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Research paper

Relationship between perceived stress and depression in Chinese front-line medical staff during COVID-19: A conditional process model

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ABSTRACT

Background: Sustained stress during COVID-19 may be associated with depression in front-line medical staff, which would expose them to severe threats. This study aimed to examine whether the relationship between perceived stress and depression is mediated by insomnia, and whether this mediation is moderated by resilience.
Methods: For front-line medical staff, this study used online questionnaire to evaluate their perceived stress, depression, insomnia and resilience. A conditional process model was performed to examine the relationship between perceived stress and depression, as well as the mediating effect of insomnia and the moderating effect of resilience.
Results: A total of 606 front-line medical staff completed the survey. Higher level of perceived stress was significantly positively related to severe insomnia and depression. In addition, insomnia was positively related to depression, while resilience could moderate the effect of perceived stress on depression by direct and indirect paths.
Limitations: The causality among perceived stress, depression, insomnia and resilience is difficult to be verified.
Conclusions: Perceived stress is positively related to depression, and insomnia can mediate the effect of perceived stress on depression. In addition, the effect of perceived stress on depression, whether direct or indirect, is moderated by resilience, which is a protective factor for mental health.

1. Introduction

Since December 2019, COVID-19 has rapidly spread to the whole world and has evolved into a worldwide pandemic (Knight, 2020). Front-line medical staff has attracted widespread attention in this fight against COVID-19. Of note, they suffer from a higher risk of infection and a heavier workload than general people (K. Xu et al., 2020), which increases the risk of depression with further consequences that might induce job burnout and suicide (Chen et al., 2021; Huo et al., 2021; Sahimi et al., 2021; Weibelzahl et al., 2021). Several studies have shown that the incidence of depression in Chinese population at the epidemic was about 12.0%–27.9% (Ren et al., 2020; Shi et al., 2020; Wang et al., 2021), while that in front-line medical staff was up to 30%–50% (An et al., 2020; Guo et al., 2021; Li et al., 2020; Lixia et al., 2021). Undoubtedly, front-line medical staff is the high-risk group of depression (Kang et al., 2020), and adequate attention focused on the mental status of front-line medical staff is critical in the face of major epidemic disasters.

Perceived stress is considered to be the predisposing factor of depression (Cristobal-Narvaez et al., 2020; Zhang et al., 2020). During COVID-19, the front-line medical staff may encounter many stressors, including but not limited to fatigue, the uncertainty and novelty of the

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virus, and the huge gap between treatment expectations and treatment outcomes, all of which may aggravate individual depression (Asmundson and Taylor, 2020; Qiu et al., 2021). Moreover, a multicenter study has found that Chinese medical staff were generally under stress during the epidemic, with 50.7% showing symptoms of depression (Liu et al., 2020). Admittedly, the association between perceived stress and depression exists, but the underlying mediating and moderating mechanisms behind this association have not been identified in front-line medical staff.

Front-line medical staff not only suffer from excessive stress but also general insomnia. A longitudinal study has demonstrated that high levels of stress can induce and maintain insomnia (Garefelt et al., 2020). Moreover, other studies have found insomnia is a predictor of depression, tending to occur earlier than depression (Baglioni et al., 2011; Perlis et al., 1997). Accordingly, we speculate that insomnia may be an intermediate process from perceived stress to depression. In fact, previous studies have found the effect of insomnia on the relationship between perceived stress and depression in certain groups, but the findings are not consistent (Hsieh et al., 2021; Liu et al., 2017; Liu et al., 2021; Picchioni et al., 2010). And importantly, whether these findings could be duplicated to front-line medical staff during COVID-19 still remains unexplored. In addition, examining moderating factors is a gap in the aforementioned studies, which will be filled in the current study.

The psychological outcomes of different individuals under the same stress are different, and this heterogeneity might originate from many factors, in which resilience is one of the most important ones. Resilience is recognized as an individual's ability to effectively moderate and maintain mental health in the face of frustration or adversity and has a positive effect on moderating depression (Infurna and Luthar, 2018). Especially in the background of COVID-19, front-line medical staff face different degrees of stress (Zhang and Ma, 2020). Although they have a stronger sense of professional mission, the overall level of resilience is not strong (L. Xu et al., 2020). Therefore, in order to prevent medical staff from serious depression and other psychological disorders, the construction of resilience is particularly important.

In summary, this study aimed to examining whether the relationship between perceived stress and depression was mediated by insomnia, and whether the effects of perceived stress on depression and the mediating role of insomnia were moderated by resilience. Answering these questions could help develop better intervention programs to reduce or avoid depression in front-line medical staff. The conceptual framework of the study is shown in Fig. 1, and three hypotheses were proposed:

Hypothesis 1. Perceived stress would be positively and directly related to depression.

Hypothesis 2. Insomnia plays a mediating effect between perceived stress and depression.

Hypothesis 3. Resilience could moderate the effects of perceived stress and insomnia on depression.

2. Materials and methods

2.1. Participants

The front-line medical staff in this study refers to the medical and health staff who directly participate in the screening, detection, treatment, nursing and other COVID-19-related work, and have contact with confirmed or suspected cases in accordance with government, health authority, or medical institution requirements (The State Council joint prevention and control mechanism of March 12, 2020).

Participants were recruited from February 14 to March 29, 2020. The study used a snowball sampling strategy, and conducted an anonymous cross-sectional survey of front-line medical staff through online questionnaire. The survey contents include general demographic characteristics, perceived stress, depression, insomnia and resilience. The questionnaire was distributed through "Wenjuanxing" Survey Platform (Ranxing Technology, China) in China, and forwarded through Wechat to front-line medical staff, which is one of the most important social platforms in China. A questionnaire can only be validly submitted if all contents are answered. Finally, 606 questionnaires were collected and included in the study. The Ethics Committee of the Institute of Psychology of the Chinese Academy of Sciences approved this study, and all participants volunteered to participate in the survey of the project.

2.2. Assessment and measurements

2.2.1. 10-Item Perceived Stress Scale (PSS-10)

The scale mainly assesses the level of individual perceived stress and the ability of subjects to deal with stress by investigating the subjects' feelings or thoughts about certain events in recent a month (Cohen et al., 1983). PSS-10 contains 10 items, 6 of them assess the pressure perception, and the remaining 4 items represent ability perception. Item 4, 5, 7 and 8 are entitled reverse scoring items. The whole scale adopts the 5-level scoring method with an overall score of 0–40. A higher score indicates a greater severity of perceived stress. Cronbach's α for this questionnaire in the current study was 0.801.

2.2.2. Patient Health Questionnaire (PHQ-9)

The scale is widely used to screen depression (Kroenke et al., 2001). PHQ-9 scale contains 9 items, and each item is scored on a 4-point scale.

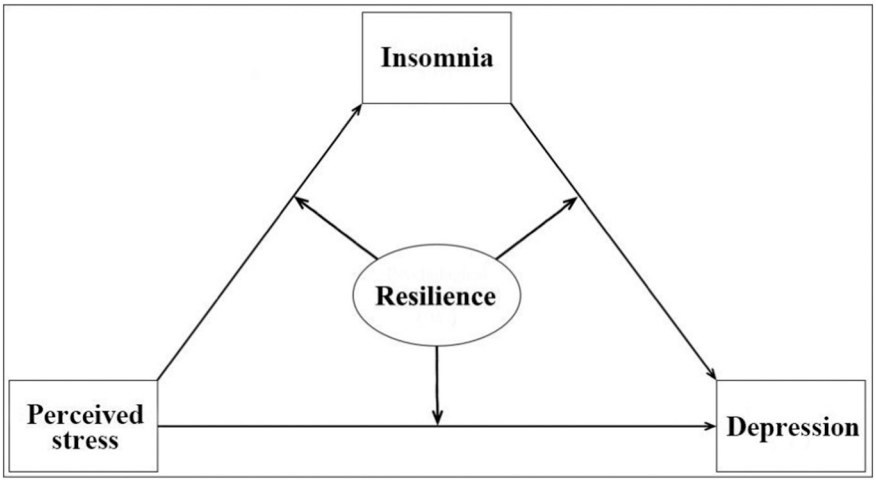

Fig. 1. A conditional process model for the relationship between perceived stress and depression.

The total score is between 0 and 27, with a higher score indicating a greater level of depression. Cronbach's α of the scale was 0.907 in this study.

2.2.3. Insomnia Severity Index (ISI)

ISI scale is used to evaluate the sleep status of subjects in the past two weeks (Thorndike et al., 2011). Its content mainly includes 7 questions such as sleep status, sleep maintenance and sleep satisfaction. The score for each question is scored on a 5-point scale from 0 to 4, with a total score between 0 and 28. A higher score indicates a more serious insomnia. The Cronbach's α measured in this study was 0.939.

2.2.4. 10-Item Connor-Davidson Resilience Scale (CD-RISC-10)

CD-RISC-10 was developed by Campbell-Sills et al. based on the CD-RISC scale (Campbell-Sills and Stein, 2007), which is mainly used to evaluate the resilience levels of subjects in recent a month. The score of each item is 0 to 4, and the total score of the scale is between 0 and 40. A higher score indicates a better resilience level. Its Cronbach's α was 0.963.

2.3. Covariates

In this study, some demographic information was reported: gender (male/female), age, body mass index (BMI), ethnicity (Han population/Non-Han population), marital status (single, married, divorced, and widowed), educational level (high school, bachelor's degree, master's degree, and doctoral degree), family income (low, medium, and high), job position (doctor, nurse, and other medical staff), length of service (<1 year, 1–5 years, 6–10 years, 11–20 years, and >20 years), daily working hours (≤6 h, 6–8 h, 8–10 h, and >10 h), SARS experience (yes/no) and physical illness (yes/no).

2.4. Statistical analysis

The data were preliminarily analyzed using IBM SPSS statistics 24.0. Firstly, for data validity, we examined the common method bias. Secondly, descriptive analyses were conducted for demographic information. Then, the Shapiro-Wilk test was used to test the normality of each continuous key variable. The total score of PSS-10, PHQ-9, CD-RISC-10 and ISI did not satisfy the normal distribution in our dataset. Therefore, the median (M) and inter-quartile range (IQR) were used to describe their distribution characteristics, and Spearman correlation analysis was carried out to evaluate the correlation between each variable. Finally, the collinearity test between variables was conducted.

The conditional process model was completed through the process v3.5 plugin. Specifically, Hypothesis 1 and 2 were tested by the mediation model (Model 4), and Hypothesis 3 was tested by the moderated mediation model (Model 59). Both models had the same independent, dependent, and mediating variables, being perceived stress, depression, and insomnia, respectively, except for resilience, which was included as a moderating variable in the moderated mediation model. And all the regression coefficients calculated by the above two models were also controlled for gender, age, BMI, ethnicity, marital status, education level, family income, job position, length of service, daily working hours, SARS experience and physical diseases. In addition, the non-parametric percentile bootstrap method was used to test both models. The bootstrap sample size was set at 5000, the confidence interval was 95%, and all continuous variables were meant centering. Compared with the causal steps approach and Sobel test, the bootstrap method has higher test efficiency, and there is no requirement for normality of data.

3. Result

3.1. Common method bias

The common method bias, controlled by anonymous measures and partial items reverse scoring in the process of data collection, was assessed by the Harman one-way test via SPSS 24.0. The results of unrotated exploratory factor analysis showed that 5 characteristic root factors were greater than 1. The load of the first factor (i.e. the maximum factor) was 36.24%, which is less than the critical value of 40%. Therefore, there is no serious common method bias in this study.

3.2. Characteristics of the participants

As shown in Table 1, a total of 606 front-line medical staff participated in and effectively filled in the questionnaire, including 114 males (18.81%) and 492 females (81.19%). The median age of participants was 35 years (IQR = 11.25) and the median BMI was 22.04 (IQR = 4.27). Of the total sample, 556 (91.75%) were Han population, 454 (74.92%) were married, 446 (73.60%) had a bachelor's degree, and 402 (66.34%) had a middle income. The study included 205 (33.83%) doctors, 334 (55.12%) nurses and 67 (11.06%) other medical staff. Of these, 194 (32.01%) had 11–20 years of service and 163 (26.90%) had 6–10 years. 268 (44.22%) worked 8–10 h daily and 244 (40.26%) worked 6–8 h. In addition, 262 (43.23%) reported having SARS experience and 137 (22.61%) had physical illness.

3.3. Descriptive analysis and correlation test of scale scores

The distribution status, M, IQR and Spearman correlation coefficient of key variables in the study were represented in Table 2. The results

Table 1
Demographic characteristics of front-line medical staff.

Variable	$N = 606$	
Gender, n (%)		
Male	114	(18.81)
Female	492	(81.19)
Age, M (IQR)	35	(11.25)
BMI, M (IQR)	22.04	(4.27)
Ethnicity, n (%)		
Han population	556	(91.75)
Non-Han population	50	(8.25)
Marital status, n (%)		
Single	125	(20.63)
Married	454	(74.92)
Divorced and widowed	27	(4.46)
Educational level, n (%)		
High school	14	(2.31)
Bachelor degree	446	(73.60)
Master degree	92	(15.18)
Doctoral degree	54	(8.91)
Family income, n (%)		
Low	106	(17.49)
Medium	402	(66.34)
High	98	(16.17)
Job position, n (%)		
Doctor	205	(33.83)
Nurse	334	(55.12)
Other medical staff	67	(11.06)
Length of service, n (%)		
<1 year	25	(4.13)
1–5 years	85	(14.03)
6–10 years	163	(26.90)
11–20 years	194	(32.01)
>20 years	139	(22.94)
Daily working hours, n (%)		
≤6 h	40	(6.60)
6–8 h	244	(40.26)
8–10 h	268	(44.22)
>10 h	54	(8.91)
SARS experience, n (%)		
Yes	262	(43.23)
No	344	(56.77)
Physical illness, n (%)		
Yes	137	(22.61)
No	469	(77.39)

Table 2
Descriptive analysis and correlation coefficients of key variables.

	Skewness	Kurtosis	M	IQR	1	2	3	4
1.PSS-10	−0.588	1.149	19.00	7.00	1			
2.PHQ-9	1.145	0.903	5.00	8.00	0.482**	1		
3.ISI	−0.750	0.740	28.00	12.00	0.323**	0.622**	1	
4.CD-RISC-10	1.101	1.100	5.00	7.00	−0.310**	−0.474**	−0.340**	1

** $P < 0.01$ (two tailed), the correlation is significant.

showed that perceived stress was positively related to depression ($r = 0.482$, $P < 0.01$), insomnia ($r = 0.323$, $P < 0.01$), and negatively related to resilience ($r = -0.310$, $P < 0.01$); Depression was positively related to insomnia ($r = 0.622$, $P < 0.01$) and negatively related to resilience ($r = -0.474$, $P < 0.01$). There was a significant negative relation between resilience and insomnia ($r = -0.340$, $P < 0.01$).

3.4. Collinearity test

Since the process plug-in is based on the principle of linear regression to establish the mediation/regulation effect model, and there is also a significant correlation between each variable, multi-collinearity test is particularly important. The results showed that the variance inflation factor (VIF) was less than 10, and tolerance was greater than 0.1, indicating that no serious multi-collinearity existed in data.

3.5. Mediating effect analysis

As shown in Table 3, perceived stress was positively related to depression ($\beta = 0.428$, 95% Cl: [0.370, 0.486], $P < 0.001$). After adding the mediating variable insomnia, the positive relation between perceived stress and depression was still significant ($\beta = 0.287$, 95% Cl: [0.236, 0.338], $P < 0.001$). Moreover, perceived stress was also positively related to insomnia ($\beta = 0.305$, 95% Cl: [0.234, 0.376], $P < 0.001$), and insomnia was positively related to depression ($\beta = 0.462$, 95% Cl: [0.407, 0.517], $P < 0.001$). This indicated that perceived stress was not only directly related to depression, but also indirectly related to depression through insomnia which played a partial mediating role. Respectively, the contribution rates of direct and indirect effects in the total effect were 67.06% (0.287/0.428) and 32.94% (0.141/0.428) (Table 4).

3.6. Moderated mediation analysis

The results of moderating effect of resilience were shown in Table 5. The direct effect of perceived stress on depression was significantly moderated by resilience ($\beta = -0.012$, 95% Cl: [−0.016, −0.008], $P < 0.001$). In addition, resilience also had a moderating effect on the mediation path, and the moderation was stronger for the first half path of the mediation process than that for the second half path (perceived stress × resilience: $\beta = -0.010$, 95% Cl: [−0.016, −0.004], $P < 0.001$; insomnia × resilience: $\beta = -0.007$, 95% Cl: [−0.012, −0.001], $P = 0.018$).

Table 4
Total, direct and indirect effects of perceived stress on depression.

	Effect	Boot SE	Boot LLCI	Boot ULCI
Direct effect	0.287	0.026	0.236	0.338
Indirect effect	0.141	0.023	0.098	0.187
Total effect	0.428	0.030	0.370	0.486

Simple slope analysis can more intuitively demonstrate the moderating effect of different levels of resilience. As shown in Fig. 2, whether the resilience was at low or high level, perceived stress had a positive effect on insomnia and depression, and the positive effect of insomnia on depression was also significant. The difference was that insomnia and depression were more serious at low-level resilience, while high-level resilience only partly weaken the effects of perceived stress and insomnia on depression.

4. Discussion

In the background of COVID-19, previous studies on depression in front-line medical staff mainly focused on its incidence and the exploration of risk factors, with few studies reporting the mediating/moderating mechanism of depression. The current study mitigates this gap by revealing the internal mechanism of insomnia and resilience in the link between perceived stress and depression. This finding will provide a further understanding of front-line medical staff's depression status, and contribute to better prevention and moderation of their future psychological problems. We found that insomnia is a mediating factor from perceived stress to depression, and there is a partial mediating relationship. Resilience has a certain moderating effect both in direct and indirect paths.

Perceived stress is significantly related to depression (Du et al., 2020; Luo et al., 2021), which has been proved again in the current study (Hypothesis 1). Moreover, insomnia can be used to explain part of the effect of perceived stress on depression (Hypothesis 2). In other words, higher perceived stress can lead to depression in front-line medical staff by causing insomnia. Theoretically, this relationship is reasonable. Spielman's model points out that the interaction between individual insomnia predispositional characteristics and stressors can lead to the

Table 3
Conditional process model effects (model 4).

Dependent variable	Independent variable(s)	Coefficient	*SE*	*t*	*P*	95% Cl
Depression	Perceived stress	0.428	0.030	14.461	<0.001	0.370, 0.486
		$R^2 = 0.320$, $F = 21.394$, $P < 0.001$				
Insomnia	Perceived stress	0.305	0.036	8.462	<0.001	0.234, 0.376
	Constant	6.213	3.467	1.792	0.074	−0.595, 13.021
		$R^2 = 0.163$, $F = 8.885$, $P < 0.001$				
Depression	Perceived stress	0.287	0.026	11.073	<0.001	0.236, 0.338
	Insomnia	0.462	0.028	16.538	<0.001	0.407, 0.517
	Constant	3.700	2.361	1.567	0.118	−0.938, 8.337
		$R^2 = 0.535$, $F = 48.546$, $P < 0.001$				

Table 5
Conditional process model effects (model 59).

Dependent variable	Independent variable(s)	Coefficient	*SE*	*t*	*P*	95% Cl
Insomnia	Perceived stress	0.249	0.036	6.927	<0.001	0.178, 0.319
	Resilience	−0.182	0.028	−6.406	<0.001	−0.238, −0.126
	Perceived stress × Resilience	−0.010	0.003	−3.401	<0.001	−0.016, −0.004
	Constant	3.044	3.379	0.901	0.368	−3.593, 9.682
		$R^2 = 0.221$, $F = 11.148$, $P < 0.001$				
Depression	Perceived stress	0.260	0.025	10.557	<0.001	0.212, 0.309
	Insomnia	0.383	0.029	13.360	<0.001	0.326, 0.439
	Resilience	−0.141	0.019	−7.240	<0.001	−0.179, −0.103
	Perceived stress × Resilience	−0.012	0.002	−5.944	<0.001	−0.016, −0.008
	Insomnia × Resilience	−0.007	0.003	−2.369	0.018	−0.012, −0.001
	Constant	10.022	2.236	4.483	<0.001	5.631, 14.413
		$R^2 = 0.591$, $F = 50.017$, $P < 0.001$				

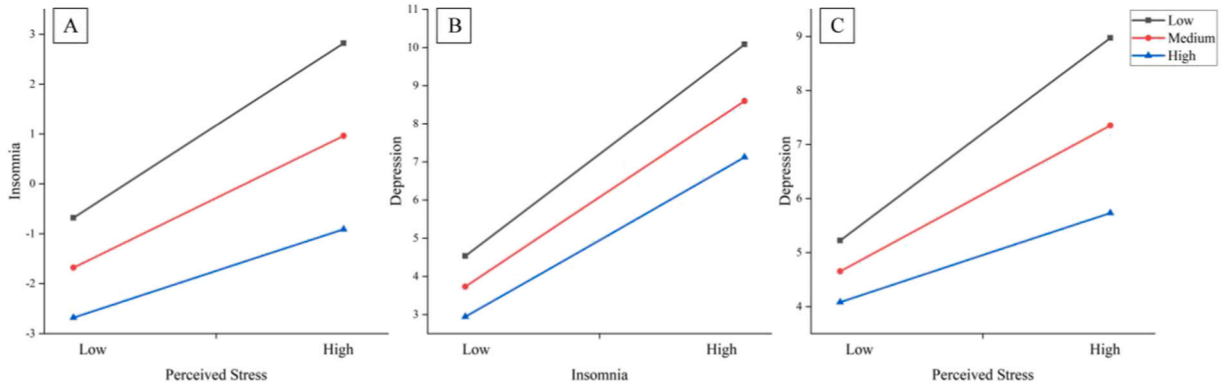

Fig. 2. Simple slope analysis of different levels of resilience
Note. (2A) Resilience moderates the effect between perceived stress and insomnia; (2B) Resilience moderates the effect between insomnia and depression; (2C) Resilience moderates the effect between perceived stress and depression.

onset of insomnia, and continuous insomnia will increase the risk of depression (Spielman, 1986; Spielman et al., 1996). In addition, biological mechanism studies have found insomnia is a disorder adaptive reaction to stressors or threatening stimulation (Gold, 2015; McNamara and Auerbach, 2010). When individuals perceive stress or threatening stimulation, they will suffer from acute insomnia symptoms by inducing fear emotions and activating the "fight or flight" system. This will activate the holistic high alertness, and leave the body in a conditioned fear response (CR) (Perogamvros et al., 2020), causing increased skin electrical activity (Broman and Hetta, 1994), heart rate (Bonnet and Arand, 1998), and cortisol levels (Vgontzas et al., 2001). These activities will awake chronic insomnia symptoms and further cause inflammation (Irwin, 2015), while changes in cortisol and inflammation levels have a variety of links with depression (Sapolsky et al., 2000; Slavich and Irwin, 2014). Therefore, improving sleep quality can effectively alleviate depression in front-line medical staff under high level of perceived stress.

Consistent with our initial hypothesis, the current research revealed a moderating role of resilience in the occurrence of depression (Hypothesis 3). Specifically, lower resilience has a stronger effect on depression, which is similar to the conclusion of Karatsoreos et al. that low levels of resilience increase vulnerability to disease (Karatsoreos and McEwen, 2013). On the one hand, individuals with different levels of resilience tend to adopt different coping styles. When facing stressful events, they will experience different stress intensities, resulting in different outcomes (positive/negative) (Connor and Davidson, 2003). For example, individuals with higher resilience prefer to adopt an active coping style (Feder et al., 2009), which may change their views or cognition of stressors, thereby reducing perceived stress. In addition, resilience not only represents the recovery effect of the current stasis state, but also encapsulates the positive or enhanced functions due to adversity experience (such as SARS experience) (Nishimi et al., 2021). These positive changes can improve the individual's response capacity (Fredrickson and Branigan, 2005), and also strengthen the control of the vagus nerve to improve the recovery ability, then reduce the occurrence of depression (Oveis et al., 2009). On the other hand, a previous study has found endogenous stressors (such as insomnia) can cause neuroendocrine dysfunction (Buysse et al., 2008). Especially, stressors can increase cortisol concentration by triggering and activating HPA axis (Voderholzer et al., 2012). However, resilience can moderate the relationship between stressors and cortisol concentration (Lehrer et al., 2020), and the stress reaction caused by neurohormones to sleep deprivation (Sun et al., 2014).This indicates that improving the resilience of front-line medical staff can not only reduce the risk of depression, but also weaken the impact of perceived stress and insomnia on individuals. It is worth noting that higher stress can lead to insomnia, and insomniacs also usually feel higher stress (Ellis et al., 2014), which in turn aggravates sleep disorder (Veeramachaneni et al., 2019). This influence of vicious cycle may explain why resilience moderates the first half of the mediation process (perceived stress → insomnia) more strongly than the second half (insomnia → depression).

Several limitations of this survey are worth considering. Firstly, the study is a cross-sectional study, so the causal relationship between variables needs to be further demonstrated by longitudinal research. Secondly, the study was conducted through an online questionnaire and for subjects who did not submit the questionnaire, their information was not available, and thus selection bias might exist. However, it is gratifying that the collection of the research data was completed within one month of the initial stability of COVID-19, and the respondents were able to truthfully feedback their psychological status at that time.

Therefore, the recall bias was relatively small, ensuring the reliability of the research results to some extent. Thirdly, due to the questionnaires used in this study are self-evaluation questionnaires, the follow-up study should be conducted in combination with clinical diagnosis to objectively evaluate mental health status. Finally, confounding factors have been collected as much as we can, but some are still not included, such as the severity of epidemics in the workplace and the adequacy of medical resources.

5. Conclusion

In conclusion, our research develops the internal mechanism between perceived stress and depression of front-line medical staff, and provides a theoretical support for the implementation of future interventions. Our results demonstrate the impact of perceived stress on depression includes two paths, direct and indirect, and the indirect path is realized through insomnia. In addition, both paths were moderated by resilience, which is a protective factor for mental health. Therefore, the health authorities need to pay attention to the stress status of front-line medical staff and provide opportune interventions to effectively release stress. In addition, relieving insomnia is beneficial to reduce the level of depression. To keep the sleep quality, shift timely and arranging working hours reasonably are needed. Necessarily, some intervention measures can be applied, such as drug intervention, cognitive insomnia behavior therapy, etc. Finally, resilience is important to relieve insomnia and depression. Strengthening the resilience level of front-line medical staff can make them have strong adaptability, so as to reduce the risk of insomnia and depression, which requires hospitals to regularly carrying out psychological counseling to enhance their positive emotions.

Author Contributions Statement

Peng Li: Methodology, Formal analysis, Writing – Original Draft; Zhen Liang: Study design; Zhaojing Yuan: Writing – Original Draft; Guohua Li: Investigation; Yanni Wang: Review & Editing; Wei Huang: Investigation; Lingyun Zeng: Investigation; Wei Qian: Investigation; Jiezhi Yang: Data curation; Xin Zhou: Investigation; Junchang Li: Investigation; Li Su: Review & Editing; Yongjie Zhou: Project administration, Supervision.

Declaration of competing interest

All authors declare that they have no conflicts of interest.

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