How to prevent in-hospital COVID-19 infection and reassure women about the safety of pregnancy: Experience from an obstetric center in China

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Abstract

Objective: This study aimed to describe the emergency responses to coronavirus disease 2019 (COVID-19) for pregnant patients at our hospital and their effect on hospital operations and patients' outcomes.

Methods: We developed strategies to prevent hospital-associated transmission of COVID-19 in obstetric care. Infrastructure, including the fever clinic and wards, were modified. Outpatient volume was controlled and screening processes were strictly performed. Verification of the virus was compulsory for non-surgery and non-emergency patients. Emergency operations were performed in a negative pressure theater with surgeons fully protected. Outcomes were analyzed and the patients' characteristics were evaluated. The effect of intervention on depressed and anxious patients was assessed. Data from the first 2 months of 2019 and 2020 were compared.

Results: No in-hospital COVID-19 infections occurred in our unit. During the epidemic, patient volume significantly decreased. While major characteristics of patients were similar, a higher prevalence of gestational hypertension was found in 2020 than in 2019. Psychological

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interventions showed optimistic effects in ameliorating depression and anxiety at the beginning of the COVID-19 pandemic.
Conclusions: Our strategies were effective in preventing in-hospital infection of COVID-19 and reassuring women about the safety of pregnancy. Monitoring and managing psychological issues were necessary during this critical period.

Introduction

In December 2019, clusters of patients with pneumonia of an unknown cause were reported in Wuhan, China.[1] Further investigation identified a novel coronavirus, which was initially termed 2019-nCoV, and was subsequently named severe acute respiratory syndrome coronavirus 2. The ongoing epidemic of coronavirus disease 2019 (COVID-19) has become a global health concern. As recorded by the World Health Organization, the number of confirmed cases by 2 April 2020 has surpassed 896,000 globally.[2] Little is known about the effect of COVID-19 on pregnant women and neonates. In a report of 10 neonates delivered by mothers who had COVID-19 infection, adverse perinatal outcomes, such as premature labor, fetal distress, and even death, were reported.[3] Currently, the route of neonatal infection, such as the transplacental route, during delivery, or by postnatal close contact with an infected mother, is unclear.

Zhongda Hospital, Southeast University, is an academic and tertiary medical center in Nanjing, Jiangsu Province. The Department of Obstetrics has approximately 2000 deliveries per year. This hospital is also designated as a unique Guidance Center and Quality Control Center for Maternal Critical Care of Jiangsu Province, and is a regionally maternal referral center for critically ill pregnant women. Nanjing was assessed as a high-risk region by the government on 26 January 2020, with 93 COVID-19 cases confirmed. At this time, Nanjing was officially appointed as one of the four referring hospitals for COVID-19-infected patients in the city because of its nationally recognized critical care medicine. Since the outbreak of the pandemic COVID-19, three patients have been diagnosed with COVID-19 infection in our hospital. Therefore, we developed strategies to prevent hospital-associated transmission in obstetric care.

In this study, we describe our experience in how we prepared for the COVID-19 epidemic to prevent in-hospital infection among pregnant women in a regional referring obstetric center. We also examined the effects of COVID-19 on patient volume and pregnancy outcomes in 2020. Gestational diabetes mellitus (GDM) and gestational hypertension (GHTN), which are two of the most common complications of pregnancy, were further analyzed and compared with the data in 2019. The occurrence of depression and anxiety in pregnant women was reported.

Materials and methods

Workflows for the outpatient clinic and telemedicine

With extensive use of fifth generation (5G) technology and hospital webapps, we had the ability to offer routine obstetric care through our clinic and telemedicine services for outpatients at the same level in 2020 as that before the COVID-19 outbreak. For clinic visitors, a strict pre-screening procedure was conducted (Figure 1). Temperature measurement and epidemic history were acquired upon arrival to hospital. Women with symptoms were triaged to the Fever Clinic for further COVID-19 testing, including nasopharyngeal swabs. Patients with a low risk (Class I according

to the National Health Commission of China) were suggested to have a follow-up in the community clinic. Close monitoring or hospitalization was proposed when it was evaluated as necessary.

For non-emergent patients (e.g., those with a routine examination appointment), an online clinic through telemedicine, which was supported by our Information Technology Center, was provided. Online courses on education of blood glucose and pressure monitoring were provided to pregnant women. These women were asked to upload their data to the National Metabolic Management Center, which was established by Professor Zhang, Zhongda Hospital, to create an integrated online and offline solution for diabetes, as well as for other metabolic diseases.[4] Obstetricians in our
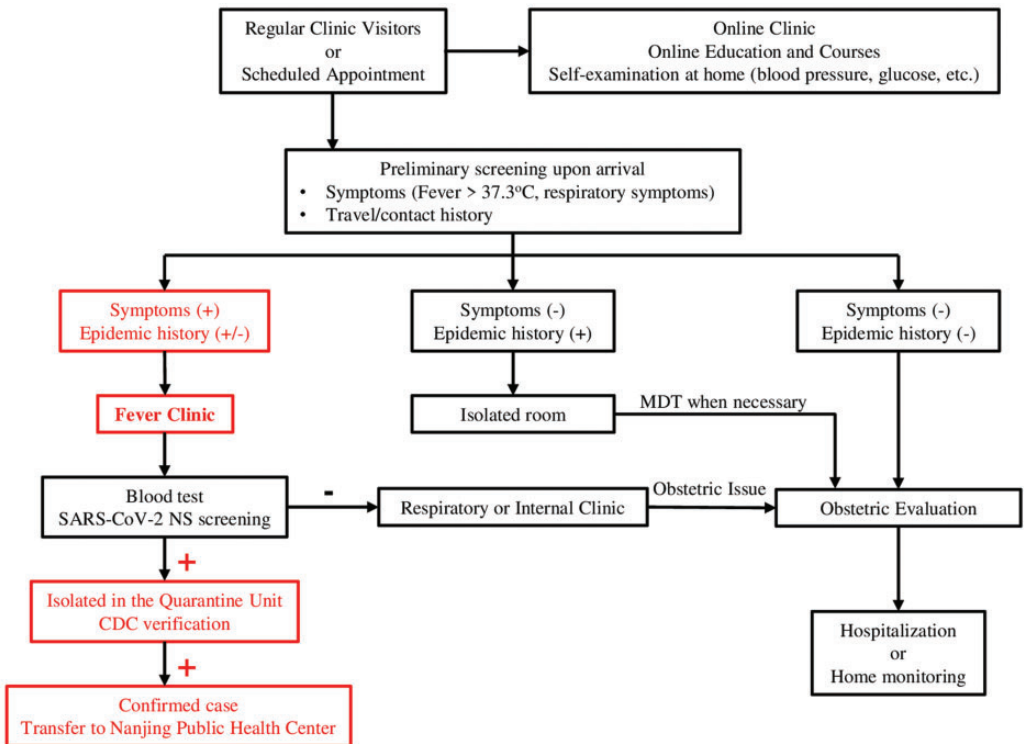

Figure 1. Flowchart for managing outpatients. MDT: multidisciplinary team; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2; NS: nasopharyngeal; CDC: Center for Disease Control.

department followed up and advised patients via text messages or phone calls. For those who required instant intervention, an on-site examination was required. Medication, when necessary, was prescribed and delivered directly to the patient's home from the hospital through our delivery service system.

The numbers of patients who visited the outpatient clinic, Emergency Department, and hospital in January and February of 2020 were collected and compared with the data from the same period in 2019 to evaluate the effects of these strategies on controlling patient flow. Additionally, pregnancy outcomes were reviewed and compared, including GHTN and GDM.

Hospitalization and surgeries

With regard to strategies, the obstetric floor was modified as per the Guideline of the Emergency Leadership Committee of Zhongda Hospital at the initial stage of the COVID-19 outbreak in January 2020. All of the patients' rooms were adapted to a single-patient unit. Additional ventilation equipment was installed, and air was routinely monitored and assessed by third-party engineers with a centralized designed Airborne Infection Isolation Room in the hospital as a back-up unit as required.

Guidance for in-hospital patients was adjusted to prevent imported COVID-19 infections (Figure 2). At the peak of the epidemic, we suspended all elective operations. Admission for elective patients was resumed recently when the situation was ameliorated. Patients with no requirement for surgery were accommodated in single rooms for a nasopharyngeal swab test upon admission. For semi-elective patients, such as those with tumors, nasopharyngeal swab tests were performed before surgery. Positive results were verified by Provincial Centers for Disease Control and Prevention and COVID-19-confirmed patients were

immediately transferred to the Nanjing Public Health Center. For emergencies without verification of COVID-19, surgery was performed in a negative pressure operating theater.[5] Participating surgeons and medical staff were fully equipped with personal protective gear, including a cap, a pair of goggles, an N95 mask, and shoe covers. Disposable surgical gowns and single-use gloves were also used. All medical waste was handled by following the Clinical Waste Management Procedures. The theater was sterilized after surgery. Post-operation reverse transcription-polymerase chain reaction was performed to determine the presence of the virus.

Newborn management

Because the maternal–fetal or maternal–neonatal transmission pattern of COVID-19 is unknown and the possibility of vertical transmission cannot be excluded, precautions in every aspect were conducted for delivery of pregnant women in whom COVID-19 was unconfirmed. Therefore, we opted for early, rather than delayed, cord clamping after labor,[6] even though the World Health Organization considers that delayed clamping is highly unlikely to increase the risk[7] (Figure 2). Samples of amniotic fluid, umbilical cord blood, and nasopharyngeal swabs were tested. Newborns were temporarily isolated from their mothers, and breastfeeding was temporarily not allowed until the mother tested negative for COVID-19.

Psychological care and monitoring

While the effect of mental health on pregnancy outcomes was documented, maternal psychological changes were also evaluated and intervention was performed during the epidemic.[8] At the top of the list, our patients were promptly informed about updated information of COVID-19 from
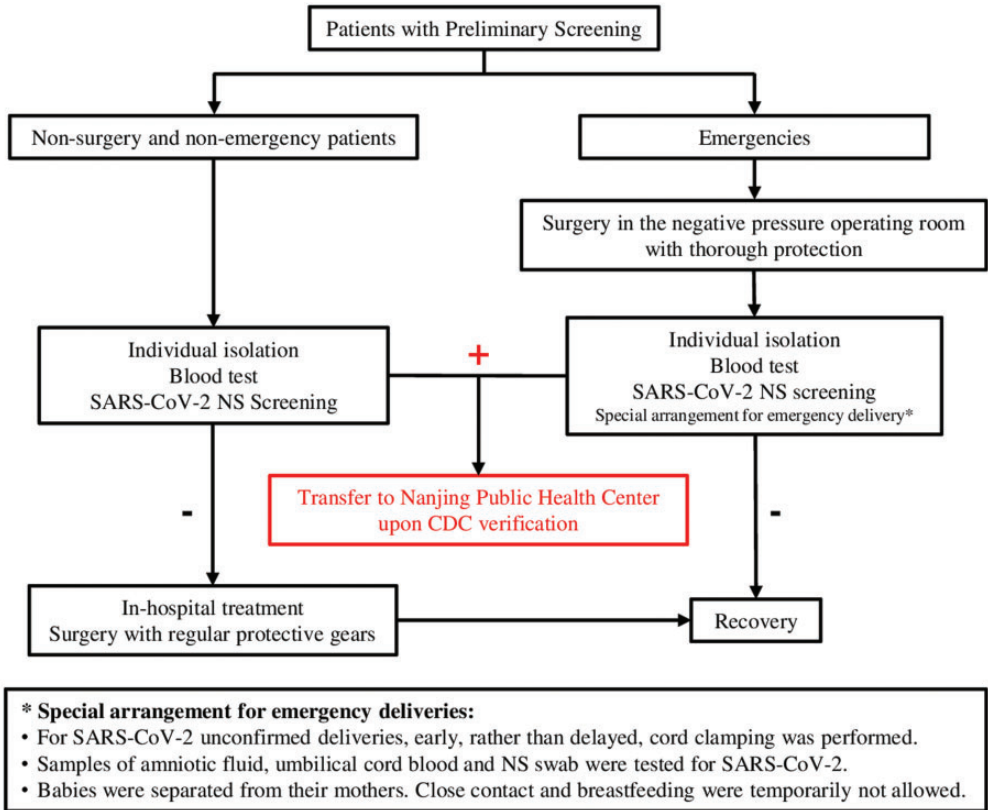
Figure 2. Flowchart of patients who required further management in hospital. SARS-CoV-2: severe acute respiratory syndrome coronavirus 2; NS: nasopharyngeal; CDC: Center for Disease Control.

Provincial Centers for Disease Control and Prevention every day through webapps. Wearing masks, keeping social distances, and reducing outdoor activities were advised at the peak of the pandemic. At the same time, immediate clarification and discussion of the rumors and misleading messages were believed to be important for eliminating the patients' anxiety and stress. Furthermore, the outcome of healthy and successful deliveries in our department during the pandemic was shared among our patients. Interestingly, we found that ameliorating stress and building the patients' self-confidence were useful. Moreover, the patients were encouraged to maintain a normal lifestyle, participate in regular physical exercise, obtain sufficient sleep, and maintain sufficient social contact over the phone or through online channels. In case of those suffering from high stress, psychological consultation was available at the Department of Psychology.

To evaluate the mental status of our patients, a structured questionnaire was distributed before and during the outbreak through online groups. The extent of depression, anxiety, and fear was graded as none, mild, moderate, and severe, and the stress level was assessed using a 0 to 10 scoring scale. The self-evaluated results were collected and the characteristics of psychological performances were analyzed.

Data collection and analysis

The study was approved by the Ethics Committee and Review Board of Zhongda Hospital. The patients provided verbal consent for using their data. All data were collected from the Hospital Information System and analyzed by Prism 8.3.1 (GraphPad Software, San Diego, CA, USA). The t-test was used to analyze changes in patient flow. The chi-square test was applied to evaluate obstetric outcomes, and the paired t-test was used to compare the psychological status before and after our intervention. A p value < 0.05 was considered statistically significant.

Results

Hospital-acquired infection in mothers and neonates

There were 2458 outpatient visits, 316 emergent visits, 385 hospital admissions, and 271 deliveries in the first 2 months of 2020. During this time, there was no in-hospital infection or transmission in either mothers or neonates. We encountered one woman who reported a close contact history with a patient with COVID-19. According to our proactive protocols, emergency delivery was conducted in a negative pressure operation theater. The neonate was temporarily separated in an individual chamber until samples of amniotic fluid, umbilical cord blood, and nasopharyngeal swabs showed that COVID-19 was not present. The mother was also COVID-19-negative.

Outpatient, emergency, and hospitalization numbers of patients during the epidemic

The weekly summary of patient volume in each month was collected. Patient volume from outpatients, the Emergency Department, and hospitalization was significantly decreased in February 2020 after initiation of new hospital policies compared with January 2020 (all $p < 0.05$) (Figure 3). The new hospital policies significantly decreased the volume of outpatient visits, emergency room visits, and hospitalization in February 2020 compared with February 2019 (all $p < 0.05$).
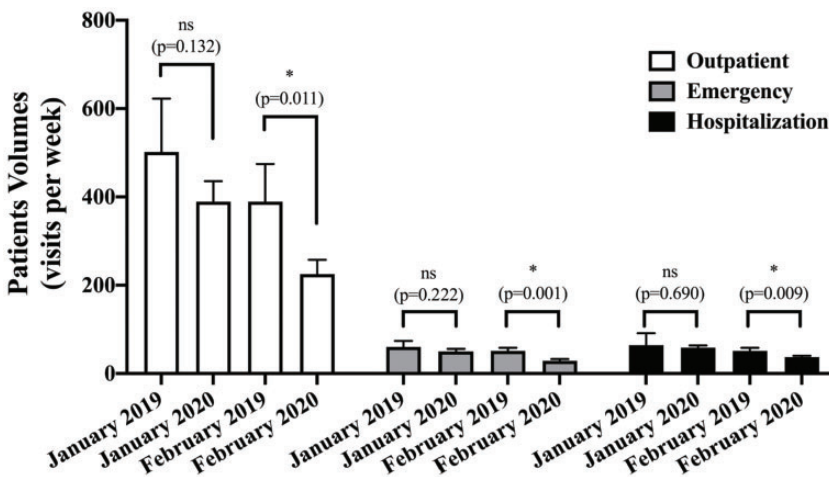

Figure 3. Comparison of patient volume from outpatient visits, Emergency Department visits, and hospitalization between January and February of 2019 and 2020. *$p < 0.05$. ns: not significant.

Incidence of GHTN during the epidemic

Between January and February 2020, 271 pregnant women delivered 280 newborns in our department compared with 311 pregnant women and 317 newborns in 2019 (Table 1). The rate of women who were nulliparous in 2020 was significantly lower than that in 2019 ($p = 0.009$). The prevalence of GHTN was significantly higher in 2020 compared with 2019 ($p = 0.002$). The prevalence of GDM was not different between the two time periods. Outcomes of pregnancy, including neonatal outcomes, in January and February in 2020 were similar to those in January and February in 2019.

Outcomes of patients with GDM and GHTN

There were no changes in maternal and neonatal outcomes in women with GDM between 2019 and 2020. There were no significant changes in maternal and neonatal outcomes in women with GHTN between 2019 and 2020, except for the Apgar score at 1 minute ($p = 0.003$) (Table 2).

Table 1. Characteristics of all deliveries in January and February of 2019 and 2020.

Characteristic	Overall information		
	2019	2020	p value
Number of Deliveries	311	271	
Age (years)	30.19 ± 4.63	29.99 ± 4.67	0.603
< 20	1 (0.32)	1 (0.37)	0.867
20–34	263 (84.57)	226 (83.39)	
≥ 35	47 (15.11)	44 (16.24)	
Nulliparity	193 (62.06)	139 (51.29)	0.009
Gestational age at delivery	38.37 ± 2.42	38.46 ± 2.20	0.625
Body mass index	21.62 ± 3.09	21.54 ± 3.03	0.767
Underweight	37 (11.90)	42 (15.50)	0.394
Normal	233 (74.92)	195 (71.95)	
Overweight	37 (11.90)	33 (12.18)	
Obese	4 (1.28)	1 (0.37)	
Mode of delivery			
CS	134 (43.09)	123 (45.39)	0.577
SVD	177 (56.91)	148 (54.61)	
Number of deliveries			
1	303 (97.43)	262 (96.68)	0.476
2	7 (2.25)	9 (3.32)	
Death	1 (0.32)	0 (0)	
Complications of pregnancy			
GHTN	3 (0.96)	14 (5.17)	0.002
GDM	34 (10.93)	30 (11.07)	0.958
Preterm delivery	58 (18.65)	36 (13.28)	0.079
Neonatal outcomes	317	280	
Birth weight	3230.31 ± 655.75	3273.96 ± 660.62	0.419
Apgar score at 1 minute	9.74 ± 0.88	9.78 ± 0.77	0.547
Apgar score at 5 minutes	9.88 ± 0.61	9.94 ± 0.37	0.156
NICU	49 (15.46)	33 (11.79)	0.193

Values are mean ± standard deviation or n (%). CS: cesarean section; SVD: spontaneous vaginal delivery; GHTN: gestational hypertension; GDM: gestational diabetes mellitus; NICU: neonatal intensive care unit.

Table 2. Analysis of characteristics and outcomes of gestational diabetes mellitus and gestational hypertension.

Characteristic	Patients with gestational diabetes mellitus		
	2019 (n = 34)	2020 (n = 30)	p value
Number of deliveries	34	30	
Age (years)	32.24 ± 4.81	31.80 ± 4.69	0.233
< 20	0 (0)	0 (0)	0.785
20–34	23 (67.65)	22 (73.33)	
≥ 35	11 (32.35)	8 (26.67)	
Gestational age			
Preterm	6 (17.65)	2 (6.67)	0.265
Full term	28 (82.35)	28 (93.33)	
Delivery mode			
CS	15 (44.12)	15 (50)	0.638
SVD	19 (55.88)	15 (50)	
Fetal number			
1	34 (100)	29 (96.67)	1
2	0 (0)	1 (3.33)	
Death	0 (0)	0 (0)	
Pre-eclampsia			
Presence	0 (0)	3 (10)	0.097
Absence	34 (100)	27 (90)	
Neonatal outcomes	34	31	
Fatal macrosomia	5 (14.71)	4 (12.90)	0.875
Birth weight	3395.95 ± 464.88	3374.33 ± 545.66	0.867
Apgar score at 1 minute	9.91 ± 0.29	9.90 ± 0.40	0.921
Apgar score at 5 minutes	10 ± 0	9.97 ± 0.18	0.299
NICU	3 (8.82)	2 (6.45)	0.720
Characteristic	Patients with gestational hypertension		
	2019	2020	p value
Number of deliveries	3	14	
Age (years)	32.67 ± 2.30	32.29 ± 5.48	0.909
< 20	0	0	0.541
20–34	3	10	
≥ 35	0	4	
Gestational age			
Preterm	1	1	0.331
Full term	2	13	
Delivery mode			
CS	3	12	0.486
SVD	0	2	
Fetal number			
1	2 (66.67)	14 (100)	1
2	1 (33.33)	0 (0)	
Death	0 (0)	0 (0)	
Pre-eclampsia			
Presence	1 (33.33)	7 (50)	0.600
Absence	2 (66.67)	7 (50)	

Table 2. Continued.

	Patients with gestational diabetes mellitus		
Characteristic	2019 (n = 34)	2020 (n = 30)	p value
Neonatal outcomes	4	14	
Fatal macrosomia	1 (25)	3 (21.43)	0.659
Birth weight	3100 ± 1201.04	3450 ± 649.26	0.121
Apgar score at 1 minute	9.50 ± 0.58	10 ± 0	0.003
Apgar score at 5 minutes	10 ± 0	10 ± 0	1
NICU	1 (25)	0 (0)	0.351

Values are mean ± standard deviation or n (%). CS: cesarean section; SVD: spontaneous vaginal delivery; NICU: neonatal intensive care unit.

Table 3. Analysis of psychological assessment.

	Psychological assessment Before intervention (n = 126)	After intervention (n = 126)	p value
Category			
Depression	38.10%	24.60%	
None	78	95	0.004
Mild	40	30	
Moderate	4	0	
Severe	4	1	
Anxiety	28.57%	23.02%	
None	90	97	0.173
Mild	28	25	
Moderate	6	3	
Severe	2	1	
Fear	67.46%	45.24%	
None	41	69	<0.001
Mild	60	51	
Moderate	22	6	
Severe	3	0	
Stress score	8.50 ± 5.06	7.63 ± 4.84	0.003

Psychological intervention effectively relieves depression, fear, and stress in pregnant women

The reliability values of our questionnaires were > 0.9 for pre- and post-intervention, which indicated a high reflection of the women's psychological status. Among a total of 126 patients, 38.1% of them had depression, 28.57% of them had anxiety, and 67.46% of them reported fear at the initial stage in January 2020 pre-intervention (Table 3). Interventions via online consultation and education resulted in a significant decrease in pregnant women's depression ($p = 0.004$) and fear ($p < 0.001$) compared with before intervention. The self-evaluated stress score was significantly decreased post-intervention compared with pre-intervention ($p = 0.003$).

Discussion

We introduced emergency responses to the COVID-19 outbreak and established some strategies. Our study showed the following findings. (1) No hospital-acquired COVID-19 infection in pregnant women was found after new policies were applied in our hospital. (2) With a decrease in patients' visits with the help of telemedicine, pregnancy outcomes were successful (3) Interestingly, the number of patients with GHTN was increased in January and February of 2020 compared with January and February of 2019. (4) Psychological issues were increased in 2020, and intervention was required and helpful, especially during this critical period.

Respiratory viruses, such as H5N1 viruses, are transmitted via maternal vertical transmission,[9] while possible vertical transmission of human coronavirus was hypothesized in a pilot study.[10] However, there is no evidence supporting vertical transmission of severe acute respiratory syndrome coronavirus and Middle East respiratory syndrome coronavirus. During the COVID-19 epidemic, two cases of confirmed neonatal infection were reported.[11] One case was diagnosed at 17 days of life and had a history of close contact with the mother and babysitter who were COVID-19-positive. However, another neonate was separated temporarily from the infected mother and tested positive for COVID-19 infection 36 hours following delivery This prompted questions about whether the virus could spread by vertical transmission.[12] Liu et al.[13] identified 13 pregnant patients with COVID-19 who were admitted to hospitals outside of Wuhan and Chen et al.[14] reported nine of these patients in a hospital in Wuhan. Amniotic fluid, cord blood, and neonatal throat swab samples of these patients tested negative for COVID-19. Although preliminary evidence from these small groups of cases suggest that COVID-19 cannot be vertically transmitted, further studies with large samples are required to validate these findings. Tests of amniotic fluid, cord blood, neonatal throat swabs, as well as breastmilk samples, of suspected and confirmed COVID-19 should always be requested.

In a Wuhan Hospital, up to 29% of hospital-associated infection of COVID-19 among medical professionals was documented.[15] Preventing hospital-acquired infection is important during this critical period. Our finding of no hospital-acquired infection suggested the effectiveness of our policies in volume control and prevention of the virus. Furthermore, we rearranged workflow for hospitalization and surgery after preliminary COVID-19 screening. One principle that we followed was isolated management of any suspected patients and newborns with COVID-19. One of our patients who had close contact with a patient with COVID-19 and her newborn was successfully managed. Therefore, we highly recommended interim strategies in volume control, workflow rearrangement, and screening.

Despite the restriction, essential medical services were still offered and guaranteed in our department during the COVID-19 epidemic. Our physicians operated telemedical platforms, individual operation and delivery rooms were fully prepared with ventilation system, and personal protective equipment was available in case of an emergency. With the help of 5G wireless technology and communication, online clinics and remote consultation have rapidly developed in China. These techniques have provided an important supplement to facilitate medical services during the COVID-19 epidemic. Non-emergency patients were recommended to make an online appointment and consult with our obstetricians with image transmission without compression, which facilitated the accuracy in diagnosis and advice as required. Psychological

evaluation and intervention were also provided by Apps on mobiles and questionnaires. These strategies definitely improved care of the patients, at least through available physician–patient communication, and their application in medical practice in such a scenario might be helpful.

Generally, pregnancy outcomes, including maternal and neonatal outcomes, during the 2020 epidemic were the same as those in 2019. We found that the prevalence of GHTN in the COVID-19 epidemic was increased compared with that in the beginning of 2019. Indeed, hypertension and diabetes are the most common comorbidities occurring in pregnant populations. The association and effects of mental status on GHTN and pre-eclampsia have been reported in the literature.[16–18] Psychological stress and depression during this period may play a role in pregnant women's health. Therefore, psychological monitoring and intervention in such a public health situation are important.

We were aware of the elevation in concern among our patients. According to the questionnaires, 38.10% of our patients suffered from mild to severe depression and 28.57% of them showed anxiety. These rates are much higher than the reported 15% to 23% under non-epidemic situations.[19] Although, our study was a single time-point comparison without further follow-ups, the importance of mental well-being of pregnant women and their pregnancy outcomes have already been documented.[8] Therefore, online education and consultation, including updates of COVID-19 information to relieve stress due to a lack of knowledge, advice, and mentoring patients during a pandemic, as well as professional psychological support, should be emphasized in obstetric management. A long-term study specifically focusing on the effect of COVID-19 on mental health among the maternal population is urgently required for the public and healthcare providers.

Conclusions

Our current management strategies were effective in preventing hospital-acquired infection of COVID-19 and ensuring the safety of pregnant women physically and mentally at the same time. Our findings might provide useful information for preparing a hospital protocol in most similar scenarios outside our medical center.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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