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

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The trends of psychosomatic symptoms and perceived stress among healthcare workers during the COVID-19 pandemic in China: Four cross-sectional nationwide surveys, 2020–2023

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ABSTRACT

An unseen wave of vast infection was detected in China in December 2022, and healthcare workers faced inevitable challenges and heavy stress. We aimed to present a dynamic mental health map and, most importantly, provide a timely report of the current situation in healthcare workers. The current study conducted four national cross-sectional online surveys from February and March 2020, Apr 2022, and Jan 2023. The Psychosomatic Symptom Scale (PSSS) and Perceived Stress Scale-10 (PSS-10) were used to assess psychosomatic symptoms and perceived stress. Fourteen thousand nine hundred forty-five participants (8578 healthcare workers and 6367 others) participated in the surveys. The prevalence of psychosomatic syndrome, reflected by PSSS, was 19.3% (Wave1), 22.9% (Wave2), 36.4% (Wave3), and 60.7% (Wave4) among healthcare workers, compared to 24.0% (Wave1), 35.7% (Wave2), 34.2% (Wave3) and 50.5% (Wave4) among the others. In addition, healthcare workers exhibited lower PSSS total scores at the beginning but higher in later waves. Despite their infection status, they now suffer from more severe psychosomatic symptoms than the rest of society. Our findings suggest that healthcare workers in China have now experienced severe psychosomatic symptoms and tremendous stress. Therefore, there is an urgent need to utilize social support for them.

1. Introduction

Since late December 2019, novel pneumonia caused by coronavirus disease 2019 (COVID-19) has been reported in the Chinese city of Wuhan and has spread rapidly domestically and internationally (Li et al., 2020). The World Health Organization (WHO) officially declared the COVID-19 outbreak as a global health emergency on January 30, 2020. As of January 8, 2023, over 659 million confirmed cases and over 6.6 million deaths had been reported globally (WHO website). Severe respiratory symptoms, rapid transmission capacity, and high mortality, make COVID-19 a painful disease that negatively affects mental and physical health (Wiersinga et al., 2020; Yuan et al., 2022).

Psychosomatic refers to the intersection of psychological and biological factors associated with health and disease (Bauer et al., 2011), and the factors such as gender, age, education, and occupation affecting people's psychosomatic health (Bulloch et al., 2021; Lai et al., 2020; Li

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et al., 2020). Healthcare workers were faced with higher infection risks, long work shifts, family relationship disturbs, and other stressors, which may result in severe psychosomatic problems. Some studies have reported more severe insomnia, anxiety, depression, somatization, and obsessive-compulsive symptoms in healthcare workers compared to non-healthcare workers during the COVID-19 epidemic (Marvaldi et al., 2021; Zhang et al., 2020), especially for women, physical disability and peoples with poor sleep quality (Steptoe and Di Gessa, 2021). In another study during the COVID-19 pandemic, approximately one-third of Chinese healthcare workers exhibited at least one dimension of psychological symptoms (Xiong et al., 2022). A survey of healthcare workers suggests that higher levels of perceived stress are positively correlated with severe insomnia and depression (Li et al., 2022). In a similar survey of healthcare workers, 14.2% reported depression, 43.1% reported mild or high anxiety, 31.6% reported sleep disturbances, and 46.0% reported emotional exhaustion (Van Wert et al., 2022). A recent cross-sectional study showed that 35.07% of healthcare workers reported psychosomatic symptoms, higher perceived stress, and more severe anxiety and depression (Wang et al., 2023). In addition, female gender, nurses, high exposure chances, somatic symptoms, and lack of medical training were among the risk factors for developing psychosomatic problems among healthcare workers (Chew et al., 2020b; Dong et al., 2022; Le et al., 2021; Pham et al., 2021).

Up to now, trends in psychosomatic problems and perceived stress among healthcare workers at different pandemic stages remain unknown. A systematic review, primarily of hospitalized patients, has estimated that 54% to 73% of patients may experience common psychosomatic symptoms, including fatigue, brain fog, dyspnea, digestive issues, loss of taste and smell, and depression (Groff et al., 2021; Nasserie et al., 2021). Another paper described that nearly 2 million people with COVID-19 found that 23% reported long-term symptoms (Wang et al., 2022), which are symptoms and effects that persist months after COVID-19 infection, including fatigue, pain, cognitive impairment, and mood disorders (Ceban et al., 2022a, 2022b, 2021; Renaud-Charest et al., 2021). In summary, serious psychosomatic problems remain in the recovery phase after COVID-19 infection (Hao et al., 2020; Ho et al., 2021). However, it is unclear whether COVID-19 infected stage, post-infection recovered stage, and uninfected stage have different effects on psychosomatic symptoms and stress. Notably, in December 2022, China witnessed a nationwide outbreak of COVID-19 with Omicron (SARS-CoV-2 variants) infections. The rapidly increasing number of patients was taking up healthcare resources, leading to a shortage of healthcare workers and other resources. Furthermore, many infected healthcare workers have to continue work risking more severe stress and psychosomatic problems than previous outbreaks. The Chinese government provided psychological assistance services during the outbreak, including telephone, internet, and apps-based counseling or interventions. However, timely assessments and mental health interventions for frontline healthcare workers were relatively limited (Jia et al., 2021; Lai et al., 2020). Notably, a timely survey could be critical to map their stress and psychosomatic symptoms. Otherwise, the healthcare workers' negative emotions will not only affect their health but also hinder the daily care of patients, leading to worse results (Coifman et al., 2021).

The current study conducted four nationwide online surveys successively from 2020 to 2023, which investigated information on psychosomatic symptoms and perceived stress among healthcare workers and non-healthcare workers during different outbreak periods over the three years of the epidemic. We hypothesized that over time and as the outbreak spread, healthcare workers would have a higher prevalence of psychosomatic symptoms and more significant perceived stress than the rest. This study aimed to investigate the dynamics of psychosomatic symptoms and perceived stress among healthcare workers at different stages of COVID-19 and to understand the impact of varying infection states on psychosomatic symptoms and stress, which may serve as vital evidence to guide healthcare workers in promoting psychosomatic health.

2. Materials and methods

2.1. Study design and participants

The study is four cross-sectional studies conducted by the Chinese Society of Psychosomatic Medicine (CSPM). This survey was administered through Wen Juan Xing (Changsha Renxing Science and Technology, Shanghai, China), an online survey company, and published on the Internet and WeChat platforms. The study conducted four separate nationwide online surveys from 2020 to 2023. The first two waves were conducted during the initial Wuhan outbreak: Feb 3, 2020, to Feb 11, 2020 (Wave1), Mar 7, 2020, to Mar 16, 2020 (Wave2); the third wave was conducted during the rising phase of the Shanghai outbreak: Apr 1, 2022, to Apr 8, 2022 (Wave3), and the last survey was a nationwide outbreak: Jan 1, 2023, to Jan 8, 2023 (Wave4). Participants were recruited nationally using a snowball sampling method (Kennedy--Shaffer et al., 2021). Participants were asked about the presence of dementia, hemianopia, severe disease, delayed response and unable to complete the test independently, the ones who answered YES were excluded from the study. The study protocol follows the provisions of the Declaration of Helsinki. This study was approved by the Medical Ethics Committee of ZhongDa Hospital of Southeast University (approval number 2020ZDSYLL011-P01). Informed consent was first obtained from the subjects in a web-based survey and was completed by checking the "yes" box in an electronic questionnaire. The survey was anonymous and the confidentiality of the information was ensured. The detailed process of online survey quality control is shown in the *Supplementary Methods*.

2.2. Measurements

We focused on changes in psychosomatic symptoms and stress perception dynamics under four waves of breakouts in all participants, using the Chinese version of validated measurement tools (Cohen et al., 1983; Li et al., 2020). Demographic data were self-reported by the participants, including occupation (healthcare workers: medical doctors or nurses, and non-healthcare workers, excluding nonmedical personnel working in hospitals or medical institutions), sex, age, marital status, educational level, health status (Participants were asked "Do you currently have any mental disease (including depression, anxiety, etc.) or physical disease (hypertension, diabetes, ect.)?" If the answer was no, they were defined as healthy), infection status (Currently positive SARS-CoV-2 antigen tests were defined as infected for a clearer description of the infection status. A person previously diagnosed with COVID-19 and currently negative for SARS-CoV-2 antigen tests is defined as recovered, and a person who has never been infected with COVID-19 is defined as uninfected).

2.2.1. Psychosomatic symptom

Psychosomatic symptom was measured using the psychosomatic symptom scale (PSSS) (Li et al., 2020; Yue et al., 2023). The PSSS is a 26-item self-report scale developed by the CSPM with high reliability and validity (Shah et al., 2022; Wang et al., 2023). The scale consists of somatic (S) and psychological (P) factors score. 19 somatic symptoms involving neurological cardiopulmonary, digestive, urogenital and other organ systems were selected for the S factors score, and 7 questions assessing depression, anxiety, obsessive compulsive symptoms, anger and suicidal thoughts were drafted for the P factors score. All items are rated using a 4-point Likert-type scale, ranging from 0 (never) to 3 (always) based on the frequency of related events. The total score of PSSS ranges from 0 to 78. The higher the scores, the more severe the psychosomatic symptom. A cut-off score of 11 for females and 10 for males is considered "confirmed psychosomatic syndrome". The Cronbach's alpha was 0.93 in this study. The complete PSSS can be found in

supplemental Table. S1.

2.2.2. Perceived stress scale-10 (PSS-10)

The perceived stress scale-10 (PSS-10) is internationally accepted as a vital tool for assessing an individual's perceived stress (Cohen et al., 1983), which evaluates the degree of perception that aspects of one's life are uncontrollable, unpredictable and overloaded. The Chinese version of the PSS-10 has demonstrated good reliability and validity (Lu et al., 2017; Wang et al., 2011). It is a self-report instrument covering 10 items, which is responded to on a 5-point Likert-type scale from 0 (never) to 4 (almost always) to yield a total score ranging from 0 to 40, with higher scores representing higher self-perceived stress. The Cronbach's alpha was 0.78 in the current sample.

2.3. Statistical analysis

The Demographics data were categorical variables and represented the number and percentage (%). The PSSS and PSS scores were continuous variables and expressed the means and standard deviations. Subgroup analyses were performed for healthcare and non-healthcare workers. Chi-square tests were used to compare group differences of categorical variables. Mann-Whitney tests were used to compare independent groups on continuous variables nonnormally distributed. Analysis of variance (ANOVA) and Chi-square tests were used to assess differences in reported prevalence of poor psychosomatic problems.

To investigate the differences between healthcare and non-healthcare workers on psychosomatic symptoms and perceived stress in different infection status, A 2 group (healthcare workers, Non-healthcare workers) × 3 Infection status (Recovered, Infected, Uninfected) mixed-model ANOVA was performed to compare the PSSS and PSS scale scores, with group as a between-subject variable and infection status as within-subject variables. The Greenhouse-Geisser method was employed to correct the degrees of freedom when the sphericity assumption was violated. Effect sizes were also estimated using partial eta squared (η2 p). Post hoc analyses were conducted when a significant interaction was found, and Bonferroni correction was used to control possible type I error caused by multiple comparisons. The reliability of the PSSS and PSS was assessed by Cronbach's alpha, which assesses the internal consistency of each item. Pearson correlation analysis was used to detect the correlation between PSSS scores and PSS scores. All hypotheses were tested at a two-sided significance level of $P < 0.05$. Data analysis was performed using SPSS statistical software version 22.0 (IBM Corp., Armonk, NY, United States).

3. Results

3.1. Demographic characteristics

A total of 15,629 questionnaires were collected from the four national cross-sectional surveys, with 14,945 valid questionnaires (Fig. 1).

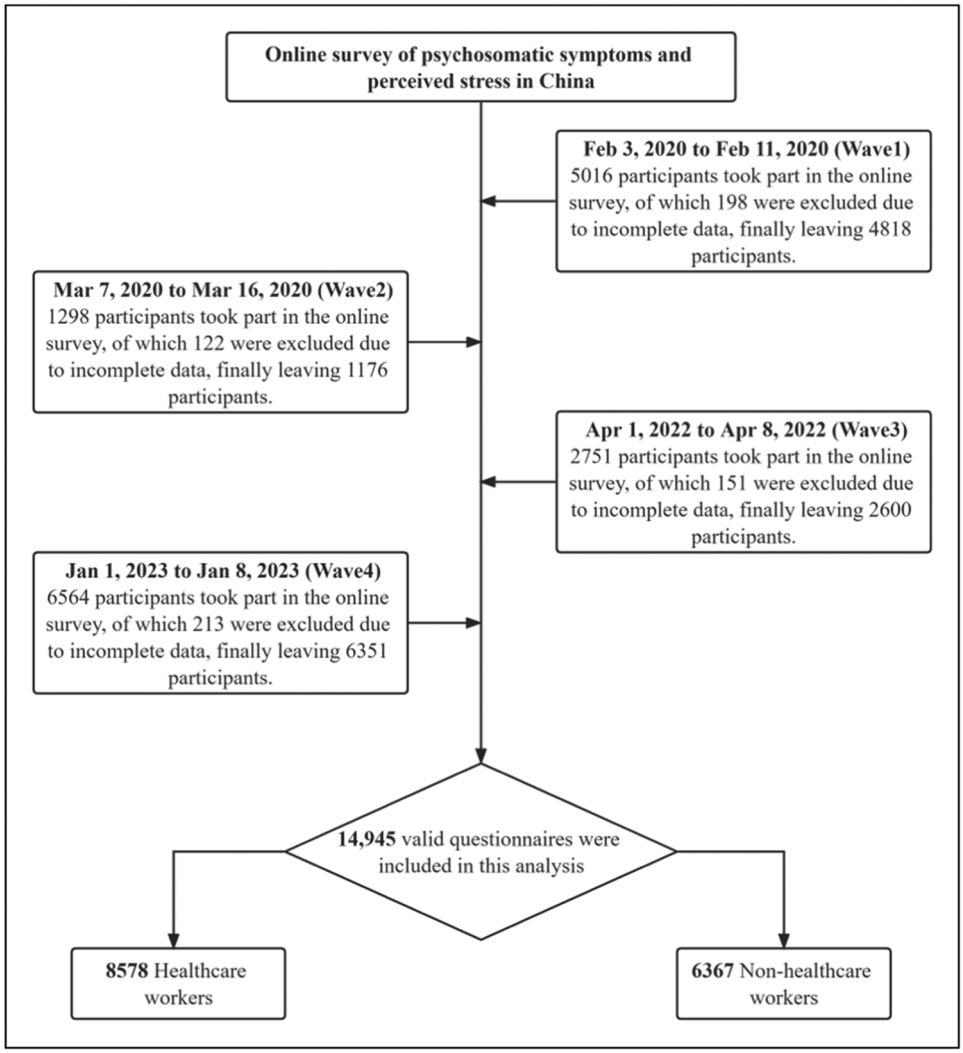

Fig. 1. Flow diagram of the study.

Table 1
Demographic Characteristics in healthcare workers versus non-healthcare workers.

Characteristics	Total	Wave1 Healthcare workers	Non-healthcare workers	Wave2 Healthcare workers	Non-healthcare workers	Wave3 Healthcare workers	Non-healthcare workers	Wave4 Healthcare workers	Non-healthcare workers
Overall, n	14,945	2704	2114	634	542	1169	1431	4071	2280
Sex, n (%)									
Male	4674 (31.2)	570(21.1)	661(31.3)	182(28.7)	184(33.9)	292(25)	555(38.8)	1236(30.4)	994(43.6)
Female	10,271 (68.7)	2134(78.9)	1453(68.7)	452(71.3)	358(66.1)	877(75)	876(61.2)	2835(69.6)	1286(56.4)
Age (years), n (%)									
<18	168(1.1)	0	24(1.1)	1(0.2)	3(0.6)	92(7.9)	15(1.0)	3(0.1)	30(1.3)
18–25	2414 (16.2)	200(7.4)	473(22.4)	39(6.2)	85(15.7)	182(15.6)	298(20.8)	219(5.4)	918(40.3)
26–30	2614 (17.5)	573(21.2)	260(12.3)	94(14.8)	80(14.8)	427(36.5)	507(35.4)	515(12.7)	158(6.9)
31–40	3933 (26.3)	1014(37.5)	507(24.0)	213(33.6)	117(21.6)	252(21.6)	209(14.6)	1284(31.5)	337(14.8)
41–50	3465 (23.2)	604(22.3)	542(25.6)	182(28.7)	149(27.5)	196(16.8)	185(12.9)	1199(29.5)	408(17.9)
51–60	1856 (12.4)	292(10.8)	222(10.5)	91(14.4)	64(11.8)	20(1.7)	139(9.7)	739(18.2)	289(12.7)
>60	495(3.3)	21(0.8)	86(4.1)	14(2.2)	44(8.1)	0	78(5.5)	112(2.8)	140(6.1)
Marital status, n (%)									
Single	4159 (27.8)	529(19.6)	724(34.2)	72(11.4)	130(24.0)	234(20.0)	825(57.7)	575(14.1)	1070(46.9)
Married	10,256 (68.6)	2078(76.8)	1296(61.3)	541(85.3)	378(69.7)	900(77.0)	562(39.3)	3364(82.6)	1137(49.9)
Divorced/Widow	530(3.5)	97(3.6)	94(4.4)	21(3.3)	34(6.3)	35(3.0)	44(3.1)	132(3.2)	73(3.2)
Education, n(%)									
Primary	63(0.4)	0	31(1.5)	1(0.2)	6(1.1)	0	14(1.0)	1(0.1)	10(0.4)
Middle/High	905(6.1)	46(1.7)	317(15.0)	21(3.3)	87(16.1)	12(1.0)	137(9.6)	74(1.8)	211(9.3)
College	10,961 (73.3)	1993(73.7)	1447(68.4)	449(70.8)	352(64.9)	910(77.8)	1109(77.5)	2929(71.9)	1772(77.7)
Graduate	3016 (20.0)	665(24.6)	319(15.1)	163(25.7)	97(17.9)	247(21.1)	171(11.9)	1067(26.2)	287(12.6)
Health status, n (%)									
Healthy	11,181 (74.8)	2225(82.3)	1613(76.3)	525(82.8)	376(69.4)	888(76.0)	1029(71.9)	2806(68.9)	1719(75.4)
Psychiatric diseases	2928 (19.6)	479(17.7)	501(23.7)	102(16.8)	143(26.4)	177(15.1)	249(17.4)	858(21.1)	419(18.4)
Somatic diseases	836(5.6)	0	0	7(1.1)	23(4.2)	104(8.9)	153(10.7)	407(10.0)	142(6.2)
Infection status, n (%)									
Recovered	4584 (72.2)	NA	NA	NA	NA	NA	NA	2967(72.9)	1617(70.9)
Infected	787 (12.4)	NA	NA	NA	NA	NA	NA	620(15.2)	167(7.3)
Uninfected	980 (15.4)	NA	NA	NA	NA	NA	NA	484(11.9)	496(21.8)
PSSS total score, Mean(SD)	10.26 (10.21)	6.21(6.98)	6.95(7.22)	6.23(6.69)	9.50(9.58)	9.10(9.91)	8.36(9.80)	15.02(11.15)	12.70(11.30)
PSSS psychological factors score, Mean (SD)	2.90 (3.43)	2.00(2.58)	2.26(2.81)	1.96(2.44)	3.12(3.52)	2.97(3.47)	2.95(3.61)	3.73(3.79)	3.23(3.78)
PSSS somatic factors score, Mean(SD)	7.36 (7.47)	4.21(4.92)	4.68(5.08)	4.27(4.82)	6.38(6.59)	6.13(6.94)	5.41(6.80)	11.29(8.13)	9.47(8.24)
The cut-off score of PSSS, n (%)									
<11 in females or <10 in males	9044 (60.5)	2181(80.7)	1607(76.0)	489(77.1)	354(65.3)	743(63.6)	942(65.8)	1599(39.3)	1129(49.5)
≥11 in females or ≥10 in males	5901 (39.5)	523(19.3)	507(24.0)	145(22.9)	188(35.7)	426(36.4)	489(34.2)	2472(60.7)	1151(50.5)
PSS total score, Mean (SD)	13.37 (6.39)	11.6(5.70)	12.04(6.23)	11.28(5.71)	12.45(6.74)	13.57(6.19)	14.49(6.00)	14.61(6.64)	14.48(6.39)

Note: PSSS:psychosomatic symptom scale; PSS: perceived stress scale.

Table 1 presents demographic features of the whole sample and compared 8578 healthcare workers (2704 in the Wave1, 634 in the Wave2, 1169 in the Wave3, 4071 in the Wave4) to 6367 non-healthcare workers (2114 in the Wave1, 542 in the Wave2, 1431 in the Wave3, 2280 in the Wave4). Of them, majority of investigators were female (10,271, 68.7%), age of 31–40 (3933, 26.3%), married (10,256, 68.6%), college (10,961, 73.3%), good health status (11,181, 74.8%).

3.2. Development of psychosomatic problems and perceived stress over time

We explored the development of psychosomatic problems and perceived stress over time in healthcare workers and non-healthcare workers. The total and factor scores of PSSS and PSS were analyzed using the ANOVA, with group (Healthcare workers, Non-healthcare

workers) and time point (Wave1, Wave2, Wave3, Wave4) as independent variables.

For PSSS total score, the interaction effect for group × time point was significant ($F = 39.408$, $p < 0.001$, $\eta 2\, p = 0.008$). Post hoc tests revealed that on the group level. Significant differences were found between the two groups in each of the four waves (all $p < 0.05$), with the total PSSS scores of healthcare workers being smaller than non-healthcare workers in the first two waves and larger in the last two waves (Fig. 2.a). Moreover, in the healthcare workers group, the PSSS total score showed a significant increasing trend with time ($F = 531.736$, $p < 0.001$, $\eta 2\, p = 0.096$), only in the Wave1 and the Wave2 is no difference (Table 1, Fig. 2.a). Among non-healthcare workers, the total PSSS score showed an incremental increase over time, with no significant difference between the Wave2 and Wave3 ($p = 0.112$), and the highest in the Wave4 (Table 1, Fig. 2.a). In addition, the prevalence of psychosomatic symptoms as defined by the cut-off score of the PSSS was 19.3% (Wave1), 22.9% (Wave2), 36.4% (Wave3) and 60.7% (Wave4) among healthcare workers, compared to 24.0% (Wave1), 35.7% (Wave2), 34.2% (Wave3) and 50.5%(Wave4) among non-healthcare workers (Table 1). There were significant differences between the two groups in Wave1, Wave2, and Wave4 ($\chi^2 = 15.206$, 20.097, 62.538, all $p < 0.001$), and no significant differences in Wave3 ($\chi^2 = 1.453$, $p = 0.228$) (see *supplement* Fig. S1.a). Moreover, each item of the PSSS scale was further analyzed (Li et al., 2020). Depressed mood (psychological symptoms) and sleep problems (somatic symptoms) were the most pronounced in the first three waves, as well as somatic symptoms were more prominent in the Wave4, such as dizziness, discomfort of throat, dryness of mouth, and tiredness (see *supplement* Fig. S2). Further analysis of the changes in psychological (P) factors and somatic(S) factors score are presented with detailed results in the *supplementary results*.

For PSS total score, the interaction effect for group × time point was significant ($F = 6.410$, $p < 0.001$, $\eta 2\, p = 0.001$). Post hoc tests showed that in the first three waves healthcare workers had lower PSS total scores than non-healthcare workers (all $p < 0.05$), and there was no difference between the two groups in the Wave4 ($p = 0.42$). In addition, among healthcare workers, there were significant differences in multiple comparisons(all $p < 0.05$), except for no significant difference between Wave1 and Wave2, with the highest total PSS score in the Wave4. Among non-healthcare workers, there was no difference between the Wave1 and the Wave2, and no significant between the Wave3 and the Wave4 (Fig. 2. d).

In addition, the pearson correlation analysis was used to detect the correlation between PSSS scores, P-factor scores, S-factor scores, and PSS scores of the two groups at different time points. The total and factor scores of the PSSS showed broadly positive correlations with the PSS scores under various conditions (*r*-value ranges from 0.308 to 0.685, all $p < 0.05$)(see *supplement* Table. S2).

3.3. Group differences in psychosomatic symptoms and perceived stress across infection status in Wave4

A 2 group (Healthcare workers, Non-healthcare workers) × 3 Infection status (Recovered, Infected, Uninfected) ANOVA was performed to compare the PSSS and PSS scores.

For PSSS total score, the interaction effect for group × infection status was not significant($F = 2.386$, $p = 0.092$, $\eta 2\, p = 0.001$). The main

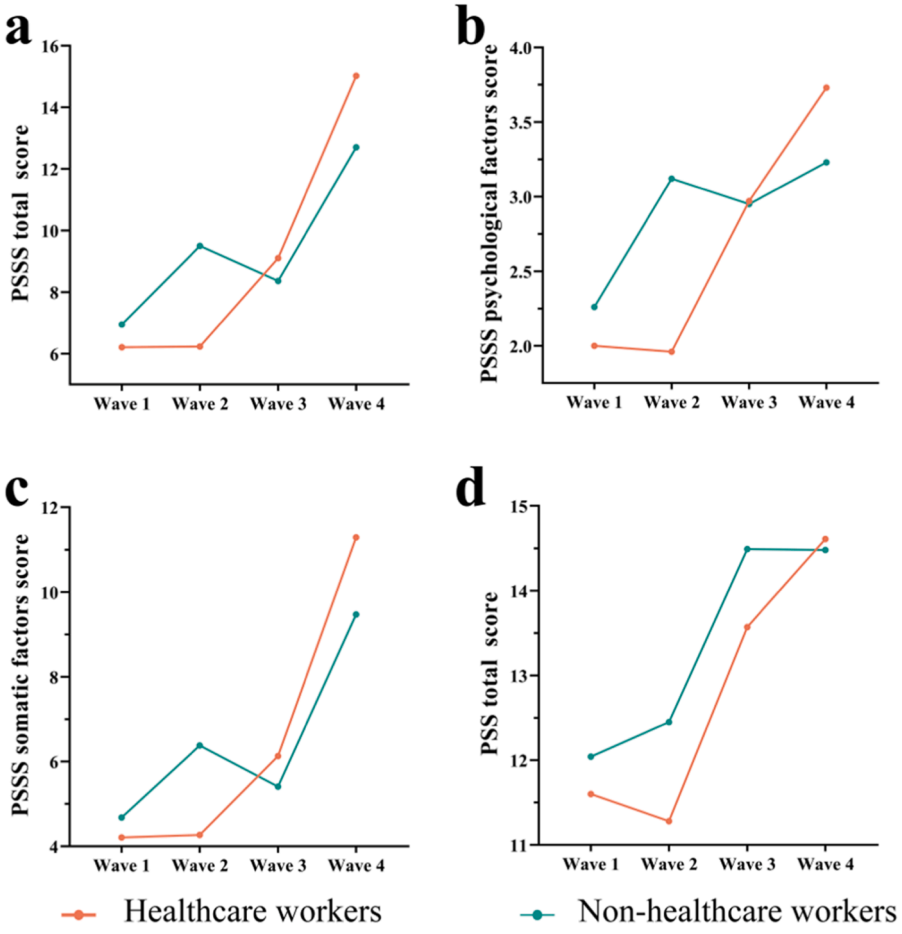

Fig. 2. Line diagram of psychosomatic problems and perceived stress in four waves dynamic changes of investigation. PSSS: psychosomatic symptom scale. PSS: perceived stress scale.

effect for group level was significant ($F = 8.984$, $p = 0.003$, η2 $p = 0.001$), and the total score for healthcare workers (Mean±SD: 15.15 ± 0.23) is greater than non-healthcare workers (13.93 ± 0.34). The main effect for infection status was significant ($F = 175.207$, $p < 0.001$, η2 $p = 0.052$), the participants with infected status had the highest scores (20.26 ± 0.47) and uninfected participants had the lowest scores (9.63 ± 0.35) (Fig. 3.a). Furthermore, the prevalence of severe psychosomatic problems based on the cut-off score of the PSSS was 60.2% (Recovered), 79.2% (Infected) and 40.3% (Uninfected) in healthcare workers, compared with 54.7% (Recovered), 76.0% (Infected) and 28.2% (Uninfected) in non-healthcare workers (see *supplement* Fig. S1.b). For psychological (P) factors and somatic(S) factors score comparisons, see the *supplementary results*.

For PSS total score, the results showed the interaction effect for group × infection status was not significant ($F = 0.448$, $p = 0.639$, η2 $p < 0.001$). The main effect for group was not significant ($F = 17.478$, $p = 0.765$, η2 $p < 0.001$). The main effect for infection status was significant ($F = 41.262$, $p < 0.001$, η2 $p = 0.005$), the participants with infected status had the highest scores (15.82 ± 0.29) and uninfected participants had the lowest scores (13.73 ± 0.21) (Fig. 3.d).

4. Discussion

To the best of our knowledge, it is the first time that data from four national cross-sectional surveys of the pandemic from 2020 to 2023 focused on Chinese healthcare workers and others on psychosomatic symptoms and perceived stress. In this study, the prevalence of psychosomatic syndrome among healthcare and non-healthcare workers consistently increased over time during the COVID-19 pandemic, especially in the December 2022 outbreak, when 60.7% of healthcare workers and 50.5% of non-healthcare workers reported severe psychosomatic syndromes. In addition, healthcare workers had lower total PSSS scores than non-healthcare workers in Waves 1 and 2, while healthcare workers had higher total PSSS scores than non-healthcare workers in Waves 3 and 4. We further analyzed, for the Wave 4 epidemic, the effect of different infection states on psychosomatic problems. Our results found that psychosomatic problems and perceived stress were most severe in the infected condition, with no significant difference between healthcare and non-healthcare workers, but recovered individuals were more severe than the uninfected individuals, with healthcare workers being more severe than non-healthcare workers. Total and factor scores of the PSSS showed a broad positive correlation with the PSS scores. Depressed mood and sleep problems were the most prominent symptoms in the first three waves, while somatic symptoms were more prominent in the fourth wave, such as dizziness, throat discomfort, dry mouth, and tiredness. In conclusion, our findings raise concerns about the mental and physical health of healthcare workers.

In our results, the total PSSS scores of healthcare workers have continued to rise over time. During the COVID-19 pandemic, healthcare workers have been at the forefront of the fight against the virus. Thus, they have been exposed to unprecedented situations, often beyond their typical level of experience and training, and have been chronically

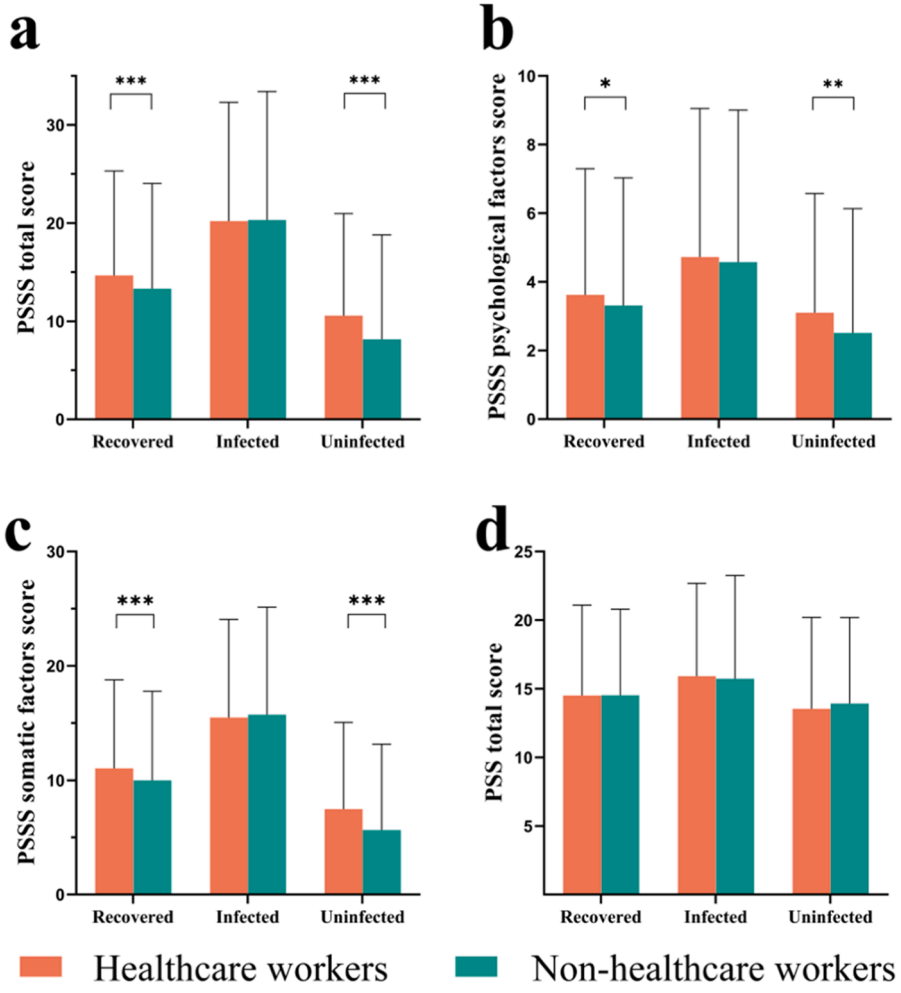

Fig. 3. Group differences in psychosomatic symptoms and perceived stress in the Wave4 of different infection states. PSSS: psychosomatic symptom scale. PSS: perceived stress scale. * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

overwhelmed. In addition, healthcare workers' direct contact with patients and increased exposure to high-stress environments aggravated the mental and physical burden on all healthcare workers (Aragonès et al., 2022). Meanwhile, comparing the trends of psychosomatic problems of non-healthcare workers, the psychosomatic problems and perceived stress situation of healthcare workers were smaller than that of non-healthcare workers in the early stage of the epidemic, suggesting that non-healthcare workers were unable to adapt quickly when faced with such an unexpected public health event, in addition to the enforced isolation policies in various regions, thus developing severe psychological and physical problems. Many studies consistently reported serious mental health problems such as anxiety, depression, stress, sleep problems, and post-traumatic symptoms among the general public early in the COVID-19 epidemic (Dragioti et al., 2022). But when faced with the same high-stress situations, healthcare workers show a higher level of adaptability than others. The training process for physicians is long and rigorous, and with this intense training experience, they may be more resilient than any other professional worker (West et al., 2020). However, at the beginning of the third wave of the survey, healthcare and non-healthcare workers had significantly higher mental and physical health problems. Still, healthcare workers had more growth, which was more pronounced in the fourth wave. The third wave of surveys is in April 2022, 2 years after COVID-19 was declared a global public health event. Non-healthcare workers have experienced different emotions or stress caused by COVID-19 due to the various risks of infection. However, with increasing knowledge of how to prevent and control COVID-19 (Peeling et al., 2022) and an adequate supply of masks, citizens have slowly become accustomed to routine prevention of COVID-19. They have gained the ability to reduce the risk of infection. However, healthcare workers are mentally and psychologically stressed in the face of the constant threat of infection and chronic high workloads, producing more severe psychosomatic symptoms. A meta-analysis that included 24,541 healthcare workers from 34 studies showed that 34% of healthcare workers had post-traumatic stress disorder (PTSD) symptoms and 14% had severe PTSD symptoms (Andhavarapu et al., 2022). In a multicenter study of 906 healthcare workers, the most common symptom was headache (32.3%), and 33.4% of participants reported symptoms such as anxiety and depression, also suggesting a bi-directional association between somatic symptoms and psychological outcomes (Chew et al., 2020a). Another study suggested that during the COVID-19 outbreak in Shanghai, China, healthcare workers had significantly higher than average scores of depression, anxiety, and insomnia. Working hours, work unit, work environment, and age were significant factors for burnout, depression, and anxiety among healthcare workers (Tang et al., 2022). Overall, we found a shift in the population prone to major psychosomatic health problems from non-healthcare workers to healthcare workers as the epidemic progressed. It suggests that healthcare workers are at greater risk in the later stages of COVID-19.

We further observed that perceived stress also increased progressively over time, with healthcare workers remaining lower than non-healthcare workers in the first three waves. Until the fourth wave, there was no difference between the two groups. In addition to the common stresses associated with the outbreak, they will feel other stresses because of the different stressors they may be exposed to. Healthcare workers' stressors are daily tasks, including job dissatisfaction and work conflicts (Zhou et al., 2020), while non-healthcare workers have a higher unemployment rate (Achdut and Refaeli, 2020). Perceived stress will also rise as the epidemic continues and the global economy is the doldrums. Because of the specificity of the medical profession, they have better resilience than other professionals (West et al., 2020), so the perceived stress of healthcare workers is lower than the rest. In addition, our results found a positive correlation between PSSS and total PSS scores, which is also largely consistent with previous results (Wang et al., 2023).

Additionally, our study analyzed the effects of COVID-19 infection status on psychosomatic health in Wave4. Our results suggest that patients with ongoing infection had more severe psychosomatic symptoms and higher prevalence than COVID-19 recovered and uninfected patients, with no difference between healthcare and non-healthcare workers. However, post-infection recovered patients had more severe psychosomatic symptoms than uninfected patients, and healthcare workers were more prominent. When people are informed of COVID-19 infection, they not only suffer from physical pain such as fever, coughing, and weakness (Huang et al., 2020), but also face great pessimism, anxiety, panic, and a variety of psychiatric problems (Phiri et al., 2021; Yuan et al., 2022). A meta-analysis study found that COVID-19-infected individuals had the highest prevalence of PTSD (94%), followed by sleep problems (63%), depression (28%), anxiety (29%), and stress (29%) (Dragioti et al., 2022). Remarkably, recovered individuals still presented higher levels of psychiatric-psychological problems. Some studies have reported that common symptoms after COVID-19 infection include fatigue, brain fog, respiratory difficulties, digestive issues, loss of taste and smell, and depression, which may persist for months after the initial infection, which happen to be psychosomatic symptoms (Wang et al., 2022). A follow-up study of survivors found that compared to non-infected patients, those who were infected continued to face higher levels of psychiatric problems 12 months after discharge, with 44% of patients still suffering from anxiety symptoms, 42% suffering from depressive symptoms, and 42% at increased risk of PTSD (Chommeloux et al., 2023). During the current national outbreak, a large number of healthcare workers recovered and were requested to return to work immediately without adequate recovery and rest, in which case healthcare workers were subjected to more physical and mental stress.

Comparing data from cross-sectional epidemiological surveys conducted at different time points is an excellent way to obtain trends in psychosomatic problems and perceived stress over time. To this study, the psychosomatic and perceived stress problems of healthcare workers are becoming more severe as the epidemic progresses, and there is an urgent need to implement interventions for the mental health of healthcare workers. For example, at the hospital level, reducing work demands and workload while increasing rest periods and incentives may help protect healthcare workers' mental and physical health. At the social level, social organizations like CSPM have proposed intervention programs for mental and physical health services by providing lectures, questionnaires, hotlines and face-to-face psychotherapy. Furthermore, cognitive behavioral therapy (CBT) is a psychosocial intervention aimed at improving psychosocial health, especially Internet CBT that can prevent the spread of infection during the pandemic (Soh et al., 2020). Internet CBT also has the advantages of portability, flexibility, low cost, and self-direction (Zhang and Ho, 2017), which can be the first choice for psychosocial interventions (Ho et al., 2020).

Our study also has some limitations. First, this study had different sample sizes in the four waves. Second, this study has a considerable bias in gender, which is predominantly female, which may bias the results. Thrid, the psychological outcome evaluation was based on an online questionnaire. In future studies, we encourage the use of clinical interviews for a comprehensive assessment of the questions. Finally, burnout is a significant public health problem, and with pandemic-induced burnout causing people to feel emotionally exhausted (Lau et al., 2022). In future research, burnout, stress, psychosomatic symptoms, and their potential connections should be examined..

Conclusion

In summary, we conducted four nationwide surveys from February 2020 to January 2023. Ultimately, it was found that as COVID-19 continued to be an epidemic, people gave a severe psychosomatic problems that showed a continuous increase. Among them, non-healthcare workers were more severe in the early stage of the epidemic, and healthcare workers showed more prominent performance in the later stage. In addition, psychosomatic problems are more severe in the post-infection recovery phase than in the non-infected population.

These results can provide valuable information for hospital administrators and government agencies to provide timely and personalized assistance and interventions for the mental health of healthcare workers.

Statement of ethics

All participants provided their online informed consent. This study was approved by the Medical Ethics Committee of ZhongDa Hospital of Southeast University (approval number 2020ZDSYLL011-P01).

Data sharing

De-identified participant data will be available in anonymised form from the corresponding author on reasonable request with approval from ZhongDa Hospital, School of Medicine, Southeast University.

Author contributions

YG Yuan and WH Jiang designed the study. All authors were involved in data collection. CG Jiang and WH Jiang analyzed data. CG Jiang, WH Jiang, YY Yue, L Li, YG Yuan interpreted the findings. CG Jiang and WH Jiang created the first draft of the manuscript. CG Jiang, WH Jiang, YY Yue, L Li, XH Shen, J Chen, RJ Ding and YG Yuan critically revised and approved the manuscript.

Declaration of Competing Interest

The authors declare that they have no conflicts of interests.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2023.115301.

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