



# Healthy lifestyle changes and mental health of healthcare workers during the COVID-19 pandemic in China

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## Abstract

This study investigated lifestyle changes in physical activity, sleep, and diet among healthcare workers and their impact on their mental health during the COVID-19 pandemic in China. Healthcare workers (N = 589) completed an online survey about demographic and personal characteristics, working experiences, COVID-19-related stressors, lifestyle changes, and mental health (anxiety and depression) about three months after the lift of the lockdown policy in China. Lifestyle Changes (including changes in physical activity, sleep, and diet), Generalized Anxiety Disorder (GAD-7), and Depression (PHQ-9) were used to measure main outcomes. Of the participants, 39.7% (N = 234) had less physical activity, 36.0% (N = 212) slept less, and 41.8% (N = 246) ate healthier than before pandemic. Lower educational level, working within original hospitals, less physical activity and less sleep time was associated with increased anxiety. Working within original hospitals, less physical activity and an unhealthier diet was associated with increased depression. In summary, healthcare workers who became less healthy in lifestyles experienced a higher level of anxiety and depression symptoms during the COVID-19 pandemic. Strategies to promote healthy living and improve mental health among healthcare workers should be developed and implemented both during the ongoing COVID-19 pandemic and beyond.

**Keywords** COVID-19 · Lifestyle change · Healthcare workers · Mental health · Anxiety · Depression

## Introduction

Caused by the novel acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Mahase, 2020), the COVID-19 pandemic is the most severe public health emergency ever declared by the World Health Organization (WHO). The pandemic caused more than 6 million deaths worldwide and widespread disruption in psychological well-being among healthcare workers and the general public (Johns Hopkins Coronavirus Resource Center, 2022; Vindegaard & Benros, 2020;

Wiersinga et al., 2020). Implementation of emergent lockdown policies and health behavior changes such as wearing face masks and social distancing was widely used to prevent the spread of the virus, but this led to the physical and social isolation of the population, affecting their lifestyles and mental health (Chu et al., 2020; Galea et al., 2020).

On the one hand, the COVID-19 pandemic significantly affected people's lifestyles, including changes in physical activity, sleep, and diet. For example, due to the lockdown policy around the world, people had to stay at home and changed the way, intensity, and frequency of exercising (Cervera-Martínez et al., 2021; Stockwell et al., 2021). In addition, many people reported that they slept less than before or did not sleep well during the pandemic (Cheng et al., 2020; Wozniak et al., 2021; Youssef et al., 2020). In the United Arab Emirates, people deviated from a healthy Mediterranean diet (Cheikh Ismail et al., 2020), and Italians aged 18–30 years adhered more to the Mediterranean diet compared to younger and older people (Di Renzo et al., 2020).

On the other hand, the pandemic also caused a substantial increase in the prevalence of mental health problems around the world (Hossain et al., 2020; Pfefferbaum & North, 2020).

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The prevalence of anxiety and depression was 8.3% and 14.6%, respectively, among Chinese adults (Lei et al., 2020), and 37.4% and 43.7%, respectively, among Chinese adolescents aged 12–18 years (Zhou et al., 2020). Mental health issues were also prevalent among healthcare workers during the pandemic (Krystal, 2020; Sahebi et al., 2021; Zhang, et al., 2022; Zhang et al., 2020b). Nearly half of the healthcare workers suffered from psychiatric symptoms, including suicidal ideation, PTSD, anxiety, and depression both in the United States and in China during the pandemic (Lai et al., 2020; Young et al., 2021). Poor mental health left many healthcare workers feeling exhausted and burnout, which not only affected their ability to provide safe, high-quality care (Leo et al., 2021), but also led to higher turnover rates and a shortage of qualified healthcare workers, which in turn, put patients at risk (Stefanovska—Petkovska et al., 2020; Turale et al., 2020). Therefore, it is essential to improve the mental health of healthcare workers during the fight against COVID-19 pandemic.

Indeed, in addition to COVID-19-related stressors and demographic variables (De Brier et al., 2020; Muller et al., 2020), lifestyle factors (e.g., smoking, physical activity, alcohol intake, and diet) were also important for mental health (Walsh, 2011). For instance, previous research demonstrated that German and Chinese university students with more frequent physical activity, non-smoking, and non-vegetarian diets had better mental health (Velten et al., 2018), while swedes who were physical inactive and engaged in risky consumption of alcohol experienced more severe anxiety and depression symptoms (Molarius et al., 2009). Previous research also found that improvements in lifestyle, including more physical activity, better sleeping, less tobacco smoking, and a healthier diet were effective in improving overall mental health and reducing symptoms of depression and anxiety (Bailey et al., 2018; Firth et al., 2020; Jacka et al., 2017; Scott et al., 2021).

During the COVID-19 pandemic, some researchers explored the relationship between a lifestyle change and mental health. For example, the disruption of physical activity was a major risk factor for depression among young Americans (Giuntella et al., 2021). Passive lifestyle changes (e.g., increased sedentary behaviors, decreased physical activity, worsened diet, increased alcohol intake, and smoking) negatively impacted Swedes' mental health (Blom et al., 2021). However, few studies focused on healthcare workers. Although a cross-sectional study investigated how the relationship between lifestyle changes and mental health varied among healthcare workers with a different sense of coherence levels. Besides, they didn't explore how changes in eating habits impacted people's mental health (Tanaka et al., 2021). What's more, in the fight against the COVID-19 pandemic, healthcare workers in China generally experienced higher levels of psychological burden and

faced other challenges, including a high risk of infection and inadequate protection from contamination, overwork, and exhaustion (Kang et al., 2020; Lai et al., 2020). Although previous research found that people with high levels of emotional exhaustion tended to make negative lifestyle choices (e.g., drinking alcohol and smoking) (Petrelli et al., 2018), few studies investigated how lifestyle changes in Chinese healthcare workers during COVID-19 affect their mental health.

This study filled this gap by investigating how lifestyle changes among healthcare workers influenced their mental health (e.g., anxiety and depression) three months after the lifting of the lockdown policy in Wuhan during the regular control of COVID-19 in China. We hypothesized that lifestyle changes, such as lower engagement in physical activity, declined sleep quality, and unhealthy eating patterns, would predict higher levels of anxiety and depression among healthcare workers.

## Materials and methods

### Sample and study design

This study was conducted between July 9th – July 17th, 2020, three months after the lift of the lockdown policy in Wuhan on April 8, 2020. We developed and distributed the study through an online survey system ([www.wjx.com](http://www.wjx.com)). All the participants reported being full-time healthcare workers in Public Hospitals in China. All respondents consented to participate in this study upon opening the survey link and their participation was voluntary with no monetary payments. The participants' responses were anonymous.

### Measures

Data on demographic variables, working experiences, and COVID-19-related stressors among the participants were collected through a self-reported questionnaire. Demographic variables include age, marital status, educational level, and the number of children they have. Working experiences related questions include the length of working experiences. COVID-19-related stressors include working experience during the pandemic, working units, whether he/she had close others, friends, classmates, or workmates being infected with COVID-19, and whether they received mental health services during the pandemic.

We measured changes in healthcare workers' engagement in physical activity with the following item: 'The amount of time I spend in physical activity each week compared to the time before the COVID-19 pandemic', (-1 = *Reduced by 0.5 h or more*, 0 = *Nearly no change*, +1 = *Increased by 0.5 h or more*). Then we measured changes in healthcare workers'

sleeping time with the following item: ‘The amount of time I spend sleeping each day compared to the time before the COVID-19 pandemic’, (-1 = *Reduced by 0.5 h or more*, 0 = *Nearly no change*, +1 = *Increased by 0.5 h or more*). Then we measured changes in healthcare workers’ engagement in dietary health with the following six items: ‘The number of times I eat (1) vegetables, (2) beans and white meat per week compared to the time before the COVID-19 pandemic’, (-1 = *Reduced by 1 or more times*, 0 = *Nearly no change*, +1 = *Increased by 1 or more times*); ‘The number of times I eat (3) red meat, (4) unhealthy snacks, (5) sweets, (6) drink sugar-sweetened beverages, per week compared to the time before the COVID-19 pandemic’, (-1 = *Increased by 1 or more times*, 0 = *Nearly no change*, +1 = *Decreased by 1 or more times*). Participants’ responses to the six items on dietary health were averaged to generate a mean score ranging from -1 to +1. Negative values indicate unhealthy eating patterns, while positive values indicate healthier eating patterns, and 0 indicates no changes in people’s eating patterns. The Cronbach’s alpha of the changes in the diet was 0.74 in this study, which indicated good reliability.

The 7-item Generalized Anxiety Disorder Scale (GAD-7) was developed by Spitzer and colleagues to measure the severity of generalized anxiety disorder during the past few weeks (Spitzer et al., 2006) on a four-point Likert type scale (0 = *not at all*, 3 = *nearly every day*). Participants’ responses were summed to generate a total score ranging from 0 to 21. A higher score indicates a higher severity of generalized anxiety disorder. For the GAD-7, a total score of  $\geq 10$  indicated possible anxiety, with the optimal point for sensitivity (89%) and specificity (82%) (Spitzer et al., 2006). The reliability of the Generalized Anxiety Disorder-7 in the current study is excellent (Cronbach’s  $\alpha = 0.94$ ).

The 9-item Patient Health Questionnaire (PHQ-9) was developed by Kroenke and colleagues to measure the severity of depression during the past few weeks (Kroenke et al., 2001) on a four-point Likert type scale from (0 = *not at all*, 3 = *nearly every day*). Participants’ responses were summed to generate a total score ranging from 0 to 27, and a higher score indicates a higher severity of depression. A total score of  $\geq 10$  indicated possible major depression, with a sensitivity of 85% and specificity of 89% (Manea et al., 2012). The reliability of the Patient Health Questionnaire-9 in the current study is excellent (Cronbach’s  $\alpha = 0.92$ ).

## Statistical analyses

The statistical difference in the distribution of anxiety and depression across different demographic and personal characteristics, working experiences, COVID-19-related stressors, and lifestyle changes was assessed using the chi-square test. We used multivariate ordinal regression models to explore the association between various factors and

the mental health status of the participants. The strength of association was reported as odds ratio (OR) and 95% CI. All statistical analyses were performed using SPSS 26.0.

## Results

Overall, 589 healthcare workers completed this study. Based on the GAD-7 scores, 80 participants (13.6%) suffered from moderate to severe anxiety (GAD-7 score  $\geq 10$ ) and similarly, according to PHQ-9 scores, 87 participants (14.8%) suffered from moderate to severe depression (PHQ-9 score  $\geq 10$ ). The reason for the 10-point cutoff has been explained above (Manea et al., 2012; Spitzer et al., 2006). The demographic and personal characteristics, working experiences, and COVID-19-related stressors were described in Table 1. About half of the participants were 30–39 years old ( $n = 258$ , 43.8%). Nearly two-thirds were married ( $n = 400$ , 67.9%), and about two fifths of them had 1 child ( $n = 232$ , 39.4%). Most of the participants had a bachelor’s degree or higher ( $n = 549$ , 93.2%), and about half of the participants had worked for more than 10 years ( $n = 250$ , 42.4%). About one-quarter worked in ICU or COVID-19 isolation wards ( $n = 163$ , 27.7%), and nearly three-quarters worked within their original employers ( $n = 436$ , 74.0%). Only a minority of the participants had close others, friends, classmates, or workmates infected ( $n = 5$ , 0.8%), and a small number of participants received mental health services during the pandemic ( $n = 44$ , 7.5%). According to the chi-square test, Table 1 also revealed that participants with different educational levels had different levels of anxiety ( $p < 0.01$ ).

The lifestyle changes of the healthcare workers were shown in Table 2. We found that about half of the participants reported no change in physical activity ( $n = 309$ , 52.5%), 234 participants (39.7%) reported a lower level of physical activity and 46 participants (7.8%) reported a higher level of physical activity than before COVID-19. Similarly, about half of the participants had no change in sleeping ( $n = 348$ , 59.1%), 212 participants (36.0%) reported less sleep time and 29 participants (4.9%) reported more sleep time than before. And about half of the participants reported no change in diet ( $n = 269$ , 45.7%), while 74 participants (12.6%) reported less healthy eating patterns and 246 participants (41.8%) reported healthier eating patterns than before. Chi-square test also revealed that participants who had changes in physical activity, sleeping, and diet had different levels of anxiety, ( $p < 0.01$ ) (Table 2). In addition, participants who had changes in sleeping had different levels of depression ( $p < 0.01$ ).

The results of binary logistic regression analyses were displayed in Table 3. We found that educational level and working within original employers during the COVID-19 pandemic negatively predicted severity of anxiety

**Table 1** Factors influencing the mental health of healthcare workers: Demographic and personal characteristics, working experiences, and COVID-19-related stressors

Variables	Total	Anxiety		$\chi^2$	Depression		$\chi^2$
		No to mild	Moderate to severe		No to mild	Moderate to severe	
Demographic and personal characteristics:							
-Age:				0.816			1.432
20–29 years old	233(39.6%)	205(88.0%)	28(12.0%)		201(86.3%)	32(13.7%)	
30–39 years old	258(43.8%)	220(85.3%)	38(14.7%)		215(83.3%)	43(16.7%)	
≥ 40 years old	98(16.6%)	84(85.7%)	14(14.3%)		86(87.8%)	12(12.2%)	
-Marital status:				0.185			2.290
Married	400(67.9%)	344(86.0%)	56(14.0%)		347(86.8%)	53(13.2%)	
Unmarried/Divorced/Widowed	189(32.1%)	165(87.3%)	24(12.7%)		155(82.0%)	34(18.0%)	
-Educational level:				7.082***			0.932
Below bachelor's degree	40(6.8%)	29(72.5%)	11(27.5%)		32(80.0%)	8(20.0%)	
Bachelor's degree or above	549(93.2%)	480(87.4%)	69(12.6%)		470(85.6%)	79(14.4%)	
-Number of children:				2.279			1.093
None	214(36.3%)	190(88.8%)	24(11.2%)		179(83.6%)	35(16.4%)	
1 child	232(39.4%)	200(86.2%)	32(13.8%)		202(87.1%)	30(12.9%)	
2–3 children	143(24.3%)	119(83.2%)	24(16.8%)		121(84.6%)	22(15.4%)	
Working experiences:							
-Length of working experiences:				4.130			5.140
< 1 year	26(4.4%)	24(92.3%)	2(7.7%)		25(96.2%)	1(3.8%)	
1–5 years	114(19.4%)	101(88.6%)	13(11.4%)		94(82.5%)	20(17.5%)	
5–10 years	199(33.8%)	176(88.4%)	23(11.6%)		175(87.9%)	24(12.1%)	
> 10 years	250(42.4%)	208(83.2%)	42(16.8%)		208(83.2%)	42(16.8%)	
COVID-19-related stressors:							
-Working Units:				2.072			3.492
ICU	145(24.6%)	128(88.3%)	17(11.7%)		125(86.2%)	20(13.8%)	
COVID-19 isolation wards	18(3.1%)	16(88.9%)	2(11.1%)		14(77.8%)	4(22.2%)	
Non-infective wards	146(24.8%)	129(88.4%)	17(11.6%)		130(89.0%)	16(11.0%)	
Other	280(47.5%)	236(84.3%)	44(15.7%)		233(83.2%)	47(16.8%)	
-Have close others, friends, classmates or workmates infected:				0.793			0.874
Yes	5(0.8%)	5(100.0%)	0(0.0%)		5(100.0%)	0(0.0%)	
No	584(99.2%)	504(86.3%)	80(13.7%)		497(85.1%)	87(14.9%)	
-Working experience during the COVID-19 pandemic:				3.570			6.838*
Being sent to assist other areas for COVID-19 pandemic control	109(18.5%)	99(90.8%)	10(9.2%)		100(91.7%)	9(8.3%)	
Working within original employers	436(74.0%)	372(85.3%)	64(14.7%)		366(83.9%)	70(16.1%)	
Deployed to other departments within original working hospitals	37(6.3%)	31(83.8%)	6(16.2%)		29(78.4%)	8(21.6%)	
Not working	7(1.2%)	7(100.0%)	0(0.0%)		7(100.0%)	0(0.0%)	
-Whether received mental health services during the COVID-19 pandemic:				0.199			0.438
Yes	44(7.5%)	39(88.6%)	5(11.4%)		39(88.6%)	5(11.4%)	
No	545(92.5%)	470(86.2%)	75(13.8%)		463(85.0%)	82(15.0%)	

Note. \* =  $p < 0.01$ , \*\*\* =  $p < 0.001$

symptoms, while changes in physical activity, and changes in sleeping time positively predicted severity of anxiety symptoms. Participants with a higher education level experienced

a lower level of anxiety during the pandemic (OR = 0.341, 95%CI = 0.149–0.778). Those who reported engaging in a lower level of physical activity reported higher levels

**Table 2** Factors influencing the mental health of healthcare workers: lifestyle changes during the COVID-19 pandemic

Lifestyle change		Total	Anxiety		$\chi^2$	Depression		$\chi^2$
			No to mild	Moderate to severe		No to mild	Moderate to severe	
Physical activity	Being unhealthy	234(39.7%)	189(80.8%)	45(19.2%)	11.846***	196(83.8%)	38(16.2%)	2.059
	No change	309(52.5%)	281(90.9%)	28(9.1%)		269(87.1%)	40(12.9%)	
	Being healthy	46(7.8%)	39(84.8%)	7(15.2%)		37(80.4%)	9(19.6%)	
Sleeping	Being unhealthy	212(36.0%)	167(78.8%)	45(21.2%)	16.519***	165(77.8%)	47(22.2%)	14.656***
	No change	348(59.1%)	316(90.8%)	32(9.2%)		312(89.7%)	36(10.3%)	
	Being healthy	29(4.9%)	26(89.7%)	3(10.3%)		25(86.2%)	4(13.8%)	
Diet	Being unhealthy	74(12.6%)	60(81.1%)	14(16.9%)	6.814**	58(78.4%)	16(21.6%)	4.754*
	No change	269(45.7%)	243(90.3%)	26(9.7%)		237(88.1%)	32(11.9%)	
	Being healthy	246(41.8%)	206(83.7%)	40(16.3)		207(84.1%)	39(15.9%)	

\* =  $p < 0.1$ , \*\* =  $p < 0.05$ , \*\*\* =  $p < 0.01$

**Table 3** Association between various factors and anxiety and depression among healthcare workers

Variables	Anxiety		Depression	
	$\beta$	OR (95% CI)	$\beta$	OR (95% CI)
Demographic and personal characteristics:				
-Age:				
30–39 years old	-0.072	0.931(0.395–2.193)	0.204	1.226(0.544–2.765)
≥40 years old	-0.626	0.535(0.174–1.638)	-0.520	0.594(0.198–1.787)
-Educational level:				
Bachelor's degree or above	-1.076**	0.341(0.149–0.778)	-0.455	0.634(0.264–1.525)
Working experiences:				
-Length of working experiences:				
1–5 years	0.402	1.494(0.296–7.532)	1.735	5.669(0.694–46.331)
5–10 years	0.204	1.227(0.245–6.144)	0.992	2.697(0.323–22.518)
> 10 years	1.044	2.841(0.484–16.667)	1.726	5.616(0.605–52.121)
COVID-19-related stressors:				
-Working Units:				
COVID-19 isolation wards	0.162	1.176(0.227–6.098)	0.585	1.796(0.450–7.165)
Non-infective wards	-0.271	0.763(0.307–1.896)	-0.952**	0.386(0.165–0.902)
Other	-0.047	0.954(0.423–2.153)	-0.493	0.611(0.293–1.273)
-Working experience during the COVID-19 pandemic:				
Working within original employers	0.967*	2.629(0.988–6.996)	1.762***	5.823(2.238–15.152)
Deployed to other departments within original working hospitals	0.805	2.237(0.581–8.616)	1.968***	7.159(2.019–25.393)
Not working	-18.667	-	-18.173	-
-Changes in physical activity time per week				
Being unhealthy	0.668**	1.950(1.119–3.397)	0.071*	1.073(0.628–1.833)
Being healthy	0.627	1.871(0.724–4.839)	0.571	1.770(0.737–4.248)
-Changes in daily sleeping time				
Being unhealthy	0.932***	2.539(1.470–4.385)	1.048	2.851(1.678–4.843)
Being healthy	0.406	1.501(0.401–5.622)	0.813	2.256(0.689–7.388)
-Changes in eating per week				
Being unhealthy	0.932	1.752(0.805–3.810)	0.629*	1.875(0.894–3.933)
Being healthy	0.406	1.392(0.775–2.503)	0.143	1.154(0.658–2.025)
Constant	-2.015	0.133	14.129	0.016
Hosmer–Lemeshow Tests (P value)	0.610		0.748	

\* =  $p < 0.1$ , \*\* =  $p < 0.05$ , \*\*\* =  $p < 0.01$

of anxiety (OR = 1.950, 95%CI = 1.119–3.397), and similarly, those who slept less during the COVID-19 pandemic reported higher levels of anxiety symptoms (OR = 2.539, 95%CI = 1.470–4.385). Surprisingly, participants were at a higher risk to suffer from anxiety when there was no change in their working place, compared to those who were sent to assist other areas for COVID-19 pandemic control (OR = 2.629, 95%CI = 0.988–6.996).

The results also showed that working units and working experience during the COVID-19 pandemic negatively predicted severity of depression symptoms, while changes in physical activity, and changes in diet positively predicted severity of depression symptoms among healthcare workers. Participants working in non-infective wards experienced a lower level of depression during the pandemic (OR = 0.386, 95%CI = 0.165–0.902). Those who became less healthy in terms of physical activity reported higher levels of depression (OR = 1.073, 95%CI = 0.628–1.833), and similarly, those who became less healthy in terms of diet also reported higher levels of depression (OR = 1.875, 95%CI = 0.894–3.933). Surprisingly, participants were at a higher risk to suffer from depression when they worked within original working hospitals (OR = 5.823, 95%CI = 2.238–15.152), or were deployed to other departments within original working hospitals (OR = 7.159, 95%CI = 2.019–25.393), compared to those who were sent to assist other areas for COVID-19 pandemic control (Table 3).

## Discussion

This study explored how lifestyle changes among healthcare workers influenced their mental health three months after the lifting of the lockdown policy in Wuhan during the COVID-19 pandemic in China. The results showed that mental health problems were common among healthcare workers three months after lifting the lockdown policy, with 13.6% and 14.8% of healthcare workers reporting moderate to severe anxiety and depression symptoms, respectively. The results also indicated that becoming unhealthier in terms of physical activity and sleep were significant predictors of moderate to severe anxiety symptoms among healthcare workers. And becoming unhealthier in terms of physical activity and diet were significant predictors of moderate to severe depression symptoms. In addition, the results revealed that working within original hospitals during the COVID-19 pandemic was a significant predictor of moderate to severe anxiety and depression. The lower level of education predicted moderate to severe anxiety and working in a non-infective ward predicted moderate to severe depression.

The prevalence of mental health problems among healthcare workers following the COVID-19 pandemic was consistent with previous studies in public health emergencies,

such as SARS and MERS (Chong et al., 2004; Lee et al., 2007, 2018; Liu et al., 2012), and also consistent with studies during the COVID-19 pandemic (Lai et al., 2020; Pappa et al., 2020), indicating that healthcare workers' mental health problems were not alleviated even three months after the lifting of the lockdown policy in Wuhan.

Healthcare workers generally changed their lifestyles during the COVID-19 pandemic, and this change affected their mental health, which was consistent with research in SARS (Nickell et al., 2004; Yu et al., 2005). Similarly, the current study showed that healthcare workers with lifestyle changes, especially those becoming unhealthier in terms of physical activity, sleeping, and diet, reported higher levels of anxiety and depression, which was consistent with previous findings (Wozniak et al., 2021). These results highlighted the importance of exploring lifestyle factors that affect the mental health of healthcare workers, as such factors were typically underestimated in previous research (Walsh, 2011).

Our findings showed that reduced sleeping time was a significant predictor of anxiety and depression among healthcare workers, which was consistent with the survey of Chinese pediatricians (Cheng et al., 2020). Indeed, several studies had shown a link between lack of sleep and mental conditions including anxiety and depression (Alvaro et al., 2013; Ben Simon et al., 2020; Youssef et al., 2020). Therefore, to improve the mental health of healthcare workers, it was necessary to ensure adequate sleep duration and improve their sleep quality. Besides, we found that reduced physical activity was a predictor of anxiety among healthcare workers, which was in line with previous study (Shah et al., 2021). More strategies promoting physical activity need to be implemented to improve the mental health of healthcare workers (Paluska & Schwenk, 2000). Furthermore, we found that healthcare workers becoming unhealthier in diet patterns experienced higher levels of depression, which was consistent with previous research on the impact of diet on mental health (Marx et al., 2021). Therefore, ensuring a healthy diet for healthcare workers, especially during public health emergencies when normal diet patterns were disrupted (Zhang et al., 2020a), was critical to improve their mental health.

Healthcare workers working in non-infective wards experienced fewer depression symptoms than those in the ICU, which was consistent with previous research (Wozniak et al., 2021), suggesting that the work environment might influence healthcare workers' mental health. In line with previous research, higher educational level (bachelor's degree or above) was a protective predictor of anxiety among healthcare workers (Yáñez et al., 2020). This protective effect may be related to high resilience in regards to strain or stresses (Bjelland et al., 2008). The results surprisingly showed that healthcare workers working within the original working hospitals were significant predictors of anxiety and depression



symptoms. This may be related to the psychological typhoon eye effect, which demonstrating that the farther away from the place of a catastrophic event, the higher the level of anxiety in the population (Lindell & Earle, 1983; Maderthaler et al., 1978). This result was consistent with previous research during the COVID-19 pandemic (Yáñez et al., 2020) and during the SARS pandemic (Xie et al., 2011). A key factor for psychiatrists to consider when screening mentally vulnerable populations were the distance from the epicenter (Tang et al., 2020; Zhang et al., 2020c), our findings can help determine areas where healthcare workers may need more psychiatric assistance, which has implications for improving the mental health of healthcare workers.

The present study contributes to our understanding of the relationship between the lifestyle changes and mental health. To the best of our knowledge, this study is the first study in China to examine the impact of lifestyle changes on the mental health of healthcare workers from three perspectives: physical activity, sleep, and diet during the COVID-19 pandemic. Given the widespread mental health problems caused by the pandemic, this study explored how lifestyle changes affected the mental health of healthcare workers. Indeed, the results of this study provided evidence that lifestyle change, particularly became unhealthier in terms of physical activity and sleep, were significant predictors of severer anxiety and depression among Chinese healthcare workers. Previous research on lifestyle changes and mental health either only measured peoples' general lifestyle (e.g., total food intake) (Youssef et al., 2020), or focused on smoking and alcohol consumption (Fukunaga et al., 2021). The current study measured healthcare workers' diet patterns according to the recommendations for a healthy diet by WHO to better determine the impact of diet pattern changes on healthcare workers' mental health (WHO, 2020). By measuring lifestyle changes across three dimensions: physical activity, sleeping, and diet, the current study provided a more comprehensive measure of the impact of lifestyle changes on healthcare workers' mental health during the COVID-19 pandemic.

The results of the study have implications for developing effective interventions to improve the mental health of healthcare workers during the pandemic of infectious diseases such as COVID-19. Considering the enormous psychological problems that healthcare workers may face during a pandemic, improving their mental health through simple lifestyle interventions such as physical activity, sleep, and diet may be a cost-effective strategy (Blake et al., 2020; Lange & Nakamura, 2020). Given the ongoing world COVID-19 pandemic and the varying degrees of implementation of lockdown policies due to changes in the pandemic, this has broad and ongoing implications for improving the mental health of healthcare workers and the general public. Future research is needed to continue to develop simple and easy-to-use interventions to protect people's mental health

during pandemics as well as during regular outbreak prevention and control (Zhang, 2022; Zhang et al., 2021).

The present study has some limitations. First, this study is cross-sectional, we cannot infer causal relationships between lifestyle changes and mental health among healthcare workers. Second, the sample of this study was healthcare workers in China, and the findings may not be generalizable to healthcare workers or the general public in other countries due to the different severity of the COVID-19 pandemic and different prevention strategies implemented in each country. Third, although this study provides evidence that healthy lifestyles improve mental health status, how to set up simple interventions to promote healthy living among healthcare workers during the pandemic, and thus effectively improve their mental health status, requires the development, implementation, and evaluation of healthy lifestyle intervention strategies in the future. In addition, due to errors in the questionnaire setting, we were not able to explore gender differences in the mental health of healthcare workers, future researches need to continue to focus on gender differences in lifestyle and their impact on mental health of healthcare workers.

## Conclusion

In summary, this study explored the relationship between lifestyle changes and mental health among healthcare workers during the COVID-19 pandemic. The results enriched our understanding of the impacts of lifestyle changes on the mental health of healthcare workers and helped policymakers to screen healthcare workers most likely to experience mental health problems. During COVID-19 and similar infectious disease pandemics, promoting a healthy lifestyle (e.g., maintaining adequate physical activity and sleep time, and keeping a healthy diet) may be promising strategies to improve the mental health of healthcare workers during public health emergencies.

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**Data availability** The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Declarations

**Informed consent** Informed consent was obtained from all individual participants included in the study.

**Disclosure** No potential conflict of interest was reported by the authors.

## References

- Alvaro, P. K., Roberts, R. M., & Harris, J. K. (2013). A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. *Sleep, 36*(7), 1059–1068. <https://doi.org/10.5665/sleep.2810>
- Bailey, A. P., Hetrick, S. E., Rosenbaum, S., Purcell, R., & Parker, A. G. (2018). Treating depression with physical activity in adolescents and young adults: A systematic review and meta-analysis of randomised controlled trials. *Psychological Medicine, 48*(7), 1068–1083. <https://doi.org/10.1017/s0033291717002653>
- Ben Simon, E., Vallat, R., Barnes, C. M., & Walker, M. P. (2020). Sleep loss and the socio-emotional brain. *Trends in Cognitive Sciences, 24*(6), 435–450. <https://doi.org/10.1016/j.tics.2020.02.003>
- Bjelland, I., Krokstad, S., Mykletun, A., Dahl, A. A., Tell, G. S., & Tambs, K. (2008). Does a higher educational level protect against anxiety and depression? The HUNT study. *Social Science & Medicine, 66*(6), 1334–1345. <https://doi.org/10.1016/j.socscimed.2007.12.019>
- Blake, H., Bermingham, F., Johnson, G., & Tabner, A. (2020). Mitigating the Psychological Impact of COVID-19 on Healthcare Workers: A Digital Learning Package. *International journal of environmental research and public health, 17*(9). <https://doi.org/10.3390/ijerph17092997>
- Blom, V., Lönn, A., Ekblom, B., Kallings, L. V., Väisänen, D., Hemmingsson, E., ... Ekblom-Bak, E. (2021). Lifestyle habits and mental health in light of the two COVID-19 pandemic waves in Sweden, 2020. *International Journal of Environmental Research and Public Health, 18*(6). <https://doi.org/10.3390/ijerph18063313>
- Cervera-Martínez, J., Atienza-Carbonell, B., Mota, J. C., Bobes-Bascarán, T., Crespo-Facorro, B., Esteban, C., ... Balanzá-Martínez, V. (2021). Lifestyle changes and mental health during the COVID-19 pandemic: A repeated, cross-sectional web survey. *Journal of Affective Disorders, 295*, 173–182. <https://doi.org/10.1016/j.jad.2021.08.020>
- Cheikh Ismail, L., Osaili, T. M., Mohamad, M. N., Al Marzouqi, A., Jarrar, A. H., Abu Jamous, D. O., ... Al Dhaheri, A. S. (2020). Eating Habits and Lifestyle during COVID-19 Lockdown in the United Arab Emirates: A Cross-Sectional Study. *Nutrients, 12*(11), 3314. <https://doi.org/10.3390/nu12113314>
- Cheng, F.-F., Zhan, S.-H., Xie, A.-W., Cai, S.-Z., Hui, L., Kong, X.-X., ... Yan, W.-H. (2020). Anxiety in Chinese pediatric medical staff during the outbreak of Coronavirus Disease 2019: a cross-sectional study. *Translational pediatrics, 9*(3), 231–236. <https://doi.org/10.21037/tp.2020.04.02>
- Chong, M.-Y., Wang, W.-C., Hsieh, W.-C., Lee, C.-Y., Chiu, N.-M., Yeh, W.-C., ... Chen, C.-L. (2004). Psychological impact of severe acute respiratory syndrome on health workers in a tertiary hospital. *The British Journal of Psychiatry: the Journal of Mental Science, 185*, 127–133. <https://doi.org/10.1192/bjp.185.2.127>
- Chu, D. K., Akl, E. A., Duda, S., Solo, K., Yaacoub, S., & Schünemann, H. J. (2020). Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: A systematic review and meta-analysis. *Lancet, 395*(10242), 1973–1987. [https://doi.org/10.1016/S0140-6736\(20\)31142-9](https://doi.org/10.1016/S0140-6736(20)31142-9)
- De Brier, N., Stroobants, S., Vandekerckhove, P., & De Buck, E. (2020). Factors affecting mental health of health care workers during coronavirus disease outbreaks (SARS, MERS & COVID-19): A rapid systematic review. *PLoS ONE, 15*(12), e0244052. <https://doi.org/10.1371/journal.pone.0244052>
- Di Renzo, L., Gualtieri, P., Pivari, F., Soldati, L., Attinà, A., Cinelli, G., ... De Lorenzo, A. (2020). Eating habits and lifestyle changes during COVID-19 lockdown: An Italian survey. *Journal of Translational Medicine, 18*(1), 229. <https://doi.org/10.1186/s12967-020-02399-5>
- Firth, J., Solmi, M., Wootton, R. E., Vancampfort, D., Schuch, F. B., Hoare, E., ... Stubbs, B. (2020). A meta-review of “lifestyle psychiatry”: The role of exercise, smoking, diet and sleep in the prevention and treatment of mental disorders. *World Psychiatry, 19*(3), 360–380. <https://doi.org/10.1002/wps.20773>
- Fukunaga, A., Inoue, Y., Yamamoto, S., Miki, T., Nanri, A., Ishiwari, H., ... Mizoue, T. (2021). Association Between Adherence to Healthy Lifestyles and Depressive Symptoms Among Japanese Hospital Workers During the COVID-19 Pandemic. *Asia-Pacific Journal of Public Health, 33*(8), 847–853. <https://doi.org/10.1177/10105395211007604>
- Galea, S., Merchant, R. M., & Lurie, N. (2020). The Mental Health Consequences of COVID-19 and Physical Distancing: The Need for Prevention and Early Intervention. *JAMA Internal Medicine, 180*(6), 817–818. <https://doi.org/10.1001/jamainternmed.2020.1562>
- Giuntella, O., Hyde, K., Saccardo, S., & Sadoff, S. (2021). Lifestyle and mental health disruptions during COVID-19. *Proceedings of the National Academy of Sciences of the United States of America, 118*(9). <https://doi.org/10.1073/pnas.2016632118>
- Hossain, M. M., Tasnim, S., Sultana, A., Faizah, F., Mazumder, H., Zou, L., ... Ma, P. (2020). Epidemiology of mental health problems in COVID-19: a review. *F1000Res, 9*, 636. <https://doi.org/10.12688/f1000research.24457.1>
- Jacka, F. N., O’Neil, A., Opie, R., Itsiopoulos, C., Cotton, S., Mohebbi, M., ... Berk, M. (2017). A randomised controlled trial of dietary improvement for adults with major depression (the ‘SMILES’ trial). *BMC Medicine, 15*(1), 23. <https://doi.org/10.1186/s12916-017-0791-y>
- Johns Hopkins Coronavirus Resource Center. (2022). COVID-19 Global Map. Retrieved June 10, 2022 from <https://coronavirus.jhu.edu/map.html>
- Kang, L., Li, Y., Hu, S., Chen, M., Yang, C., Yang, B. X., ... Liu, Z. (2020). The mental health of medical workers in Wuhan, China dealing with the 2019 novel coronavirus. *Lancet Psychiatry, 7*(3), e14. [https://doi.org/10.1016/s2215-0366\(20\)30047-x](https://doi.org/10.1016/s2215-0366(20)30047-x)
- Kroenke, K., Spitzer, R. L., & Williams, J. B. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine, 16*(9), 606–613. <https://doi.org/10.1046/j.1525-1497.2001.016009606.x>
- Krystal, J. H. (2020). Responding to the hidden pandemic for health-care workers: Stress. *Nature Medicine, 26*(5), 639–639. <https://doi.org/10.1038/s41591-020-0878-4>
- Lai, J., Ma, S., Wang, Y., Cai, Z., Hu, J., Wei, N., ... Hu, S. (2020). Factors Associated With Mental Health Outcomes Among Health Care Workers Exposed to Coronavirus Disease 2019. *JAMA Network Open, 3*(3), e203976. <https://doi.org/10.1001/jamanetworkopen.2020.3976>
- Lange, K. W., & Nakamura, Y. (2020). Lifestyle factors in the prevention of COVID-19. *Global Health Journal, 4*(4), 146–152. <https://doi.org/10.1016/j.glohj.2020.11.002>
- Lee, A. M., Wong, J. G. W. S., McAlonan, G. M., Cheung, V., Cheung, C., Sham, P. C., ... Chua, S. E. (2007). Stress and psychological distress among SARS survivors 1 year after the outbreak. *Canadian Journal of Psychiatry. Revue Canadienne de Psychiatrie, 52*(4), 233–240. <https://doi.org/10.1177/070674370705200405>
- Lee, S. M., Kang, W. S., Cho, A.-R., Kim, T., & Park, J. K. (2018). Psychological impact of the 2015 MERS outbreak on hospital workers and quarantined hemodialysis patients. *Comprehensive Psychiatry, 87*, 123–127. <https://doi.org/10.1016/j.comppsy.2018.10.003>



- Lei, L., Huang, X., Zhang, S., Yang, J., Yang, L., & Xu, M. (2020). Comparison of prevalence and associated factors of anxiety and depression among people affected by versus people unaffected by quarantine during the COVID-19 epidemic in Southwestern China. *Medical Science Monitor*, *26*, e924609. <https://doi.org/10.12659/msm.924609>
- Leo, C. G., Sabina, S., Tumolo, M. R., Bodini, A., Ponzini, G., Sabato, E., & Mincarone, P. (2021). Burnout among healthcare workers in the COVID 19 Era: A review of the existing literature. *Frontiers in Public Health*, *9*, 750529. <https://doi.org/10.3389/fpubh.2021.750529>
- Lindell, M. K., & Earle, T. C. (1983). How close Is close enough: Public perceptions of the risks of industrial facilities. *Risk Analysis*, *3*(4), 245–253. <https://doi.org/10.1111/j.1539-6924.1983.tb01393.x>
- Liu, X., Kakade, M., Fuller, C. J., Fan, B., Fang, Y., Kong, J., ... Wu, P. (2012). Depression after exposure to stressful events: Lessons learned from the severe acute respiratory syndrome epidemic. *Comprehensive Psychiatry*, *53*(1), 15–23. <https://doi.org/10.1016/j.comppsy.2011.02.003>
- Maderthaner, R., Guttman, G., Swaton, E., & Otway, H. J. (1978). Effect of distance upon risk perception. *Journal of Applied Psychology*, *63*(3), 380–382. <https://doi.org/10.1037/0021-9010.63.3.380>
- Mahase, E. (2020). Coronavirus covid-19 has killed more people than SARS and MERS combined, despite lower case fatality rate. *BMJ*, *368*, m641. <https://doi.org/10.1136/bmj.m641>
- Manea, L., Gilbody, S., & McMillan, D. (2012). Optimal cut-off score for diagnosing depression with the Patient Health Questionnaire (PHQ-9): A meta-analysis. *CMAJ : Canadian Medical Association Journal*, *184*(3), E191-196. <https://doi.org/10.1503/cmaj.110829>
- Marx, W., Lane, M., Hockey, M., Aslam, H., Berk, M., Walder, K., ... Jacka, F. N. (2021). Diet and depression: Exploring the biological mechanisms of action. *Molecular Psychiatry*, *26*(1), 134–150. <https://doi.org/10.1038/s41380-020-00925-x>
- Molarius, A., Berglund, K., Eriksson, C., Eriksson, H. G., Lindén-Boström, M., Nordström, E., ... Ydreborg, B. (2009). Mental health symptoms in relation to socio-economic conditions and lifestyle factors—a population-based study in Sweden. *BMC Public Health*, *9*, 302. <https://doi.org/10.1186/1471-2458-9-302>
- Muller, A. E., Hafstad, E. V., Himmels, J. P. W., Smedslund, G., Flottorp, S., Stensland, S. Ø., ... Vist, G. E. (2020). The mental health impact of the covid-19 pandemic on healthcare workers, and interventions to help them: A rapid systematic review. *Psychiatry Research*, *293*, 113441–113441. <https://doi.org/10.1016/j.psychres.2020.113441>
- Nickell, L. A., Crighton, E. J., Tracy, C. S., Al-Enazy, H., Bolaji, Y., Hanjrah, S., ... Upshur, R. E. G. (2004). Psychosocial effects of SARS on hospital staff: Survey of a large tertiary care institution. *CMAJ : Canadian Medical Association Journal*, *170*(5), 793–798. <https://doi.org/10.1503/cmaj.1031077>
- Paluska, S. A., & Schwenk, T. L. (2000). Physical activity and mental health. *Sports Medicine*, *29*(3), 167–180. <https://doi.org/10.2165/00007256-200029030-00003>
- Pappa, S., Ntella, V., Giannakas, T., Giannakoulis, V. G., Papoutsis, E., & Katsaounou, P. (2020). Prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic: A systematic review and meta-analysis. *Brain, Behavior, and Immunity*, *88*, 901–907. <https://doi.org/10.1016/j.bbi.2020.05.026>
- Petrelli, F., Scuri, S., Tanzi, E., Nguyen, C., & Grappasonni, I. (2018). Public health and burnout: a survey on lifestyle changes among workers in the healthcare sector. *Acta Biomed*, *90*(1), 24–30. <https://doi.org/10.23750/abm.v90i1.7626>
- Pfefferbaum, B., & North, C. S. (2020). Mental health and the covid-19 pandemic. *New England Journal of Medicine*, *383*(6), 510–512. <https://doi.org/10.1056/NEJMp2008017>
- Sahebi, A., Nejati-Zarnaqi, B., Moayedi, S., Yousefi, K., Torres, M., & Golitaleb, M. (2021). The prevalence of anxiety and depression among healthcare workers during the COVID-19 pandemic: An umbrella review of meta-analyses. *Progress in Neuro-Psychopharmacology & Biological Psychiatry*, *107*, 110247–110247. <https://doi.org/10.1016/j.pnpbp.2021.110247>
- Scott, A. J., Webb, T. L., Martyn-St James, M., Rowse, G., & Weich, S. (2021). Improving sleep quality leads to better mental health: A meta-analysis of randomised controlled trials. *Sleep Medicine Reviews*, *60*, 101556. <https://doi.org/10.1016/j.smrv.2021.101556>
- Shah, S. M. A., Mohammad, D., Qureshi, M. F. H., Abbas, M. Z., & Aleem, S. (2021). Prevalence, psychological responses and associated correlates of depression, anxiety and stress in a global population, during the coronavirus disease (COVID-19) pandemic. *Community Mental Health Journal*, *57*(1), 101–110. <https://doi.org/10.1007/s10597-020-00728-y>
- Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine*, *166*(10), 1092–1097. <https://doi.org/10.1001/archinte.166.10.1092>
- Stefanovska-Petkovska, M., Stefanovska, V. V., Bojadjeva, S., & Bojadjev, M. I. (2020). Psychological distress, burnout, job satisfaction and intention to quit among primary healthcare nurses. *Health Services Management Research*, *34*(2), 92–98. <https://doi.org/10.1177/0951484820971444>
- Stockwell, S., Trott, M., Tully, M., Shin, J., Barnett, Y., Butler, L., ... Smith, L. (2021). Changes in physical activity and sedentary behaviours from before to during the COVID-19 pandemic lockdown: A systematic review. *BMJ Open Sport & Exercise Medicine*, *7*(1), e000960. <https://doi.org/10.1136/bmjsem-2020-000960>
- Tanaka, K., Tahara, M., Mashizume, Y., & Takahashi, K. (2021). Effects of lifestyle changes on the mental health of healthcare workers with different sense of coherence levels in the Era of COVID-19 pandemic. *International Journal of Environmental Research and Public Health*, *18*(6). <https://doi.org/10.3390/ijerph18062801>
- Tang, P. M., Zhang, S. X., Li, C. H., & Wei, F. (2020). Geographical identification of the vulnerable groups during COVID-19 crisis: Psychological typhoon eye theory and its boundary conditions. *Psychiatry and Clinical Neurosciences*, *74*(10), 562–563. <https://doi.org/10.1111/pcn.13114>
- Turale, S., Meechanman, C., & Kunaviktikul, W. (2020). Challenging times: Ethics, nursing and the COVID-19 pandemic. *International Nursing Review*, *67*(2), 164–167. <https://doi.org/10.1111/inr.12598>
- Velten, J., Bieda, A., Scholten, S., Wannemüller, A., & Margraf, J. (2018). Lifestyle choices and mental health: A longitudinal survey with German and Chinese students. *BMC Public Health*, *18*(1), 632. <https://doi.org/10.1186/s12889-018-5526-2>
- Vindegard, N., & Benros, M. E. (2020). COVID-19 pandemic and mental health consequences: Systematic review of the current evidence. *Brain, Behavior, and Immunity*, *89*, 531–542. <https://doi.org/10.1016/j.bbi.2020.05.048>
- Walsh, R. (2011). Lifestyle and mental health. *The American Psychologist*, *66*(7), 579–592. <https://doi.org/10.1037/a0021769>
- WHO. (2020). *Healthy diet*. Retrieved on June 10, 2022 from <https://www.who.int/en/news-room/fact-sheets/detail/healthy-diet>
- Wiersinga, W. J., Rhodes, A., Cheng, A. C., Peacock, S. J., & Prescott, H. C. (2020). Pathophysiology, transmission, diagnosis, and treatment of coronavirus disease 2019 (COVID-19): A Review. *JAMA*, *324*(8), 782–793. <https://doi.org/10.1001/jama.2020.12839>
- Wozniak, H., Benzakour, L., Moullec, G., Buetti, N., Nguyen, A., Corbaz, S., ... Cereghetti, S. (2021). Mental health outcomes of

- ICU and non-ICU healthcare workers during the COVID-19 outbreak: A cross-sectional study. *Annals of Intensive Care*, 11(1), 106. <https://doi.org/10.1186/s13613-021-00900-x>
- Xie, X.-F., Stone, E., Zheng, R., & Zhang, R.-G. (2011). The ‘Typhoon Eye Effect’: Determinants of distress during the SARS epidemic. *Journal of Risk Research*, 14(9), 1091–1107. <https://doi.org/10.1080/13669877.2011.571790>
- Yáñez, J. A., Afshar Jahanshahi, A., Alvarez-Risco, A., Li, J., & Zhang, S. X. (2020). Anxiety, distress, and turnover intention of healthcare workers in Peru by their distance to the Epicenter during the COVID-19 crisis. *The American Journal of Tropical Medicine and Hygiene*, 103(4), 1614–1620. <https://doi.org/10.4269/ajtmh.20-0800>
- Young, K. P., Kolcz, D. L., O’Sullivan, D. M., Ferrand, J., Fried, J., & Robinson, K. (2021). Health care workers’ mental health and quality of life during COVID-19: Results From a mid-pandemic, National Survey. *Psychiatric Services*, 72(2), 122–128. <https://doi.org/10.1176/appi.ps.202000424>
- Youssef, N., Mostafa, A., Ezzat, R., Yosef, M., & El Kassas, M. (2020). Mental health status of health-care professionals working in quarantine and non-quarantine Egyptian hospitals during the COVID-19 pandemic. *Eastern Mediterranean Health Journal*, 26(10), 1155–1164. <https://doi.org/10.26719/emhj.20.116>
- Yu, H. Y. R., Ho, S. C., So, K. F. E., & Lo, Y. L. (2005). Short communication: The psychological burden experienced by Hong Kong midlife women during the SARS epidemic. *STRESS AND HEALTH*, 21(3), 177–184. <https://doi.org/10.1002/smi.1051>
- Zhang, J., Lai, S., Lyu, Q., Zhang, P., Yang, D., Kong, J., ... Ding, G. (2020a). Diet and nutrition of healthcare workers in COVID-19 epidemic-Hubei, China, 2019. *China CDC Weekly*, 2(27), 505–506. <https://doi.org/10.46234/ccdcw2020a.121>
- Zhang, N. (2022). Risk perception, mental health distress, and flourishing during the COVID-19 pandemic in China: The role of positive and negative affect. *Current Psychology*, 1–9,. <https://doi.org/10.1007/s12144-021-02624-4>
- Zhang, N., Hong, D., Yang, H., Mengxi, G., Huang, X., Wang, A., & Wang, L. (2022). Risk perception, anxiety, and depression among hospital pharmacists during the COVID-19 pandemic: The mediating effect of positive and negative affect. *Journal of Pacific Rim Psychology*. <https://doi.org/10.1177/18344909221101670>
- Zhang, N., Wu, K., & Wang, W. (2020b). Timely mental health services contribute to the containment of COVID-19 pandemic in China. *Global Health Research and Policy*, 5, 40. <https://doi.org/10.1186/s41256-020-00168-x>
- Zhang, N., Yang, S., & Jia, P. (2022). Cultivating resilience during the COVID-19 pandemic: A socioecological perspective. *Annual Review of Psychology*, 73(1), 575–598. <https://doi.org/10.1146/annurev-psych-030221-031857>
- Zhang, S. X., Wang, Y., Rauch, A., & Wei, F. (2020c). Unprecedented disruption of lives and work: Health, distress and life satisfaction of working adults in China one month into the COVID-19 outbreak. *Psychiatry Research*, 288, 112958. <https://doi.org/10.1016/j.psychres.2020.112958>
- Zhou, S. J., Zhang, L. G., Wang, L. L., Guo, Z. C., Wang, J. Q., Chen, J. C., ... Chen, J. X. (2020). Prevalence and socio-demographic correlates of psychological health problems in Chinese adolescents during the outbreak of COVID-19. *European Child & Adolescent Psychiatry*, 29(6), 749–758. <https://doi.org/10.1007/s00787-020-01541-4>

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