



Research article

Mental state, biological rhythm and social support among healthcare workers during the early stages of the COVID-19 epidemic in Wuhan

Yixiu Liu^{a,1}, Lei Li^{b,c,1}, Xingmei Jiang^{b,c}, Yihao Liu^d, Rui Xue^{b,c}, Hua Yu^{b,c}, Wei Wei^{b,c}, Yajing Meng^{b,c}, Zhe Li^{b,c,*}^a Department of Intensive Care Unit, West China Hospital, Sichuan University, No.37 Guoxue Alley, Chengdu, China^b Mental Health Center, West China Hospital, Sichuan University, No. 28 Dianxin South Road, Chengdu, China^c Sichuan Clinical Medical Research Center for Mental Disorders, No. 28 Dianxin South Road, Chengdu, China^d Department of Psychology, College of Life and Environmental Science, University of Exeter, Exeter, United Kingdom

ARTICLE INFO

Keywords:

COVID-19

Healthcare worker

Stress buffering effect

Social support

Biological rhythm

ABSTRACT

Background: The COVID-19 pandemic has put the mental health of healthcare workers at risk. However, the potential psychosocial factors underlying mental health problems, such as depression and anxiety, require further investigation. The present study aimed to explore the factors that influence the mental state of healthcare workers.

Methods: A total of 276 healthcare workers completed a set of online self-report questionnaires from February 4 to 7, 2020, in the following order: general information related to the COVID-19 outbreak, Biological Rhythms Interview of Assessment in Neuropsychiatry, Beck Depression Inventory-II, Beck Anxiety Inventory, and Social Support Rating Scale.

Results: Our study revealed that both social support and age moderated the ability of biological rhythm disturbance to exacerbate depression ($R^2 = 0.47$; effect size $f^2 = 0.85$). Higher levels of social support buffered the amplification of depression associated with increased biological rhythm disturbance in all age groups, and especially in younger individuals (mean age = 26.57, $se = 0.04$). Depressive symptoms were predicted by both social and sleeping rhythms, whereas anxiety symptoms were predicted only by social rhythm. Married individuals had lower biological rhythm disturbance ratings and higher social support ratings. Females also reported higher ratings in social support.

Conclusions: Our study suggests that biological rhythm intervention along with social support can reduce the negative effect of biological rhythm disturbance on mood disorders, especially in younger people. We also provide evidence for the ability of social support to buffer stress in a major health crisis and demonstrate the effects of marital status and sex, which provide a different perspective for studying mental crisis management.

1. Introduction

Since the outbreak of the COVID-19 pandemic, the majority of the world's health services have taken on serious responsibilities [1] and the crisis management approach to mental health has come under the spotlight [2, 3]. Recent studies have shown that more than 36.9% of healthcare workers in Wuhan, China have experienced subthreshold mental health disturbance, among which 6.2% have experienced severe disturbance [4], 50.4% depression, 44.6% anxiety, and 34.0% insomnia

[5]. However, little is understood about the psychosocial processes underlying these mental disorders.

A potential psychosocial mechanism causing these disorders is the intense workload of healthcare staff that disturbs their biological rhythms, especially sleeping, appetite, and patterns of social interaction [6]. Empirical studies have shown that low-quality sleep leads to depression and anxiety [7, 8], which could explain the increased prevalence of mood disorders during the COVID-19 pandemic [5]. Moreover, the effects of poor sleep on mood disorders are influenced by individual factors, such as age [9]. However, there is limited research on biological

* Corresponding author.

E-mail address: jay_li@163.com (Z. Li).

¹ These authors contributed equally to the work.

rhythm disturbance in different age groups of healthcare workers during the current pandemic.

Another potential factor affecting the development of mood disorders is the limited social support available to healthcare workers during the pandemic. Social support refers to support measures that are accessible to individuals through their social relationships with other people, groups, and the wider community [10, 11], and that can be divided into objective support, subjective support, and utilisation of support [12]. Early empirical studies have shown that depression and anxiety are negatively associated with social support [13, 14], especially subjective support [15]. A study also reported that social support available to healthcare workers during the pandemic was negatively associated with depression and anxiety [16].

Social support can reduce the impact of stressful or negative events on depression, as strong social relationships help individuals cope with stress, a process also known as the stress buffering effect [17, 18]. Empirical studies have led to numerous models that explore the ability of social support to buffer effects of stress-related depression [19, 20, 21] and stressful or negative life events [22] across various age groups. Additional studies have shown that stress caused by negative life events might be caused by the disturbance of social rhythm [23, 24]. As a sub-factor of biological rhythm, the social rhythm of healthcare workers is also severely affected by the pandemic due to various stressors, such as the mandatory quarantine. Therefore, even limited social support is likely to exert a buffering effect in the pandemic similar to that reported in previous studies [19, 20, 21, 22]. However, the COVID-19 pandemic differs from other stressful incidents, such as pregnancy, so the role of social support requires further investigation.

During the pandemic, each healthcare worker may have access to different levels of social support, as some people may have closer relationships (e.g., marriage) than others. Accordingly, social support can be divided into three components [25]: the social support which objectively presents in one's relationships, or objective support; the support one perceives to be available, or subjective support; and how much social support one actually uses, or utilisation of support. Whether social support is sensitive to such differences among workers is unclear.

In the present study, we aimed to investigate the psychosocial processes underlying depression and anxiety among healthcare workers during the COVID-19 pandemic. First, we compared the consistency of our results for depression and anxiety with previous studies. Second, we explored whether biological rhythm and social support sub-factors could serve as predictors of depression and anxiety, and we hypothesized that sleeping rhythm and subjective social support would be the most significant predictors. Finally, we tested whether social support can buffer the ability of biological rhythm disturbance to amplify mood disorders in different age groups.

2. Methods

2.1. Participants

In this study, we recruited medical staff who worked in Renmin Hospital of Wuhan University at the early stages of the COVID-19 outbreak. At that time, most healthcare workers in the hospital were voluntarily relocated from outside of Wuhan under the major health crisis action by the National Health Commission of the People's Republic of China. No other categories of medical staff, such as therapists, were registered in the action. The 364 participants were from three hospitals in China: West China Hospital, Sichuan University (n = 126), The Second Affiliated Hospital of Chongqing Medical University (n = 120), and the Cheeloo College of Medicine, Shandong University (n = 118). All participants were recruited through WeChat, a Chinese social media application similar to Microsoft Teams, with a QR code linked to the survey posted in the WeChat working group chat. All participants were asked to sign an online informed consent form before participating. To ensure anonymity and honest responses, the survey did not collect personal

information, such as names, and it was conducted according to established ethical guidelines. The study was approved by the Ethics Committee of West China Hospital, Sichuan University (No. 2020-178).

Healthcare workers were included if they (1) had a valid medical license; (2) were currently engaged in clinical work; and (3) have never been diagnosed with any disorder listed in the Diagnostic and Statistical Manual of Mental Disorders (4th edition).

2.2. Quality control

To ensure data quality, each IP address was allowed to submit only one set of survey responses.

2.3. Procedure

A cross-sectional online survey was conducted from February 4 to 7, 2020. Healthcare workers were invited to participate by snowball sampling. A set of custom-made questionnaires was designed based on literature and expert consultation in order to collect demographic data on age, sex, educational background, ethnicity, religion, and marital status. After participants had read a complete description of the survey and signed informed consent, they filled out the questionnaires using the WeChat Mini program. The initial set of invitees (n = 10) was selected to ensure a broad representation of sex, age, education level, academic or medical specialty, as well as medical or academic institution. The selected participants were then asked to forward the questionnaire to 10 other colleagues whom they considered suitable for the survey, and this second set forwarded the questionnaire in the same way, and so on.

2.4. Instruments

A Chinese translation of the Biological Rhythms Interview of Assessment in Neuropsychiatry (BRIAN) [6, 26], which is a 21-item self-report questionnaire, was used to measure biological rhythms such as sleeping, activity, socialisation, eating, and circadian patterns (e.g., "Do you have problems waking up at your usual time? How frequently?"). Responses were ranked from 1 (= never) to 4 (= always).

Depression was measured with a Chinese version of Beck Depression Inventory-II (BDI-II) [27], which is a self-report questionnaire containing 21 instructive items addressing the severity of depression in adolescents

Table 1. Demographic characteristics of the study participants.

Characteristic	Category	N = 276	Proportion (%)
Age in yr, mean (SD; range)		33.80	
		(7.21; 22–57)	
Sex	Male	69	25.0
	Female	207	75.0
Education	Diploma	55	19.9
	Undergraduate	188	68.1
	Postgraduate	33	12.0
Ethnicity	Han Chinese	235	85.1
	Tibetan Chinese	3	1.1
	Muslim Chinese	1	0.4
	Yi Chinese	4	1.4
	Other	15	5.4
	Prefer not to say	18	6.5
Religion	Yes	19	6.9
	No	257	93.1
Marital status	Single	60	21.7
	Married	207	75.0
	Divorced	9	3.3
	Widow	0	0

Note: SD: standard deviation.

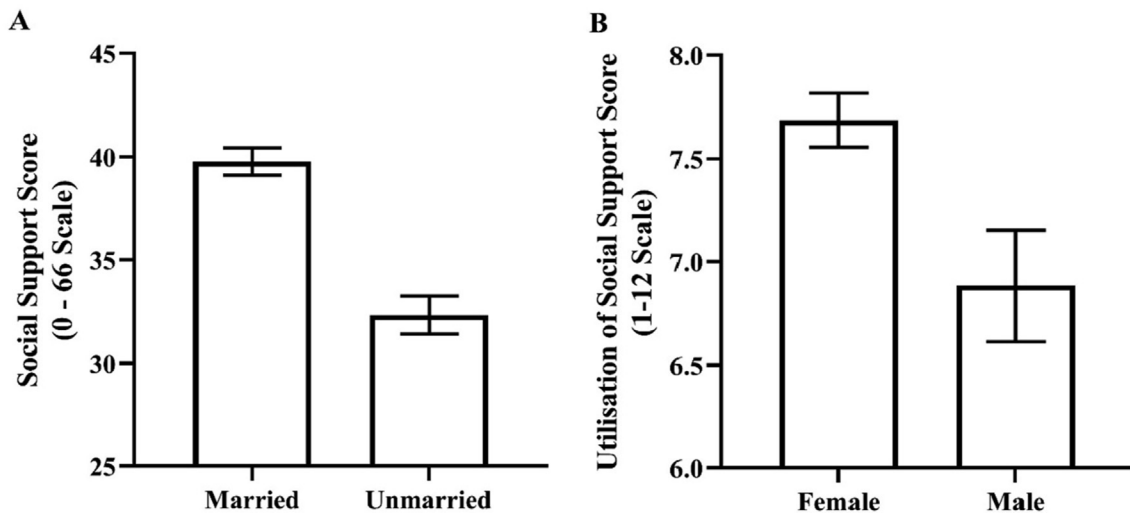


Figure 1. Differences in social support depending on (A) marital status and (B) sex. Married healthcare workers reported higher social support score than unmarried workers, while females reported higher use of social support than males.

and adults Beck, Steer [28]. Every four instructive items were presented in a progressive order with possible scores of 1 (= I do not feel sad), 2 (= I feel sad), 3 (= I am sad all the time and I cannot snap out of it), and 4 (= I am so sad and unhappy that I cannot stand it).

Anxiety was measured using a Chinese version of the Beck Anxiety Inventory (BAI) [29], a self-report questionnaire of 21 instructive items addressing the severity of anxiety (e.g., feeling wobbliness in legs) in adolescents and adults Beck, Epstein [30]. The responses were ranked from 1 (= not at all) to 4 (= severely, it bothers me a lot).

Social Support was assessed using the Social Support Rating Scale (SSRS), which consists of 10 items and three dimensions: objective support, subjective support, and utilisation of support [31]. The total score was the sum of the scores on each dimension, and higher scores reflected higher levels of social support.

2.5. Statistical analysis

Statistical analysis was performed with SPSS 26.0. Differences in the demographic characteristics between participants were assessed using analysis of variance (ANOVA). Comparisons of more than two subgroups were performed using post-hoc analysis with Bonferroni adjustment when a main effect was detected. Pearson correlation analysis was then used to explore associations between input and output variables, and correlated factors were entered into a multiple linear regression model to determine the largest predictor. Exploratory moderation analysis was carried out to explore pathways underlying these associations. Post-hoc power analysis was performed using G-Power 3.1 with an alpha level of $p < 0.05$. The recommended effect sizes were as follows: small (effect size $f^2 = 0.02$), medium (effect size $f^2 = 0.15$), and large (effect size $f^2 = 0.35$) [32].

3. Results

3.1. Participants

Of the 364 healthcare workers invited to the study, 276 completed the survey. The average age of the whole sample (207 females, 69 males) was 33.80 years. Most of the participants reported being Han Chinese ($n = 235$), married ($n = 207$), not having a religion ($n = 257$) and having an undergraduate education ($n = 188$) (Table 1).

3.2. Individual differences in social support

Participants' characteristics were matched to detect significant individual differences in social support. Marital status had a significant group

effect on overall social support [$F(1,274) = 34.07, p < 0.001, \eta_p^2 = 0.111$] and its sub-factors [subjective: $F(1,274) = 30.01, p < 0.001, \eta_p^2 = 0.099$; objective: $F(1,274) = 34.07, p < 0.001, \eta_p^2 = 0.100$; utilisation: $F(1,274) = 4.60, p = 0.033, \eta_p^2 = 0.017$] (Figure 1A), suggesting that married healthcare workers received higher overall social support than unmarried workers. In addition, female participants rated their utilisation of social support as higher than males [$F(1,274) = 8.64, p = 0.004, \eta_p^2 = 0.031$] (Figure 1B), but two-way ANOVA revealed no effect of marital status or sex on the utilisation of support [$F(1,274) = 0.69, p = 0.406, \eta_p^2 = 0.003$].

3.3. Individual differences in biological rhythm

As shown in Figure 2, the feeding subscale of BRIAN was lower in the unmarried group than in the married group [$F(1,274) = 4.57, p = 0.033, \eta_p^2 = 0.016$], suggesting that married healthcare workers had better diet regulation. No significant difference was found in other characteristic factors such as sleeping rhythm [$F(1,274) = 2.52, p = 0.113, \eta_p^2 = 0.009$] or circadian rhythm [$F(1,274) = 0.203, p = 0.652, \eta_p^2 = 0.001$].

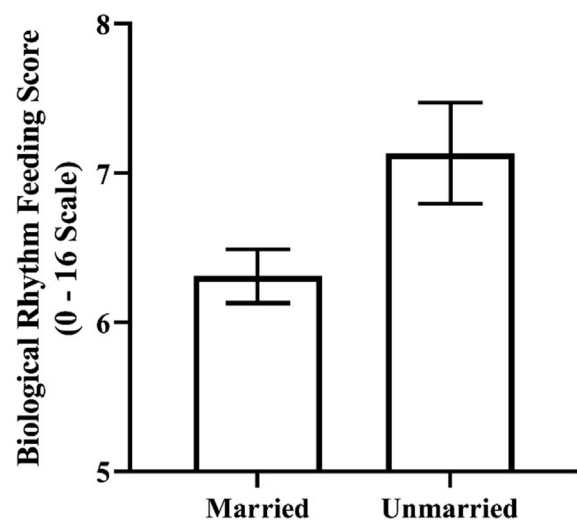


Figure 2. Differences in feeding rhythm depending on marital status. Unmarried healthcare workers reported higher disturbance in their feeding rhythm than married workers.

Table 2. Correlation matrix of social support subscales, depression level, anxiety level, and sample age.

N = 276	1	2	3	4	5	6
1. Objective Support						
2. Subjective Support	$r_s = 0.53^*$					
3. Support Utilisation	$r_s = 0.53^{**}$	$r_s = 0.52^{**}$				
4. Depression	$r_s = -0.19^*$	$r_s = -0.30^*$	$r_s = -0.17^*$			
5. Anxiety	$r_s = -0.10$	$r_s = -0.08$	$r_s = -0.02$	$r_s = 0.56^{**}$		
6. Age	$r_s = 0.08$	$r_s = 0.16^*$	$r_s = 0.01$	$r_s = -0.09$	$r_s = -0.04$	
Mean	21.57	8.89	7.49	6.77	5.48	33.79
Standard deviation	5.90	3.50	1.99	8.19	7.97	7.21
Range	4–28	3–16	3–9	0–40	0–54	22–57

Note: * $p < 0.05$; ** $p < 0.001$. Cronbach's alpha was 0.828 for the SSRS questionnaire, 0.921 for the BDI-II questionnaire, and 0.944 for the BAI questionnaire. Age did not significantly correlate with overall social support.

3.3.1. Exploratory correlations in social support subscales

The correlation matrix of social support subscales, depression level, anxiety level, and sample age (Table 2) showed that healthcare workers with greater access to overall social support were less likely to report depressive symptoms ($r_s = -0.25, p < 0.001$), but no significant correlation was found between social support and anxiety ($r_s = -0.10, p_s = 0.088$).

3.3.2. Exploratory correlations in biological rhythm subscales

The correlation matrix of BRIAN subscales, depression, level, anxiety level, and sample age (Table 3) showed that overall BRIAN score positively correlated with depression ($r_s = 0.63, p_s < 0.001$) and anxiety ($r_s = 0.52, p_s < 0.001$).

3.3.3. Linear regression and moderation effect

To identify potential predictors of depression, SSRS subscales were entered into linear regression analysis, which showed that depression could be predicted by subjective support ($\beta = -0.30, t = -5.19, p < 0.001$) (Table 1). Similarly, BRIAN subscales were entered into linear regression analysis, which indicated that depression could be predicted by social rhythm ($\beta = 2.03, t = 13.46, p < 0.001$) and sleeping rhythm ($\beta = 1.24, t = 9.67, p < 0.001$) (Table 2), while anxiety could be predicted only by social rhythm ($\beta = 0.24, t = 9.70, p < 0.001$) (Table 3). BRIAN and SRSS also significantly correlated with each other as predictors ($r_s = -0.21, p_s < 0.001$), and the collinearity test suggested that there was no multi-collinearity in the regression model (BRIAN, Tolerance = 0.96, VIF = 1.05; SRSS, Tolerance = 0.94, VIF = 1.06).

To examine the buffering effect of social support and age on the association between biological rhythm disturbance and depression, a double moderation analysis was performed, which indicated that higher amplification of depressive scores was significantly associated with an increase in biological rhythm disturbance in younger population with low social support [$\Delta R^2 = 0.47, F(1,270) = 46.96, p < 0.001$] (Table 4).

BRIAN subscales were entered into linear regression analysis to determine the predictor(s) of depression and anxiety. As shown in Table 5, depression was predicted by the social rhythm ($\beta = 2.03, t = 13.46, p < .001$) and sleeping rhythm ($\beta = 1.24, t = 9.67, p < .001$). Anxiety was predicted by social rhythm ($\beta = .24, t = 9.70, p < .001$; Table 6).

Specifically, among the different levels of social support, high social support (mean = 47.60) had the strongest buffering effect on the amplification of depression symptoms associated with biological rhythm disturbance in all age groups [young age (mean age = 26.57): $\beta = 0.45, se = 0.06, t = 7.20, p < 0.001$; middle age (mean age = 33.79): $\beta = 0.32, se = 0.05, t = 6.53, p < 0.001$; old age (mean age = 41.00): $\beta = 0.21, se = 0.06, t = 3.52, p = 0.005$] (Figure 3A). Among the three age groups, the buffering effect was the highest in the younger population, followed by the middle and old age groups. A similar trend was observed with moderate social support, which however had a weaker buffering effect than high social support in all age groups [young age: $\beta = 0.54, se = 0.46, t = 11.90, p < 0.001$; middle age: $\beta = 0.42, se = 0.03, t = 12.68, p < 0.001$; old age: $\beta = 0.30, se = 0.04, t = 6.13, p < 0.001$] (Figure 3B). Low social support had the weakest buffering effect among the three tested groups, and the effect was again higher in the young age group ($\beta = 0.62, se = 0.05, t = 11.97, p < 0.001$) than in the middle age ($\beta = 0.50, se = 0.05, t = 11.11, p < 0.001$) and old age groups ($\beta = 0.38, se = 0.06, t = 6.26, p < 0.001$) (Figure 3C). Low social support was also associated with the highest relative overall depression score.

4. Discussion

The present study explored the differences in biological rhythms and social support and their association with depression and anxiety among healthcare workers during the early stages of the COVID-19 epidemic. Our results showed that the overall SSRS negatively correlated with depression but not with anxiety, partially consistent with the results of a recent study

Table 3. Correlation matrix of BRIAN subscales, depression, level, anxiety level, and sample age.

N = 276	1	2	3	4	5	6	7	8
1. Sleeping								
2. Activity	$r_s = 0.61^{**}$							
3. Social	$r_s = 0.58^{**}$	$r_s = 0.69^{**}$						
4. Feeding	$r_s = 0.56^{**}$	$r_s = 0.56^{**}$	$r_s = 0.53^{**}$					
5. Circadian	$r_s = 0.45^{**}$	$r_s = 0.37^{**}$	$r_s = 0.45^{**}$	$r_s = 0.50^{**}$				
6. Depression	$r_s = 0.50^{**}$	$r_s = 0.55^{**}$	$r_s = 0.63^{**}$	$r_s = 0.45^{**}$	$r_s = 0.35^{**}$			
7. Anxiety	$r_s = 0.50^{**}$	$r_s = 0.43^{**}$	$r_s = 0.51^{**}$	$r_s = 0.36^{**}$	$r_s = 0.30^{**}$	$r_s = 0.56^{**}$		
8. Age	$r_s = -0.05$	$r_s = 0.07$	$r_s = 0.04$	$r_s = -0.16^*$	$r_s = -0.03$	$r_s = -0.09$	$r_s = -0.04$	
Mean	9.63	8.26	6.30	6.48	6.30	6.77	5.48	33.79
Standard deviation	2.96	3.61	2.46	2.59	2.67	8.19	7.97	7.21
Range	5–16	5–19	4–13	4–12	3–12	0–40	0–54	22–57

Note: * $p < 0.05$; ** $p < 0.001$. Cronbach's alpha of the BRIAN questionnaire was 0.913. BRIAN: Biological Rhythms Interview of Assessment in Neuropsychiatry.

Table 4. Simple slope analysis of the ability of social support to moderate the effect of biological disturbance on depressive symptoms among different age groups (N = 276).

Age	Low Social Support			Moderate Social Support			High Social Support		
	B	SE	t	B	SE	t	B	SE	t
Young age	-0.62	.05	-11.97**	0.54	0.05	11.90**	0.45	0.06	7.20**
Middle age	-0.50	.05	-11.11**	0.42	0.03	12.68**	0.33	0.05	6.53**
Old age	-0.38	0.06	-6.26**	0.30	0.05	6.13**	0.21	0.06	3.52**
R ²	0.47								
F	46.96**								

Note: *p < 0.05; **p < 0.001. Post-hoc power analysis was conducted using G-Power 3.1 with a sample size of 276 and an alpha level of p < 0.05. R² = 0.47 indicated an effect size of f² = 0.85 and revealed a multiple regression power of 0.99. The recommended effect sizes used for this assessment were: small (f² = 0.02), medium (f² = 0.15), and large (f² = 0.35).

[16]. We also found that subjective support positively correlated with age and could be therefore used to predict depression. Social support and utilisation of support were sensitive to marital status, with unmarried healthcare workers (single, divorced and widowed) receiving less social support than married ones. Moreover, the total BRIAN score positively correlated with depression and anxiety, consistent with previous results [33, 34, 35], while social and sleeping rhythms proved to be effective predictors of depressive symptoms in contrast to activity and feeding rhythms. Taken together, our study showed that social support may buffer the negative effects of biological rhythm disturbance on the development of depressive symptoms, especially in younger people.

Married healthcare workers reported higher social support and use of support than single and divorced participants. An earlier study has shown that high levels of social support are associated with a strong sense of belonging [35] which, in this case, comes from the married family. Future studies could investigate whether providing stronger external support to unmarried healthcare workers can help them improve their sense of belonging.

Female participants were found to use more social support than males, consistent with previous results [36]. This may be explained by the fact that women tend to care more for other people, which may increase their desire to seek support [36, 37]. Therefore, psychoeducation programs relating to social support could be designed and delivered specifically to male healthcare workers.

Our results suggested that social and sleeping rhythms can effectively predict depression symptoms, which is partially consistent with previous studies in other populations [33, 34, 38]. Decreased social rhythms reduce people's ability and opportunities to seek social support, leading to higher risk of developing depression [39, 40]. Indeed, unmarried healthcare workers in our study had difficulty using social support. Sleeping rhythms have also been significantly associated with mood disorders [41]. Thus, social and sleeping rhythms can be considered as key predictors of depressive symptoms in healthcare workers involved in the management of severe health crises.

In contrast to a recent study [38], we found that activity or feeding rhythms cannot predict depressive symptoms. The feeding rhythm is

Table 5. Linear regression analysis of BRIAN subscales to identify potential predictors of depression (N = 276).

BRIAN subscale	B	SE	β	t
Social rhythm	1.35	.22	0.42	6.21**
Sleeping rhythm	0.34	0.16	0.14	2.20*
Activity rhythm	0.34	0.18	0.13	1.89*
Feeding rhythm	0.21	0.19	0.07	1.08
Circadian rhythm	0.05	0.18	0.02	0.27
R ²	0.44			
F	42.49**			

Note: *p < 0.05; **p < 0.001. BRIAN: Biological Rhythms Interview of Assessment in Neuropsychiatry; SE: standard error.

considered a “zeitgeber” (timer) for the regulation of the circadian clock, as the molecules generated by biochemical reactions during a meal regulate other biological rhythms [42]. Thus, delaying a meal could lead to metabolic syndrome due to chrono-disruption [43]. However, this seems to be case sensitive to the pandemic. The eating patterns of our participants were only slightly disrupted, as the meal times of healthcare workers are relatively fixed by local authorities. Physical activity rhythms are also believed to reduce depressive symptoms [44], but the typical daily shift rotation of healthcare workers in the present case was disrupted by the pandemic. These results suggest that eating and activity rhythms may not be good predictors of depression among healthcare workers during the COVID-19 pandemic.

Our study revealed a double moderating role of social support and age, suggesting that social support can buffer the amplification of depressive symptoms associated with biological rhythm disturbance in all age groups. Our findings are comparable to previous studies reporting that social support may reduce the impact of stress on depression [19, 20, 21] and greatly influence the psychosocial stress caused by negative events [45]. Hence, the social relationships of our participants may have reduced the severe stress caused by the COVID-19 crisis, thus preventing the development of depression. Nevertheless, it should be noted that most previous studies focused on the effects of stress rather than the stressful event itself, and that the literature has reported contradictory results regarding the ability of social support to buffer the effects of stressful life events [45, 46]. In addition, most studies on the social buffering effect in real-life scenarios included moderate stress events, such as job loss or relationship breakdown [46]. The present study is the first to observe the buffering effect of social support during a global health crisis and may provide valuable information for future research in the same field. However, we focused on mood disorder symptoms among healthcare workers, so additional studies are needed to investigate the buffering effect by monitoring their stress levels.

The buffering effect of all levels of social support was stronger in the younger age group than in middle-aged and older participants. This result suggests that younger healthcare workers are more susceptible to

Table 6. Linear regression analysis of BRIAN subscales to identify potential predictors of anxiety (N = 276).

BRIAN subscale	B	SE	β	t
Social rhythm	1.00	0.24	0.32	4.24**
Sleeping rhythm	0.47	0.17	0.20	2.76*
Activity rhythm	0.15	0.20	0.06	0.73
Feeding rhythm	0.10	0.21	0.03	0.46
Circadian rhythm	0.11	0.20	0.03	0.56
R ²	0.30			
F	22.74**			

Note: *p < 0.05; **p < 0.001. BRIAN: Biological Rhythms Interview of Assessment in Neuropsychiatry; SE: standard error.

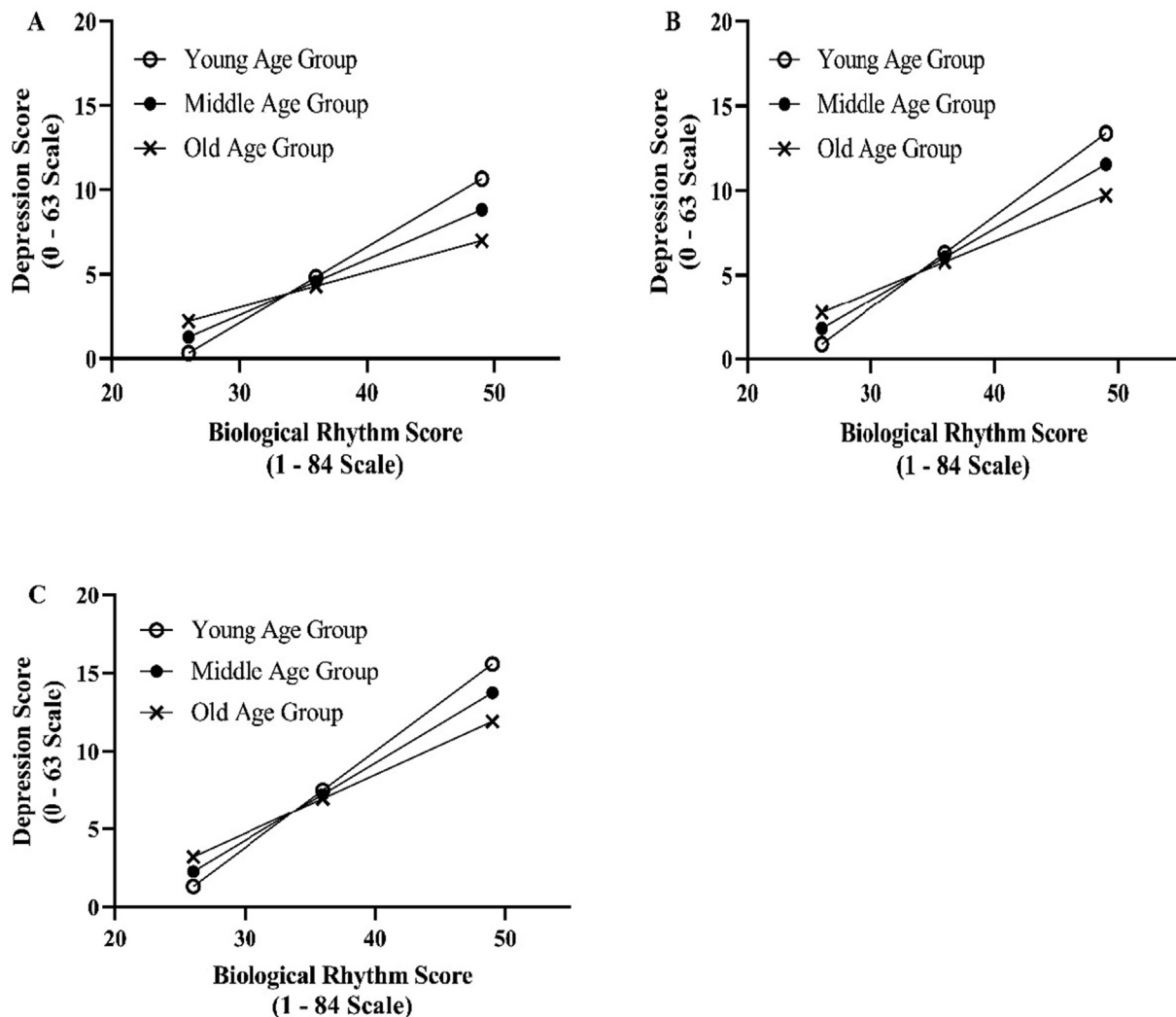


Figure 3. Buffering effect of (A) high social support, (B) moderate social support, and (C) low social support on the amplification of depressive symptoms associated with biological rhythm disturbance in different age groups.

disturbances in biological rhythms, although older people are known to be more vulnerable to biological rhythm disturbances that can lead to depression and anxiety [47]. This discrepancy between age groups could be explained by the fact that altered biological rhythms may not cause depression, but instead may result from it. Indeed, insomnia and sleeping issues may sometimes result from, rather than cause, depression [48], and disturbances in biological rhythms may emerge only during depression and anxiety episodes [49].

Older healthcare workers may have greater experience in managing negative emotions and stress than younger staff, which means they may be less affected by altered biological rhythms. A previous study found that older individuals used more passive strategies such as avoidance to regulate emotion, whereas the younger population preferred pro-active strategies such as social support [50]. In our case, there was limited access to pro-active strategies, which might have enhanced the effect of passive emotion regulation strategies. Future studies can focus on identifying individual differences in emotion regulation strategies in order to develop new intervention models against future major health crises.

4.1. Limitations

The present study was an exploratory cross-sectional study and did not compare healthcare workers with normal population or pre-pandemic with post-pandemic characteristics. In addition, our sample was small and demographically imbalanced by sex and marital status,

which may reduce the generalizability of the findings to other categories of medical staff. The snowball sampling method may also cause selection bias, also reducing the generalizability of our results. Moreover, the study did not consider that influence factors related to the pandemic are constantly changing and that initial conditions differed across countries.

Despite these limitations, the present study may serve as a guide for the development of targeted psychological intervention to strengthen the mental health status of healthcare workers during infectious disease epidemics. Nevertheless, our results should be verified in future research, and follow-up studies should investigate the long-term psychological effects of the COVID-19 epidemic on healthcare staff. Such research should also further explore the role of social support and biological rhythms in mitigating the effects of the pandemic on depressive and anxiety symptoms.

5. Conclusions

Our study suggests that high levels of social support may buffer the increase in depressive scores associated with biological rhythm disturbance, especially in younger healthcare workers. The present research evaluates for the first time the buffering effect of social support on depressive symptoms during a major health crisis and provides essential information on how social support and interventions in biological rhythms can reduce mental health problems among healthcare workers in potential future epidemics of serious infectious diseases.

Declarations

Author contribution statement

Yixiu Liu; Lei Li; Yihao Liu: Analyzed and interpreted the data; Wrote the paper.

Xingmei Jiang: Performed the experiments; Wrote the paper.

Rui Xue, Hua Yu and Wei Wei: Performed the experiments.

Yajing Meng: Performed the experiments; Contributed reagents, materials, analysis tools or data.

Zhe Li: Conceived and designed the experiments.

Funding statement

This work was supported by Zhe Li from Science and Technology Department of Sichuan Province (2022YFS0349); Department of Human Resources and Social Security of Sichuan Province ([2020] 291-20); Applied Psychology Research Center of Sichuan Province (CSXL-202A08); Science and Technology Bureau of Chengdu (2021-YF05-01336-SN).

Author Yixiu Liu was supported by Science and Technology Department of Sichuan Province (2021YFS0331).

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

Supplementary content related to this article has been published online at <https://doi.org/10.1016/j.heliyon.2022.e09439>.

Acknowledgements

We thank all the participants involved the study. We would especially like to thank Mengya Zhao and Ruichong Shuai from the University of Exeter for providing valuable advice on this paper.

References

- D. Wang, V. Gupta, Crisis Intervention [Internet], StatPearls, 2020.
- S.M. Mukhtar, Mental health and psychosocial aspects of coronavirus outbreak in Pakistan: psychological intervention for public mental health crisis, *Asian J. Psychiatr.* 51 (2020) 102069.
- X. Jiang, L. Deng, Y. Zhu, et al., Psychological crisis intervention during the outbreak period of new coronavirus pneumonia from experience in Shanghai, *Psychiatr. Res.* 286 (2020) 112903.
- L. Kang, S. Ma, M. Chen, et al., Impact on mental health and perceptions of psychological care among medical and nursing staff in Wuhan during the 2019 novel coronavirus disease outbreak: a cross-sectional study, *Brain Behav. Immun.* 87 (2020) 11–17.
- J. Lai, S. Ma, Y. Wang, et al., Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019, *JAMA Netw. Open* 3 (3) (2020) e203976–e.
- L.M.F. Giglio, P.V. da Silva Magalhães, A.C. Andreatza, et al., Development and use of a biological rhythm interview, *J. Affect. Disord.* 118 (1-3) (2008) 161–165.
- C.M. Morin, J. Carrier, C. Bastien, R. Godbout, Sleep and circadian rhythm in response to the COVID-19 pandemic, *Canad. J. Publ. Health = Rev. Canad. de sante Publ.* 111 (5) (2020) 654–657.
- M. Ozelik, C. Sahbaz, Clinical evaluation of biological rhythm domains in patients with major depression, *Rev. Bras. de psiquiatria (Sao Paulo, Brazil: 1999)* 42 (3) (2020) 258–263.
- K. Crowley, Sleep and sleep disorders in older adults, *Neuropsychol. Rev.* 21 (1) (2011) 41–53.
- M.R. Cunningham, A.P. Barbee, Social support, in: C. Hendrick, S. Hendrick (Eds.), *Close Relationships: A Sourcebook*, SAGE Publications, 2000, pp. 273–285.
- L.F. Berkman, T. Glass, Social integration, social networks, social support, and health, *Soc. Epidemiol.* 1 (2000) 137–173.
- M. Bender, Y. van Osch, W. Slegers, M. Ye, Social support benefits psychological adjustment of international students, *J. Cross Cult. Psychol.* 50 (7) (2019) 827–847.
- G.W. Brown, B. Andrews, T. Harris, Z. Alder, L. Bridge, Social support, self-esteem and depression, *Psychol. Med.* 16 (4) (1986) 813–831.
- T. Field, M. Diego, J. Delgado, L. Medina, Yoga and social support reduce prenatal depression, anxiety and cortisol, *J. Bodyw. Mov. Ther.* 17 (4) (2013) 397–403.
- L.K. Geogre, D.G. Blazer, D.C. Hughes, N. Fowler, Social support and the outcome of major depression, *Br. J. Psychiatr.* 154 (4) (1989) 478–485.
- H. Xiao, Y. Zheng, D. Kong, S. Li, N. Yang, The effects of social support on sleep quality of medical staff treating patients with coronavirus disease 2019 (COVID-19) in January and February 2020 in China, *Med. Sci. Mon. Int. Med. J. Exp. Clin. Res.: Int. Med. J. Experiment. Clin. Res.* 26 (2020) e923549-1.
- N. Lin, M.W. Woelfel, S.C. Light, The buffering effect of social support subsequent to an important life event, *J. Health Soc. Behav.* 26 (3) (1985) 247–263.
- S. Cohen, T.A. Wills, Stress, social support, and the buffering hypothesis, *Psychol. Bull.* 98 (2) (1985) 310.
- T. Takizawa, T. Kondo, S. Sakihara, M. Ariizumi, N. Watanabe, H. Oyama, Stress buffering effects of social support on depressive symptoms in middle age: reciprocity and community mental health, *Psychiatr. Clin. Neurosci.* 60 (6) (2006) 652–661.
- C. Cheng, Role of perceived social support on depression in Chinese adolescents: a prospective study examining the buffering model, *J. Appl. Soc. Psychol.* 27 (9) (1997) 800–820.
- M. Raffaelli, F.C.D. Andrade, A.R. Wiley, O. Sanchez-Armass, L.L. Edwards, C. Aradillas-Garcia, Stress, social support, and depression: a test of the stressing model. I. middle age. Reciprocity, *J. Res. Adolesc.* 23 (2) (2013) 283–289.
- T.R. Adams, L.A. Rabin, V. Da Silva, M.J. Katz, J. Fogel, R.B. Lipton, Social support buffers the impact of depressive symptoms on life satisfaction in old age, *Clin. Gerontol.* 39 (2) (2016) 139–157.
- S. Malkoff-Schwartz, E. Frank, B. Anderson, et al., Social rhythm disruption and stressful life events in the onset of bipolar and unipolar episodes, *Psychol. Med.* 30 (5) (1998) 1005–1016.
- S. Malkoff-Schwartz, E. Frank, B. Anderson, et al., Social rhythm disruption and stressful life events in the onset of bipolar and unipolar episodes, *Arch. Gen. Psychiatr.* 55 (8) (2000) 702–707.
- A.H. Ciccia, T. Threats, Role of contextual factors in the rehabilitation of adolescent survivors of traumatic brain injury: emerging concepts identified through modified narrative review, *Int. J. Lang. Commun. Disord* 50 (4) (2015) 436–451.
- D.T.L. Shek, Reliability and factorial structure of the Chinese version of the Beck depression inventory, *J. Clin. Psychol.* 46 (1) (1990) 35–43.
- Z. Wang, C.-M. Yuan, J. Huang, et al., Reliability and validity of the Chinese version of Beck Depression Inventory-II among depression patients, *Chin. Ment. Health J.* 25 (6) (2011) 476–480.
- A.T. Beck, R.A. Steer, G. Brown, Beck depression inventory–II, *Psychol. Assess* (1996).
- Y. Ke, T. Ng, H.L. Yeo, M. Shwe, Y.X. Gan, A. Chan, Psychometric properties and measurement equivalence of the English and Chinese versions of the Beck Anxiety Inventory in patients with breast cancer, *Support. Care Cancer* 25 (2) (2017) 633–643.
- A.T. Beck, N. Epstein, G. Brown, R.A. Steer, An inventory for measuring clinical anxiety: psychometric properties, *J. Consult. Clin. Psychol.* 56 (1988) 893–897.
- S. Xiao, Theoretical basis and application in research of social support rating scale, *J. Clin. Psychiatr.* 4 (1994) 98–100.
- J. Cohen, *Statistical Power Analysis for the Behavioral Sciences*, Academic Press, 2013.
- C.M. Morin, J. Carrier, C. Bastien, R. Godbout, Sleep and circadian rhythm in response to the COVID-19 pandemic, *Can. J. Publ. Health* 111 (5) (2020) 654–657.
- M. Ozelik, C. Sahbaz, Clinical evaluation of biological rhythm domains in patients with major depression, *Braz. J. Psychiatr.* 42 (3) (2020) 258–263.
- A. Germain, D. Kupfer, Circadian rhythm disturbances in depression, *Hum. Psychopharmacol. Clin. Exp.* 23 (7) (2008) 571–585.
- O.S. Dalgard, C. Dowrick, V. Lehtinen, et al., Negative life events, social support and gender difference in depression, *Soc. Psychiatr. Psychiatr. Epidemiol.* 41 (6) (2006) 444–451.
- K.S. Kendler, L.M. Thornton, C.A. Prescott, Gender differences in the rates of exposure to stressful life events and sensitivity to their depressogenic effects, *Am. J. Psychiatr.* 158 (4) (2001) 587–593.
- T.C. Mondin, T. de Azevedo Cardoso, L.D. de Mattos Souza, et al., Mood disorders and biological rhythms in young adults: a large population-based study, *J. Psychiatr. Res.* 84 (2017) 98–104.
- A. Kupferberg, L. Bicks, G. Hasler, Social functioning in major depressive disorder, *Neurosci. Biobehav. Rev.* 69 (2016) 313–332.
- R.M.A. Hirschfeld, S.A. Montgomery, M.B. Keller, et al., Social functioning in depression: a review, *J. Clin. Psychiatr.* 61 (4) (2000) 268–275.
- C.A. McClung, How might circadian rhythms control mood? Let me count the ways, *Biol. Psychiatr.* 74 (4) (2013) 242–249.
- T. Abreu, M. Bragança, The bipolarity of light and dark: a review on Bipolar Disorder and circadian cycles, *J. Affect. Disord.* 185 (2015) 219–229.
- C. Wyse, Does human evolution in different latitudes influence susceptibility to obesity via the circadian pacemaker? Migration and survival of the fittest in the modern age of lifestyle-induced circadian desynchrony, *Bioessays* 34 (11) (2012) 921–924.
- A.P. Bailey, S.E. Hetrick, S. Rosenbaum, R. Purcell, A.G. Parker, Treating depression with physical activity in adolescents and young adults: a systematic review and meta-analysis of randomised controlled trials, *Psychol. Med.* 48 (2017) 7.

- [45] P.K. Maulik, W.W. Eaton, C.P. Bradshaw, The effect of social networks and social support on common mental disorders following specific life events, *Acta Psychiatr. Scand.* 122 (2) (2010) 118–128.
- [46] T.D. Wade, K.S. Kendler, Absence of interactions between social support and stressful life events in the prediction of major depression and depressive symptomatology in women, *Psychol. Med.* 30 (4) (2000) 965–974.
- [47] I.C. Costa, H.N. Carvalho, L. Fernandes, Aging, circadian rhythms and depressive disorders: a review, *Am. J. Neurodegenerat. Disease* 2 (4) (2013) 228.
- [48] L. Lustberg, C.F. Reynolds III, Depression and insomnia: questions of cause and effect, *Sleep Med. Rev.* 4 (3) (2000) 253–262.
- [49] C.-M. Oh, H.Y. Kim, H.K. Na, K.H. Cho, M.K. Chu, The effect of anxiety and depression on sleep quality of individuals with high risk for insomnia: a population-based study, *Front. Neurol.* 10 (2019) 849.
- [50] F. Blanchard-Fields, R. Stein, T.L. Watson, Age differences in emotion-regulation strategies in handling everyday problems, *J. Gerontol. B Psychol. Sci. Soc. Sci.* 59 (6) (2004) 261–269.