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# Mental health among pregnant women under public health interventions during COVID-19 outbreak in Wuhan, China

Ke Xu<sup>a,1</sup>, Ya Zhang<sup>a,1</sup>, Yuanyuan Zhang<sup>a</sup>, Qiao Xu<sup>b</sup>, Lan Lv<sup>b</sup>, Jianduan Zhang<sup>a,\*</sup>

<sup>a</sup> Department of Maternal and Child Health, School of Public Health, Tongji Medical College, Huazhong University of Science and Technology, 13 Hangkong Rd, Wuhan, Hubei, China

<sup>b</sup> Maternal and Child Health Hospital of Jiangnan District, 50 Machangjiao Rd, Wuhan, Hubei, China

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## ABSTRACT

Coronavirus disease 2019 (COVID-19) has become a pandemic. As the first city struck by the COVID-19 outbreak, Wuhan had implemented unprecedented public health interventions. The mental health of pregnant women during these anti-epidemic controls remains unknown. A total of 274 pregnant women living in Wuhan during the COVID-19 outbreak took part in our investigation online. The data on mental health conditions were evaluated using Edinburgh Postnatal Depression Scale (EPDS), Self-Rating Anxiety Scale (SAS), Chinese Perceived Stress Scale (CPSS), and Pittsburgh Sleep Quality Index (PSQI). We also collected the information on physical health status and precautionary measures against COVID-19. The prevalence of depression, anxiety, stress, and poor sleep quality was 16.1%, 13.9%, 42.7%, 37.6%, respectively. Comparing to SAS, PSQI score in pregnant women who participated in the survey after April 8 (date of Wuhan reopening), those data collected before April 8 were significantly higher. High levels of stress, severe health concerns over the fetus, and poor hygienic practices were negatively associated with mental health conditions. In conclusion, a large proportion of pregnant women reported psychological symptoms during the epidemic, which negatively related to the severe health concerns over fetus and poor hygienic practices. More psychological support during the epidemic would promote maternal mental well-being.

## 1. Introduction

Coronavirus disease 2019 (COVID-19) is infectious viral pneumonia caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which was first revealed in Wuhan, China (Pan et al., 2020; Bai et al., 2020). The disease's spread was declared a Public Health Emergency of International Concern and a pandemic by WHO (WHO, 2020). The virus has infected more than 142 million individuals, with over 3.0 million deaths as of April 20, 2021 (Johns Hopkins Coronavirus Resource Center, 2021). As the first city struck by the COVID-19 outbreak, citizens in Wuhan have witnessed the rapid spread of the virus and severe shortage of healthcare resources in the early stage of the epidemic, together with fears and (mis)information overload in social media. They also experienced unprecedented public health interventions, including a 76-day city lockdown, strict social distancing measures, and home isolation. (Pan et al., 2020; Gao et al., 2020).

The epidemic has created enormous disruptions to daily life and

could also affect people's mental well-being in the disease-struck regions. For example, Gao (Gao et al., 2020) has reported increased depression, anxiety, and a combination of depression and anxiety (CDA) in the general Chinese population during the COVID-19 outbreak. The elderly suicide rate in Hong Kong has also shown a sharp increase amid the epidemic of the Severe Acute Respiratory Syndrome (SARS) in 2003 (Chan et al., 2006), which was linked to social disengagement, stress, anxiety, and disease-related fears (Yip et al., 2010).

Females are predisposed to more severe anxiety and PTSD in epidemic outbreaks (Wang et al., 2020; Yali and Lobel, 1999), especially for pregnant women who undergo physiological, social, and emotional changes (Ding et al., 2014). Hence, the mental health of pregnant women may be more vulnerable to public health interventions such as city lockdown and home quarantine than the general population during the outbreak of COVID-19 (Yang et al., 2021). A meta-analysis has demonstrated that, compared to the non-pandemic period, the State-Trait Anxiety Inventory (STAI) scores on the maternal anxiety

\* Correspondence author.

E-mail address: [jd\\_zh@mail.hust.edu.cn](mailto:jd_zh@mail.hust.edu.cn) (J. Zhang).

<sup>1</sup> The authors contributed equally.

scale during pregnancy and postpartum period were significantly higher during the COVID-19 pandemic (Hessami et al., 2020). The aggravated ill mental state of pregnant women could further lead to adverse outcomes of their offspring (Stein et al., 2014), such as preterm birth, low birth weight, and negative affectivity in early childhood, internalizing behavior in school-age, high risk of depression, and low social competence in adolescent (Barker et al., 2011; Megan et al., 2011; Korhonen et al., 2012; Susan et al., 2009). Therefore, the psychological impact of COVID-19 on pregnant women cannot be ignored. One recent study demonstrated a significantly increased prevalence of anxiety and depressive symptoms in pregnant women (Wu et al., 2020), which was conducted in ten provinces across China without Wuhan. We conducted a survey focusing on maternal mental health in Wuhan, the epicenter of the COVID-19 outbreak, to establish the prevalence of psychological symptoms and the severity and identify related factors in the pregnant population during the outbreak.

## 2. Methods

### 2.1. Study design and participants

This questionnaire-based cross-sectional survey was conducted via an online crowdsourcing platform (<https://www.wjx.cn/>) from February 27 to May 8, 2020. Pregnant women living in Wuhan during the COVID-19 outbreak were all candidates for the survey. The participants were reached through any of the following approaches: 1) the Maternal and Child Health Hospital (MCH) in Jiangnan District introduced the study in its WeChat (the Chinese version of Facebook) public platform with the link of the questionnaire shared; 2) some community healthcare personnel in the District shared the link of the questionnaire to pregnant women in their registers; and 3) the nurses in the MCH hospital guided pregnant women during their prenatal visit after the restoration of their post lockdown medical services. Jiangnan District is the most affected area in Wuhan. A total of 274 women were included in the final analysis.

Our study protocol was approved by the Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology, before the initiation of this survey (2020-S052). The informed consent was obtained from the participants prior to questionnaire filling, and the investigation was carried out under the Declaration of Helsinki.

### 2.2. Data collection

Our study focused on the symptoms of depression, anxiety, stress, and sleep quality, using self-evaluation as the outcome variables. The Edinburgh Postnatal Depression Scale (EPDS) is the most widely used measure for postpartum depressive symptoms and prenatal depressive symptoms (Cox et al., 1987; Felice et al., 2006). It contains 10 items with a score  $\geq 10$  representing depressive symptoms (Guo et al., 2009). The Self-Rating Anxiety Scale (SAS), a four-rating scale with 20 items, was used to measure the level of anxiety in the past month (Wang and Chi, 1984). The total score ranges from 25 to 100, with  $\geq 50$  represents anxiety symptoms. Chinese Perceived Stress Scale (CPSS), a self-reported scale of 14 items, was applied to measure the extent of perceived stress during the past month (Chu, 2005). The total score ranges from 0 to 56, with scores higher than 25 indicating a high perceived stress level (Cohen et al., 1983). Pittsburgh Sleep Quality Index (PSQI) is an 18-item self-report scale for evaluating adult sleep quality and sleep disturbances. Participants whose score  $> 5$  were characterized as having poor sleep quality (Liu et al., 1996; Smyth, 2000). All the adopted Chinese versions of measurement tools were validated, showing satisfactory reliability and validity (Guo et al., 2009; Wang and Chi, 1984; Chu, 2005; Liu et al., 1996).

Other health related information in the current study are: 1) demographic data, including age, educational level, residential location during the COVID-19 outbreak, family members living together; 2)

history of maternity, including gravidity and parity, gestational age, pregnancy disorders, high-risk pregnancy (yes, no); 3) health conditions during epidemic of COVID-19, including symptoms related to COVID-19 (fever, fatigue, dry cough, sore throat, headache, anhelation, dyspnea, inappetence, nausea, diarrhea, stomachache), concern of themselves being infected (no/little, mild, moderate, severe), concern of fetus being affected by the outbreak (no/little, mild, moderate, severe); 4) hands hygienic measures including the hands hygienic practices (avoiding touching eyes, mouth and nose with hands, washing hands before eating and after using toilet, and avoiding directly touching objects in public place) with hygienic practice score calculated (1 point for each practice, the total score ranges from 0 to 3); 5) information on prenatal care included the cancellation of prenatal examination during the epidemic (yes, no) and related causes, remote counselling services provided by healthcare staff (yes, no), and counselling services seeking behaviors (yes, no).

### 2.3. Statistical analysis

The normally distributed variables, such as age, gestational age, were described as mean with standard deviation (SD), whereas the skewed variables, such as the total score of SAS, EPDS, CPSS, and PSQI were presented as medians and interquartile ranges (IQRs). The categorical variables, like educational level and pregnancy disorders, were presented as the frequency with proportion. Chi-square test and Mann-Whitney U test were used to compare the proportions of the positive outcomes between two groups. We compared the participants' mental well-being investigated before and after April 8, 2020 (date of Wuhan reopening) by a generalized linear model. Multivariable logistic regression was applied to identify the related factors of the mental health outcomes. All statistical analyses and graphing were performed using SPSS statistical software version 26.0 and Graphpad version 8.0. P values were 2-tailed with statistical significance set at 0.05.

## 3. Results

### 3.1. Characteristics of pregnant women

The analyses included 274 participants with a mean (SD) age of 30.4 (3.8) years and 87.2%  $< 35$  years old ( $n = 239$ ). Over half were first pregnancy ( $n = 141$ , 51.5%), with college education ( $n = 203$ , 74.1%), living with their husband ( $n = 246$ , 89.8%). The mean (SD) gestational age was 21.4 (7.5) weeks, with the majority in the second trimester ( $n = 216$ , 78.8%). Around half ( $n = 135$ , 49.3%) were enrolled in communities or hospitals. The proportions of pregnancy comorbidities and high-risk pregnancies were 23.4% and 10.6%, respectively. Only 1.5% ( $n = 4$ ) had any contact history with COVID-19 patients but no one infected. Twelve percent ( $n = 33$ ) reported serve concern of fetus being affected during epidemic, 13.1% ( $n = 36$ ) moderate concern, 40.5% ( $n = 111$ ) mild concern, and 34.3% ( $n = 94$ ) no/little concern. Regarding the prenatal check-up, the cancellation was up to 67.2% during the outbreak, with the top three reasons being the concern of being infected in hospitals (82.6%), hospitals stopped the provision of related service (37.0%), hospitals were designated for COVID-19 treatment (27.7%). Around 40% received remote services from healthcare staff, and 26.3% have actively sought prenatal counseling services (Table 1).

### 3.2. Mental health status

The median (IQR) scores of EPDS, SAS, CPSS, PSQI were 5.0 (2.0–8.0), 41.0 (33.0–46.0), 24.0 (16.0–28.0), 4.0 (3.0–7.0). The prevalence of depression ( $n = 44$ , 16.1%), anxiety ( $n = 38$ , 13.9%), stress ( $n = 117$ , 42.7%), and poor sleep quality ( $n = 103$ , 37.6%). A total of 62.4% developed at least one of the four symptoms. The scores of EPDS, SAS, CPSS, and PSQI were  $5.77 \pm 4.54$ ,  $40.68 \pm 9.09$ ,  $21.67 \pm 8.52$ , and  $5.02 \pm 2.90$  (mean  $\pm$  standard deviation), respectively. All the

**Table 1**  
Description of the basic data.

Variables	n(%) <sup>a</sup>	Variables	n(%) <sup>a</sup>
Age, years	30.4 ± 3.8 <sup>b</sup>	The canceled prenatal check-ups	
<35	239 (87.2)	Regular prenatal care <sup>c</sup>	70 (38.0)
≥35	35 (12.8)	Blood glucose test	28 (15.2)
Gestational age, weeks	21.4 ± 7.5 <sup>b</sup>	Toxoplasma test	17 (9.2)
Avoiding touching eyes, mouth and nose with hands		Down's Syndrome screening	48 (26.1)
Yes	219 (79.9)	B-ultrasonography examination	60 (32.6)
No	55 (20.1)	Others	41 (22.3)
Washing hands before eating and after using toilet		Healthcare personnel provided the counselling services	
Yes	261 (95.3)	Medical personnel of towns or maternal and child health county hospitals	9(8.3)
No	13(4.7)	Community healthcare workers	54 (49.5)
Avoiding directly touching objects in public area		Medical personnel in Maternal and Child Health hospital at district, city and provincial levels	19 (17.4)
Yes	246 (89.8)	Medical staff at the general hospitals	24 (22.0)
No	28 (10.2)	Others	17 (15.6)
Feeling the epidemic is serious		Services mode of remote services	
Not serious	38 (13.9)	Telephone counseling	82 (75.2)
Mild serious	153 (55.8)	WeChat /QQ consulting	35 (32.1)
Moderate serious	59 (21.5)	Provision of prenatal care booklet	12 (11.0)
Severe serious	24(8.8)	Text-message query	13 (11.9)
		Others	5(4.6)

<sup>a</sup> Data were presented as n(%) unless otherwise indicated.

<sup>b</sup> Data were presented as mean±standard deviation.

<sup>c</sup> Regular prenatal care includes abdominal circumference, blood pressure, etc.

measurement tools showed satisfactory reliability (Cronbach's  $\alpha$ ) in our study (EPDS, 0.85; SAS, 0.80; CPSS, 0.80; PSQI, 0.84).

Both depressive and anxiety symptoms were found closely associated with the concern of being infected (depression:  $Z=-3.9$ ,  $P<0.001$ ; anxiety:  $Z=-3.9$ ,  $P<0.001$ ), the concern of fetus being affected (depression:  $Z=-4.6$ ,  $P<0.001$ ; anxiety:  $Z=-4.4$ ,  $P<0.001$ ), subjective sleep quality (depression:  $Z=-2.5$ ,  $P=0.01$ ; anxiety:  $Z=-4.1$ ,  $P=0.02$ ) and hygienic practice score (depression:  $Z=-2.3$ ,  $P=0.02$ ; anxiety:  $Z=-2.3$ ,  $P=0.02$ ). Among the pregnant women with high perceived stress or poor sleep quality, proportions of no/little concern of being infected (stress:  $Z=-2.5$ ,  $P=0.01$ ; sleep:  $Z=-2.4$ ,  $P=0.02$ ) and the fetus being affected (stress:  $Z=-3.4$ ,  $P<0.001$ ; sleep:  $Z=-4.0$ ,  $P<0.001$ ), good subjective sleep quality (stress:  $Z=-3.4$ ,  $P<0.001$ ; sleep:  $Z=-9.4$ ,  $P<0.001$ ) were significantly lower than the control. Gestational age was also associated with symptoms of depression and sleep quality (depression:  $\chi^2=18.14$ ,  $P<0.001$ ; sleep:  $\chi^2=6.29$ ,  $P=0.04$ ) (Table 2).

Fig. 1 presents the comparisons of outcome scores between the two stages (before and after April 8). The scores of SAS ( $\beta=0.059$ , 95%CI, 0.0068–0.11), PSQI ( $\beta=0.146$ , 95%CI, 0.0054–0.29) in the city lockdown stage were significantly higher than that of the city reopening stage, adjusting for age, gestational age, and proportion of high-risk pregnancies. Besides, the scores of sleep disturbance ( $\beta=0.808$ , 95%CI, 0.21–1.41) of PSQI, were also statistically different in the two stages.

There was no statistical difference in the total score of CPSS and EPDS, and all dimensions of the PSQI, except sleep disturbance in the two stages.

### 3.3. Related factors for maternal mental health outcomes

Logistic regression analysis showed that, compared with little/no concern of fetus being affected, severe concern was highly associated with the four mental health symptoms, i.e., depression (OR=6.64, 95%CI, 1.70–25.92), anxiety (OR=4.30, 95%CI, 1.16–15.96), stress (OR=4.10, 95%CI, 1.62–10.41) and poor sleep quality (OR=3.94, 95%CI, 1.54–10.10). Moderate concern was also related to all the symptoms except sleep (depression: OR=4.17, 95%CI, 1.12–15.58; anxiety: OR=4.32, 95%CI, 1.22–15.26; stress: OR=2.91, 95%CI, 1.28–6.61). Moreover, high stress in the pregnant population during the COIVD-19 outbreak was related to all the other symptoms (depression: OR=13.01, 95%CI, 4.63–36.57; anxiety: OR=11.86, 95%CI, 3.90–36.05; sleep: OR=1.86, 95%CI, 1.08–3.19). Compared with those in the second or the third trimester, women in the first trimester had a higher risk of having depressive symptoms (second trimester: OR=0.15, 95%CI, 0.03–0.72) and being stressed (last trimester: OR=0.24, 95%CI, 0.06–0.94). The adjusted odds ratio of depressive symptoms were greater among those with postgraduate education or above (OR=7.36, 95%CI, 1.32–40.95) than those with high school or below, lower among those with a higher score in hygienic practices than those with 0 scores (1 score: OR=0.02, 95%CI, 0.00–0.57; 3 score: OR=0.09, 95%CI, 0.01–0.83) (Table 3).

## 4. Discussion

Our study showed a large proportion of pregnant women in Wuhan reported mental health symptoms during the COIVD-19 epidemic, including depression, anxiety, high stress, and poor sleep quality. Over 60% of participants scored above the threshold for at least one of the psychological indices. 16.1%, 13.9%, 42.7%, and 37.6% of our participants were likely to have depression, anxiety, high stress, poor sleep quality, respectively. A majority had to cancel their prenatal check-ups, with a tiny proportion received some remote counseling services. High-level pressure, severe health concerns over the fetus, early pregnancy, and high educational levels were identified as risk factors of mental health status.

Our study demonstrated that high perceived stress was an independent risk factor for depression, anxiety, and sleep quality in the pregnancy population. This finding is consistent with the previous findings suggesting a close association between antenatal depressive symptoms and stressful experiences during pregnancy (Lancaster et al., 2010; Shakeel et al., 2015). An earlier report also indicated high perceived stress was a common predictor of chronic anxiety symptoms in pregnancy (Bayrampour et al., 2015). The perceived stress stem from the emerging infectious disease outbreak, health-related concerns, home confinement, and shortage of medical resources (Stein et al., 2014; Xie et al., 2020; Fu et al., 2020) may result in poor sleep condition, including difficulty in falling asleep and short sleep duration in some pregnant women (Alan et al., 2020; Lin et al., 2021).

In our study, participants with moderate-severe concerns about their fetuses tended to develop symptoms of depression, anxiety, and stress, which was consistent with previous studies (Mortazavi et al., 2021; Rief et al., 2012; Mohammadi et al., 2019; Mortazavi et al., 2016). In our study, approximately 25% of participants reported moderate-severe concerns about their fetuses being affected by the outbreak. However, only a small proportion of them reported any contact history (1.5%) or symptoms of COVID-19 (5.1%). Therefore, some participants seemed to have exaggerated concerns relative to their actual infection risk. Some anxiety symptoms, also known as health anxiety, may arise from inappropriate or exaggerated concerns about one's health status and dysfunctional beliefs about health and illness (Rief et al., 2012). It is a

**Table 2**  
The distributions of the four mental health conditions by covariates.

Variables	EPDS Score <sup>a,b</sup>			SAS Score			CPSS Score <sup>c</sup>			PSQI Score <sup>d</sup>		
	<10	≥10	P	<50	≥50	P	≤25	>25	P	≤5	>5	P
Gestational age <sup>e</sup>	N(%)	N(%)	value	N(%)	N(%)	value	N(%)	N(%)	value	N(%)	N(%)	value
The first trimester	8(3.5)	8(18.2)	0.0001	11(4.7)	5(13.2)	0.051	5(3.2)	11(9.6)	0.094	8(4.7)	8(7.8)	0.043
The second trimester	190	26		191	25		127	89		143	73	
	(82.6)	(59.1)		(80.9)	(65.8)		(80.9)	(76.1)		(83.6)	(70.9)	
The third trimester	32(13.9)	10		34(14.4)	8(21.1)		25(15.9)	17		20(11.7)	22	
		(22.7)					(14.5)			(21.4)		
Pregnancy comorbidities <sup>e</sup>			0.066			0.197			0.178			0.145
Yes	49(21.3)	15		52(22.0)	12		32(20.4)	32		35(20.5)	29	
		(34.1)			(31.6)			(27.4)			(28.2)	
No	181	29		184	26		125	85		136	74	
	(78.7)	(65.9)		(78.0)	(68.4)		(79.6)	(72.6)		(79.5)	(71.8)	
Concern of themselves being infected <sup>h</sup>			<0.0001			<0.0001			0.013			0.018
No concern	124	14		126	12		87(55.4)	51		93(54.4)	45	
	(53.9)	(31.8)		(53.4)	(31.6)		(43.6)			(43.7)		
Mild concern	88(38.3)	14		92(39.0)	10		58(36.9)	44		65(38.0)	37	
		(31.8)			(26.3)			(37.6)			(35.9)	
Moderate concern	12(5.2)	10		10(4.2)	12		8(5.1)	14		7(4.1)	15	
		(22.7)			(31.6)			(12.0)			(14.6)	
Severe concern	6(2.6)	6(13.6)		8(3.4)	4(10.5)		4(2.5)	8(6.8)		6(3.5)	6(5.8)	
Concern of fetus being affected <sup>h</sup>			<0.0001			<0.0001			0.001			<0.0001
No concern	88(38.3)	6(13.6)		88(37.3)	6(15.8)		63(40.1)	31		71(41.5)	23	
							(26.5)			(22.3)		
Mild concern	96(41.7)	15		101	10		67(42.7)	44		68(39.8)	43	
		(34.1)		(42.8)	(26.3)			(37.6)			(41.7)	
Moderate concern	27(11.7)	9(20.5)		26(11.0)	10		15(9.6)	21		20(11.7)	16	
		(26.3)			(26.3)			(17.9)			(15.5)	
Severe concern	19(8.3)	14		21(8.9)	12		12(7.6)	21		12(7.0)	21	
		(31.8)			(31.6)			(17.9)			(20.4)	
Subjective sleep quality <sup>g</sup>			0.012			<0.0001			0.001			<0.0001
Great	46(20.0)	4(9.1)		49(20.8)	1(2.6)		38(24.2)	12		48(28.1)	2(1.9)	
							(10.3)					
Good	144	26		149	21		96(61.1)	74		119	51	
	(62.6)	(59.1)		(63.1)	(55.3)			(63.2)		(69.6)	(49.5)	
Bad	40(17.4)	14		38(16.1)	16		23(14.6)	31		4(2.3)	50	
		(31.8)			(42.1)			(26.5)			(48.5)	
Hygienic practices score <sup>g,h</sup>			0.020			0.023			0.076			0.169
0	3(1.3)	4(9.1)		5(2.1)	2(5.3)		2(1.3)	5(4.3)		4(2.3)	3(2.9)	
1	13(5.7)	1(2.3)		11(4.7)	3(7.9)		7(4.5)	7(6.0)		6(3.5)	8(7.8)	
2	35(15.2)	12		37(15.7)	10		24(15.3)	23		28(16.4)	19	
		(27.3)			(26.3)			(19.7)			(18.4)	
3	179	27		183	23		124	82		133	73	
	(77.8)	(61.4)		(77.5)	(60.5)		(79.0)	(70.1)		(77.8)	(70.9)	

<sup>a</sup> EPDS Score >10 represents depressive symptoms.

<sup>b</sup> SAS Score ≥50 represents anxiety symptoms.

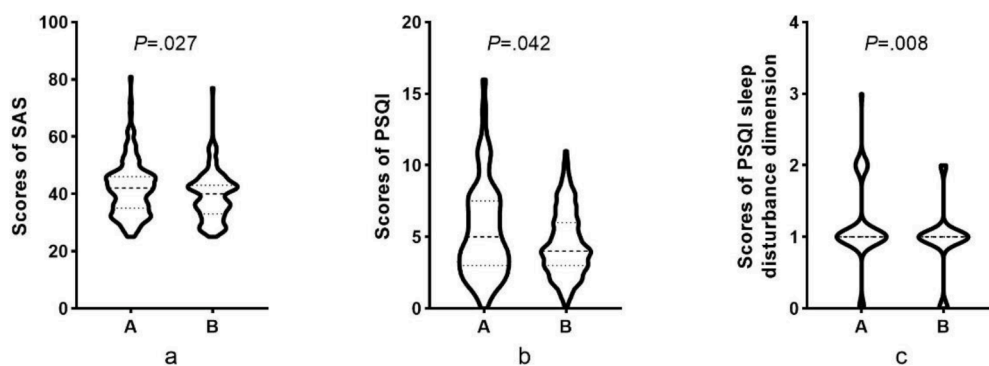
<sup>c</sup> CPSS Score >25 represents high level of perceived stress.

<sup>d</sup> PSQI Score >5 represents poor sleep quality.

<sup>e</sup> P values were calculated with a Chi-Square test unless otherwise indicated<sup>f</sup>P values were calculated with a Fisher exact test.

<sup>g</sup> P values were calculated with a Mann-Whitney U test.

<sup>h</sup> Hygienic practices score: hand hygienic practices include avoiding touching eyes, mouth and nose with hands, washing hands before eating and after using toilet, avoiding directly touching objects in public place; 1 point for one practice, total score ranges from 0 to 3.



**Fig. 1.** Comparison of scores of EPDS, SAS and PSQI before and after April 8

Adjusted for age, gestational age and proportion of high-risk pregnancy using Generalized Linear Models. The scale score in the figure is the raw data.

A: Before and after April 8; B: After April 8; a: P value were derived from GLM (Gamma distribution); b: P value were derived from GLM (Tweedie distribution); c: P value were derived from GLM (Multinomial distribution).

**Table 3**  
Logistic regression analysis of the associated factors of the four mental health conditions.

Variables	OR (95% CI)			
	EPDS, depressive symptom	SAS, anxiety symptom	CPSS, stress symptom	PSQI, sleep quality
Educational level (ref-high school or below)				
College education	1.69(0.45–6.26)	1.71(0.49–6.00)	0.98(0.46–2.08)	1.27(0.57–2.84)
Postgraduate education or above	7.36(1.32–40.95)*	1.05(0.15–7.59)	0.51(0.17–1.50)	1.49(0.50–4.43)
Living with their husband (ref-Yes)	0.91(0.22–3.74)	1.59(0.40–6.25)	0.72(0.29–1.77)	1.54(0.63–3.79)
Gestational age (ref-the first trimester)				
The second trimester	0.15(0.03–0.72)*	0.61(0.14–2.70)	0.42(0.13–1.39)	0.83(0.26–2.64)
The third trimester	0.27(0.05–1.56)	0.61(0.11–3.30)	0.24(0.06–0.94)*	1.13(0.30–4.23)
Pregnancy comorbidities (ref-no)	1.63(0.65–4.09)	1.55(0.62–3.87)	1.36(0.74–2.51)	1.26(0.68–2.35)
Symptoms related to COVID-19 (ref-no)	2.77(0.80–9.61)	2.02(0.58–7.00)	1.26(0.53–3.00)	1.86(0.77–4.52)
Cancelling prenatal examination (ref-no)	2.33(0.84–6.47)	1.66(0.64–4.32)	1.21(0.69–2.12)	0.96(0.54–1.72)
Concern of fetus being affected (ref- no)				
Mild concern	2.20(0.68–7.07)	1.24(0.39–3.79)	1.39(0.75–2.55)	1.79(0.94–3.40)
Moderate concern	4.17(1.12–15.58)*	4.32(1.22–15.26)*	2.91(1.28–6.61)*	2.10(0.89–4.93)
Severe concern	6.64(1.70–25.92)**	4.30(1.16–15.96)*	4.10(1.62–10.41)**	3.94(1.54–10.10)**
Hygienic practices score (ref -0)				
1	0.02(0.00–0.57)*	0.92(0.07–11.55)	0.38(0.05–2.89)	2.34(0.31–17.67)
2	0.15(0.01–1.54)	0.98(0.11–8.49)	0.29(0.05–1.82)	1.07(0.18–6.31)
3	0.09(0.01–0.83)*	0.52(0.07–4.20)	0.24(0.04–1.39)	1.00(0.18–5.52)
Hight stress (ref - normal)	13.01(4.63–36.57)***	11.86(3.90–36.05)***	—	1.86(1.08–3.19)*

Abbreviation: CI, confidence interval; OR, odds ratio.

\* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$ .

high possibility for individuals to expose to health anxiety in infectious disease outbreaks (Blakey and Abramowitz, 2017; Blakey et al., 2015). Over half of the pregnant women reported health anxiety in Ireland during the COVID-19 outbreak (Corbett et al., 2020). These findings demonstrated that more effort should be made for the public to better understand of the diseases, avoid somatosensory amplification and reduce the over-concern of the health conditions. In addition, during the outbreak, a series of restrictive measures had greatly interfered the access to routine health services, including prenatal health checks, which might further intensify pregnant women's concerns about their fetus's health, affecting their sleep condition and mental well-being (Dong et al., 2020; Lin et al., 2021).

Participants with depressive symptoms were less likely to take vigilant hygienic practices. The previous studies reported the higher depressive symptoms were related to the more inferior health practices, including hygiene-related practices (Walker et al., 1999; Ranasinghe et al., 2016). Although the specific mechanisms remain unclear, the unhealthy behaviors might serve as a means of coping with depressive symptoms or could be regarded as the symptoms of depression (Zuckerman et al., 1989). Therefore, the efforts to change pregnant women's health practices might require considering their mental health status (Leung et al., 2003).

Our study also revealed that pregnant women with high educational levels tended to develop depressive symptoms, consistent with some previous findings. (Liu et al., 2021; Moghanibashi-Mansourieh., 2020; Wang et al., 2021). People with higher education levels usually engage more in work, however, the home quarantine during the outbreak directed their attention to some other aspects, such as family health, safety, and financial security, leading to more worries (Wang et al., 2021). However, some studies contradict our results, suggesting that low education is a risk factor for depression (Khademian et al., 2021; Antiporta et al., 2021; Necho et al., 2020). It is still unclear about the association between education and antenatal depression. More studies are needed to understand the complex relationship between education and antenatal depression and the underlying mechanism in such public health emergencies.

We found that depressive symptoms and high stress were more likely to occur in the first trimester of pregnancy. We assumed this might partially relate to unplanned or unwanted pregnancies, although related information was not available in our study (Bunevicius et al., 2009). Nevertheless, our results indicate pregnant women's mental state, especially in the early stage of pregnancy, might require special

attention during such public health emergencies.

After adjusting for maternal age, gestational age, and proportion of high-risk pregnancy, participants' anxiety situation and sleep quality investigated after April 8 (city reopening stage) were significantly better than those participated during the city lockdown stage. A longitudinal study has demonstrated a decreasing temporal trend of anxiety levels in a general population during and after the SARS outbreak (Leung et al., 2005). Although our findings were based on a cross-sectional design, it might also imply that anxiety symptoms and poor sleep quality could be buffered by effective epidemic control and restoration of social and life order.

Our study found no statistical significance in depression and stress levels between those investigated before and after April 8. The depressive symptoms and high stress among the pregnant women may persist long after the 'peak' of the epidemic due to their concern on the potential infection risk resulting from restored population mobility after reopening.

Over 60% of participants scored above the threshold for at least one of the psychological indices. The assessment and intervention for perinatal mental status should be a priority in public health emergencies. Particular attention should be given to pregnant women in the first trimester, with high-level education, high stress, and severe health concerns. Under the circumstance of home quarantine and short of medial supply, online machine learning-driven intervention platforms, online clinical consultation, and psychological hotlines applied in maternal health care are warranted (Jaroszewski et al., 2019). Regarding long-term health impacts, we should focus on depression and anxiety triggered by persistent high pressure in the post-COVID-19 period and their children's development status and mental health. Determination of whether these children have developmental delays or behavior problems is an important question for future research.

Several limitations are also worth mentioning. First, due to the data collection challenge in Wuhan during the COVID-19 outbreak, relatively few participants took part in our study. Second, there is no data available to compare the pregnant women's psychological conditions in Wuhan with those in other unaffected areas. Third, due to the nature of the online survey, we did not have control over who does and does not respond to the survey, which could have led non-respondent bias. Our conclusion might be more representative to pregnant women with higher educational levels. Fourth, women with pre-existing mental health conditions, like depression and insomnia, might be more likely to report elevated psychiatric symptoms during the outbreak. However, we

did not have relevant information to exclude them from the study, which might have resulted in a biased prevalence of mental symptoms in our study. Fifth, although our study compared the participants' mental well-being investigated before and after April 8, the schedule of city reopening was announced on March 24. Therefore, the actual difference in anxiety and fear of residents between the lockdown and post-lockdown periods could be more tremendous.

In summary, a large proportion of pregnant women reported psychological symptoms during the epidemic. The women of early pregnancy, high educational level, and severe health concern over the fetus, and high stress were at risk of developing mental health symptoms. Furthermore, the anxiety level and sleep quality could be buffered by effective epidemic control and work resumption. Our findings suggested more psychological support for pregnant women during the epidemic to relieve psychological pressures and serious health-related concerns to promote perinatal mental well-being.

### Contributors

Ke Xu: Writing-Original Draft, Writing-Review & Editing, Investigation; Ya Zhang: Investigation, Formal analysis; Yuanyuan Zhang: Formal analysis; Qiao Xu: Investigation; Lan Lv: Investigation; Jianduan Zhang: Methodology, Writing-Review & Editing, Supervision.

### Declaration of competing interest

No conflict of interest was declared by the authors.

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