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Factors related to perceived stress during the COVID-19 epidemic context among the general population in China: A cross-sectional nationwide study

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ABSTRACT

Background: This study aimed to investigate factors related to high stress levels among the general population in China during the novel coronavirus disease (COVID-19) pandemic when its containment measures were in place and to identify the most stressed populations.

Methods: A nationwide study was conducted online among 5,039 adults in all 31 provinces in mainland China between March 1 and March 16, 2020. Bivariate analysis and multivariate logistic regressions were performed to explore the related factors of high perceived stress.

Results: Among all respondents, 36.0% reported a high level of stress. Respondents in Hubei province (the epicenter) were more likely to report high stress levels than those in low epidemic areas. Respondents who went outside every day or every other day reported greater odds of experiencing a high level of stress than those who went outside every 8–14 days. People with higher risk perceptions were more prone to report high stress levels. Respondents aged 16–35 were more likely to report high stress than respondents aged 46 or older. Lower household income and lower health literacy were related to increased odds of reporting high stress levels.

Limitations: We used a convenience sample and self-reported survey data.

Conclusions: We identified risk factors for high stress levels related to the epidemic (epidemic intensity in residential areas, risk perception, and frequency of going outside) and other vulnerabilities (younger age, low household income, low health literacy). Our findings can directly inform interventions and policies for mitigating stress among the general population for this or future epidemics.

Introduction

The novel coronavirus disease (COVID-19) was first reported in December 2019 in Wuhan, China, and subsequently spread across the country (Wang et al., 2020a). During the peak of the epidemic, the Chinese government adopted unprecedented containment measures to control COVID-19 transmission, including lockdown measures imposed in all cities in Hubei province (Tian et al., 2020), the partial suspension of public transportation, the closing of public spaces, the close management of communities, social distancing, and stay-at-home orders for the general population. These were subsequently adopted by other worst-hit countries (CCDC, 2020; Teslya et al., 2020).

The pandemic, as well as its containment measures, brought about great challenges for the general population, which further developed into stresses (Brooks et al., 2020; Bruine de Bruin, 2020). Studies have reported a high prevalence of perceived stress (Yang et al., 2020; Yan et al., 2021) and elevated mental health problems (Li et al., 2020) among the general population in China during the epidemic. High stress can compromise the immune system, which, in turn, increases an individual's susceptibility to contracting infectious diseases (Fancourt & Steptoe, 2020; Pedersen et al., 2010), leading to mental health problems (Husky et al., 2020; Islam et al., 2020; Tang et al., 2020; Taylor et al.,

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2020) and possibly even suicide (Elbogen et al., 2020). Investigating specific stressors during an infectious disease emergency can be instrumental in the success of targeted efforts aimed at providing better mental health services and the optimization of disease containment measures to mitigate mental health consequences. Several studies have investigated factors related to mental health among the general population in China and have identified a myriad of risk factors related to the epidemic itself (e.g., contact history of COVID-19, risk perception, exposure to COVID-19 at work) (Du et al., 2020; Wang et al., 2020c; Sun et al., 2021; Wang et al., 2021a) as well as psychosocial factors (e.g., resilience, coping style, social support) (Hou et al., 2021; Liu et al., 2021; Yan et al., 2021). In addition to environmental event stressors caused by the epidemic, several social event stressors were attributable to epidemic containment measures (Chu et al., 2020; Shaw, 2021; Shi et al., 2021; Wang, 2021b), such as economic challenges caused by business closures (Li et al., 2020; Zhou & Guo, 2021), interpersonal and social disturbances when practicing social distancing (Zhao et al., 2020; Zhu et al., 2021), and heightened information inequalities due to inadequate literacy (Chu et al., 2020). However, to our knowledge, few studies have systematically investigated stress-related factors resulting from social and environmental event stressors caused by the epidemic among the general population to whom mental health services are not regularly accessible during an epidemic or pandemic (COVID-19 Prevention and Control Team, 2020; Wang et al., 2020d).

The possibility of contracting COVID-19 challenged the entire general public in China during the epidemic. Living in high-risk regions (e.g., at the epicenter of the disease or in denser urban areas), a higher frequency of going outside, and a lack of protective resources (e.g., medical masks) could increase risk of exposure to COVID-19. Biologically vulnerable populations, such as older adults, also faced higher risks of contracting COVID-19 (Chen et al., 2020; WHO, 2020a). Additionally, some people (e.g., residents in epicenters, older people, those with low education levels) reported high levels of risk perception during the epidemic (Wang et al., 2020e), which may be another stress-related factor (Jia et al., 2020; C. Wang et al., 2020b; Wang et al., 2020c; Wu et al., 2009).

On the other hand, coping with the social consequences of epidemic control strategies could be challenging for certain populations. Large-scale work closures during the epidemic caused profound losses of income (Wang et al., 2020c), which further deteriorated low-income individuals' ability to pay for potential testing, COVID-19 treatment fees, or even daily expenses. A reduced frequency of going outside, either compulsorily or voluntarily (Liu et al., 2020) because of stay-at-home orders (CCDC, 2020), limited individuals' social interactions (Hawryluck et al., 2004; Vinck et al., 2019). In general, individuals with low health literacy (Sorensen et al., 2012; The Lancet, 2009) may have found it difficult to follow up with and understand epidemic information, due to encountering scientific words and information bombardment, which could exaggerate their fears and uncertainty regarding the epidemic. Thus, we were interested in studying whether such populations were more stressed during the epidemic.

In this study, we aimed to investigate potential risk factors for high stress in the COVID-19 epidemic context among the general adult population in China one month after the lockdown in Wuhan city, when the epidemic and its containment measures were in place. Evidence of risk factors from our study can help identify the most vulnerable populations under stress associated with COVID-19 and can create a greater potential to engage in better mental health assistance for these populations.

Methods

Study design and participants

National cross-sectional data was collected between March 1 and March 16, 2020, from all 31 provincial-level regions in mainland China (excluding Hong Kong, Macau, and Taiwan). The main inclusion criterion was that participants must be community residents of Chinese nationality aged 16 years or older who could read Mandarin. The online questionnaire link was distributed, and the household member who matched the criteria and whose birth date was closest to the survey day was selected as the representative of the household. Detailed sampling size calculation, sampling strategy, and data collection were previously reported (Wang et al., 2020e). Among the 5,409 households contacted, 5,124 agreed to participate in our study (response rate 94.7%). Eighty-five questionnaires (1.7%) were excluded because of inconsistent answers to logic questions or due to respondents' being under 16 years old, resulting in 5,039 valid questionnaires in total. This sample included both Han people (non-minority) and ethnic minorities (Tibetan, Yi, Uyghur, etc.). Before their answering the questions, the questionnaire instructions informed all participants that their participation was voluntary and anonymous and that they could quit at any time. No compensation was provided. The study was reviewed and approved by the Ethics Committee of the School of Public Health at Zhejiang University (ZGL202002-3).

Measures

Perceived stress was assessed using a four-item version of the Perceived Stress Scale (PSS) (Cohen et al., 1983), rated on a 5-point Likert scale ranging from 0 (never) to 4 (very often). The Chinese version of this scale was translated and validated by Tingzhong Yang, with Cronbach's alpha values of 0.90 (Yang & Huang, 2003). A computed score above 25 (out of a total possible range of 0 to 56) was interpreted as high perceived stress (Yang & Huang, 2003). The binary stress variable was used as the primary outcome.

Respondents were asked about their residential province and were categorized into three groups based on the cumulative number of confirmed cases reported in that province as of March 1, 2020, when the study was carried out. Hubei province, a statistical outlier (67,103 confirmed cases), was defined as the large number group. Of the 30 remaining provinces, we used a median split to define the first 15 provinces ($\geq$296 confirmed cases) as the medium number group, and the last 15 provinces ($\leq$252 confirmed cases) as the small number group. Respondents self-reported their residential area type with two options (1-urban area, 2-rural areas) and were grouped accordingly. Respondents' average frequency of going outside during the epidemic was also collected, and the options were coded as 1 (went outside every day or every other day), 2 (went outside every 3–7 days), 3 (went outside every 8–14 days), and 4 (went outside every 15 days or more). Among respondents who had tried to purchase masks (excluding individuals who chose "no"), individuals who chose "yes but cannot buy one" were grouped as experiencing an inadequate supply of masks, while those who responded "yes and bought successfully" were grouped as experiencing an adequate supply of masks. The respondents' ages were obtained, and they were further divided into four age groups (i.e., people aged 16–25 years, 26–35, 36–45, and $\geq$ 46).

Risk perception was measured by having the respondents use a 5-point Likert scale ranging from 1 (not worried at all) to 5 (very worried), to rank their perceived possibility of contracting COVID-19. Answers were then categorized as low (1–2), medium (3), and high (4–5), representing different risk perception groups.

Respondents were asked about their monthly household income, with the options of "less than ¥ 3,000," "¥ 3,000–¥ 5,000," "¥ 5,001–¥ 10,000," and "more than ¥ 10,000," and they were grouped accordingly. Health literacy was measured by two questions adapted from previous studies (Wang et al., 2018), concerning the ability to search for and understand COVID-19-related information, using a 5-point Likert scale ranging from 0 (strongly agree) to 4 (strongly disagree). Respondents were categorized into high or low health literacy groups based on the 50th percentile cutoff of health literacy scores (half of them scored higher than 4).

Respondents' ethnicity (e.g., Han, Tibetan, Yi, Uyghur, etc.) was

asked, and they were grouped into the Han (non-minority) group and the minority group. Respondents' gender (male/ female) and education level (middle school and under/ high school/ college and above) were also collected.

Statistical analyses

Descriptive analyses were conducted to describe the individual characteristics and perceived stress of respondents, and their associations were assessed using Chi-square tests, t-tests, and bivariate logistic regressions. Multivariate logistic regressions were performed to explore related factors of stress. To test whether associations were robust to the dichotomy we used, we did multiple linear regression with continuous perceived stress scores as the outcome, as a sensitivity analysis. All statistical analyses were performed using SPSS 24.0 with the statistical significance set at $p < 0.05$.

Results

Of the 5,039 respondents (Table 1), more than half were females (58.5%) aged 16–35 years (63.3%), and had a monthly income higher than ¥ 5,000 (53.7%). About half of the respondents resided in rural areas and had a college or above education level. A total of 598 (11.9%) respondents lived in Hubei province, and 805 (16.0%) were minorities. During the epidemic, 943 respondents (18.7%) never went outside, and 2,118 (42.0%) went out every eight days or more. Of the 4,921 respondents attempting to purchase masks, around one-fifth (21.7%) experienced an inadequate supply. Almost half (49.4%) of the respondents had high risk perceptions. There were 15.1% of respondents who reported it was difficult to understand COVID-19-related information, and 31.8% reported it was hard to find correct and comprehensive information.

Respondents reported an average score of 21.9 (SD = 8.3) for perceived stress, with over one-third (36.0%) experiencing a high level of stress (Table 1). The proportion of high stress was greatest among those who went out every day or every other day (38.2%), was less among those who went out every 3–7 days (35.6%), and further decreased among those who went out every 8–14 days (32.3%). However, it increased among those who only went out every 15 days or longer (36.3%) (Table 2). Further bivariate regression suggests that, when compared with those who went outside every day or every other day, respondents who went out every 8–14 days showed a lower proportion of stress ($p < 0.05$). The results also show that the proportion of respondents reporting high stress decreased with age. Those aged 16–25 years reported higher stress than those over 45 years old (38.2% vs. 31.8%, $p < 0.05$). Respondents with a higher risk perception, lower household income, and poorer health literacy also showed more stress ($p < 0.001$).

The multivariate logistic regression model (Table 3) suggests that respondents residing in Hubei province (adjusted odds ratio [aOR] = 1.30, 95%CI [1.05, 1.60]) had higher adjusted odds of reporting high perceived stress, compared with those residing in provinces with a small number of confirmed cases. Respondents with a medium level (aOR = 1.34, 95%CI [1.11, 1.61]) and a high level (aOR = 1.91, 95%CI [1.61, 2.27]) of risk perceptions were more likely to report high stress than those with a low level of risk perceptions. Respondents who went outside every 8–14 days had lower odds of reporting high stress (aOR = 0.75, 95%CI [0.60, 0.95]) than those who went outside every day or every other day. Respondents in the age group of 16–25 years old (aOR = 1.51, 95%CI [1.25, 1.83]) and those in the 26–35 age group (aOR = 1.39, 95%CI [1.15, 1.69]) were more likely to report high stress than the older respondents (≥ 46 years).

Respondents with the lowest (aOR = 1.34, 95%CI [1.09, 1.65]) and medium (aOR = 1.29, 95%CI [1.08, 1.53]) household income status had greater odds of reporting high stress than those with the highest household income status. Respondents with lower health literacy were

Table 1
Sociodemographic characteristics, perceived stress, risk perception, health literacy, frequency of going outside, and inadequate supply of masks of respondents during the COVID-19 (n=5,039).

	n (%)
Sociodemographic characteristics	
Age	
≥46	1008 (20.0)
36–45	839 (16.7)
26–35	1174 (23.3)
16–25	2018 (40.0)
Gender	
Male	2090 (41.5)
Female	2949 (58.5)
Urbanicity	
Urban	2492 (49.5)
Rural	2547 (50.5)
Ethnicity	
Han (Non-minority)	4234 (84.0)
Minority	805 (16.0)
Education level	
College and above	2534 (50.3)
High school	1837 (36.5)
Middle school and under	668 (13.3)
Monthly household income	
> ¥ 10,000 ($1,449)	1286 (25.5)
¥ 5001–¥ 10,000 ($725–$1,449)	1422 (28.2)
¥ 3,000–¥ 5,000 ($435–$725)	1485 (29.5)
< ¥ 3,000 ($ 435)	846 (16.8)
Perceived stress	
In recent month, how often have you felt that you were unable to control the important things in your life?	
Never	1091 (21.7)
Almost never	1156 (22.9)
Sometimes	2351 (46.7)
Fairly often	367(7.3)
Very often	74(1.5)
In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	
Never	837 (16.6)
Almost never	1355 (26.9)
Sometimes	2258 (44.8)
Fairly often	492(9.8)
Very often	97(1.9)
In the last month, how often have you felt confident about your ability to handle your personal problems?	
Never	247(4.9)
Almost never	218(4.3)
Sometimes	1463 (29.0)
Fairly often	2649 (52.6)
Very often	462(9.2)

(*continued on next page*)

Table 1 (*continued*)

	n (%)
In the last month, how often have you felt that things are going your way?	
Never	355(7.0)
Almost never	538 (10.7)
Sometimes	2402 (47.7)
Fairly often	1518 (30.1)
Very often	226(4.5)
Perceived stress (continuous), Mean (SD)	21.9(8.3)
Perceived stress (categorical)	
High (>25)	1815 (36.0)
Low (≤25)	3224 (64.0)
Confirmed cases in residential province	
Small	2028 (40.2)
Medium	2413 (47.9)
Large (Hubei province)	598 (11.9)
Frequency of going outside	
Went outside every day or every other day	1059 (21.0)
Went outside every 3–7 days	1862 (37.0)
Went outside every 8–14 days	542 (10.8)
Went outside every 15 days or more	1576 (31.3)
Inadequate supply of masks (n=4,921)	
No (yes and bought successfully)	3855 (78.3)
Yes (yes but cannot buy one)	1066 (21.7)
Risk perception	
Are you worried about yourself contracting COVID-19?	
Low (no worried at all/ not worried)	1011 (20.1)
Medium (fair)	1539 (30.5)
High (worried/ very worried)	2489 (49.4)
Health literacy	
Hard to understand COVID-19 related knowledge and information	
Strongly disagree	348(6.9)
Disagree	2471 (49.0)
Fair	1461 (29.0)
Agree	587 (11.6)
Strongly agree	172(3.4)
Hard to find correct and comprehensive COVID-19 related information	
Strongly disagree	218(4.3)
Disagree	1541 (30.6)
Fair	1679 (33.3)
Agree	1230 (24.4)
Strongly agree	371(7.4)
Health literacy (continuous), Mean (SD)	4.4(1.7)
Health literacy (categorical)	
High (scores≥5)	2522 (50.0)
Low (scores≤4)	2517 (50.0)

2.48 times as likely to report high stress (95%CI [2.19, 2.81]) as those with high health literacy.

The linear regression model (Appendix Table A1) shows similar relationships and further indicates that an inadequate supply of masks (β = 0.90, 95%CI [0.36, 1.44]), a lower education level (β = 0.89, 95%CI [0.14, 1.64]), and a minority status (β = 0.88, 95%CI [0.22, 1.53]) were associated with higher stress scores.

Discussion

To our knowledge, this study is the first to investigate factors related to perceived stress among the nationwide general population during the COVID-19 epidemic in China when its containment measures were in place. Among all respondents, 36.0% reported a high level of stress. Living in Hubei province, having higher risk perceptions, being of a younger age, earning a lower household income, and having lower health literacy were related to increased odds of reporting high stress levels. In addition, going outside every 8–14 days was related to lower stress levels, compared with going outside every day or every other day.

Despite a considerable proportion of respondents in non-endemic provinces reporting high stress levels, residents in Hubei province reported even higher levels of stress, corresponding to data from other comparative studies in China (Qiu et al., 2020; Wang et al., 2020d). Residents in Hubei province reported greater difficulties during the epidemic, as they experienced higher risks of contracting the virus, strict lockdown policies, and discrimination, and reported higher risk perceptions (Gao et al., 2020; Yuan et al., 2020). All findings suggest that timely mental health aid for residents in epicenters should be implemented during and after an epidemic, as these residents suffer the most during an outbreak.

A reduced frequency of going outside could lower the likelihood of contracting COVID-19 during the epidemic; however, the lack of social interaction may affect interpersonal relationships and mental health. Thus, the associations between the frequency of going outside and perceived stress may be complicated. Participants who went outside most frequently reported the highest stress levels, while those who went outside every 8–14 days reported lower stress levels, which demonstrates a beneficial mental effect of social distancing behaviors during the epidemic. Considering the Chinese population's overall adherence to social distancing behaviors during the epidemic (Liu et al., 2020), people in our study who went outside frequently (81.6% of whom were aged 21–50 years) may have needed to do so for mandatory reasons (e.g., duty or for work), despite facing the increased risk of contracting the virus and, in turn, increased stress levels. For example, bus drivers continued working to maintain necessary public transportation, even at the peak of the epidemic, which elevated their risk of contracting COVID-19. Thus, the mental health status of those performing essential duties during an epidemic should be given special attention. Surprisingly, participants who substantially reduced their frequency of going outside (i.e., those who went outside every 15 days or more) reported slightly increased stress, notwithstanding the lack of social interaction and the sedentary lifestyle induced by excessive durations of staying at home (Brooks et al., 2020; Hawryluck et al., 2004). These slight mental effects could be attributed to the robust function of online systems allowing for socialization, which compensated for changes to normal life. However, we only captured the stress levels of the general population one month after the social distancing orders; thus, the long-term impact of a reduced frequency of going outside remains unclear. Studies and reviews have revealed that experiences of long quarantine duration during epidemics are related to psychological distress (Brooks et al., 2020; Hawryluck et al., 2004). Governments should maintain a balance between controlling the spread of COVID-19 through social distancing and maintaining public mental health. Advocating for an adequate frequency of going outside despite social distancing orders might be beneficial in reducing public stress levels.

Masks are personal protective equipment designed to reduce the transmission of respiratory infectious disease, the lack of which leads to higher risks of contracting the virus, especially for those who go out frequently during epidemics. At the beginning of the epidemic, the demand for protective equipment far exceeded supply, which was then

Table 2
Association of sociodemographic characteristics, risk perception, health literacy, frequency of going outside, inadequate supply of masks with perceived stress (n=5,039).

	High Perceived Stress* n (%)	χ2/t	p	Bivariate regression OR(95%CI)	P
Sociodemographic characteristics					
Age		14.113	0.003		
≥46	321(31.8)			Ref	
36–45	285(34.0)			1.10(0.91,1.34)	0.333
26–35	439(37.4)			1.28(1.07,1.53)	0.007
16–25	770(38.2)			1.32(1.13,1.55)	0.001
Gender		1.308	0.253		
Male	772(36.9)			Ref	
Female	1043(35.4)			0.93(0.83,1.05)	0.253
Urbanicity		5.960	0.015		
Urban	856(34.3)			Ref	
Rural	959(37.7)			1.15(1.03,1.30)	0.015
Ethnicity		4.025	0.045		
Han (Non-minority)	1500(35.4)			Ref	
Minority	315(39.1)			1.17(1.004,1.37)	0.045
Education level		12.886	0.002		
College and above	856(33.8)			Ref	
High school	689(37.5)			1.18(1.04,1.33)	0.011
Middle school and under	270(40.4)			1.33(1.12,1.58)	0.001
Monthly household income		35.466	<0.0001		
> ¥ 10,000 ($1,449)	396(30.8)			Ref	
¥ 5,001–¥ 10,000 ($725–$1,449)	489(34.4)			1.18(1.003,1.38)	0.046
¥ 3,000–¥ 5,000 ($435–$725)	572(38.5)			1.41(1.20,1.65)	<0.0001
< ¥ 3,000 ($ 435)	358(42.3)			1.65(1.38,1.98)	<0.0001
Confirmed cases in residential province		2.374	0.305		
Small	728(35.9)			Ref	
Medium	855(35.4)			0.98(0.87,1.11)	0.748
Large (Hubei province)	232(38.8)			1.13(0.94,1.37)	0.196
Frequency of going outside		5.738	0.125		
Went outside every day or every other day	405(38.2)			Ref	
Went outside every 3–7 days	663(35.6)			0.89(0.76,1.04)	0.155
Went outside every 8–14 days	175(32.3)			0.77(0.62,0.96)	0.019
Went outside every 15 days or more	572(36.3)			0.92(0.78,1.08)	0.310
Inadequate supply of masks (n=4,921)		1.472	0.225		
No (yes and bought successfully)	1376(35.7)			Ref	
Yes (yes but cannot buy one)	402(37.7)			1.09(0.95,1.26)	0.225
Risk perception		91.657	<0.0001		
Low (no worried at all/ not worried)	262(25.9)			Ref	
Medium (fair)	505(32.8)			1.40(1.17,1.67)	0.0002
High (worried/ very worried)	1048(42.1)			2.08(1.77,2.44)	<0.0001
Health literacy					
Hard to understand COVID-19 related knowledge and information		308.402	<0.0001		
No (disagree/ strongly disagree)	726(25.8)			Ref	
Fair	674(46.1)			2.27(1.95,2.63)	<0.0001
Yes (agree/ strongly agree)	415(54.7)			2.92(2.52,3.39)	<0.0001
Hard to find correct and comprehensive COVID-19 related information		218.668	<0.0001		
No (disagree/ strongly disagree)	401(22.8)			Ref	
Fair	673(40.1)			2.47(2.16,2.82)	<0.0001
Yes (agree/ strongly agree)	741(46.3)			3.48(2.95,4.11)	<0.0001
Health literacy (continuous), Mean (SD)	3.90(1.69)	17.681	<0.0001	0.74(0.71,0,76)	<0.0001
Health literacy (categorical)		276.652	<0.0001		
High (scores≥5)	625(24.8)			Ref	
Low (scores≤4)	1190(47.3)			2.72(2.42,3.07)	<0.0001

* respondents with scores higher than 25

accompanied by panic purchasing. Individuals in our study who had trouble obtaining medical masks reported higher stress scores. Governments should consider that an inadequate supply of personal protective resources will not only impede disease control but also will worsen public mental health. Thus, timely resource production and allocation policies should be a priority.

Not all factors that increase the possibility of contracting COVID-19 are related to higher stress levels. Despite older people's higher vulnerability (Chen et al., 2020; WHO, 2020a), higher risk perception (Bruine de Bruin, 2020), and lower health literacy (Greenhalgh, 2015), they showed lower stress levels than their younger counterpart; this indicated that older age is an important protective factor for lower stress levels. Similarly, Cai et al. (2020) found that COVID-19 survivors aged 60 or above reported less severe stress response symptoms. Lower stress levels among older adults could partly be due to better stress coping capacities and richer life experience (e.g. living through past epidemics or pandemics) (Neubauer et al., 2019; Yang & Huang, 2003), whereas younger adults may be more worried about disruptions to their academic, social, occupational, and economic activities caused by the epidemic (Nwachukwu et al., 2020).

We found that personal risk perceptions, which could be influenced by environmental risk levels, standards of acceptable risk, and exposure to risk communication (Marshall et al., 2007), were positively associated with higher stress levels, which corresponded with findings among residents in the U.K. (Jia et al., 2020). Maintaining assuring and effective communications between authorities and the general public may be an efficient way to lessen stress by enhancing safety and reducing excessive risk perceptions among the public.

Table 3
Logistic multivariate models for the association between sociodemographic characteristics, risk perception, health literacy, frequency of going outside, inadequate supply of masks, and perceived stress (n=4,921).

	Perceived Stress aOR (95%CI)	p
Sociodemographic characteristics		
Age		
≥46	Ref	
36–45	1.17(0.95,1.44)	0.143
26–35	1.39(1.15,1.69)	0.001
16–25	1.51(1.25,1.83)	<0.0001
Gender		
Male	Ref	
Female	0.96(0.84,1.08)	0.480
Urbanicity		
Urban	Ref	
Rural	1.00(0.87,1.14)	0.970
Ethnicity		
Han (Non-minority)	Ref	
Minority	1.09(0.91,1.30)	0.350
Education level		
College and above	Ref	
High school	1.03(0.89,1.20)	0.699
Middle school and under	1.06(0.86,1.30)	0.575
Monthly household income		
> ¥ 10,000 ($1,449)	Ref	
¥ 5,001–¥ 10,000 ($725–$1,449)	1.16(0.98,1.38)	0.090
¥ 3,000–¥ 5,000 ($435–$725)	1.29(1.08,1.53)	0.005
< ¥ 3,000 ($ 435)	1.34(1.09,1.65)	0.006
Confirmed cases in residential province		
Small	Ref	
Medium	1.09(0.95,1.26)	0.219
Large (Hubei province)	1.30(1.05,1.60)	0.018
Frequency of going outside		
Went outside every day or every other day	Ref	
Went outside every 3–7 days	0.90(0.76,1.06)	0.214
Went outside every 8–14 days	0.75(0.60,0.95)	0.017
Went outside every 15 days or more	0.88(0.73,1.05)	0.155
Inadequate supply of masks		
No (yes and bought successfully)	Ref	
Yes (yes but cannot buy one)	1.10(0.95,1.28)	0.206
Risk perception		
Low (no worried at all/ not worried)	Ref	
Medium (fair)	1.34(1.11,1.61)	0.002
High (worried/ very worried)	1.91(1.61,2.27)	<0.0001
Health literacy		
High (≥5)	Ref	
Low (≤4)	2.48(2.19,2.81)	<0.0001

Table A1
Linear multivariate models for the association between sociodemographic characteristics, risk perception, health literacy, frequency of going outside, inadequate supply of masks, and perceived stress (n=4,921).

	Perceived Stress β (95%CI)	p
Sociodemographic characteristics		
Age		
≥46	Ref	
36–45	0.20(-0.53,0.94)	0.593
26–35	0.72(0.03,1.41)	0.042
16–25	1.10(0.42,1.78)	0.001
Gender		
Male	Ref	
Female	0.05(-0.41,0.50)	0.843
Urbanicity		
Urban	Ref	
Rural	-0.03(-0.51,0.44)	0.889
Ethnicity		
Han (Non-minority)	Ref	
Minority	0.88(0.22,1.53)	0.009
Education level		
College and above	Ref	
High school	-0.05(-0.59,0.49)	0.856
Middle school and under	0.89(0.14,1.64)	0.020
Monthly household income		
> ¥ 10,000 ($1,449)	Ref	
¥ 5,001–¥ 10,000 ($725–$1,449)	0.78(0.18,1.39)	0.011
¥ 3,000–¥ 5,000 ($435–$725)	0.89(0.26,1.52)	0.005
< ¥ 3,000 ($ 435)	0.96(0.19,1.72)	0.014
Confirmed cases in residential province		
Small	Ref	
Medium	0.06(-0.44,0.57)	0.810
Large (Hubei province)	1.80(1.02,2.58)	<0.0001
Frequency of going outside		
Went outside every day or every other day	Ref	
Went outside every 3–7 days	0.18(-0.42,0.79)	0.557
Went outside every 8–14 days	-0.56(-1.40,0.27)	0.188
Went outside every 15 days or more	-0.17(-0.83,0.48)	0.606
Inadequate supply of masks		
No (yes and bought successfully)	Ref	
Yes (yes but cannot buy one)	0.90(0.36,1.44)	0.001
Risk perception		
Low (no worried at all/ not worried)	Ref	
Medium (fair)	2.03(1.39,2.67)	<0.0001
High (worried/ very worried)	3.58(2.99,4.18)	<0.0001
Health literacy		
High (≥5)	Ref	
Low (≤4)	3.70(3.25,4.15)	<0.0001

DW=1.966; F=28.810, $p < 0.001$; R^2=0.102

Respondents of low household income status reported high stress levels, which corresponded with findings in Austria (Pieh et al., 2020). During the COVID-19 epidemic, more than a quarter of people in China reported a significant reduction in household income (Wang et al., 2020c). Studies in the U.S. showed that those of a lower household income status suffered more profound economic impacts from the epidemic (Sánchez et al., 2020), and were more prone to work outside due to financial distress (Weill et al., 2020). Our results showed that this population was also more likely to experience shortages of masks. Additionally, low household income is itself a chronic stressor (Wethington et al., 2015). The confluence of these factors exacerbated already high stress levels among poor individuals and demonstrated that income gaps can lead to mental health disparities. Thus, providing financial security for low-income households during epidemics is recommended.

Participants with lower health literacy showed higher stress levels, the negative mental effects of which were overlooked in previous studies in epidemic contexts; this result is consistent with findings among Japanese workers in their daily lives (Tohmiya et al., 2018). The marginal populations, such as low-income and minority ethnic groups and those with low education levels, who reported higher stress scores in our study, also typically possesses low health literacy levels (Greenhalgh, 2015), which further caused their feelings of helplessness during an epidemic. To address this, more accessible, straight-forward, and comprehensible information about epidemics is needed to reduce public panic, especially for disadvantaged populations, and health education aimed at elevating public health literacy is needed both during and after an epidemic.

In addition, sensitivity analyses based on linear regression suggested that an inadequate supply of masks, lower education levels, and minority status were associated with higher stress scores, even though these factors were not significantly associated with high stress based on results of the logistic regression. These variables were potential risk factors for increased stress. The impact of these additional risk factors warrants further investigation, with particular attention paid to those experiencing an inadequate supply of masks, people with low education levels, and ethnic minorities, in addition to the vulnerable populations mentioned above. Though the logistic regression showed lower odds of reporting high stress levels among those who went outside every 8–14 days than those who went outside every day or every other day, the linear regression indicated no differences in stress scores between these two populations. The mental effects of the frequency of going outside during epidemics deserve further investigation.

Mental health services and related policies should focus more on residents in epicenters, younger adults, minority populations, and those from lower-income households, which is in accordance with the approach of psychological first aid (WHO, 2011). Governments should account for mental health disparities when implementing policies or measures to address both public mental health and epidemic control strategies, as there is a wide range of stress levels among the general population. Considering that we may be living with the pandemic for a while and may confront other infectious diseases emergencies in the near future, programs aimed to improve public health literacy may be an efficient way to relieve stress among the general population. WHO created a specific webpage to inform people on how to confront the "infodemic" situation during the pandemic (WHO, 2020b). This information is helpful for those who are stressed from information overload. However, offline health education about COVID-19 is necessary, aimed at the disadvantaged population, who are stressed but unable to access updated information due to a lack of electronic devices and/or low health literacy.

Limitations

Our study has several limitations. First, convenience sampling methods limited the representativeness of our sample. However, we maintained balanced sociodemographic distributions in this convenience sample and used provinces as stratifiers to improve representativeness. Second, the cross-sectional nature of this study limited the ability to determine causality. Only a limited set of covariates was accounted for in the adjusted analysis; therefore, residual confounding exists among detected associations. Last, self-reported questionnaires could induce recall bias and social desirability, even though we asked participants to recall their experience in recent months and answer all questions truthfully.

Conclusion

Our study identified factors related to high perceived stress levels (i.e., epidemic intensity in residential areas, frequency of outside activities, risk perception) and the most vulnerable populations (i.e., younger people, people from poor families, people with low health literacy) due to the stress during the COVID-19 epidemic among the general population in China. These findings can directly inform interventions and policies aimed at mitigating epidemic-related mental health impacts during this outbreak or future outbreaks. The evidence from this large survey is also valuable for international comparisons to understand the global impact of COVID-19 on mental health and related stressors.

Contributors

XZ, XW conceptualized the study design. XW, JX, LL, YZ, and FJ design the questionnaire. XW, JX, YZ, and FJ collected the data. XJ, XZ, XW, ZX, and KS contributed to the data interpretation. JX drafted the manuscript while XZ, XW, LL, KS, and WH revising the paper critically for important intellectual content. All authors contributed to and have approved the final manuscript.

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Declaration of Competing Interest

None

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Appendix

Table A1

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