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.

Journal of Affective Disorders 281 (2021) 567–573

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Sleep Conditions Associate with Anxiety and Depression Symptoms among Pregnant Women during the Epidemic of COVID-19 in Shenzhen

Wei Lin [a], Bo Wu [a], Bin Chen [a], Guiying Lai [a], Shengbin Huang [b], Shaoli Li [c], Kefu Liu [c], Chuyan Zhong [a], Weikang Huang [a], Shixin Yuan [d], Yueyun Wang [a,d,*]

[a] Department of Healthcare, Affiliated Shenzhen Maternity and Child Healthcare Hospital, Southern Medical University, Shenzhen 518028, China
[b] Department of Epidemiology and Health Statistics, School of Public Health, Zhenzhou University, Zhenzhou 450001, China
[c] Department of Health Education, Affiliated Shenzhen Maternity and Child Healthcare Hospital, Southern Medical University, Shenzhen 518048, China
[d] Research Institute of Maternity and Child Healthcare, Affiliated Shenzhen Maternity and Child Healthcare Hospital, Southern Medical University, Shenzhen 518048, China

ARTICLE INFO

Keywords:
Sleep
Anxiety
Depression
Coronavirus Disease 2019
Pregnant women

ABSTRACT

Background: Pregnant women often encounter psychiatric symptoms and declined sleep quality as pregnancy proceeds. The associations between sleep conditions and anxious and depressive symptoms among pregnant women remained to be investigated, particularly during the epidemic of COVID-19.

Methods: An online cross-sectional survey on pregnant women was conducted at the time period of fast increasing cases of COVID-19 in Shenzhen. The Self-Rating Anxiety Scale (SAS) and the Patient Health Questionnaire (PHQ-9) were applied to detect anxious and depressive symptoms. Multivariable logistic regressions models were established to explore the associations of sleep conditions with psychological symptoms.

Results: In total, 751 pregnant women were enrolled, with a mean age of 30.51 years (Standard deviation: 4.28). Overall, 82.7% of the respondents considered low risk of being infected by COVID-19. The prevalence of anxiety and depression symptoms during the epidemic of COVID-19 among pregnant women were 13.4% and 35.4%, respectively, but most of which were mild. Variables referred to poor sleep conditions were strongly associated with anxious and depressive symptoms, including random or late time of going to bed, difficulty in falling sleep, short sleep duration, and ordinary or poor subjective sleep quality.

Limitations: Non-random sample restricted generalization of our findings to the whole population of pregnant women.

Conclusions: Our research revealed a notable proportion of the pregnant women who exhibited mild anxiety and depression symptoms during the epidemic of COVID-19 in Shenzhen. Targeted interventions in improving sleep conditions might help alleviate gestational anxious and depressive symptoms.

1. Introduction

A novel global health emergency, the appearance of Coronavirus Disease 2019 (COVID-19), has been firstly reported from December, 2019 (Zhu et al., 2020). COVID-19 caused an outbreak of pneumonia in Wuhan, Hubei province, and quickly appeared in the other provinces of China (Li et al., 2020). As of 31 May 2020, data from the World Health Organization (WHO) demonstrated that there were 5,934,936 confirmed cases and 367,166 confirmed deaths occurred globally (available at: https://www.who.int/docs/default-source/coronaviruse/situation-reports). COVID-19 is a highly contagious disease caused by the most recently discovered coronavirus, which is similar to the pathogen of the severe acute respiratory symptom (SARS), belonged to a beta-coronavirus family and being spread to humans via some uncertain intermediate hosts (Paules et al., 2020; Velavan and Meyer, 2020). The initial presenting symptoms have been identified to be fever, dry cough, and dyspnea in most observations so far (Jiang et al., 2020). An incubation period of COVID-19 was estimated of 2~14 days and has a mean of around 5 days when integrating public available cases (Linton et al., 2020). Spread via virus-laden respiratory droplets was considered as the

* Corresponding author at: Department of Healthcare, Affiliated Shenzhen Maternity and Child Healthcare Hospital, Southern Medical University, No. 3012 Fuqiang Road, Futian District, Shenzhen 518028, China.
E-mail address: wangyueyun@126.com (Y. Wang).

https://doi.org/10.1016/j.jad.2020.11.114
Received 27 March 2020; Received in revised form 2 November 2020; Accepted 20 November 2020
Available online 26 November 2020

main route of transmission, whereas other potential transmitted routes were also disclosed, e.g. fecal-oral transmission (Zhang et al., 2020). Earlier modeling studies attempted to estimate the reproduction number (R0), which was usually applied to reflect the severity of infectious diseases, suggesting a comparable transmission risk of COVID-19 to H1N1 and SARS (Fang et al., 2020). Moreover, it brought serious concerns and worries to the public due to close human-to-human transmission, in particular of suspected asymptomatic carrier transmission of COVID-19 (Bai et al., 2020).

The Chinese government quickly took efforts to slow down the epidemic of COVID-19, and extended home quarantine to nearly all provinces and cities by the end of January, 2020. People then seldom went outside except for purchasing necessities, and were recommended to stay in a social isolated status at home. Simultaneously, there was urgent shortage of protective supplies across the country, such as protective masks, suits, and medical equipment. Under these circumstances, the ongoing spread of COVID-19 might lead to psychosocial impacts of non-infected persons, similar to the reports during the outbreak of SARS (Cheng and Cheung, 2005; Lee et al., 2006). Recently, a series of psychosocial features was identified in the general public in mainland China immediately after the COVID-19 outbreak, including depression, anxiety, and stress (Wang et al., 2020a), and the severity maintained longitudinally during the peak of COVID-19 epidemic (Wang et al., 2020b). Recent studies found that 7.9% of psychiatric patients (Hao et al., 2020) and 0.4% of general workforce (Tan et al., 2020) suffer from insomnia during the COVID-19 pandemic. However, the majority of studies targeted on the epidemiology, causes, clinical manifestation and diagnosis, treatment, prevention and control of COVID-19, there was still limited known information on the mental health status of specific vulnerable populations varied with the epidemic of COVID-19.

Women at pregnancy were thought to be a susceptible subgroup to unstable emotions, and subsequently emotional or mental problems in this period could result in adverse child outcomes (Glover, 2014). Although at present there was no evidence that pregnant women were at higher risk of being infected by COVID-19 than the general population, nor did they demonstrate intrauterine infection caused by vertical transmission (Chen et al., 2020), pregnant women might have to face with more stressful events because of higher demands for specific healthcare. During the 2003 SARS outbreak, researchers found that pregnant women tended to overestimate the risk of being infected by SARS and adopted behavioral strategies to mitigate their risk (Lee et al., 2006). They also measured the psychological responses of pregnant women and reported a comparable depressive level but a slightly higher level of anxiety when compared to pre-SARS controls (Lee et al., 2006). Similar negative bio-psychosocial impacts on the pregnant women were also demonstrated in Zika virus that caused another infectious disease. The fears of being infected could induce psychosocial adjustment of pregnant women, like negative feelings, changes in behavioral customs, attitudes towards body image, and prevention demands (Filgueiras et al., 2017). Nevertheless, potential psychiatric responses to COVID-19 among pregnant women remained to be investigated.

In addition to common mental problems, most pregnant women often encountered declined sleep quality as pregnancy proceeds (Polo-Kantola et al., 2017), which was supposed to be linked with the onset, exacerbation, and relapse of mood disorders (Rumble et al., 2015). The sleep quality of pregnant women were negatively associated with the stress level they received (Li et al., 2016), to some possible extent, generated from an emerging infectious disease outbreak in response (Oh et al., 2017; Wang et al., 2020a). Hence, priority should be taken place in understanding the sleep conditions of pregnant women during the epidemic of COVID-19 as well. Based on above-mentioned concerns, we attempted to detect the mental manifestations of pregnant women in Shenzhen when suffering the rapid spread of the novel COVID-19, as well as to explore whether sleep conditions impact on their mental health status in the current study, which may provide future directions for the formulation of psychological healthcare interventions during analogous public health emergencies.

2. Methods

2.1. Study setting and subjects

We conducted a cross-sectional survey in Shenzhen city from February 17th to March 16th 2020, in which the coronavirus infection increased rapidly in mainland China. Shenzhen is an economically developed region with density migrants, located in the central of Guangdong province, Southern China. Thus, it tended out to be one of the cities that were largely affected by the coronavirus infection except Hubei province, reported more than 420 confirmed infections from January to early March, 2020. The targeted population of this study was local pregnant women. Pregnant women who visited obstetric clinics in maternity and child healthcare hospitals of Shenzhen need to receive maternal education courses, and would automatically become members of the Pregnant Woman School (PWS). We successfully distributed a unique two-dimensional code to candidate pregnant women through the WeChat groups that involved in all PWSs, which linked with the electronic questionnaire. We then recruited pregnant women who were willing to participate. Furthermore, a snowball sampling strategy was also applied as we put a recruitment notice through official release by Shenzhen Maternity and Child Healthcare Hospital (SMCHH). Each follower would receive this notice. Here, the majority of the followers are pregnant women, as the official account is linked with the appointment of antenatal examination services. We also encouraged the public that got this notice to pass this survey to pregnant women around. Women without severe physical or mental disorders diagnosed by a clinician before were invited for participation. A full explanation of the study objectives, contents, procedures, associated benefits and risks was provided in front of the questionnaire. During the survey time period, pregnant women, who confirmed their willing to participate in this survey, selected the option of voluntary participation for informed consent, and then got access to finish an online questionnaire. Therefore, a convenient sample of pregnant women in Shenzhen was recruited. The study protocol was approved by the Institutional Review Board of SMCHH.

2.2. Measurement

A self-administrated questionnaire contained socio-demographic information and subjective health and behavior evaluation was applied, accompanied by the measure of anxiety and depression symptoms. In order to avoid blank or invalid answers, all items of the questionnaire were set as required questions.

2.2.1. Socio-demographic characteristics

Socio-demographic variables included age, ethnicity, marital status, local household registration, education, employment status, monthly income level, health insurance, parity and gestational weeks for the current pregnancy. Details of the categorical division of nominal or ordinal variables were shown in Table 1.

2.2.2. Subjective health and behavior evaluation

Women were further asked to estimate coronavirus related events and daily behaviors during the epidemic of COVID-19. Firstly, coronavirus related contact histories were asked by two questions: "*Have you (or your family members) ever had close contacts related to the coronavirus in recent one month?*", with two options (Yes/No). Here, people who had close contacts were defined as: ever been to the outbreak or epidemic areas, or having close contact with confirmed or suspected cases. Secondly, women were successively asked "*whether there were confirmed or suspected coronavirus infections in the community you lived, or among your acquaintances and family members?*", with triple options (Yes/No/Uncertain). Thirdly, whether women took proper precautions against the

Table 1
Socio-demographic characteristics, subjective health and behavior evaluation of all respondents (N=751).

Variables	Number	Percentage (%)
Socio-demographic Characteristics		
Age (years)	30.51±4.28	
<30	325	43.3
30~34	292	38.8
≥35	134	17.8
Ethnicity		
Han ethnicity	700	93.2
Other ethnicities	51	6.8
Marital status		
Single/divorced	26	3.5
Married	725	96.5
Local household registration		
No	353	47.0
Yes	398	53.0
Education		
Senior high school or below	176	23.4
College or above	575	76.6
Employment status		
Unemployed	230	30.6
Employed	521	69.4
Monthly income (RMB)		
≤5,000	245	32.6
5,001~8,000	196	26.1
>8,000	310	41.3
Health insurance		
No	66	8.8
Yes	685	91.2
Parity for current pregnancy		
First	514	68.4
Second	214	28.5
Third or more	23	3.1
Gestational weeks for current pregnancy		
<14	74	9.9
14~27	290	38.6
≥28	387	51.5
Coronavirus related events		
Close contacts related to the coronavirus of themselves		
No	718	95.6
Yes	33	4.4
Close contacts related to the coronavirus of their family members		
No	716	95.3
Yes	35	4.7
Confirmed or suspected coronavirus infections in the community they lived		
No	602	80.1
Yes	66	8.8
Uncertain	83	11.1
Confirmed or suspected coronavirus infections among their acquaintances		
No	635	84.6
Yes	12	1.6
Uncertain	104	13.8
Confirmed or suspected coronavirus infections among their family members		
No	738	98.3
Yes	0	0.0
Uncertain	13	1.7
Taking precautions against the coronavirus infection		
No	3	0.4
Yes	748	99.6
Subjective risk of being infected by the coronavirus		
Low	621	82.7
Moderate	115	15.3
High	15	2.0
Subjective life impact by the coronavirus		
Mild	54	7.2
Moderate	460	61.3
Severe	237	31.6
Subjective psychological impact by the coronavirus		
Mild	170	22.6
Moderate	499	66.4
Severe	82	10.9
Daily behaviors during the epidemic of COVID-19		
Time spent in physical exercise per day (minutes)		
None	158	21.0
< 30	432	57.5
≥ 30	161	21.4
Time spent in the internet or social medias per day (hours)		
<3	165	22.0
3~5	215	28.6
>5	371	49.4
Time spent in news related to the coronavirus per day (hours)		
<1	382	50.9
1~3	288	38.3
>3	81	10.8
Sleep conditions during the epidemic of COVID-19		
Time of going to bed		
Random time	83	11.1
Before 00:00	536	71.4
After 00:00	132	17.6
Difficulty in falling sleep		
No	506	67.4
Yes	245	32.6
Sleep duration at night		
Short	87	11.6
Moderate	467	62.2
Long	197	26.2
Subjective sleep quality		
Good	362	48.2
Ordinary	305	40.6
Poor	84	11.2
Mental symptoms during the epidemic of COVID-19		
SAS standardized score	40.73±7.89	
Anxiety symptom		
None	650	86.6
Mild	84	11.2
Moderate	16	2.1
Severe	1	0.1
PHQ-9 score	3.97±4.09	
Depression symptom		
None	485	64.6
Mild	198	26.4
Moderate	50	6.7
Severe	16	2.1
Extremely severe	2	0.3

coronavirus, such as use of protective masks or disinfection supplies, was also collected. According to above-mentioned events, a self-rating score ranged from 0 to 10 was applied to estimate life and psychological impacts, as well as risk of being infected by the coronavirus. Different levels of impacts were defined according to one's score: mild (0~3), moderate (4~7), and severe (8~10). Similarly, risk of being infected was divided into three groups (low, moderate, and high). In addition, pregnant women estimated the time they spent per day in physical exercise, using the internet or social media, and following news related to the coronavirus.

2.2.3. Sleep conditions

Sleep conditions during the epidemic of COVID-19 were surveyed, including time of going to bed, difficulty in falling sleep, sleep duration at night, and subjective sleep quality. Time of going to bed was differentiated in triple situations: before 00:00, after 00:00, and at a random time. The frequency of difficulty in falling sleep was assessed with the response options "never," "less than once a week", "once or twice a week", and "three to five times a week". Here, women selected the latter two options were considered with difficulty in falling sleep. Sleep duration was represented by the total sleep time in average, which was divided into three groups: short (<7 hours), moderate (7~9 hours), and long (>9 hours) duration. Women then self-rated their sleep quality with "good", "ordinary", and "poor" level.

2.2.4. Anxiety and depression symptom measures

Anxious symptom among pregnant women was detected by the Self-Rating Anxiety Scale (SAS). The SAS has been applied in Chinese populations in numerous studies, performing good validity and acceptable

reliability (Kang et al., 2016; Ma et al., 2019). The Cronbach's α of SAS in the current study was 0.756. It composed of 20 items with 4-point options (range: 1=never, 2=sometimes, 3=often, 4=very often) to capture symptoms of anxiety. Women would gain an original score (ranged from 20 to 80) by aggregating individual scores of 20 items, and multiply by 1.25 to calculate a standard score. A cut-off standard score of 50 or higher was recommended to identify anxious symptom, with higher scores suggesting more severe levels of anxiety. Different levels of anxiety were illustrated with distinct standard scores: mild (50~59), moderate (60~69), and severe (≥70).

The Patient Health Questionnaire (PHQ)-9 was used to measure depression symptom and its severity. Nine items with typical depression symptoms were responded on a 4-point Likert-type scale: 0=never, 1=several days, 2= more than half of the days, 3=nearly every day. As previous studies did (Lu et al., 2018), the severity of depression was classified by the total score as the following: mild (5~9), moderate (10~14), severe (15~19), and extremely severe (20~27). A cut-off score of 5 or higher was considered with depression symptom. This scale has been confirmed to be a reliable and valid tool in assessing mental health in the Chinese population (Lu et al., 2018; Zhang et al., 2020). The Cronbach's α of PHQ-9 in this study was 0.871.

2.3. Statistically analysis

Continuous variables were described by means and standard deviation, while categorical variables were displayed by numbers and percentages. Chi-square test was applied to detect different prevalence of anxiety and depression symptoms across varied sleep conditions. Multivariable logistic regressions models were established to explore the associations of sleep conditions with anxious and depressive symptoms. Odds ratios (OR) and 95% confident intervals (CI) were also calculated. Three models adjusted for different confounders as the following order: age only (model 1), socio-demographic characteristics (model 2), subjective infected risk and life impact by the coronavirus and daily behaviors, addition to socio-demographic characteristics (model 3). Two-tailed tests with p values less than 0.05 were thought to be statistically significant. All statistical analyses were performed by using SPSS 21.0 (IBM SPSS Statistics, New York, United States).

3. Results

In total, 751 pregnant women in Shenzhen city were enrolled in this study. Socio-demographic characteristics of all respondents were shown in Table 1. The mean age of them was 30.51 years (Standard deviation: 4.28). Among these respondents, the majorities were Han-ethnic (93.2%) and married (96.5%). Over a half (53.0%) of participants had local household registration, and more than three quarters (76.6%) attended college or higher educated institution. Over two thirds (69.4%) of pregnant women were employed, and approximately one third (32.6%) of them had relatively lower monthly income (less than 5,000 RMB), along with a high proportion (91.2%) of owning health insurance. For most of these women (68.4%), the current pregnancy was at the first parity, and nearly half of them (51.5%) were in the third trimester of pregnancy (over 28 gestational weeks).

Coronavirus related events were also displayed in Table 1. Of all respondents, only a minority reported a close contact related to the coronavirus for themselves (4.4%) or their family members (4.7%). Less than one tenth of them (8.8%) reported that there were confirmed or suspected coronavirus infections in the community where they lived, leaving high proportions of no report or uncertain situations. There were less reports on confirmed or suspected coronavirus infections among their acquaintances (1.6%), or even none report among their family members (0.0%). Nearly all women (99.6%) reported having taken precautions against the coronavirus infection. Only 2.0% of them thought they were at high risk of being infected by the coronavirus, while 15.3% and 82.7% of the respondents considered moderate or low risk, respectively. More than thirty percent (31.6%) and ten percent (10.9%) of pregnant women reported severe life and psychological impacts by this novel virus, respectively.

During the epidemic of COVID-19, one fifth of pregnant women did not have physical exercise, 57.5% of them took exercise for less than 30 minutes, and the remaining one fifth spent over 30 minutes in exercise. About half of the participants (49.4%) spent over five hours per day in the internet or social media, whereas 10.8% of pregnant women followed news related to the coronavirus for more than three hours per day. Sleep conditions of pregnant women during the epidemic of COVID-19 were also surveyed (Table 1). Most of participants (71.4%) went to bed before 00:00, the rest of them slept after 00:00 (17.6%) or with a random time (11.1%). Sixty-two percent of pregnant women had a moderate sleep duration (7~9 hours), while 11.6% and 26.2% of them reported a shorter or longer duration. Almost one third (32.6%) of the women had difficulty in falling sleep. Less than half of the women (48.2%) reported a good subjective sleep quality, 40.6% of them replied an ordinary level, and 11.2% of them complained a bad sleep quality.

Of all participant, the mean standardized score of SAS scale was 40.73 (standard deviation: 7.89). The prevalence of anxiety symptom among pregnant women was 13.4% (11.2% for mild, 2.1% for moderate, and 0.1% for severe symptom, respectively). The mean score of PHQ-9 scale was 3.97 (standard deviation: 4.09). Totally 35.4% of women showed depression symptom during the epidemic of COVID-19. The proportions of mild, moderate, severe, and extremely severe symptom were 26.4%, 6.7%, 2.1%, and 0.3%, respectively (Table 1).

The anxious and depressive symptoms of pregnant women distributed differently across distinct sleep conditions (all P values were less than 0.05, Table 2 and 3). The associations of sleep conditions with anxiety and depression during the epidemic of COVID-19 also remained robust even after adjusting for various potential confounders in different models. Sleep variables found to be associated with anxiety symptom were: random (OR=2.67, 95%CI: 1.36~5.22) or late (OR=2.19, 95%CI: 1.23~3.91) time of going to bed, difficulty in falling sleep (OR=4.02, 95%CI: 2.45~6.58), ordinary (OR=4.33, 95%CI: 2.16~8.67) and poor subjective sleep quality (OR=27.34, 95%CI: 12.37~60.44) (Table 2). Similar associations of sleep conditions with depression symptom were also observed: random (OR=4.38, 95%CI: 2.55~7.50) or late (OR=2.78, 95%CI: 1.79~4.31) time of going to bed, difficulty in falling sleep (OR=6.04, 95%CI: 4.19~8.72), short sleep duration (OR=2.08, 95%CI: 1.24~3.50), ordinary (OR=4.70, 95%CI: 3.19~6.93) and poor subjective sleep quality (OR=17.55, 95%CI: 9.09~33.88) (Table 3).

4. Discussion

To our knowledge, this study was the first investigation to examine sleep conditions and psychological symptoms of pregnant women in response to the epidemic of COVID-19, and helpfully to guide the direction of maintaining mental health among emotionally sensitive groups when undergoing public health emergency of international or nationwide concerns. We observed that even though few pregnant women had COVID-19 related close contacts (direct or indirect), nor considered a high risk of being infected, a substantial proportion (77.4%) of them still complained moderate or severe psychological impacts by COVID-19, higher than the rate (53.8%) reported in the general population (Wang et al., 2020a). However, only 2.3% of respondents reported moderate to severe anxiety symptoms, and 9.1% of them reported moderate to extremely severe depression symptoms, which were all lower than the rates (anxiety: 28.8%, depression: 16.5%) in the general population (Wang et al., 2020a), leaving relatively higher proportions of mild symptoms both for anxiety (11.2%) and depression (26.4%) in our study. These interesting findings suggested that pregnant women probably had minor mental symptoms matched with low subjective risk of contracting infection, yet an overestimate of subjective psychological impact.

Compared to studies conducted prior to the appearance of COVID-19

Table 2
Associations of sleep conditions with anxiety symptom among pregnant women during the epidemic of COVID-19 (N=751).

Sleep conditions	With anxiety symptom n(%)	Without anxiety symptom n(%)	P value	Model 1 OR (95%CI)	Model 2 OR (95%CI)	Model 3 OR (95%CI)
Time of going to bed						
Random time	19 (22.9)	64 (77.1)	<0.001	**2.50 (1.38, 4.54)**	**2.72 (1.47, 5.01)**	**2.67 (1.36, 5.22)**
Before 00:00	51 (9.5)	485 (90.5)		1.00 (reference)	1.00 (reference)	1.00 (reference)
After 00:00	31 (23.5)	101(76.5)		**2.82 (1.71, 4.65)**	**2.87 (1.72, 4.80)**	**2.19 (1.23, 3.91)**
Difficulty in falling sleep						
No	33 (6.5)	473 (93.5)	<0.001	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	68 (27.8)	177 (72.2)		**5.53 (3.51, 8.72)**	**5.71 (3.60, 9.07)**	**4.02 (2.45, 6.58)**
Sleep duration at night (hours)						
Short	19 (21.8)	68 (78.2)	0.029	**1.93 (1.07, 3.46)**	**1.99 (1.10, 3.62)**	1.63 (0.84, 3.14)
Moderate	62 (13.3)	405 (86.7)		1.00 (reference)	1.00 (reference)	1.00 (reference)
Long	20 (10.2)	177 (89.8)		0.68 (0.40, 1.17)	0.70 (0.40, 1.21)	0.58 (0.32, 1.06)
Subjective sleep quality						
Good	12 (3.3)	350 (96.7)	<0.001	1.00 (reference)	1.00 (reference)	1.00 (reference)
Ordinary	43 (14.1)	262 (85.9)		**4.90 (2.52, 9.52)**	**5.10 (2.60, 10.01)**	**4.33 (2.16, 8.67)**
Poor	46 (54.8)	38 (45.2)		**36.49 (17.59, 75.70)**	**43.27(20.25, 92.47)**	**27.34 (12.37, 60.44)**

Model 1: Adjusted for age (continues)
Model 2: Adjusted for age (continues), ethnicity, local household registration, marital status, education, monthly income, employment, health insurance, parity and gestational week for current pregnancy
Model 3: Adjusted for age (continues), ethnicity, local household registration, marital status, education, monthly income, employment, health insurance, parity and gestational week for current pregnancy, subjective life impact and risk of being infected by the coronavirus, time spent in physical exercise and using the internet or social medias per day.

Table 3
Associations of sleep conditions with depression symptom among pregnant women during the epidemic of COVID-19 (N=751).

Sleep conditions	With depression symptom n(%)	Without depression symptom n(%)	P value	Model 1 OR (95%CI)	Model 2 OR (95%CI)	Model 3 OR (95%CI)
Time of going to bed						
Random time	49 (59.0)	34 (41.0)	<0.001	**3.62 (2.24, 5.85)**	**4.42 (2.64, 7.40)**	**4.38 (2.55, 7.50)**
Before 00:00	145 (27.1)	391 (72.9)		1.00 (reference)	1.00 (reference)	1.00 (reference)
After 00:00	72 (54.5)	60 (45.5)		**3.17 (2.14, 4.70)**	**3.35 (2.22, 5.04)**	**2.78 (1.79, 4.31)**
Difficulty in falling sleep						
No	107 (21.1)	399 (78.9)	<0.001	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	159 (64.9)	86 (35.1)		**6.99 (4.97, 9.85)**	**7.25 (5.09, 10.32)**	**6.04 (4.19, 8.72)**
Sleep duration at night (hours)						
Short	44 (50.6)	43 949.4)	0.007	**2.09 (1.31, 3.34)**	**2.24 (1.38, 3.64)**	**2.08 (1.24, 3.50)**
Moderate	158 (33.8)	309 (66.2)		1.00 (reference)	1.00 (reference)	1.00 (reference)
Long	64 (32.5)	133 (67.5)		0.90 (0.63, 1.29)	0.95 (0.66, 1.38)	0.88 (0.59, 1.29)
Subjective sleep quality						
Good	57 (15.7)	305 (84.3)	<0.001	1.00 (reference)	1.00 (reference)	1.00 (reference)
Ordinary	142 (46.6)	163 (53.4)		**4.77 (3.31, 6.87)**	**5.11 (3.50, 7.46)**	**4.70 (3.19, 6.93)**
Poor	67 (79.8)	17 (20.2)		**21.22 (11.56, 38.96)**	**23.38 (12.43, 43.98)**	**17.55 (9.09, 33.88)**

Model 1: Adjusted for age (continues)
Model 2: Adjusted for age (continues), ethnicity, local household registration, marital status, education, monthly income, employment, health insurance, parity and gestational week for current pregnancy
Model 3: Adjusted for age (continues), ethnicity, local household registration, marital status, education, monthly income, employment, health insurance, parity and gestational week for current pregnancy, subjective life impact and risk of being infected by the coronavirus, time spent in physical exercise and using the internet or social medias per day.

using the same assessment tool, the overall prevalence of antenatal anxiety in our study (13.4%) was close to that in Shanghai (11.4%) (Ma et al., 2019), but lower than those in Changchun (20.6%) (Kang et al., 2016), Zhoushan (17.4%~22.7% in different trimesters of pregnancy) (Zhang et al., 2018), and combined population in Guangdong and Shandong provinces (27.5%) (Minglu et al., 2020). Regard to antenatal depression, there was scarce literature using PHQ-9 assessment among Chinese pregnant women. The prevalence of depression in our study was 35.4%, much higher than the rate (12.0%) among postmenopausal women in Zhejiang province (Li et al., 2019) when using a cut-off point of PHQ-9 scores ≥5 (Li et al., 2019). If the cut-off scores were set to ≥10 (moderate to extremely severe levels), the prevalence was changed to be 9.1%, approaching the result (8.1%) of previously investigated female population (Zhou et al., 2014), but still higher than the general population (5.3% ~5.9%) (Hall et al., 2018; Zhou et al., 2014). As previous studies summarized, the prevalence of antenatal depressive and anxious symptoms varies widely, fluctuating somewhere ranged from 5% to 38% (Hernandez-Reif et al., 2018). The reasons for varied prevalence possibly lied in diverse cultural, social, economic, and religious backgrounds in different countries and regions (Zhang et al., 2018). Besides, different measurement instruments, cut-off scores, and samples from distinct trimesters of pregnancy across multiple studies could also contribute to these inconsistencies. Since most of measurement instruments were self-administered and subjective rating, the prevalence of mental disorders might be over or under estimated to some extent. Therefore, restrictive standard diagnosis tools could be required in further investigations, such as using the Diagnostic and Statistical Manual of Mental Disorders (DSM) (Park and Kim, 2020).

In line with the general population of which 84.7% spent 20-24 hours per day at home due to home quarantine (Wang et al., 2020a), most women tended to take no or less physical exercise (less than 30 minutes per day) when staying at home in the current study. On the contrast, they spent much time (more than 5 hours per day) in the internet or social media, since the internet was thought to be the primary health information channel (Wang et al., 2020a). These daily customs probably did affect the sleep conditions of pregnant women. We found that women might experience less insufficient (11.6%) and more excessive (26.2%) sleep duration in our study when compared to the

rates of pregnant women (23.9% and 20.9%, respectively) (Xu et al., 2017), and general women (24.2% and 16.0%, respectively) (Chen et al., 2018) in previous multi-center surveys. Moreover, the subjective sleep quality of them might also be improved, as we noticed a lower proportion of poor quality in our study (11.2%) than the earlier counterparts (15.3%) (Xu et al., 2017). It has been verified that both insufficient and excessive sleep were associated with a variety of changes in well-being, physical and psychological parameters (Pines, 2017). Hence, despite the potential promotion of longer sleep among pregnant women during the epidemic of COVID-19, monitoring sleep quality of the public dynamically should be listed as a routine matter of primary healthcare.

Sleep disturbance was believed to engage in mental disorders, as researchers thought sleep related variables might play a key role in psychiatric comorbidity processes (Baglioni et al., 2016). In our study, we detected strong associations of short sleep duration, and ordinary or poor subjective sleep quality with anxiety and depression symptoms. Our findings were roughly consistent with previous researches with slight differences. Similarity existed that short or poor sleep significantly increased odds of experiencing anxiety and depression disorders during pregnancy (Bei et al., 2015; Yu et al., 2017; Zhai et al., 2015; Zhong et al., 2015), implying certain impacts of sleep on maternal mental health whether under emergency situations or not. Discrepancies were mainly owing to different evaluation methods or classification criteria of sleep variables and mental symptoms, with heterogeneity between studies (Gonzalez-Mesa et al., 2019). Besides, these associations might vary in different stages of pregnancy (Polo-Kantola et al., 2017). Our study also identified random or late time of going to bed to play risky roles in mental symptoms during the epidemic of COVID-19, and random time of going to bed had higher odds than a late but regular time, particularly for depression symptom (OR:4.38 vs. 2.78). Studies on shift-workers have shown that sleep and circadian rhythm disruption (SCRD) could result not only in cognitive impairment, but also psychiatric illness including depression (Jagannath et al., 2017). As a manifestation of SCRD, it could be inferred that irregular time of going to bed might act in a greater harmful way than simple staying up late. Likewise, we observed that difficulty in falling sleep, a typical symptom of insomnia, could exacerbate both anxious and depressive symptoms. Biological mechanisms of associations between insomnia and psychological symptoms possibly lied as follows: cognitive and affective alterations (Jackson et al., 2014), impaired emotional regulation and stability (Yoo et al., 2007), persistent arousal and chronic activation of hyperactivity in the hypothalamic–pituitary–adrenal (HPA) axis (Balbo et al., 2010).

There were several limitations in our study. Firstly, due to a voluntary participation option of online surveys, the current study sample was not a random group of pregnant women in Shenzhen, reaching a restricted generalization of our findings to the whole population of pregnant women. According to distinct epidemic levels of COVID-19 in different regions, our results could be used as a contemporaneous reference for other cities with similar epidemic status. In addition, it was ideally to collect historical information of the study subjects using the same measurements prior to this novel infectious disease, in order to provide direct comparison of “before and after COVID-19” and detect possible variations (Wang et al., 2020b). Secondly, we could not conclude causal relations because of cross-sectional study design, thus, the associations identified in our study should be verified in further prospective studies. Thirdly, as a common shortage of similar studies, most of the variables were derived from a self-reported questionnaire rather than assessment by psychiatric professionals, which might be more susceptible to information bias. We followed the implementation procedures of other observational studies and applied widely-used assessment tools to ensure the comparability between studies. Furthermore, due to a length limit of online questionnaire, we failed to put the Pittsburgh Sleep Quality Index (PSQI) into our questionnaire when we have to compromise the application of PHQ-9 and SAS. However, four key questions referred to sleep conditions were all originated from the PSQI questionnaire, including time of going to bed, difficulty in falling sleep, sleep duration at night, and subjective sleep quality. As other researchers did (Xu et al., 2017), it might not restrict the exploration of potential associations. Fourth, this study did not record the occupation of participants which could be a confounding factor. Some participants could be healthcare workers and they are more vulnerable to anxiety and depression during COVID-19 pandemic (Tan et al., 2020; Chew et al., 2020). Fifth, this study did not measure specific psychiatric symptom such as panic buying of necessities (Ho et al., 2020) that could affect sleep.

5. Conclusion

Anxiety and depression were common psychological symptoms among pregnant women. We found few pregnant women had COVID-19 related close contacts, nor considered a high risk of being infected in Shenzhen during the epidemic of COVID-19. The prevalence of maternal anxious and depressive symptoms were acceptable, most of which were in mild levels. The sleep conditions of pregnant women strongly linked with their anxiety and depression symptoms. These findings might help alleviate the mental illness through targeted intervention in improving maternal sleep conditions when encountering public health emergencies.

Authorship contribution statement

All authors have made substantial contributions to this study in the various sections described below. YW, WL, BW, and SH originated the study, conceptualization, design, supervised implementation. BC, GL, SL, KL, CZ and WH acquired the data. WL, YW, and SY interpreted the data and performed statistical analysis. WL wrote the draft of the manuscript. All authors contributed to the critical revision of the manuscript and gave their final approval for the manuscript to be published.

Funding

This research received support from the Shenzhen Science and Technology Innovation Committee (Grant number: JCYJ20170307091451207), and the Sanming Project of Medicine in Shenzhen (Grant number: SZSM201612042). The funder did not involve in any part of the study process, from design to submit the article for publication.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

Acknowledgments

The authors thank all the participants for their time and efforts.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2020.11.114.

References

Baglioni, C., Nanovska, S., Regen, W., Spiegelhalder, K., Feige, B., Nissen, C., Reynolds, C.F., Riemann, D., 2016. Sleep and mental disorders: A meta-analysis of polysomnographic research. PSYCHOL BULL 142, 969–990.

Bai, Y., Yao, L., Wei, T., Tian, F., Jin, D.Y., Chen, L., Wang, M., 2020. Presumed Asymptomatic Carrier Transmission of COVID-19. JAMA.

Balbo, M., Leproult, R., Van Cauter, E., 2010. Impact of sleep and its disturbances on hypothalamo-pituitary-adrenal axis activity. INT J ENDOCRINOL 2010, 759234.

Bei, B., Coo, S., Trinder, J., 2015. Sleep and Mood During Pregnancy and the Postpartum Period. Sleep Med Clin 10, 25–33.

Chen, H., Guo, J., Wang, C., Luo, F., Yu, X., Zhang, W., Li, J., Zhao, D., Xu, D., Gong, Q., Liao, J., Yang, H., Hou, W., Zhang, Y., 2020. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. LANCET 395, 809–815.
Chen, Y., Kartsonaki, C., Clarke, R., Guo, Y., Yu, C., Bian, Z., Jiang, Q., Li, S., Chen, J., Li, L., Chen, Z., 2018. Characteristics and correlates of sleep duration, daytime napping, snoring and insomnia symptoms among 0.5 million Chinese men and women. SLEEP MED 44, 67–75.
Cheng, C., Cheung, M.W., 2005. Psychological responses to outbreak of severe acute respiratory syndrome: a prospective, multiple time-point study. J PERS 73, 261–285.
Chew, N., Lee, G., Tan, B., Jing, M., Goh, Y., Ngiam, N., Yeo, L., Ahmad, A., Ahmed, K.F., Napolean, S.G., Sharma, A.K., Komalkumar, R.N., Meenakshi, P.V., Shah, K., Patel, B., Chan, B., Sunny, S., Chandra, B., Ong, J., Paliwal, P.R., Wong, L., Sagayanathan, R., Chen, J.T., Ying, N.A., Teoh, H.L., Tsivgoulis, G., Ho, C.S., Ho, R. C., Sharma, V.K., 2020. A multinational, multicentre study on the psychological outcomes and associated physical symptoms amongst healthcare workers during COVID-19 outbreak. BRAIN BEHAV IMMUN 88, 559–565.
Fang, Y., Nie, Y., Penny, M., 2020. Transmission dynamics of the COVID-19 outbreak and effectiveness of government interventions: A data-driven analysis. J MED VIROL.
Filgueiras, M.J., Neves, C.M., Morgado, F., Caputo, F.M., 2017. Zika virus and pregnant women: A psychological approach. PSYCHOL HEALTH 32, 798–809.
Glover, V., 2014. Maternal depression, anxiety and stress during pregnancy and child outcome; what needs to be done. Best Pract Res Clin Obstet Gynaecol 28, 25–35.
Gonzalez-Mesa, E., Cuenca-Marin, C., Suarez-Arana, M., Tripiana-Serrano, B., Ibrahim-Diez, N., Gonzalez-Cazorla, A., Blasco-Alonso, M., 2019. Poor sleep quality is associated with perinatal depression. A systematic review of last decade scientific literature and meta-analysis. J PERINAT MED 47, 689–703.
Hall, B.J., Chang, K., Chen, W., Sou, K.L., Latkin, C., Yeung, A., 2018. Exploring the association between depression and shenjing shuairuo in a population representative epidemiological study of Chinese adults in Guangzhou, China. TRANSCULT PSYCHIATRY 55, 733–753.
Hao, F., Tan, W., Jiang, L., Zhang, L., Zhao, X., Zou, Y., Hu, Y., Luo, X., Jiang, X., McIntyre, R.S., Tran, B., Sun, J., Zhang, Z., Ho, R., Ho, C., Tam, W., 2020. Do psychiatric patients experience more psychiatric symptoms during COVID-19 pandemic and lockdown? A case-control study with service and research implications for immunopsychiatry. BRAIN BEHAV IMMUN 87, 100–106.
Hernandez-Reif, M., Kendrick, A., Avery, D.M., 2018. Pregnant women with depressive and anxiety symptoms read, talk, and sing less to their fetuses. J Affect Disord 229, 532–537.
Ho, C.S., Chee, C.Y., Ho, R.C., 2020. Mental Health Strategies to Combat the Psychological Impact of COVID-19 Beyond Paranoia and Panic. ANN ACAD MED SINGAP 49, 155–160.
Jackson, M.L., Sztendur, E.M., Diamond, N.T., Byles, J.E., Bruck, D., 2014. Sleep difficulties and the development of depression and anxiety: a longitudinal study of young Australian women. Arch Womens Ment Health 17, 189–198.
Jagannath, A., Taylor, L., Wakaf, Z., Vasudevan, S.R., Foster, R.G., 2017. The genetics of circadian rhythms, sleep and health. HUM MOL GENET 26, R128–R138.
Jiang, F., Deng, L., Zhang, L., Cai, Y., Cheung, C.W., Xia, Z., 2020. Review of the Clinical Characteristics of Coronavirus Disease 2019 (COVID-19). J GEN INTERN MED.
Kang, Y.T., Yao, Y., Dou, J., Guo, X., Li, S.Y., Zhao, C.N., Han, H.Z., Li, B., 2016. Prevalence and Risk Factors of Maternal Anxiety in Late Pregnancy in China. Int J Environ Res Public Health 13.
Lee, D.T., Sahota, D., Leung, T.N., Yip, A.S., Lee, F.F., Chung, T.K., 2006. Psychological responses of pregnant women to an infectious outbreak: a case-control study of the 2003 SARS outbreak in Hong Kong. J PSYCHOSOM RES 61, 707–713.
Lee, T.M., Chi, I., Chung, L.W., Chou, K.L., 2006. Ageing and psychological response during the post-SARS period. AGING MENT HEALTH 10, 303–311.
Li, F., He, F., Sun, Q., Li, Q., Zhai, Y., Wang, X., Zhang, T., Lin, J., 2019. Reproductive history and risk of depressive symptoms in postmenopausal women: A cross-sectional study in eastern China. J Affect Disord 246, 174–181.
Li, G., Kong, L., Zhou, H., Kang, X., Fang, Y., Li, P., 2016. Relationship between prenatal maternal stress and sleep quality in Chinese pregnant women: the mediation effect of resilience. SLEEP MED 25, 8–12.
Li, J.Y., You, Z., Wang, Q., Zhou, Z.J., Qiu, Y., Luo, R., Ge, X.Y., 2020. The epidemic of 2019-novel-coronavirus (2019-nCoV) pneumonia and insights for emerging infectious diseases in the future. MICROBES INFECT 22, 80–85.
Linton, N.M., Kobayashi, T., Yang, Y., Hayashi, K., Akhmetzhanov, A.R., Jung, S.M., Yuan, B., Kinoshita, R., Nishiura, H., 2020. Incubation Period and Other Epidemiological Characteristics of 2019 Novel Coronavirus Infections with Right Truncation: A Statistical Analysis of Publicly Available Case Data. J CLIN MED 9.
Lu, S., Reavley, N., Zhou, J., Su, J., Pan, X., Xiang, Q., Zhang, Y., Oldenburg, B., Wu, M., 2018. Depression among the general adult population in Jiangsu Province of China: prevalence, associated factors and impacts. Soc Psychiatry Psychiatr Epidemiol 53, 1051–1061.
Ma, X., Wang, Y., Hu, H., Tao, X.G., Zhang, Y., Shi, H., 2019. The impact of resilience on prenatal anxiety and depression among pregnant women in Shanghai. J Affect Disord 250, 57–64.
Minglu, L., Fang, F., Guanxi, L., Yuxiang, Z., Chaoqiong, D., Xueqin, Z., 2020. Influencing factors and correlation of anxiety, psychological stress sources, and psychological capital among women pregnant with a second child in Guangdong and Shandong Province. J Affect Disord 264, 115–122.
Oh, N., Hong, N., Ryu, D.H., Bae, S.G., Kam, S., Kim, K.Y., 2017. Exploring Nursing Intention, Stress, and Professionalism in Response to Infectious Disease Emergencies: The Experience of Local Public Hospital Nurses During the 2015 MERS Outbreak in South Korea. Asian Nurs Res (Korean Soc Nurs Sci) 11, 230–236.
Park, S.C., Kim, Y.K., 2020. Anxiety Disorders in the DSM-5: Changes, Controversies, and Future Directions. ADV EXP MED BIOL 1191, 187–196.
Paules, C.I., Marston, H.D., Fauci, A.S., 2020. Coronavirus Infections-More Than Just the Common Cold. JAMA.
Pines, A., 2017. Sleep duration and midlife women's health. CLIMACTERIC 20, 528–530.
Polo-Kantola, P., Aukia, L., Karlsson, H., Karlsson, L., Paavonen, E.J., 2017. Sleep quality during pregnancy: associations with depressive and anxiety symptoms. Acta Obstet Gynecol Scand 96, 198–206.
Rumble, M.E., White, K.H., Benca, R.M., 2015. Sleep Disturbances in Mood Disorders. Psychiatr Clin North Am 38, 743–759.
Tan, B., Chew, N., Lee, G., Jing, M., Goh, Y., Yeo, L., Zhang, K., Chin, H.K., Ahmad, A., Khan, F.A., Shanmugam, G.N., Chan, B., Sunny, S., Chandra, B., Ong, J., Paliwal, P. R., Wong, L., Sagayanathan, R., Chen, J.T., Ng, A., Teoh, H.L., Ho, C.S., Ho, R.C., Sharma, V.K., 2020. Psychological Impact of the COVID-19 Pandemic on Health Care Workers in Singapore. ANN INTERN MED 173, 317–320.
Tan, W., Hao, F., McIntyre, R.S., Jiang, L., Jiang, X., Zhang, L., Zhao, X., Zou, Y., Hu, Y., Luo, X., Zhang, Z., Lai, A., Ho, R., Tran, B., Ho, C., Tam, W., 2020. Is returning to work during the COVID-19 pandemic stressful? A study on immediate mental health status and psychoneuroimmunity prevention measures of Chinese workforce. BRAIN BEHAV IMMUN 87, 84–92.
Velavan, T.P., Meyer, C.G., 2020. The COVID-19 epidemic. TROP MED INT HEALTH 25, 278–280.
Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., Ho, C.S., Ho, R.C., 2020a. Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China. Int J Environ Res Public Health 17.
Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., McIntyre, R.S., Choo, F.N., Tran, B., Ho, R., Sharma, V.K., Ho, C., 2020b. A longitudinal study on the mental health of general population during the COVID-19 epidemic in China. BRAIN BEHAV IMMUN 87, 40–48.
Xu, X., Liu, D., Zhang, Z., Sharma, M., Zhao, Y., 2017. Sleep Duration and Quality in Pregnant Women: A Cross-Sectional Survey in China. Int J Environ Res Public Health 14.
Yoo, S.S., Gujar, N., Hu, P., Jolesz, F.A., Walker, M.P., 2007. The human emotional brain without sleep–a prefrontal amygdala disconnect. CURR BIOL 17, R877–R878.
Yu, Y., Li, M., Pu, L., Wang, S., Wu, J., Ruan, L., Jiang, S., Wang, Z., Jiang, W., 2017. Sleep was associated with depression and anxiety status during pregnancy: a prospective longitudinal study. Arch Womens Ment Health 20, 695–701.
Zhai, L., Zhang, H., Zhang, D., 2015. Sleep duration and depression among adults: a meta-analysis of prospective studies. DEPRESS ANXIETY 32, 664–670.
Zhang, W., Du, RH, Li, B., Zheng, X.S., Yang, X.L., Hu, B., Wang, Y.Y., Xiao, G.F., Yan, B., Shi, Z.L., Zhou, P., 2020. Molecular and serological investigation of 2019-nCoV infected patients: implication of multiple shedding routes. Emerg Microbes Infect 9, 386–389.
Zhang, X., Sun, J., Wang, J., Chen, Q., Cao, D., Wang, J., Cao, F., 2020. Suicide ideation among pregnant women: The role of different experiences of childhood abuse. J Affect Disord 266, 182–186.
Zhang, Y., Muyiduli, X., Wang, S., Jiang, W., Wu, J., Li, M., Mo, M., Jiang, S., Wang, Z., Shao, B., Shen, Y., Yu, Y., 2018. Prevalence and relevant factors of anxiety and depression among pregnant women in a cohort study from south-east China. J Reprod Infant Psychol 36, 519–529.
Zhong, Q.Y., Gelaye, B., Sanchez, S.E., Williams, M.A., 2015. Psychometric Properties of the Pittsburgh Sleep Quality Index (PSQI) in a Cohort of Peruvian Pregnant Women. J CLIN SLEEP MED 11, 869–877.
Zhou, X., Bi, B., Zheng, L., Li, Z., Yang, H., Song, H., Sun, Y., 2014. The prevalence and risk factors for depression symptoms in a rural Chinese sample population. PLOS ONE 9, e99692.
Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., Zhao, X., Huang, B., Shi, W., Lu, R., Niu, P., Zhan, F., Ma, X., Wang, D., Xu, W., Wu, G., Gao, G.F., Tan, W., 2020. A Novel Coronavirus from Patients with Pneumonia in China, 2019. N Engl J Med 382, 727–733.