recruited a proportion of healthcare workers to support the designated hospital (Huoshenshan Hospital) in Wuhan, China. The majority of front-line medical staff suffered from adverse effects, but their real health status during COVID-19 epidemic was still unknown. The aim of the study was to explore the latent relationship of the physical and mental health of front-line medical staff during this special period.

Methods: A total of 115 military medical staff were recruited between February 17th and February 29th, 2020 and asked to complete questionnaires assessing socio-demographic and clinical characteristics, self-reported sleep status, fatigue, resilience and anxiety.

Results: 55 medical staff worked within Intensive Care and 60 worked in Non-intensive Care, the two groups were significantly different in reported general fatigue, physical fatigue and tenacity ($P<0.05$). Gender, duration working in Wuhan, current perceived stress level and health status were associated with significant differences in fatigue scores ($P<0.05$), the current perceived health status ($P<0.05$) and impacted on the resilience and anxiety of participants. The structural equation modeling analysis revealed resilience was negatively associated with fatigue (β=-0.52, P<0.01) and anxiety (β=-0.24, P<0.01), and fatigue had a direct association with the physical burden (β=0.65, P<0.01); Fatigue mediated the relationship between resilience and anxiety (β=-0.305, P=0.039) as well as resilience and physical burden (β=-0.276, P=0.02).

Conclusion: During an explosive pandemic situation, motivating the effect of protective resilience and taking tailored interventions against fatigue are promising ways to protect the physical and mental health of the front-line medical staff.

1. Introduction

In December 2019, an infectious pneumonia outbreak concentrated in one seafood wholesale market was reported in Wuhan (Hubei, China). It was later confirmed that patients were infected with Severe Acute Respiratory Syndrome

Coronavirus 2 (SARS-CoV-2), the disease caused by this virus was subsequently officially named as Coronavirus Disease 2019 (COVID-19) by the World Health Organization (WHO) [1-3]. The transmission of COVID-19 mainly through respiratory droplets and close contact and its incubation period ranges from 2 to 14d [4]. COVID-19 is highly contagious which brought about a rapidly rising number of confirmed and suspected cases during the Chinese Lunar New Year holiday in China, and it spread all over the world reaching a pandemic level by the end of March. The new confirmed patients with COVID-19 in China was only 29 until March 16th, 2020, and the global confirmed patients was up to

Abbreviations: COVID-19, Coronavirus Disease 2019; WHO, World Health Organization; SEM, Structural equation modeling; SARS-CoV-2, Severe Acute Respiratory Syndrome Coronavirus 2; SARS, Severe acute respiratory syndrome; SAS, The Self-Rating Anxiety Scale; SRSS, The Self-Rating Scale of Sleep; MFI-20, The Multidimensional Fatigue Inventory; CD-RISC, The Connor-Davidson Resilience Scale; GF, General Fatigue; PF, Physical Fatigue; MF, Mental Fatigue; RM, Reduced Motivation; RA, Reduced Activity; ANOVA, Analysis of variance; RMSEA, The root mean square error of approximation; CFI, The comparative fit index; NFI, The normal fit index; PNFI, The parsimany-adjusted normal fit index; PCFI, The parsimany-adjusted comparative fit index; IFI, The incremental fit index; TLI, The Tucker-Lewis index; GFI, The goodness-of-fit index; AGFI, The adjusted goodness-of fit-index.

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167,515 [5], it meant the spread of the Chinese epidemic was in control. However, the global pandemic deserving urgent attention is still continuing.

The epidemic of COVID-19 has continued to be a major public health issue causing stress responses not only for the public but also for medical staff.

Early in the epidemic, more than 30,000 healthcare workers nationwide were assigned to Wuhan to assist in the treatment of patients at the local hospitals [6]. Then the Chinese government temporarily built two designated hospitals used to treat COVID-19 patients in Wuhan to release the capacity burden of the local hospitals, one of which was named Wuhan Huoshenshan Hospital. In the face of limited medical resources, heavy workload, lacking of specific drugs, risk of infection, and the separation from family and friends for a long time, the front-line medical staff underwent huge pressures leading to some mental problems such as stress, anxiety, depressive symptoms, insomnia, anger and fear [7]. Fatigue has always been detected among the front-line medical staff. It is a normal response to physical exertion or stress with subjectivity, it also can be a sign of a physical disorder, the epidemiological studies found that fatigue often seems to be related to anxiety and depression [8,9]. All on-the-job medical staff in Wuhan were fully engaged in the continuous combat with the prevention and control of the pandemic, the tremendous psychological stress and rescue challenge aggravated their fatigue symptoms [10]. These mentioned problems not only affected work efficiency of the front-line medical staff, but there would be a lasting effect on their overall well-being [11]. Therefore, the investigation for real health status of the front-line medical staff is of great importance.

Similar to the severe acute respiratory syndrome (SARS) epidemic, once the front-line medical staff cannot bear the stress intensity in clinical work, mental and physical sub-health is likely to happen, including headache, dizziness, anxiety, depression, compulsion and so on [12,13], how to recognize and cope with the physical and mental health problems are the key points to protect them from short-time and long-time injuries. According to the crisis intervention theory [14], the front-line medical staff could stimulate their inherent resources such as cognitive regulation and positive coping style at first to keep the balance between themselves and the environmental crisis. Eventually, the physical and mental health of the front-line medical staff would be similar to, even above their original level with the help of crisis intervention [15]. In the meantime, the combination of internal and external interventions is also necessary, which could be beneficial to the recovery or rehabilitation of the medical staff from adverse conditions.

Resilience has been regarded as a personality trait which plays a regulating role in a dynamic process, it is the ability of individuals to bounce back or to cope successfully despite adverse circumstances and crises [16-19]. However, it is still unknown what influences the resilience's effect would have on the physical and mental health of the medical staff working at Wuhan Huoshenshan Hospital, and the latent relationship between the variables regarding to their physical and mental health is not clear. Hence, we investigate the resilience, self-reported sleep status, fatigue and anxiety status, together with the psychosocial materials to explore the possible mutual effects of variables which have represented the physical and mental health of the medical staff in Wuhan Huoshenshan Hospital by structural equation modeling (SEM) approach.

2. Methods

2.1. Study participants

A cross-sectional clinical study was conducted to collect the anxiety, sleep status, resilience, fatigue and other demographic data from the participants. The inclusion criteria were as follow: (1) age less than 60; (2) continued to work at Wuhan Huoshenshan Hospital during the investigation. Participants with a history of psychological disorder, insomnia or chronic disease were excluded. Using convenience sampling, 115 eligible military medical staff were recruited into the study between 17th and 29th February 2020, all were originally based at Xinqiao Hospital, a military medical hospital in Chongqing, China. During the outbreak of COVID-19 epidemic, these 115 medical staff temporarily entered Wuhan Huoshenshan Hospital to participate in epidemic control and prevention work. All the personal information of our participants have been kept confidential.

2.2. Data collection and measuring instruments

2.2.1. Demographic and social data

Demographic data of our participants include age, gender, marital status, profession, technical title, department, years of work experience, current perceived stress level, current perceived health status, and attitude to work in Wuhan.

2.2.2. The Self-Rating Anxiety Scale (SAS)

The SAS is a self-reported scale made up of 20 items to estimate the subjective anxiety and its changes of individuals, and it covers a variety of anxiety symptoms. Each question was scored 1-4 points. An aggregate score of the 20 items then multiply by 1.25, the integer part is the standard score. The higher the standard scores, the more severe level of anxiety [20,21]. According to the result of Chinese general population, the SAS total scores of 50 points is normal, 50-59 points is mild anxiety, 60-69 points is moderate anxiety, and more than 69 points is severe anxiety [22].

2.2.3. The Self-Rating Scale of Sleep (SRSS)

The SRSS is a self-reported questionnaire which was tailored for the Chinese population by Chinese psychologist Li [23]. This scale includes 10 items, each statement has five graded answers, respectively scored as 1 to 5, total scores can range from 10 to 50. The aggregate scores of SRSS are classified into normal (scores<23), mild sleep disturbance (scores between 23 and 29), moderate sleep disturbance (scores between 30 and 39), and severe sleep disturbance (scores>39). The reliability (Cronbach'α=0.6418, P<0.001) and validity (r=0.5625, P<0.001) of SRSS have been established.

2.2.4. The Multidimensional Fatigue Inventory (MFI-20)

The MFI-20 is a 20-item self-reported measurement of fatigue. It includes five dimensions: General Fatigue (GF), Physical Fatigue (PF), Mental Fatigue (MF), Reduced Motivation (RM) and Reduced Activity (RA). Every item is rated on a 5-point Likert scale, every subscale's single total scores is summed up ranging from 4 to 20 scores. Higher total scores indicates higher level of fatigue. Validity and internal consistency have been verified to be good for different populations [24].

2.2.5. The Connor-Davidson Resilience Scale (CD-RISC-25)

The CD-RISC-25 is a self-report questionnaire that comprises of 25 items, each rated on a 5-point Likert scale (ranging from 0= "not at all true", to 4= "true nearly all of the time"), with higher scores reflecting greater resilience. Psychometric evaluation of the CD-RISC-25 conducted on clinical and general population samples found the scale had good reliability (Cronbach'α=0.89), validity, psychometric properties, good internal consistency and test-retest reliability (r=0.87) [25]. Exploratory factor analysis with the Chinese samples resulted in a 3-factor structure of CD-RISC-25, labeled respectively as Tenacity, Strength and Optimism [26].

2.3. Study procedures

Data collection of our study was completed by a Questionnaire Star platform, named Wenjuanxing (http://www.wjx.cn) relying on QR codes in Wechat with anonymity. Two uniformly trained investigators working at Wuhan Huoshenshan Hospital explained the research purpose and method to participants, issued the QR code after obtaining

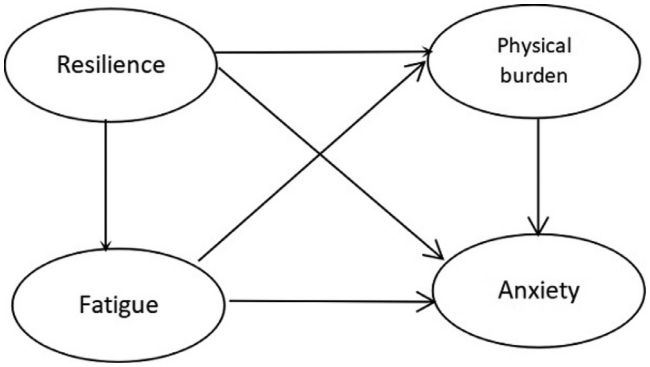

Fig. 1. Conceptual diagram for the proposed model concerning structural relations of the latent variables

consent and collected their relevant data. Once informed consents were obtained, they were asked to provide real data according to their current reality and complete questionnaires immediately. Only volunteers who agreed to participate were recruited and they were informed that they could quit the process at any time. Questionnaires with uncompleted answers or suspected unreal answers were excluded. Ethical approval from the Ethics Committee on Biomedical Research, West China Hospital of Sichuan University (2020-863) was received because Wuhan Huoshenshan Hospital was a temporary hospital with no Clinical Research Ethics Committee.

2.4. Hypotheses of SEM

Variable bundles were based on a literature review, and included 4 latent variables and the observed variables of the front-line medical staff working at Wuhan Huoshenshan Hospital: the resilience status, the fatigue status, the physical burden status, the anxiety status. Our hypotheses were as follows: ①The resilience had a statistically significant direct negative effect on the anxiety status, physical burden and fatigue status. ②The fatigue status had a statistically significant direct positive effect on the physical burden and anxiety status.③The physical burden had a statistically significant direct positive effect on the anxiety status. ④The fatigue status had a statistically significant indirect positive effect on the anxiety via the physical burden. ⑤The resilience had a statistically significant indirect negative effect on the anxiety via fatigue status or physical burden, see Fig. 1.

2.5. Statistical analysis

After checking the date accuracy, IBM SPSS Statistics (Version 22.0) and AMOS (Version 23.0) were applied to complete the data analysis. Descriptive analysis was used to describe the general data, frequencies and percentages were used for count data, and (mean±standard deviation) was used for measurement data. Comparison of difference between groups conducted by independent-sample t-test and analysis of variance (ANOVA).

The SEM was used to verify the path and synthetic relationship among participants' resilience, fatigue, anxiety and physical burden status. The Maximum Likelihood Estimation was employed for parameter estimation. As is customary, the first indicator on the far left of every latent factor was fixed at 1. Modification indices were used to guide model improvement and bootstrapping was employed to verify the significance of indirect effects between the measured factors with the bootstrap samples of 1000. In SEM, the model fit index of path analysis based on the following multiple criteria: the root mean square error of approximation (RMSEA)<0.08 [27], the comparative fit index (CFI)>0.9, the goodness-of-fit index (GFI)>0.9 [28,29], the adjusted goodness-of fit-index (AGFI)>0.9, the Tucker-Lewis fit index (TLI)>0.9, incremental fit index (IFI)>0.9, the normal fit index (NFI)>0.9, the parsimany-adjusted normal fit index (PNFI) and the parsimany-adjusted comparative fit index (PCFI)>0.5 resulted in an acceptable model [30]. Hypotheses regarding the structural relationships of the constructs in the final model were evaluated using the magnitude of path coefficients (standardized coefficient) and their significance [28]. The difference is considered as statistically significant when P values<0.05 [31].

3. Results

3.1. Demographic and social characteristics

A total of 115 medical staff completed the study questionnaires, 55 medical staff worked within Intensive Care (IC) and the remaining 60 medical staff worked in Non-intensive Care (NIC). The mean age of IC group was (32.89±5.8) years, including 9 doctors and 46 nurses. And the mean age of NIC group was (32.10±6.73) years, including 13 doctors and 47 nurses, as shown in Table 1. All the participants were basically in good physical condition and had no chronic diseases.

3.2. Comparison of the SAS, MFI-20 and CD-RISC-25 between the Intensive Care group and Non-intensive Care group

Our results showed that the total anxiety scores of the IC group was lower than that of the NIC group, and the total fatigue and resilience scores were higher than the NIC group, nevertheless, there were no statistical differences (P>0.05). Only a few dimensions of the fatigue and resilience manifested that there were significant differences (P<0.05), as shown in Table 2.

3.3. Comparison of the SAS, MFI-20 and CD-RISC-25 among different demographic characteristics

The mean total score on anxiety, fatigue, resilience of our participants were (44.63±9.79), (51.02±10.46), (66.45±13.27) respectively. As observed in Table 3, different working duration in Wuhan (T=-3.295, P=0.001), different perceived stress level (F=4.276, P=0.007) and perceived health status (F=4.978, P=0.008) had significant differences in fatigue scores during the investigation, the fatigue scores was significantly different between male and female participants (T=2.142, P=0.034); As for resilience scores and anxiety scores, only different current perceived health status of participants showed a statistically significant difference (P<0.05).

3.4. The SEM constructing process for the medical staff working at Wuhan Huoshenshan Hospital

In our research, we assumed resilience and anxiety as variables to assess a part of the mental health of the medical staff working at Huoshenshan Hospital, and assumed physical burden and fatigue to assess the partial physical health of them. Firstly, the latent variable resilience was estimated by tenacity, strength and optimism dimensions. Secondly, the work duration in Wuhan, the self-rating sleep status, the perceived health status and working intensity of the medical staff were regarded as observed variables of the latent variable physical burden. Thirdly, the latent variable fatigue was measured by GF, PF, MF, RM and RA scores. The fourth area was anxiety estimated by the subjective feelings including the perceived stress level, confidence in overcoming the epidemic and self-reported anxiety scores of the medical staff. We established a SEM to explore the association between the four latent variables and their observed variables. Finally, the chi-square ($\chi 2$) value of the model result was 111.604 with degrees of freedom=81, the P-value=0.014. And the model fit results yielded values of RMSEA=0.058, GFI=0.891, AGFI=0.838, NFI=0.844, IFI=0.952, TLI=0.935, CFI=0.950, PNFI=0.651, PCFI=0.733, which showed the model had an acceptable fit to the data.

Table 1
Demographic and social characteristics of the participants

Items		The IC group (*N*=55)		The NIC group (*N*=60)	
		Number	Percentage(%)	Number	Percentage(%)
Age(years)	≤30y	19	34.5	31	51.7
	30y~40y	29	52.7	21	35.0
	≥40y	7	12.8	8	13.3
Gender	Male	11	20	9	15.0
	Female	44	80	51	85.0
Marital status	Single	16	29.1	16	26.7
	Married	39	70.9	44	73.3
Profession	Doctor	9	16.4	13	21.7
	Nurse	46	83.6	47	78.3
Education	Undergraduate or less	45	81.8	50	83.3
	Postgraduate or more	10	18.2	10	16.7
Work experience (years)	≤10y	29	52.7	36	60.0
	>10y	26	47.3	24	40.0
Technical title	Primary	33	60.0	39	65.0
	Intermediate and above	22	40.0	21	35.0
Current perceived stress level	None	4	7.3	10	16.7
	Seldom	18	32.7	23	38.3
	Medium	25	45.5	24	40.0
	Large	8	14.5	3	5.0
Current perceived health status	Very good	17	30.9	22	36.7
	Not bad	33	60	33	55.0
	General	5	9.1	5	8.3
Attitude to work in Wuhan	Strive for it	43	78.2	36	60.0
	Volunteer	12	21.8	24	40.0
Work duration in Wuhan	<25d	26	47.3	38	63.3
	≥25d	29	52.7	22	36.7

Table 2
Anxiety, fatigue and resilience status between two groups

Items		IC group ($\bar{x}$ ±*s*)	NIC group ($\bar{x}$ ±*s*)	*T* value	*P* value
Anxiety	Total anxiety scores	42.84±9.44	46.27±9.94	-1.896	0.573
Fatigue	Total fatigue scores	52.85±9.33	49.33±11.20	1.822	0.103
	GF	12.00±2.17	10.67±3.07	2.666	0.002**
	PF	10.45±2.09	10.08±2.74	0.810	0.005**
	RA	9.89±2.45	9.88±2.96	0.015	0.060
	RM	10.00±2.53	9.28±2.73	1.457	0.280
	MF	10.51±2.50	9.42±2.92	2.143	0.184
Resilience	Total resilience scores	67.58±11.75	65.42±14.54	0.873	0.077
	Tenacity scores	33.27±6.04	32.87±7.89	0.308	0.028*
	Strength scores	23.71±4.63	22.28±4.84	1.611	0.519
	Optimism scores	10.60±2.27	10.27±2.74	0.708	0.061
Sleep status	Total SRSS scores	24.60±5.47	22.87±5.70	1.661	0.1

* *P*<0.05
** *P*<0.01.GF=General Fatigue; PF=Physical Fatigue; MF=Mental Fatigue; RM=Reduced Motivation; RA=Reduced Activity; SRSS=The Self-Rating Scale of Sleep

The results indicated the direct path from the scores for resilience to the scores for fatigue (β=-0.52, *P*<0.01) and the scores for anxiety (β=-0.24, *P*<0.01) were both significant. Fatigue showed statistically significant pathway for physical burden (β=0.65, *P*<0.01). A bootstrap sample of 1000 tested the mediating effect of the study variables. We found that in the three tested indirect path, the scores for fatigue had a significant mediating effect between the scores for resilience and the scores for anxiety (β=-0.305, *P*=0.039), resilience also demonstrated a significant indirect effect on the physical burden via the scores for fatigue (β=-0.276, *P*=0.02) of the medical staff as the confidence interval did not include 0. All of the structural paths for the model were presented in Figure 2 and Table 4.

4. Discussion

To our knowledge, this is the first study focusing on exploring the underlying relationship between variables relating to the physical and mental health of the medical staff who were in close contact with infected COVID-19 patients.

We measured the anxiety level of the medical staff under the impact of COVID-19 epidemic, the results demonstrated that there was no substantial difference between IC group and NIC group. However, it was not consistent with the anxiety scores of other two medical staff groups (direct contact treatment vs non-direct contact treatment) [32], and the anxiety scores of our two groups were both lower than the medical staff from Heilongjiang province in China as compared with the studies conducted by Liu [33] and Zhou [34] respectively, this may be because all of our participants were military medical staff with relatively better psychological endurance and adjustment ability. Meanwhile, our participants worked at Wuhan Huoshenshan Hospital, which was located in the epicenter of the crisis, they had better organizational support and more trust in equipment and infection control initiatives, so the anxiety level was not very high. In the more overloaded work environment, the tenacity of the IC group may be more easily to be stimulated than the NIC group when caring for COVID-19 patients who are in intensive care. As for fatigue level, there were significant differences between the IC group and the NIC group in terms of GF and PF scores, it seemed that the ever-increasing number of confirmed and suspected cases, front-line

Table 3
Comparison of the SAS, MFI-20 and CD-RISC among different clusters

Items	*N*(%)		Fatigue			Resilience			Anxiety		
			$\bar{x}\pm s$	*T/F* value	*P* value	$\bar{x}\pm s$	*T/F* value	*P* value	$\bar{x}\pm s$	*T/F* value	*P* value
Age	≤30y	50(43.5)	51.26±10.30	0.066	0.936	63.84±12.67	2.616	0.078	46.40±9.16	1.539	0.219
	30y~40y	50(43.5)	51.04±9.99			67.30±13.57			43.52±10.25		
	≥40y	15(13)	50.13±12.96			72.33±12.79			42.40±9.98		
Gender	Male	20(17.4)	55.50±7.90	2.142	0.034*	63.90±11.85	-0.946	0.346	45.10±7.51	0.237	0.813
	Female	95(82.6)	50.07±10.71			66.99±13.55			44.53±10.25		
Technical title	Primary	72(62.6)	51.07±10.35	0.069	0.945	65.42±13.10	-1.084	0.281	44.86±9.50	0.332	0.741
	Intermediate and above	43(37.4)	50.93±10.75			68.19±13.53			44.23±10.38		
Working duration in Wuhan	<25d	64(55.7)	48.27±10.83	-3.295	0.001**	65.34±13.35	-1.003	0.318	44.09±9.87	-0.651	0.516
	≥25d	51(44.3)	54.47±8.93			67.84±13.16			45.29±9.77		
Profession	Doctor	22(19.1)	53.41±9.06	1.195	0.234	65.95±12.13	-0.195	0.846	44.36±8.09	-0.139	0.89
	Nurse	93(80.9)	50.45±10.73			66.57±13.59			44.69±10.20		
Marital status	Married	83(72.2)	51.12±10.46	0.170	0.866	66.46±12.86	0.007	0.994	45.08±10.14	0.806	0.42
	Single	32(27.8)	50.75±10.61			66.44±14.51			43.44±8.89		
Work experience(years)	≤10y	65(56.5)	51.49±10.15	0.554	0.581	64.75±13.27	-1.575	0.118	45.23±9.28	0.753	0.453
	>10y	50(43.5)	50.40±10.91			68.66±13.08			43.84±10.48		
Department	Intensive care unit(ICU)	55(47.8)	52.85±9.33	1.822	0.071	67.58±11.75	0.873	0.384	42.84±9.40	-1.896	0.060
	General isolation ward	60(52.2)	49.33±11.20			65.42±14.54			46.27±9.94		
Attitude to work in Wuhan	Strive for it	79(68.7)	49.94±10.33	-1.654	0.101	68.05±13.25	1.937	0.055	44.76±10.35	0.215	0.830
	Volunteer	36(31.3)	53.39±10.49			62.94±12.81			44.33±8.60		
Current perceived stress level	None	14(12.2)	45.36±11.35	4.276	0.007**	71.14±15.19	1.245	0.297	43.57±10.78	2.057	0.110
	Seldom	41(35.7)	48.44±10.45			67.78±13.82			41.95±8.37		
	Medium	49(42.6)	54.08±9.54			64.10±12.88			46.51±10.50		
	Large	11(9.5)	54.18±8.75			66.00±9.01			47.55±8.73		
Current perceived health status	Very good	39(33.9)	47.21±11.12	4.978							
0.008**	71.95±13.44	6.062	0.003**	41.08±10.51	4.852	0.01*					
	Not bad	66(57.4)	52.41±10.01			64.23±12.68			45.94±9.13		
	General	10(8.7)	56.70±5.19			59.70±9.48			49.80±7.15		
Education	Undergraduate or less	95(82.6)	50.45±10.69	-1.266	0.208	66.28±13.45	-0.295	0.769	44.95±10.16	0.765	0.446
	Postgraduate or more	20(17.4)	53.70±9.04			67.25±12.70			43.10±7.91		

* $P<0.05$
** $P<0.01$

Table 4
Direct and indirect effect of the SEM

Path	Standardized coefficient	Standard error	Critical ratio	*P*-value	95% confidence interval
Fatigue <— Resilience	-0.52	0.036	-5.414	0.000**	-0.672 -0.364
Anxiety <— Resilience	-0.24	0.008	-2.651	0.008**	-1.190 -0.165
Physical burden <— Resilience	-0.18	0.090	-1.336	0.182	-0.500 0.150
Physical burden <— Fatigue	0.65	0.289	3.354	0.000**	0.160 0.904
Anxiety <— Fatigue	0.12	0.023	1.385	0.166	-0.472 0.941
Anxiety <— Physical burden	0.78	0.016	1.188	0.235	-0.115 1.674
Resilience—>Fatigue —> Anxiety	-0.305	0.200	/	0.039*	-0.890 -0.071
Fatigue—>Physical burden —> Anxiety	0.174	0.411	/	0.153	-0.050 0.991
Resilience—>Fatigue —> Physical burden	-0.276	0.100	/	0.020*	-0.496 -0.075

** $p<0.01$
* $p<0.05$

great work pressure especially in the intensive care unit, severity of illness, uncomfortable and deficient medically protective materials (such as N95 masks, goggles and protective clothing), lack of specific drugs were likely to contribute to the difference of physical fatigue between these two groups [35,36].

In our study, we found that the variables of gender, working duration in Wuhan and current perceived stress level had statistical differences when it comes to the fatigue level of the participants, and different current perceived health status showed different fatigue, resilience and anxiety level. The COVID-19 pandemic is unprecedented, the medical staff were exposed to both physical and psychological stress [37]. As reported in the previous studies, fatigue is a subjective experience that cannot be easily measured by objective methods, women usually complain more about fatigue than men [38]. Generally, male medical staff have better physical strength than female members, they would take on more tasks spontaneously in stressful work and living conditions, that may be why the fatigue scores of our male participants was higher than female participants. It is known that the failure in resistance to the existing physical and mental stress in medical personnel might induce anxiety, depression and ultimately fatigue [39,40], it is consistent

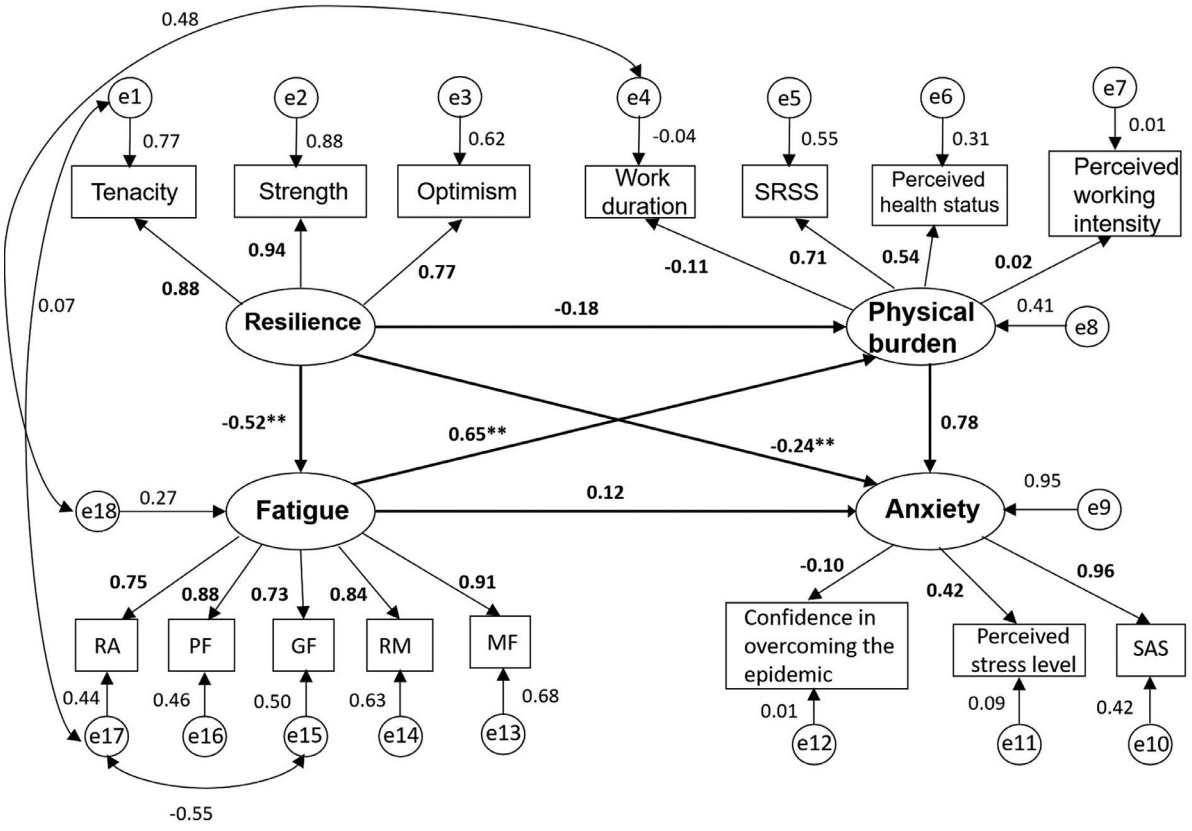

Fig. 2. The standardization coefficient of the SEM for the front-line medical staff
SRSS=The Self-Rating Scale of Sleep; SAS=The Self-Rating Anxiety Scale; GF=General Fatigue; PF=Physical Fatigue; MF=Mental Fatigue; RM=Reduced Motivation; RA=Reduced Activity; "**", $p<0.01$; "*", $p<0.05$

with our finding which higher perceived stress level was associated with higher fatigue level. It is easy to understand that mandatory long work, shift work and night shifts could induce in prolonged fatigue due to impaired recovery from work for medical professionals [41,42], the longer working duration, the more fatigue and burnout the front-line medical staff would have. As WHO said, hazards including pathogen exposure, long working hours, fatigue, occupational burnout and so on put health workers at risk of infection [43], more healthy, safe and decent working conditions for them was urgently needed. A review regarding to population-based mental health during COVID-19 stated that poor perceived health was associated with higher rates of anxiety [44]. when medical staff are in good health, they are rarely experience physical illness, they would recovery from fatigue status more effectively, less health anxiety would be generated when they faced of overwhelming media reports and treatment reality shock [45], and the effect of resilience would be mobilized more quickly to adjust the adverse impacts of negative events without the interference of physical discomfort [46].

Finally, this study applied SEM to determine the relationship among variables concerning physical and mental health of the medical staff caring for patients with COVID-19 in Wuhan Huoshenshan Hospital, but the hypotheses of the model in our study were not totally confirmed. It is noticeable that resilience level of the medical staff were shown to have statistically significant effects on both fatigue level and anxiety level. Resilience is a multidimensional concept which has increasing importance recently in coping strategies in response to hardship [47], Windle [48] and Liu et al. [49] have provided current definition that took resilience as a process, through which individuals use personal and environmental elements in order to redirect traumatic adverse and stressor of everyday life. Consistent with several studies which have confirmed the existence of a negative relationship between resilience and anxiety [50,51], we found that the higher level of resilience, the lower anxiety the medical staff would feel, we could determine the resilience as a protective factor when the front-line medical staff were confronted with the unknown and severe pandemic. The inherent implication contained in resilience explains how events are perceived and how much strength of behaviour is addressed by individuals, meanwhile, the emotional adaptation and regulation to problematic situations are highlighted through this process [52]. Furthermore, many studies have shown that higher levels of resilience not only link to improved mental health but also maintain physical health in the general population or other chronically ill populations [53,54]. In our findings, the negative relationship was verified between the levels of resilience and fatigue, fatigue level was positively associated with physical burden level. As Jeon [55] and Ristevska-Dimitrovska [56] claimed, resilience is a powerful predictor of fatigue, someone who is less resilient always has worse body image and fatigue level, their pessimism might hinder a more optimistic outlook of life to make a difference in such a grim pandemic reality. Fatigue is a outcome of how medical staff deal with crisis strikes such as problem solving and seeking social support, and continuous high-intensity workload aggravated the fatigue level of the front-line medical staff. Given that fatigue has showed the largest relative effect on one's physical function [57], prolonged fatigue would make our participants' physical function decline and even work efficiency.

In this study, the indirect effect was detected between resilience and physical burden via the fatigue level of our participants, the partial mediation effect of fatigue on resilience and anxiety was also confirmed. It revealed that the front-line medical staff with higher level of resilience had lower fatigue, so they would experience less anxiety and be in better health. Fatigue is a subjective perception and can also be a sign of subhealth status including physiological fatigue and psychological fatigue [58], resilient individuals are more likely to have cognitive flexibility which could act on fatigue feeling to regulate the decreased quality of

life [59]. Moreover, medical staff who were in sub-health and a fatigued state with poor physical functioning maybe more susceptible to virus, which induced increasing levels of anxiety relating to feelings of uncertainty and contagion fear [60,61]. Therefore, the mediating role of fatigue could have impact on both physical and psychological outcomes.

However, there are some limitations in our research. Firstly, the sample size of the front-line medical staff working at Wuhan Huoshenshan Hospital is not very large because of the heavy workload, so the accuracy of the parameter estimation cannot be guaranteed. And it is still not known whether some significant relationships have not been discovered yet, it is of great need to enroll more samples for further retrospective research. Secondly, the cross-sectional study design could not reflect the dynamic health status of the observed participants, exploring the physical and mental health change of the medical staff especially those who closely contact with the COVID-19 infected patients everyday is necessary. Thirdly, some variables concerning individual' s feeling like current perceived stress level are subjective, which may affect the reliability of the findings, so the conclusive statements about results should be interpreted with caution.

5. Conclusion

We ultimately saw the abatement of the COVID-19 epidemic in China thanks for the timely initiatives. The findings indicated that our participants underwent some impairment in physical and psychological health. In terms of SEM, we found the fatigue and anxiety of the medical staff could be mitigated by individual's resilience, resilience was also supposed to be a positive process which indirectly affected their anxiety level and physical burden by regulating the fatigue level. At the same time, the improvement of fatigue level was beneficial in protecting the physical health of the front-line medical staff. Currently, global pandemic is still developing, evidence-based physical and mental health interventions focusing on stimulating the effect of individual's resilience level and taking tailored measures against fatigue may be one of the promising strategies to alleviate the health damage caused by negative responses of the medical staff when they confront of arduous pandemic.

Author contribution

RY and JYW conceived and designed the study, they had full access to all the data of this research; DHL and XMB took responsibility for the data collection; JYW and JC drafted the manuscript; LY and XM had revised the manuscript carefully to keep the accuracy. Every author had reviewed and approved the final version of the manuscript.

Declaration of Competing Interest

In this research, we don't have any conflict of interests.

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Data availability

The datasets used and analyzed during the current study are not available due to the privacy, but it can be obtained from the corresponding author on reasonable request.

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