



OPEN The underlying mechanisms of family function on anxiety among nurses during the public health emergency

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The occurrence of public health emergency in China often makes nurses more susceptible to anxiety. The present study aimed to investigate the prevalence of anxiety among Chinese nurses during the public health emergency and explore the association between family function and anxiety and its underlying mechanisms. Family care index questionnaire, Connor-Davidson Resilience scale, physical activity rating scale and 7-item Generalized Anxiety Disorder Scale were employed to measure family function, resilience, physical activity and anxiety among 779 Chinese nurses during public health emergency. The prevalence of anxiety among nurses during public health emergency was 29.9%. Resilience partially mediated the association of anxiety with family function. Physical activity moderated the direct and indirect effects of family function on anxiety. The direct effect became insignificant when the standard scores of physical activity were 0.629 and over. In contrast, the indirect effect of family function on anxiety through resilience was stronger when the levels of physical activity increased. The present study suggested for nurses with low levels of physical activity, intervention enhancing family function should be designed to prevent anxiety. For those with higher levels of physical activity, programs aimed at strengthening family function and supporting resilience should be developed to manage anxiety.

Keywords Anxiety, Public health emergency, Family function, Resilience, Physical activity

China, as a vast country with a large population, inevitably experiences periodic occurrences of significant natural disasters, accidents, as well as public health and safety incidents¹. In the context of these incidents, medical staffs are the core of the rescue team and always present to the frontline. Nurses as the largest and most significant group of health professionals play pivotal roles in care provision and patient outcomes^{2,3}. Mental wellbeing of nurses is vital for them to fulfill their duties⁴. However, during such incidents, nurses often face multiple challenges that can adversely affect their physical and mental health. These include physical exhaustion due to increased workload, anxiety caused by nosocomial transmission and inadequate personal protective equipment (PPE), and ethically challenging decisions related to care rationing⁵. Existing literature showed in comparison to other healthcare workers, nurses were more susceptible to stress and more likely to develop psychological problems^{6–8}. Given the crucial role nurses play during major public health and safety incidents, their mental health deserves special attention and focus. It has been well-documented that anxiety is the most frequently observed mental health condition, which is of particular concern to us since it might impair cognitive functioning, decrease job performance or even lead to the medical accidents and needless workforce attrition^{9,10}. Therefore, it is of great importance to explore the psychological impact and potential factors that influence the anxiety of nurses during these incidents, in order to develop effective strategies to support their mental health and wellbeing.

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Family function and anxiety

Family, as one of the fundamental resources of social support, plays an indispensable role in shaping both physical and psychological well-being¹¹. The concept of family function encompasses the manner in which family members work collectively as a unit to navigate and cope with various stressors and challenges in their lives^{12,13}. This definition is rooted in the theoretical framework provided by Olson's Circular Pattern Theory, which emphasizes the intricate interplay between emotional bonds, governance structures, communication mechanisms, interpersonal engagement, and the family's capacity to effectively manage urgent situations. The efficiency and effectiveness of family function are frequently correlated with the levels of intimacy and adaptability exhibited within the family unit^{14,15}.

Research has consistently demonstrated that poor family function is associated with a range of internalizing symptoms, including depression, loneliness, and anxiety^{16–18}. These findings are supported by numerous studies that underscores the negative correlation between family function and anxiety level¹⁹. For instance, Shao et al. found that positive family function played an important role in reducing the stress and improving their mental well-being among Chinese medical students²⁰. Similarly, Bu et al. reported that family dysfunction had a negative effect on anxiety among nurses by the mediating effect of expressive suppression²¹. Nevertheless, evidence regarding whether the effect of family function on mental health could be replicated in a sample of nurses during the major public health and safety incidents is limited. Thus, the present study aimed to evaluate the association between family function and anxiety among nurses and its underlying mechanisms during the major public health and safety incidents.

The mediating role of resilience

Resilience, defined as an individual's capacity to adapt positively and recover from adversity, is pivotal in understanding human adaptability and mental well-being²². Central to resilience research is the Resilience Protection Model, a theoretical framework that emphasizes resilience's crucial role as a protective factor. This model proposes that resilience not only alleviates the negative impacts of stressful situations but also promotes the enhancement and progression of mental health^{23,24}. From a theoretical perspective, resilience can be conceptualized through three distinct orientations: trait, process, and outcome. The trait orientation views resilience as an enduring personality trait that provides individuals with a buffer against the adverse effects of adversity or traumatic events^{25,26}. Conversely, the process orientation emphasizes resilience as a dynamic and fluid process, enabling individuals to actively and swiftly recover from significant adversities^{27,28}. Lastly, the outcome orientation sees resilience as a functional or behavioral outcome that facilitates recovery in the aftermath of adversity^{29,30}. All three orientations to resilience would suggest a protective role of resilience in anxiety. Hu et al. found the negative correlation between resilience and negative indicators of mental health (anxiety, depression and negative affect) and positively correlation between resilience and positive indicators of mental health (life satisfaction and positive affect) via meta-analysis³¹. Previous studies showed that the anxiety level and resilience were negatively correlated among different healthcare worker groups including physicians³², front-line nurses², and overall healthcare professionals³³ during the COVID-19 pandemic. Thus, mounting evidence has suggested the protective effect of resilience on anxiety among nurses^{2,34}. Nurses with better resilience can actively handle the stress, quickly adapt to the challenges and rapidly recover from adversity³⁴. Accordingly, resilient nurses are less likely to develop anxiety.

In addition, individuals with higher levels of family function tend to be more resilient. A recent study revealed the facilitating effect of family function on resilience among adolescents and adults with a parent with lung cancer³⁵. Furthermore, resilience has been found to mediate the association between family function and health outcomes^{36–38}. Narn and colleagues showed resilience fully mediated the effect of family cohesion upon the clinical depression among North Korean refugees³⁷. Another study conducted by Lu and colleagues presented the mediating role of resilience in the association between family function and quality of life among the elderly³⁸. Based on these evidence, we speculate that family function might act on the pathway of anxiety through the mediating effect of resilience among nurses during the major public health and safety incidents.

The moderating role of physical activity

Although family function may influence anxiety indirectly via resilience, not all nurses with lower levels of family function and resilience presented higher levels of anxiety. This inconsistency in findings necessitates a deeper investigation into the influential factors that moderate the association between family function and anxiety. One potential moderating factor that has garnered significant attention in recent years is physical activity. According to the integrated model of sports performance, the positive psychological manifestations (encompassing cognitive, emotional, and physiological experiences) elicited during sporting activities exert a protective influence on an individual's physical and mental health, thereby effectively alleviating the impact of risk factors to a certain degree³⁹.

Previous research has found that physical activity can counteract the effects of negative life events and medical conditions on mental symptoms⁴⁰. Numerous epidemiological studies have provided evidence that physical activity could prevent^{41,42} and treat^{43,44} mental symptoms. Gordon et al. reported that resistance training could make moderate reduction in anxious symptoms⁴⁵.

Besides, physical activity is likely to influence mental health via a combination of psychological, psychosocial, biochemical and physiological pathways⁴⁶. Physical activity has been shown to moderate the relationship between mental health and its associated factors^{47–50}. Physical activity was also found to moderate the indirect association between childhood maltreatment and depressive symptoms among college students in China⁴⁹. Additionally, a recent study presented the intensity of physical activity moderated the association between psychological resilience and negative emotions of Chinese college students⁵⁰. Moreover, Sigfusdottir et al.

reported that the relationship between family conflict and stress was far stronger in those physically inactive adolescents, which indicated that physical activity can moderate the negative impact of family conflicts on depression for adolescents⁵¹. Based on this extensive literature review, it is reasonable to conclude that physical activity may moderate the effect of environmental and psychological factors, including family function and resilience, on mental health. Therefore, we hypothesize that physical activity may also moderate the influence of family function and resilience on anxiety among Chinese nurses during major public health and safety incidents.

Coronavirus Disease 2019 (COVID-19) was declared a disease of Public Health Emergency of International Concern by WHO on 30 January 2020, which posed a great challenge on Chinese and even the global health system^{52,53}. Under such great challenge during typical public health emergency event, mental health problems were prevalent among nurses^{54,55}. Therefore, this study conducted the cross-sectional survey by choosing the epidemic prevention and control of COVID-19 as a typical public health emergency event. The purpose of the present study was twofold: (1) to examine the prevalence of anxiety during public health emergency in China; (2) to investigate the mediating role of resilience and moderating role of physical activity in the association between family function and anxiety. Therefore, a moderated mediation model was constructed to examine the hypotheses that resilience might mediate the association between family function and anxiety and physical activity might moderate the direct and/or the indirect (resilience-anxiety path) effect of family function on anxiety among nurses in major public health and safety incidents in China (see Fig. 1).

Methods

Participants

This cross-sectional survey was conducted in early January, 2022, during the epidemic prevention and control of COVID-19, which was a typical public health and safety incidents. A total of 784 participants from five local hospitals in Jiangsu province were selected by multi-stage random cluster sampling. The sampling process included three stages. In the first stage, one city (Suzhou) was randomly chosen from Jiangsu Province, with the city serving as the cluster sampling unit. In the second stage, five hospitals were randomly selected from all the local hospitals of Suzhou, each hospital acting as a cluster sampling unit. In the third stage, a random selection of 784 nurses was made across these five hospitals in Jiangsu Province. G Power 3.1.9.7 was employed for the sample size calculation for a multiple linear regression analysis with an alpha error of 0.05, a power of 95% and an effect size of 0.15. The minimum sample size was computed to be 89. The inclusion criteria for the present study were as follows: (1) aged > 18 years, (2) working in the hospital during the epidemic prevention and control (3) volunteered to participant in the survey and (4) no dyslexia. The exclusion criterion was that the participants had a history of mental illnesses. Finally, 779 nurses were included in the formal analysis. This research received approval and written informed consent was obtained from all participants prior to the online questionnaire.

Measures

Family function has been investigated using the 5-item family care index questionnaire⁵⁶. The scale included five dimensions: adaptation, partnership, growth, affection, and resolve. A 3-point Likert scale (0 = hardly ever; 2 = almost always) is used to rate each item, with total scores ranging from 0 to 10. A higher score suggested a more highly functional family. The scale has shown impressive reliability and validity. In the present study, the Cronbach's alpha for the scale was 0.957.

Resilience was assessed by the Connor-Davidson Resilience scale (CD-RISC), which is a 25-item scale. Each item is rated on a 5-level Likert scale, ranging from 0 (never) to 4 (very often). The CD-RISC scale contains three factors including optimism (i.e., "See the humorous side of things"), strength (i.e., "Pride in your achievements"), and tenacity (i.e., "One can achieve one's goals"). The scale has been widely used and demonstrated sufficient

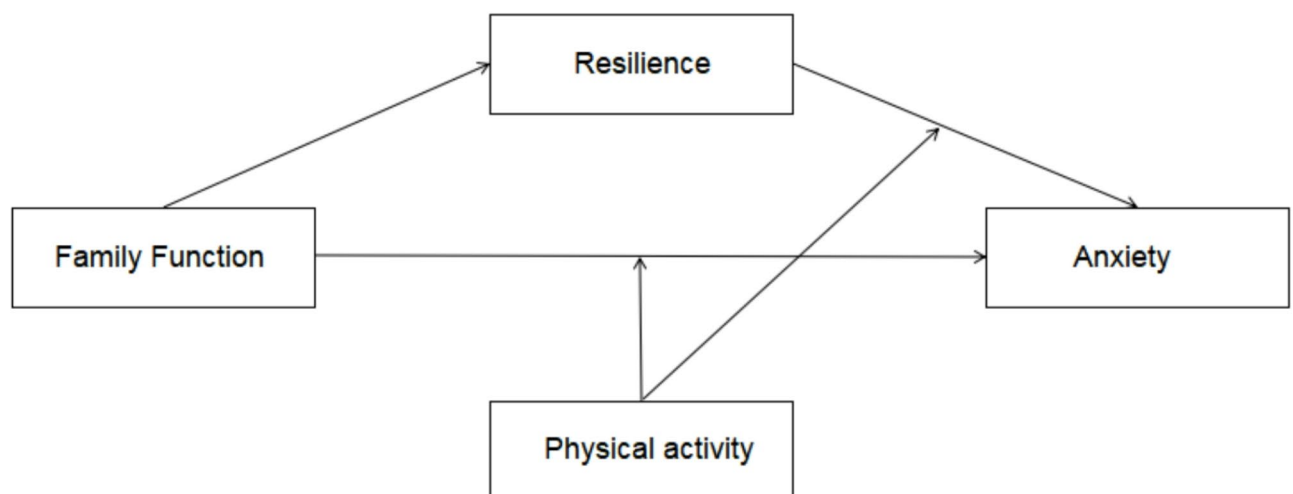


Fig. 1. The conceptual model.

reliability and validity based on Chinese population (7, 33). The Cronbach's alpha was 0.977 for the total scale, 0.812 for optimism subscale, 0.950 for strength subscale and 0.966 for tenacity subscale.

The Physical Activity Rating Scale (PARS-3) developed by Liang et al.⁵⁷ was employed to measure the participation level of physical activity from three aspects: intensity, duration and frequency. Each item is rated from 1 to 5. Physical activity score = intensity score \times (duration score - 1) \times frequency score. Thus, the total score ranges from 0 to 100. The Chinese version of the PARS-3 has been widely used in Chinese samples with adequate psychometric properties⁵⁸.

Anxiety was measured with the 7-item Generalized Anxiety Disorder Scale (GAD-7)⁵⁹. The questionnaire employs a Likert 4-level scoring response model, 1(not at all), 2(several days), 3(more than half the days), 4(nearly every day). The total score ranges from 0 to 28, with higher scores denoting higher levels of anxiety. The cut-off point for screening anxiety is 7⁹. The scale has demonstrated excellent reliability and validity based on Chinese population⁵⁹. The Cronbach's alpha in the present study was 0.958.

Demographic variables in the present study included age ("1= ≤ 30 " or "2= > 30 "), gender ("1=male" or "2=female"), marital status ("1=unmarried" or "2=married"), years of working ("1=10 years or less" or "2=More than 10 years") and technical title ("1=Junior" or "2=Intermediate or higher").

Statistical analysis

Firstly, Harman single factor test was conducted to examine common method bias⁶⁰ and descriptive analyses were performed to describe demographic characteristics. Independent t-test was employed to compare group differences in anxiety. Secondly, Pearson's correlation analyses were used to explore the bivariate correlations between all the study variables (family function, resilience, physical activity and anxiety). Thirdly, the mediating role of resilience in the association between family function and anxiety was examined by MacKinnon's four step procedure⁶¹. Four conditions should be satisfied: (1) a significant association between family function and anxiety; (2) a significant association between family function and resilience; (3) a significant relationship between resilience and anxiety when controlling for family function; (4) a significant coefficient for the indirect association between family function and anxiety through resilience. The last condition was tested by the bias-corrected percentile bootstrap method (5000 repeats), calculating a 95% bias-corrected confidence interval (CI) for the indirect effect. If zero was not included in the CI, the mediating effect was established. The parameters for the mediating effect were computed by Hayes PROCESS macro (Model 4)⁶². Finally, Hayes PROCESS macro (Model 15) was applied to test the moderated mediation model⁶². As mentioned above, the 95% bias-corrected CI that did not contain zero suggested the establishment of moderated mediation model. Then, we plotted the conditional effects and confidence bands at different values of physical activity based on Johnson-Neyman technique.

Z-scores for each variable were calculated before modelling. SPSS 26.0 (IBM Corporation) was utilised for statistical analyses in the present study. All analyses were two-tailed, and a P-value of < 0.05 indicated statistical significance.

Results

Common method Bias test

Considering the research data were collected by self-reported questionnaires, there might be a common method bias problem. Thus, Harman single factor test was performed to examine the common method bias^{9,60}. The results presented that the variance of the first factor was 22.916%, less than the reference value of 40%⁹. Therefore, common method bias was not an issue in the present study.

Demographic characteristics and anxiety

Table 1 showed the demographic characteristics and the group comparisons on anxiety. Most participants were female (94.4%), married (63.2%), and aged 30 or less (69.8%), worked 10 years or less (69.8%) and had junior technical titles (64.8%). The prevalence of anxiety among nurses during public health emergency was 29.9%.

There was a significant difference in anxiety among nurses with different technical titles. Specifically, nurses with intermediate titles or higher reported higher levels of anxiety than those with junior titles ($t = -2.072$, $p = 0.039$). Nurses aged more than 30 reported higher levels of anxiety than those aged 30 or less with a marginal significance ($p = 0.053$). No significant differences were found in anxiety by gender, marital status and years of working ($p > 0.05$).

Bivariate analysis

Descriptive statistics and correlations among variables were presented in Table 2. The results presented family function was significantly and positively correlated with resilience and all three subscales (all $p < 0.001$). Anxiety was negatively related to family function and resilience and all three subscales (all $p < 0.001$). Physical activity was only positively associated with tenacity subscale of CD-RISC ($p < 0.05$). No significant association was found between physical activity and anxiety ($p > 0.05$).

Analysis of resilience as a mediator

MacKinnon's four-step procedure was employed to test the mediation effect (see Table 3). Firstly, family function was negatively associated with anxiety ($\beta = -0.284$, $p < 0.001$) (see Model 1 in Table 3). Secondly, family function was positively related to resilience ($\beta = 0.510$, $p < 0.001$) (see Model 2 in Table 3). Thirdly, resilience was negatively associated with anxiety after controlling for family function ($\beta = 0.256$, $p < 0.001$) (see Model 3 in Table 3). Finally, the indirect effect of family function on anxiety via resilience was significant ($ab = -0.131$, $SE = 0.023$, 95% CI = $[-0.177, -0.088]$). The mediation effect accounted for 46.09% of the total effect. Therefore, all four requirements

	Respondents(<i>n</i> (%))		Anxiety(<i>M</i> ± <i>SD</i>)		<i>t</i>	<i>P</i> -value
	<i>n</i>	%	<i>M</i>	<i>SD</i>		
Gender					0.187	0.852
Male	44	5.6	3.68	4.10		
Female	735	94.4	3.57	3.99		
Marital status					0.217	0.828
Unmarried	287	36.8	3.61	4.02		
Married	492	63.2	3.55	3.99		
Years of working					-1.632	0.103
10 years or less	544	69.8	3.42	3.89		
More than 10 years	235	30.2	3.93	4.21		
Age (mean = 30.41, <i>SD</i> = 6.56)					-1.937	0.053
≤30	462	59.3	3.34	3.94		
>30	317	40.7	3.91	4.06		
Technical title					-2.072	0.039
Junior	505	64.8	3.35	3.89		
Intermediate or higher	274	35.2	3.97	4.16		

Table 1. The demographic characteristics of respondents and group comparisons on anxiety (*N* = 779).

	Mean	SD	1	2	3	4	5
1. Family function	6.80	2.78					
2. Tenacity subscale of CD-RISC	32.02	9.60	0.487***				
3. Strength subscale of CD-RISC	21.09	6.01	0.487***	0.909***			
4. Optimism subscale of CD-RISC	9.91	3.04	0.445***	0.793***	0.846***		
5. Resilience (CD-RISC)	63.02	17.88	0.501***	0.977***	0.968***	0.880***	
6. Physical activity	5.63	10.42	0.060	0.072*	0.070	0.047	0.070
7. Anxiety	3.57	4.00	-0.286***	-0.313***	-0.334***	-0.244***	-0.322***

Table 2. Descriptive statistics and correlations among the variables of interest (*N* = 779). **p* < 0.05. ****p* < 0.001.

	Model 1 (Anxiety)		Model 2 (Resilience)		Model 3 (Anxiety)	
	β	<i>t</i>	β	<i>t</i>	β	<i>t</i>
Family function	-0.284***	-8.182	0.510***	16.481	-0.153**	-3.895
Resilience					-0.256***	-6.526
<i>R</i> ² _{adj}	0.080***		0.266***		0.127***	
<i>F</i>	12.299		48.037		17.194	

Table 3. Mediation analysis (*N* = 779). All models are adjusted for age, gender, marital status, years of working and technical title. ***p* < 0.01. ****p* < 0.001.

for the mediation effect were satisfied and resilience mediated the effect of family function on anxiety during public health emergency.

Testing for moderated mediation

The present study hypothesized that physical activity might moderate the direct and indirect (the second stage of the mediation pathway: resilience-anxiety) effects of family function on anxiety. The results of the moderated mediation analysis were shown in Table 4. The interaction between resilience and physical activity had a significant effect on anxiety ($\beta = -0.009$, $p = 0.032$), indicating the association of resilience with anxiety was moderated by physical activity. Additionally, physical activity also moderated the direct effect of family function on anxiety ($\beta = 0.009$, $p = 0.047$).

Table 4 also presented the conditional direct effect of family function on anxiety and conditional effect of resilience on anxiety at different values of physical activity (1 SD above the mean, the mean, and 1SD below the mean). The direct effect of family function on anxiety was attenuated at 1SD above the mean ($\beta = -0.062$, 95% CI:

	β	SE	LLCI	ULCI
Mediator variable model (Outcome: Resilience)				
Family function	0.5103***	0.0310	0.4495	0.5711
Dependent variable model (Outcome: Anxiety)				
Family function	-0.1507**	0.0393	-0.2277	-0.0736
Resilience	-0.2562***	0.0392	-0.3331	-0.1793
Physical activity	-0.0041	0.0034	-0.0107	0.0025
Family function * Physical activity	0.0085*	0.0043	0.0001	0.017
Resilience * Physical activity	-0.0099*	0.0046	-0.019	-0.0008
	β	Boot SE	BootLLCI	BootULCI
Conditional direct effect analysis				
1 SD below the mean	-0.1987	0.0462	-0.2894	-0.1081
Mean	-0.1507	0.0393	-0.2277	-0.0736
1 SD above the mean	-0.0618	0.0595	-0.1785	0.055
Conditional indirect effect analysis				
1 SD below the mean	-0.1023	0.0266	-0.1568	-0.0534
Mean	-0.1307	0.0224	-0.1771	-0.0893
1 SD above the mean	-0.1833	0.0336	-0.2512	-0.1181
Index of moderated mediation	-0.005	0.0024	-0.0099	-0.0003

Table 4. Testing the moderated mediation effect ($N=779$). All models are adjusted for age, gender, marital status, years of working and technical title. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

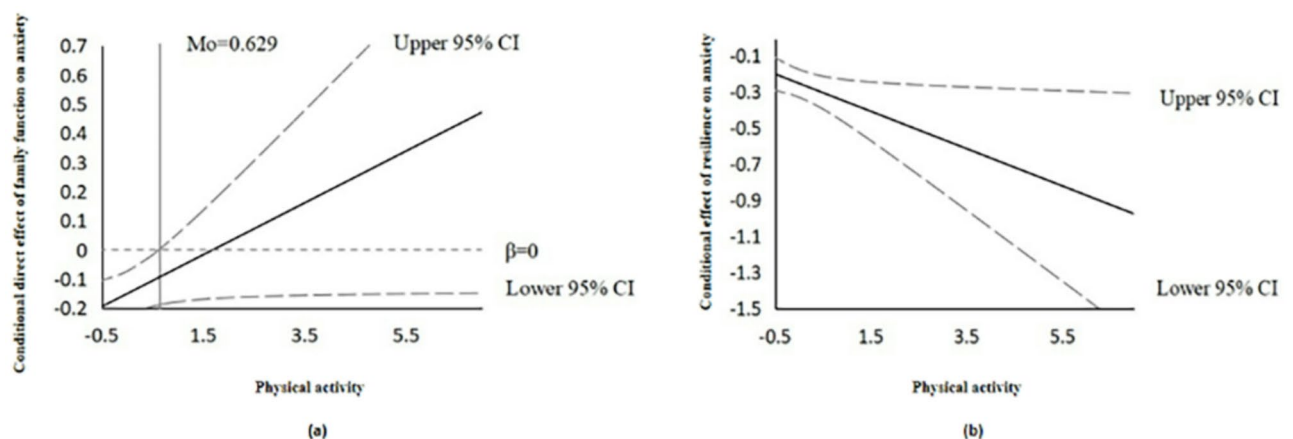


Fig. 2. The conditional effect at different values of physical activity. (a) The conditional direct effect of family function on anxiety. (b) The conditional effect of resilience on anxiety.

-0.179, 0.055) than 1 SD below the mean ($\beta = -0.199$, 95% CI: -0.289, -0.108). As presented by Johnson-Neyman technique, physical activity would moderate the direct effect of family function on anxiety when the standard scores of physical activity were lower than 0.629 since the 95% CI did not contain zero (see Fig. 2a). The direct effect became attenuated as physical activity increased.

Nonetheless, the effect of resilience on anxiety was stronger at 1 SD above the mean ($\beta = -0.102$, 95% CI: -0.157, -0.053) in comparison to 1 SD below the mean ($\beta = -0.183$, 95% CI: -0.251, -0.118). Johnson-Neyman technique showed with the increasing physical activity, the effect of resilience on anxiety became stronger (see Fig. 2b).

Discussion

The present study investigated the prevalence of anxiety in major public health and safety incidents and its influential factors. The prevalence of anxiety among nurses during public health emergency in China was 29.9%, indicating nearly one-third of nurses experience anxiety. This is consistent with the result of a similar study investigating the psychological status among 1803 registered nurses from Jiangsu province in China under the normalized COVID-19 pandemic prevention and control (29.8%). In addition, the prevalence was slightly lower than that (37%) among nurses during the COVID-19 pandemic reported by a systematic review and meta-analysis⁶³. When it comes to the comparison with the prevalence (7.3%) around the globe during the non-

epidemic stage, our finding is more than 4 times higher⁶⁴. Hence, despite a decline of anxious symptoms in the normalisation of COVID-19 epidemic prevention and control, the prevalence was still considerably high and special attentions should be paid to mitigating anxiety of nurses during this stage.

Our results revealed the technical title of nurses was significantly associated with anxiety, which is in line with the previous literature⁹. Nurses with higher technical titles had a higher likelihood of reporting anxiety than those with lower technical titles. This might be explained by different division of labor in nurses with different technical titles. Intermediate and senior nurses usually bear more responsibility in comparison to the junior nurses who are usually inexperienced and lack professional skills and clinical experience. Apart from care provision, nurses with higher technical titles usually serve as the leaders to manage the team, make the decisions, and supervise and guide junior nurses, which might make them more vulnerable to anxiety. Our results showed a marginal significance in higher anxiety levels among nurses aged over 30 compared to those 30 or younger. However, this did not definitively establish a statistically significant difference based on age, as some studies have reported mixed findings. While some studies have found a significant weak inverse correlation between anxiety and age^{65,66}, others have reported no statistically significant difference^{67,68}. Therefore, further investigation in larger and more diverse samples is crucial to confirm the validity and generalizability of this potential trend.

Consistent with our hypothesis, we found nurses' resilience partially mediated the effect of family function on anxiety, revealing the mechanisms by which family function would impact anxiety. Specifically, our results indicated that family dysfunction not only had a direct influence on nurses' anxiety but also indirectly contributed to higher levels of anxiety by weakening their resilience. The present result is in line with previous literature concerning the mediating role of resilience in the association of family function with health outcomes. Notably, recent studies have similarly identified resilience as a mediator in the effects of family satisfaction on anxiety among Chinese adolescents⁶⁹ and in the relationship between family function and mental health among diabetic patients⁷⁰. Nurses with good family functions may exhibit enhanced resilience, which is nurtured by the positive influences of their familial environments³⁵. This resilience stems not only from the profound emotional bonds and mutual support among family members but also from the family's collective ability to communicate effectively and resolve life challenges²⁴. In such supportive family environments, nurses develop resilience by acquiring the ability to maintain an optimistic outlook during adversity, adeptly manage negative emotions, and adeptly employ proactive coping strategies to overcome a wide range of life's challenges. Consequently, when confronted with pressures in major public health and safety incidents, they are capable of swiftly adjusting their mental states, thereby mitigating the emergence of anxiety symptoms.

What's more, the results of moderated mediation analysis revealed physical activity of nurses could moderate the direct and indirect association between family function and anxiety. As shown by Johnson-Neyman technique, the direct association of family function with anxiety was attenuated with enhancement of physical activity. The direct effect became insignificant when the standard scores of physical activity were 0.629 and over. In contrast, Johnson-Neyman technique also presented the indirect effect of family function on anxiety through resilience was stronger when the levels of physical activity increased. This is consistent with previous studies^{47–50}, suggesting the effect of environmental and psychological factors on mental health could be moderated by physical activity. For example, Zhang et al. suggested the association between psychological resilience and negative emotions was stronger for individuals with physical activity⁵⁰. The beneficial effects of physical activity might be driven by the hypothalamic-pituitary-adrenal axis, which was associated with the release of cortisol^{71,72}. Besides, physical activity might influence the neurophysiological processes via stimulating the expression of the brain nerve growth factor (BDNF) and supporting the functioning of the Trk-B receptor and BDNF-Trk-B signaling, which could be beneficial on affective, cognitive and social functioning in turn^{73–75}. Alternatively, physical activity could positively affect mental health through altering neurotransmitters and hormones^{76,77}, reducing chronic inflammation⁷⁸ and improving endocannabinoid system function⁷⁵. Physical activity could help individuals maintain a healthy body and be prepared to make positive changes. Under this circumstance, the protective effects of family function and resilience against anxiety might be stronger.

The results have profound implications for the amelioration of nurses' anxiety in major public health and safety incidents, both theoretically and practically. On the one hand, the present study provided a theoretically grounded foundation for an in-depth understanding of the association between family function and anxiety and its underlying mechanisms among Chinese nurses in major public health and safety incidents. This theoretical framework serves as a cornerstone for future investigations into the psychological well-being of nurses in similar high-stress environments. On the other hand, the findings could inform public health policy of the potential preventive measures of anxiety. Mental health education courses and training programs should be designed with the primary objective of improving family function, which in turn has the potential to prevent and mitigate anxiety among Chinese nurses in major public health and safety incidents. By participating in such courses and training, nurses should acquire the skills necessary to communicate openly, refrain from suppressing negative emotions, and actively seek comfort and assistance from their family and friends. This enhanced ability to engage with and utilize family support will contribute to strengthening family function, ultimately leading to a reduction in anxiety among nurses during such critical times²¹. Furthermore, resilience-focused program should be developed and prioritized to Chinese nurses with higher levels of physical activity. Healthcare organization managers must take a proactive role in implementing psychological resilience training and support measures. These measures should encompass a diverse array of resources and interventions, such as coping skill training, stress management techniques, and the cultivation of a supportive work environment^{35,79}. By employing structured intervention strategies within these programs, the psychological resilience of nurses can be significantly enhanced. This, in turn, has the potential to mitigate the adverse impact of family dysfunction on anxiety, thereby fostering a more resilient and adaptive nursing workforce capable of effectively managing the challenges posed by major public health and safety incidents.

Several limitations should be noted when interpreting the results. First, a cross-sectional study design was employed in the present study, which is difficult to explore the causal relationship between variables. In the future, longitudinal or experimental study design should be adopted to further determine the temporal sequence among variables. Second, the current research utilized self-reported questionnaires. This might result in self-reported biases, leading to the underestimation or overestimation of the associations. Further research could use multi-informant measures to collect both self-report and other-report information. Thirdly, another limitation for the present study was that all participants were only from Jiangsu province, which might limit the generalization of the results to all nurses worldwide. Further study could recruit participants from different regions to verify the results. Finally, the current model could only partially explain the relationship between family function and anxiety of Chinese nurses during public health emergency since anxiety could be affected by many variables, such as working department or roles during the public health emergency. Notably, research has shown that the working department moderated the effect of resilience on anxiety during the COVID-19 pandemic, with those working in high-risk departments exhibiting a stronger influence of resilience on their anxiety levels⁹. Nurses work in emergency department has also been found to report higher levels of anxiety during the COVID-19 pandemic due to the highly stressful environment, life-threatening conditions, long working hours^{66,80}. Thus, a more integral and comprehensive model with more factors could be constructed to better understand the anxiety of nurses in the future.

Nurses experienced higher levels of anxiety in public health emergency in China. Resilience partially mediated the association between family function and anxiety and physical activity moderated both the direct effect of family function on anxiety and the mediating effect of resilience. Specifically, the indirect effect became stronger and the direct effect became weaker with the increase of physical activity.

Data availability

The data that support the findings of this study are available on request from the corresponding authors. The data are not publicly available due to the de-identified data possibly containing information that could compromise the privacy and safety of the research participants.

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References

- Li, R. et al. Anxiety and related factors in frontline clinical nurses fighting COVID-19 in Wuhan. *Medicine* **99**, e21413. <https://doi.org/10.1097/md.00000000000021413> (2020).
- Labrague, L. J. & De los Santos, J. A. A. COVID-19 anxiety among front-line nurses: predictive role of organisational support, personal resilience and social support. *J. Nurs. Adm. Manag.* **28**, 1653–1661. <https://doi.org/10.1111/jonm.13121> (2020).
- Labrague, L. J. Pandemic fatigue and clinical nurses' mental health, sleep quality and job contentment during the covid-19 pandemic: the mediating role of resilience. *J. Nurs. Adm. Manag.* **29**, 1992–2001. <https://doi.org/10.1111/jonm.13383> (2021).
- Chorwe-Sungani, G. Assessing COVID-19-related anxiety and functional impairment amongst nurses in Malawi. *Afr. J. Prim. Health Care Fam Med.* **13**, e1–e6. <https://doi.org/10.4102/phcfm.v13i1.2823> (2021).
- Pappa, S. et al. Prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic: A systematic review and meta-analysis. *Brain. Behav. Immun.* **88**, 901–907. <https://doi.org/10.1016/j.bbi.2020.05.026> (2020).
- Chew, N. W. S. et al. A multinational, multicentre study on the psychological outcomes and associated physical symptoms amongst healthcare workers during COVID-19 outbreak. *Brain Behav. Immun.* **88**, 559–565. <https://doi.org/10.1016/j.bbi.2020.04.049> (2020).
- Salopek-Ziha, D. et al. Differences in distress and coping with the COVID-19 stressor in nurses and physicians. *Psychiatr Danub.* **32**, 287–293. <https://doi.org/10.24869/psyd.2020.287> (2020).
- Zhu, J. et al. Prevalence and influencing factors of anxiety and depression symptoms in the First-Line medical staff fighting against COVID-19 in Gansu. *Front. Psychiatry* **11**, 386. <https://doi.org/10.3389/fpsy.2020.00386> (2020).
- Hou, T. et al. The mediating role of perceived social support between resilience and anxiety 1 year after the COVID-19 pandemic: disparity between High-Risk and Low-Risk nurses in China. *Front. Psychiatry* **12**, 666789. <https://doi.org/10.3389/fpsy.2021.666789> (2021).
- Lai, J. et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. *JAMA Netw. Open.* **3**, e203976. <https://doi.org/10.1001/jamanetworkopen.2020.3976> (2020).
- Zeng, W. et al. Perceived family function and associated predictors in nurses: A Cross-Sectional study. *Front. Psychiatry* **13**, 904581. <https://doi.org/10.3389/fpsy.2022.904581> (2022).
- Cao, X., Jiang, X., Li, X., Hui Lo, M. C. & Li, R. Family functioning and its predictors among disaster bereaved individuals in China: eighteen months after the Wenchuan earthquake. *PLoS One* **8**, e60738. <https://doi.org/10.1371/journal.pone.0060738> (2013).
- Chu, Y. et al. Influence of family function on social anxiety among Chinese nursing students: the mediating role of alexithymia. *Nurs. Open. N/a*. <https://doi.org/10.1002/nop2.1385>
- Olson, D. H., Sprenkle, D. H. & Russell, C. S. Circumplex model of marital and family systems: I. Cohesion and adaptability dimensions, family types, and clinical applications. *Fam Process.* **18**, 3–28. <https://doi.org/10.1111/j.1545-5300.1979.00003.x> (1979).
- Guo, Z. F., Zhao, J. & Peng, J. N. Family function and anxiety among junior school students during the COVID-19 pandemic: a moderated mediation model. *Front. Psychiatry* **14**, 8. <https://doi.org/10.3389/fpsy.2023.1217709> (2023).
- Paclikova, K., Veselska, Z. D., Bobakova, D. F., Palfiova, M. & Geckova, A. M. What role do family composition and functioning play in emotional and behavioural problems among adolescent boys and girls? *Int. J. Public. Health* **64**, 209–217. <https://doi.org/10.1007/s00038-018-1171-x> (2019).
- Rueger, S. Y., Malecki, C. K. & Demaray, M. K. Relationship between multiple sources of perceived social support and psychological and academic adjustment in early adolescence: comparisons across gender. *J. Youth Adolesc.* **39**, 47–61. <https://doi.org/10.1007/s10964-008-9368-6> (2010).
- Demaray, M. K., Malecki, C. K., Davidson, L. M., Hodgson, K. K. & Rebus, R. J. The relationship between social support and student adjustment: A longitudinal analysis. *Psychol. Schools* **42**, 691–706. <https://doi.org/10.1002/pits.20120> (2005).
- Yang, L., Wu, M., Wang, Y. & Peng, B. The influence of family function on state anxiety of Chinese college students during the epidemic of COVID-19. *Front. Psychol.* **12**, 701945. <https://doi.org/10.3389/fpsyg.2021.701945> (2021).

20. Shao, R. Y. et al. Prevalence of depression and anxiety and correlations between depression, anxiety, family functioning, social support and coping styles among Chinese medical students. *BMC Psychol.* **8**, 19. <https://doi.org/10.1186/s40359-020-00402-8> (2020).
21. Bu, T. et al. Relationship between family function and anxiety among nurses during the COVID-19 pandemic: a mediating role of expressive suppression. *BMC Nurs.* **23**, 508. <https://doi.org/10.1186/s12912-024-02167-6> (2024).
22. Reid, R. Psychological Resilience. *Med. Leg. J.* **84**, 172–184. <https://doi.org/10.1177/0025817216638781> (2016).
23. Thibodeaux, J. Conceptualizing multilevel research designs of resilience. *J. Community Psychol.* **49**, 1418–1435. <https://doi.org/10.1002/jcop.22598> (2021).
24. Song, Q. X. et al. Family function and emotional behavior problems in Chinese children and adolescents: A moderated mediation model. *J. Affect. Disord.* **341**, 296–303. <https://doi.org/10.1016/j.jad.2023.08.138> (2023).
25. Connor, K. M. & Davidson, J. R. Development of a new resilience scale: the Connor-Davidson resilience scale (CD-RISC). *Depress. Anxiety* **18**, 76–82. <https://doi.org/10.1002/da.10113> (2003).
26. Ong, A. D., Bergeman, C. S., Bisconti, T. L. & Wallace, K. A. Psychological resilience, positive emotions, and successful adaptation to stress in later life. *J. Pers. Soc. Psychol.* **91**, 730–749. <https://doi.org/10.1037/0022-3514.91.4.730> (2006).
27. Fergus, S. & Zimmerman, M. A. ADOLESCENT RESILIENCE: A framework for Understanding healthy development in the face of risk. *Annu. Rev. Public Health* **26**, 399–419. <https://doi.org/10.1146/annurev.publhealth.26.021304.144357> (2005).
28. Luthar, S. S., Cicchetti, D. & Becker, B. Research on resilience: response to commentaries. *Child Dev.* **71**, 573–575. <https://doi.org/10.1111/1467-8624.00168> (2000).
29. Harvey, J. & Delfabbro, P. H. Psychological resilience in disadvantaged youth: A critical overview. *Aust Psychol.* **39**, 3–13. <https://doi.org/10.1080/00050060410001660281> (2004).
30. Masten, A. S. Ordinary magic: resilience processes in development. *Am. Psychol.* **56**, 227–238. <https://doi.org/10.1037/0003-066X.56.3.227> (2001).
31. Hu, T., Zhang, D. & Wang, J. A meta-analysis of the trait resilience and mental health. *Pers. Individ. Differ.* **76**, 18–27. <https://doi.org/10.1016/j.paid.2014.11.039> (2015).
32. Mosheva, M. et al. Anxiety, pandemic-related stress and resilience among physicians during the COVID-19 pandemic. *Depress. Anxiety* **37**, 965–971. <https://doi.org/10.1002/da.23085> (2020).
33. Barzilay, R. et al. COVID-19-related stress, anxiety and depression during the pandemic in a large population enriched for healthcare providers. *Translational Psychiatry* **10**, 291. <https://doi.org/10.1038/s41398-020-00982-4> (2020). Resilience.
34. Qi, Q. et al. A Study on the Relationship between Mental Resilience, Work-Family Conflict, and Anxiety of Nurses in Shandong, China. *Biomed Res Int* 4308618 (2022). (2022).
35. Shao, L., Zhong, J. D., Wu, H. P., Yan, M. H. & Zhang, J. E. The mediating role of coping in the relationship between family function and resilience in adolescents and young adults who have a parent with lung cancer. *Support Care Cancer.* **30**, 5259–5267. <https://doi.org/10.1007/s00520-022-06930-w> (2022).
36. Xia, Y., Gong, Y., Wang, H., Li, S. & Mao, F. Family function impacts relapse tendency in substance use disorder: mediated through Self-Esteem and resilience. *Front. Psychiatry.* **13**, 815118. <https://doi.org/10.3389/fpsy.2022.815118> (2022).
37. Nam, B., Kim, J. Y., DeVlyder, J. E. & Song, A. Family functioning, resilience, and depression among North Korean refugees. *Psychiatry Res.* **245**, 451–457. <https://doi.org/10.1016/j.psychres.2016.08.063> (2016).
38. Lu, C., Yuan, L., Lin, W., Zhou, Y. & Pan, S. Depression and resilience mediates the effect of family function on quality of life of the elderly. *Arch. Gerontol. Geriatr.* **71**, 34–42. <https://doi.org/10.1016/j.archger.2017.02.011> (2017).
39. Sun, Z., Gao, X. C. & Ren, P. H. The relationship between time anxiety and college students' sleep quality: the mediating role of irrational procrastination and the moderating effect of physical activity. *Front. Psychol.* **15**, 11. <https://doi.org/10.3389/fpsyg.2024.1410746> (2024).
40. Harris, A. H. S., Cronkite, R. & Moos, R. Physical activity, exercise coping, and depression in a 10-year cohort study of depressed patients. *J. Affect. Disord.* **93**, 79–85. <https://doi.org/10.1016/j.jad.2006.02.013> (2006).
41. Schuch, F. B. et al. Physical activity and incident depression: A meta-analysis of prospective cohort studies. *Am. J. Psychiatry.* **175**, 631–648. <https://doi.org/10.1176/appi.ajp.2018.17111194> (2018).
42. McDowell, C. P., Dishman, R. K., Hallgren, M., MacDonncha, C. & Herring, M. P. Associations of physical activity and depression: results from the Irish longitudinal study on ageing. *Exp. Gerontol.* **112**, 68–75. <https://doi.org/10.1016/j.exger.2018.09.004> (2018).
43. Rebar, A. L. et al. A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. *Health Psychol. Rev.* **9**, 366–378. <https://doi.org/10.1080/17437199.2015.1022901> (2015).
44. Schuch, F. B. et al. Exercise as a treatment for depression: A meta-analysis adjusting for publication bias. *J. Psychiatr Res.* **77**, 42–51. <https://doi.org/10.1016/j.jpsychires.2016.02.023> (2016).
45. Gordon, B. R., McDowell, C. P., Lyons, M. & Herring, M. P. The effects of resistance exercise training on anxiety: A Meta-Analysis and Meta-Regression analysis of randomized controlled trials. *Sports Med.* **47**, 2521–2532. <https://doi.org/10.1007/s40279-017-0769-0> (2017).
46. Mammen, G. & Faulkner, G. Physical activity and the prevention of depression: A systematic review of prospective studies. *Am. J. Prev. Med.* **45**, 649–657. <https://doi.org/10.1016/j.amepre.2013.08.001> (2013).
47. Chen, R. et al. Interpersonal trauma and risk of depression among adolescents: the mediating and moderating effect of interpersonal relationship and physical exercise. *Front. Psychiatry* **11**, 194. <https://doi.org/10.3389/fpsy.2020.00194> (2020).
48. Lin, L. et al. Internet addiction mediates the association between cyber victimization and psychological and physical symptoms: moderation by physical exercise. *BMC Psychiatry* **20**, 144. <https://doi.org/10.1186/s12888-020-02548-6> (2020).
49. Jiang, Z. et al. Childhood maltreatment and depressive symptoms among Chinese college students: A moderated mediation model of adult attachment styles and physical activity. *J. Affect. Disord.* **309**, 63–70. <https://doi.org/10.1016/j.jad.2022.04.100> (2022).
50. Zhang, Q., Miao, L., He, L. & Wang, H. The relationship between Self-Concept and negative emotion: A moderated mediation model. *Int. J. Environ. Res. Public Health* **19**. <https://doi.org/10.3390/ijerph191610377> (2022).
51. Sigfusdottir, I. D., Asgeirsdottir, B. B., Sigurdsson, J. F. & Gudjonsson, G. H. Physical activity buffers the effects of family conflict on depressed mood: A study on adolescent girls and boys. *J. Adolesc.* **34**, 895–902. <https://doi.org/10.1016/j.adolescence.2011.01.003> (2011).
52. Haldane, V. et al. Health systems resilience in managing the COVID-19 pandemic: lessons from 28 countries. *Nat. Med.* **27**, 964–980. <https://doi.org/10.1038/s41591-021-01381-y> (2021).
53. Jia, H., Fan, S. & Xia, M. Impact of the COVID-19 pandemic on household financial asset allocation: A China population study. *Front. Psychol.* **13**, 990610 (2022).
54. Chen, X. et al. The mental health status among nurses from low-risk areas under normalized COVID-19 pandemic prevention and control in China: A cross-sectional study. *Int. J. Ment Health Nurs.* **30**, 975–987. <https://doi.org/10.1111/inm.12852> (2021).
55. Jiang, Z. et al. Nurses' experience of work stress related to COVID-19 regular prevention and control in China: A qualitative study. *J. Nurs. Manag.* **30**, 375–383. <https://doi.org/10.1111/jonm.13528> (2022).
56. Chen, Y. L., Chen, S. H. & Gau, S. S. ADHD and autistic traits, family function, parenting style, and social adjustment for internet addiction among children and adolescents in Taiwan: a longitudinal study. *Res. Dev. Disabil.* **39**, 20–31. <https://doi.org/10.1016/j.ridd.2014.12.025> (2015).
57. Liang, D. Q. & Liu, S. J. The relationship between stress level and physical exercise for college students. *Chin. Mental Health J.* **8**, 5–6 (1994).

58. Yang, Q. et al. Physical activity and subjective well-being of older adults during COVID-19 prevention and control normalization: mediating role of outdoor exercise environment and regulating role of exercise form. *Front. Psychol.* **13**, 1014967. <https://doi.org/10.3389/fpsyg.2022.1014967> (2022).
59. Tiirikainen, K., Haravuori, H., Ranta, K., Kaltiala-Heino, R. & Marttunen, M. Psychometric properties of the 7-item generalized anxiety disorder scale (GAD-7) in a large representative sample of Finnish adolescents. *Psychiatry Res.* **272**, 30–35. <https://doi.org/10.1016/j.psychres.2018.12.004> (2019).
60. Doty, D. H. & Glick, W. H. Common methods bias: does common methods variance really Bias results?? *Organizational Res. Methods* **1**, 374–406. <https://doi.org/10.1177/109442819814002> (1998).
61. MacKinnon, D. P. *An Introduction To Statistical Mediation Analysis*. (Taylor & Francis Group, 2008).
62. Bolin, J. H. Introduction to mediation, moderation, and conditional process analysis: A Regression-Based approach. *J. Educ. Meas.* **51**, 335–337. <https://doi.org/10.1111/jedm.12050> (2014).
63. Al Maqbali, M., Al Sinani, M. & Al-Lenjawi, B. Prevalence of stress, depression, anxiety and sleep disturbance among nurses during the COVID-19 pandemic: A systematic review and meta-analysis. *J. Psychosom. Res.* **141**, 110343. <https://doi.org/10.1016/j.jpsychores.2020.110343> (2021).
64. Stein, D. J., Scott, K. M., de Jonge, P. & Kessler, R. C. Epidemiology of anxiety disorders: from surveys to nosology and back. *Dialogues Clin. Neurosci.* **19**, 127–136. <https://doi.org/10.31887/DCNS.2017.19.2/dstein> (2017).
65. Saeedi, M., Abedini, Z., Latif, M. & Piruzhashemi, M. Correlation between COVID-19-related health anxiety and coping styles among frontline nurses. *Bmc Nurs.* **22**, 238. <https://doi.org/10.1186/s12912-023-01344-3> (2023).
66. Cheung, T., Yip, P. S. F. & Depression Anxiety and symptoms of stress among Hong Kong nurses: A Cross-sectional study. *Int. J. Environ. Res. Public Health* **12**, 11072–11100. <https://doi.org/10.3390/ijerph120911072> (2015).
67. Nadeem, F. et al. Depression, anxiety, and stress among nurses during the COVID-19 wave III: results of a Cross-Sectional assessment. *J. Multidiscip. Healthc.* **14**, 3093–3101. <https://doi.org/10.2147/jmdh.S338104> (2021).
68. Khesht-Masjedi, M. F. et al. The relationship between gender, age, anxiety, depression, and academic achievement among teenagers. *J. Fam Med. Prim. Care* **8**, 799–804. https://doi.org/10.4103/jfmpc.jfmpc_103_18 (2019).
69. Ye, B. Z., Lau, J. T. F., Lee, H. H., Yeung, J. C. H. & Mo, P. K. H. The mediating role of resilience on the association between family satisfaction and lower levels of depression and anxiety among Chinese adolescents. *Plos One* **18**, 14. <https://doi.org/10.1371/journal.pone.0283662> (2023).
70. Bahreman, M. et al. Relationship between family functioning and mental health considering the mediating role of resiliency in type 2 diabetes mellitus patients. *Global J. Health Sci.* **7**, 254–259. <https://doi.org/10.5539/gjhs.v7n3p254> (2014).
71. Drogos, L. L. et al. Aerobic exercise increases cortisol awakening response in older adults. *Psychoneuroendocrinology* **103**, 241–248. <https://doi.org/10.1016/j.psyneuen.2019.01.012> (2019).
72. Gorham, L. S., Jernigan, T., Hudziak, J. & Barch, D. M. Involvement in sports, hippocampal volume, and depressive symptoms in children. *Biol. Psychiat -Cogn Neurosci. Neuroimag* **4**, 484–492. <https://doi.org/10.1016/j.bpsc.2019.01.011> (2019).
73. Malczynska, P., Piotrowicz, Z., Drabarek, D., Langfort, J. & Chalimoniuk, M. The role of the brain-derived neurotrophic factor (BDNF) in neurodegenerative processes and in the neuroregeneration mechanisms induced by increased physical activity. *Postepy Biochem.* **65**, 2–8. https://doi.org/10.18388/pb.2019_251 (2019).
74. Markiewicz, R., Koziol, M., Olajossy, M. & Masiak, J. Can brain-derived neurotrophic factor (BDNF) be an indicator of effective rehabilitation interventions in schizophrenia? *Psychiatr Pol.* **52**, 819–834. <https://doi.org/10.12740/PP/OnlineFirst/76040> (2018).
75. Tantimonaco, M. et al. Physical activity and the endocannabinoid system: an overview. *Cell. Mol. Life Sci.* **71**, 2681–2698. <https://doi.org/10.1007/s00018-014-1575-6> (2014).
76. Dishman, R. K. in *Medicine and Science in Sports and Exercise*. 1 edn 63–74 (9000157).
77. Laske, C. et al. Exercise-induced normalization of decreased BDNF serum concentration in elderly women with remitted major depression. *Int. J. Neuropsychopharmacol.* **13**, 595–602. <https://doi.org/10.1017/S1461145709991234> (2010).
78. Miller, A. H., Maletic, V. & Raison, C. L. Inflammation and its discontents: the role of cytokines in the pathophysiology of major depression. *Biol. Psychiatry* **65**, 732–741. <https://doi.org/10.1016/j.biopsych.2008.11.029> (2009).
79. Pu, J. F. et al. Psychological resilience and intention to stay among nurses: the mediating role of perceived organizational support. *Front. Psychol.* **15**, 8. <https://doi.org/10.3389/fpsyg.2024.1407206> (2024).
80. Alzahrani, N. S., Almarwani, A. M., Asiri, S. A., Alharbi, H. F. & Alhowaymel, F. M. Factors influencing hospital anxiety and depression among emergency department nurses during the COVID-19 pandemic: A multi-center cross-sectional study. *Front. Psychiatry* **13**. <https://doi.org/10.3389/fpsyg.2022.912157> (2022).

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Author contributions

TH and XM designed the study. WDeng and ZL collected the data and conducted literature review. ZD, GZ, ZH, ZX contributed to the literature review. XL, WDong, JZ, YC and TH drafted and revised the manuscript. TH and XM led the whole study. All the authors have read and approved the final manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

All methods in the present study were carried out in accordance with relevant guidelines and regulations. The study involving human participants were reviewed and approved by ethics committee of Second Military Medical University. The participants provided their written informed consent to participate in this study.

Additional information

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