Maternal and neonatal outcomes of pregnant patients with COVID-19: A prospective cohort study

Masoumeh Abedzadeh-Kalahroudi1 | Mojtaba Sehat2 | Zahra Vahedpour3 | Parisa Talebian4

Abstract
Objective: To determine the maternal and neonatal outcomes of pregnant women with COVID-19 infection.
Methods: A cohort study was conducted on 56 pregnant women with COVID-19 and 94 healthy pregnant women during the COVID-19 epidemic in Iran. Two groups were followed until childbirth. Demographic and obstetric information, clinical symptoms, laboratory and radiographic findings of the patients, and maternal and neonatal outcomes of the two groups were gathered by a checklist. Data were analyzed using SPSS version 16. A P value < 0.05 was considered significant.
Results: The two groups were similar in terms of maternal age, gravida, parity, and co-morbidities (P > 0.05). The rate of cesarean delivery in the exposed group was higher than that in the control group (P = 0.027; relative risk [RR] =2.23). Pre-eclampsia was seen in 19.8% of the exposed group and 7.4% of the control group (P = 0.037; RR = 2.68). The rate of preterm labor in the exposed group was higher than that in the control group (P = 0.003; RR = 2.70). Fetal distress was seen in 16.1% of the exposed group and 4.3% of the control group (P = 0.016; RR = 3.84).
Conclusion: Pregnant women with COVID-19 had an increased risk of pre-eclampsia, preterm labor, and cesarean delivery. Their fetal and neonatal outcomes were fetal distress, newborn prematurity, and low Apgar score.

Keywords
COVID-19, maternal, neonatal, outcome, pregnancy

1 INTRODUCTION

In late 2019, a new mutation of the coronavirus caused a severe respiratory disease that became known as COVID-19. Currently, this disease is a major global health problem. It is estimated that the incidence of COVID-19 in pregnant women is 1 per 200 births and the maternal mortality rate is 1 per 18 000 deliveries. Pregnancy is associated with immunosuppressive conditions. It makes pregnant women more susceptible to infectious diseases. In addition, it is possible to vertically transmit the infection from mother to fetus and causes significant infections in the fetus and newborn. Previous studies have shown that the risk of progression of viral infections such as severe acute respiratory syndrome, Middle East respiratory syndrome, and influenza is higher in pregnant women, and catching these viruses during pregnancy can lead to undesirable clinical and prenatal outcomes such as abortion, stillbirth, preterm labor, fetal distress, intrauterine growth restriction, admission to the intensive care unit (ICU), and disseminated intravascular coagulopathy. Therefore, it seems that due to immunological, physiological, and anatomical changes during pregnancy, pregnant women are more susceptible to COVID-19 infection.
women are at higher risk of COVID-19 complications and mortality. On the other hand, due to the lack of sufficient information about COVID-19 during pregnancy, all pregnant women suspected of having COVID-19 infection should be widely screened and, if confirmed, both mother and fetus should be followed up.

There is some evidence that the risk of acute infections may be higher in the late stages of pregnancy. Studies conducted during the COVID-19 pandemic showed that the majority of cases occurred during the third trimester and most women underwent cesarean delivery due to obstetric indications. Fetal distress has also been noted in several studies.

A study of 10 newborns of pregnant women with COVID-19 showed that the complications of infection in newborns were significant and included preterm labor, thrombocytopenia due to liver dysfunction, fetal distress, and respiratory distress. However, several studies reported that most of the newborns were asymptomatic and small numbers needed intensive care. In some of the newborns, the infection was transmitted. Therefore, the issue of vertical transmission remains unclear.

Most studies on the effects of COVID-19 on pregnant mothers and their newborns were conducted as a case report or retrospectively on the information of the small number of pregnant women or infants, and cohort studies on the pregnancy outcomes are limited. In one study, 675 pregnant women were assessed in New York City and it was found that 70 pregnant women were positive for COVID-19. The findings of that study showed a significant difference between the age of patients and healthy women. There was no difference between the two groups in terms of gravidity and parity. However, a significant difference was observed in co-morbid diseases such as diabetes, chronic hypertension, and body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters) >30. Obstetric outcomes such as cesarean delivery and postpartum fever in patients with COVID-19 were different from those in healthy women, but there was no significant difference between the two groups in preterm labor and neonatal outcomes, including birth weight, Apgar score, and admission to the neonatal ICU (NICU).

In another study conducted as a historical cohort in London (UKOSS) 427 pregnant women with COVID-19 were compared to 694 healthy pregnant women. It was found that the majority of women had been infected in the third trimester of pregnancy. Co-morbidities, obesity, black race, or minor ethnicities were the risk factors for COVID-19 in pregnant women. The risk of preterm labor, mother’s need for intensive care, and admission in the NICU were significantly different between the two groups. The rate of cesarean delivery in the COVID-19 group was 59% versus 29% in the control group. Five neonatal deaths and five maternal deaths were observed in the COVID-19 group. The results of a PCR test in 5% of newborns were positive.

According to the above issues, there is insufficient evidence of the clinical characteristics and complications of COVID-19 during pregnancy and childbirth. Identifying the consequences of COVID-19 infection in pregnant women compared with non-pregnant women and evaluating its effect on pregnancy and neonatal health is very important. Therefore, the aim of the present cohort study was to determine the maternal and neonatal outcomes of pregnant women with COVID-19 in Kashan, Iran.

2 MATERIALS AND METHODS

The present study was conducted on 150 pregnant women during the period of the COVID-19 pandemic from March to November 2020. The exposed group were pregnant women with COVID-19 infection admitted to Referral Hospital of Kashan University of Medical Sciences (Shahid Beheshti Hospital), and the non-exposed group were pregnant women who were referred to the midwifery clinics to receive prenatal care. In the exposed group, the diagnostic criteria were quantitative reverse transcriptase polymerase chain reaction (qRT-PCR) assay, which was prepared from sputum or pharyngeal samples of mothers and/or based on clinical manifestations, laboratory findings, and positive findings on chest computed tomography (CT) scan. Laboratory values were considered based on the pregnancy trimester according to the values provided in the reference books. The PCR test was not performed in the healthy pregnant women, but if they were suspected of having COVID-19 and had the clinical symptoms or a history of contact with a patient with COVID-19, the test would have been carried out to ensure their health. The two groups were followed up until the end of the pregnancy and their outcomes were recorded.

2.1 Measurements

In the present study, data were collected according to a checklist consisting of four parts:

1. Demographic and obstetric information of patients including maternal age, gestational age, gravidity, parity, and maternal BMI.
2. Information on COVID-19 including clinical symptoms, laboratory, and radiographic findings of patients.
3. Maternal and fetal outcomes including abortion, preterm labor, premature rupture of membranes (PROM), pre-eclampsia, type of delivery, oligohydramnios, vaginal bleeding, meconium excretion in amniotic fluid, fetal distress, intrauterine fetal death, and intrauterine fetal growth retardation.
4. Neonatal outcomes including low Apgar score, asphyxia, low birth weight, neonatal death, and admission to the NICU.

2.2 Analysis of data

Data were analyzed by SPSS software version 16 (SPSS Inc., Chicago, IL, USA). The mean, standard deviation (SD), and percentage indices were calculated. The incidence rate of different outcomes was calculated and compared between the two groups. Other comparisons were performed between the two groups using the $\chi^2$ and Student t-test according to the variable type. A P value < 0.05 was considered significant.
2.3 Ethical considerations

The present study was approved by the Ethics Committee of Kashan University of Medical Sciences with the ethics code of IRKAUMSREC.1399.002. The confidentiality of the information and the lack of adding financial and pharmaceutical costs to the patients were explained. Verbal informed consent was obtained from all participants.

3 RESULTS

During the study period, 56 pregnant women with COVID-19 and 94 healthy pregnant women were assessed and followed up. Two groups were matched in terms of gestational age at the time of entering the study.

3.1 Clinical and laboratory manifestations of COVID-19

The mean maternal age in the exposed group (women with COVID-19) was 31.6 ± 6.1 years (range 19–44 years), the mean gestational age at admission was 31.9 ± 8.22 weeks (range 7–41 weeks). The mean gestational age at delivery was 37.1 ± 3.1 weeks (range 28–41 weeks). The most common symptoms in pregnant women were fever (n = 50, 89.3%), cough (n = 22, 39.3%), and dyspnea (n = 18, 32.1%). The following symptoms were also seen: lymphopenia (n = 35, 62.5%); elevated C-reactive protein (CRP; n = 54, 96.4%); elevated LDH (n = 27, 48.2%); leukopenia (n = 5, 8.9%); anemia (n = 12, 21.4%); and an increased level of liver enzymes (n = 8, 14.2%) (Table 1).

The results of the chest CT scan in 45 (80.4%) patients were in accordance with COVID-19 infection. About two-thirds of the patients were treated with antibiotics and 35.7% with antibiotics and antiviral drugs. O₂ saturation was less than 93% in 35 patients, all of whom underwent oxygen therapy. The duration of hospitalization was 6.80 ± 8.32 days (range 1–48 days).

Six mothers were transferred to the ICU due to deterioration of the disease, of which four mothers underwent mechanical ventilation. Pregnancy was terminated by cesarean delivery at 28 weeks in one patient due to her condition. Other patients were discharged from the ICU and transferred to the ward with a good general condition. In the present study, there were no cases of maternal death. However, a spontaneous abortion was seen in a 40-year-old patient of G4 P3 with no history of abortion.

In the exposed group, 9 (16.4%) neonates were admitted to the NICU, of which eight were transferred to the NICU due to prematurity and one due to low Apgar score. Neonatal death was seen in 2 (16.6%) cases. The first case was a boy who had been born through vaginal delivery from a 31-year-old mother (G4 P1) with labor pains at 31 weeks of gestation. He had a 1-minute Apgar score of 8 and a 5-minute score of 10. However, after delivery, the baby developed sepsis, renal failure, disseminated intravascular coagulopathy, and finally died. The second case was a girl, born through cesarean delivery due to labor arrest and fetal distress at 36 weeks of gestation from a 27-year-old mother (G4 P1) with a 1-minute Apgar score of zero. She died after unsuccessful resuscitation.

In two neonates, the results of the qRT-PCR test 12–24 hours after birth were positive. The other newborns were discharged in good general condition.

3.2 Maternal and neonatal characteristics

The two groups were not different in terms of maternal age, gravida, parity, and co-morbidities such as diabetes, chronic hypertension, and hypothyroidism (P > 0.05).
The mean gestational age at delivery in the exposed and control groups were 37.1 ± 3.1 and 38.2 ± 1.35 weeks, respectively, and there was a significant difference between the two groups (£P = 0.005).

The rate of cesarean section was 67.3% in the exposed group and 47.9% in the control group with a statistically significant difference between the two groups (£P = 0.027, relative risk [RR] =1.40).

The findings showed no difference between the two groups in terms of birth height, birth weight, and sex of the neonates (£P > 0.05) (Table 2).

### 3.3 Maternal and neonatal outcomes

Table 2 shows that 32 (57.1%) women in the exposed group and 29 (30.9%) in the control group had poor maternal outcomes, and the difference between the two groups were significant (£P < 0.0001; RR = 2.42).

Pre-eclampsia was seen in 11 (19.8%) women in the exposed group and 7 (7.4%) in the control group, and the difference between the two groups were significant (£P = 0.037; RR = 2.68) (Table 3).

The rate of preterm labor was 34.5% in the exposed group and 12.8% in the control group, and the difference between the two

| TABLE 2 | Comparison of the characteristics of mothers and their newborns in the two groupsa |
|---------------------------------|---------------------------------|----------------|----------------|----------------|----------------|
| Characteristics                | Groups                           | P value | RR (95% CI) |
|--------------------------------|----------------------------------|---------|-------------|
| Maternal age (years)           | Healthy mothers                  |         |             |
| <20                            | 3 (3.2)                          | 0.085   | –           |
| 20–34                          | 73 (77.7)                        |         |             |
| ≤35                            | 18 (19.1)                        |         |             |
| Parity                         | Primipara                        | 0.131   | 0.85 (0.68–1.05) |
|                               | Multipara                        |         |             |
|                               | 73 (77.7)                        |         |             |
| Co-morbidity                   | Diabetes                         | 0.361   | 0.71 (0.35–1.45) |
|                               | Hypertension                      | 1       | 0.91 (0.35–2.33) |
|                               | Hypothyroidy                     | 1       | 0.97 (0.49–1.88) |
| BMI (kg/m²)                    | Normal                            | 0.001   | –           |
|                               | Overweight                       |         |             |
|                               | Obese                             |         |             |
| Type of delivery               | Vaginal                           | 0.027   | 1.40 (1.06–1.85) |
|                               | Cesarean delivery                |         |             |
| Neonate sex                    | Female                            | 1       | –           |
|                               | Male                              |         |             |
| Gestational age at childbirth (weeks) |                     | 0.003   | 2.70 (1.42–5.14) |
| <37                            | 12 (12.8)                        |         |             |
| >37                            | 82 (87.2)                        |         |             |
| Undesirable outcomes           | No                                | <0.0001 | 2.42 (1.63–3.58) |
|                               | Yes                               |         |             |
| Birth weight (g)b              | 2942 (679)                       | 0.181   | –           |
| Birth height (cm)b             | 49.2 (4.2)                       | 0.948   | –           |
| Gestational age at deliveryb (weeks) |                  | 0.005   | –           |
|                               | 37.1 (3.1)                       |         |             |
| Gravida b                      | 2.48 (1.5)                       | 0.699   | –           |

Abbreviations: BMI, body mass index; CI, confidence interval; RR, relative risk.

aValues are given as number (percentage).

bValues are given as mean (SD).
groups was significant ($P = 0.003; RR = 2.70$). Fetal distress was seen in 9 (16.1%) women in exposed group and 4 (4.3%) in the control group, and this difference was significant ($P = 0.016; RR = 3.84$).

The two groups were not significantly different in terms of PROM, low birth weight, admission to the NICU, and neonatal death ($P > 0.05$).

An Apgar score less than 7 was more frequent in the exposed group ($P = 0.025; RR = 25.4$).

### 4 | DISCUSSION

The findings of the present study are similar to those in several previous reports about patients with COVID-19 who had suffered from fever and cough as the most common symptoms at the time of admission. In addition, common laboratory findings were lymphopenia and elevated CRP, which was similar to other studies.

The chest CT scan had positive findings consistent with COVID-19 in 80.4% of patients, which is similar to previous reports. This finding suggests that radiological studies can be useful to identify patients who are clinically suspected of COVID-19 infection. Timely treatment of these patients leads to proper control of the disease and prevention of its related serious complications.

In total, 78.6% of patients were infected in the third trimester of pregnancy. This finding is consistent with the results of other studies and supports the need for continuing health protocols until the end of pregnancy.

Approximately 10% of hospitalized pregnant women needed respiratory support. This is lower than the results of one study in the UK, in which 17.3% of mothers were admitted to the ICU, similar to the reported rate in the general population with COVID-19, as well as to the findings of the UKOSS study.

Fortunately, there were no cases of maternal death in the present study, as in several other studies in the United States, Turkey, and China, although five maternal deaths were reported in the UKOSS study.

The results showed that the risk of cesarean delivery in the exposed group was 2.23 times higher than in the control group. This finding is similar to other studies. Although the rate of cesarean delivery in the present study is higher than in other studies, the cause of these cesarean deliveries was obstetric problems rather than COVID-19, while in several studies more than 50% of the cesarean deliveries were due to COVID-19 pneumonia. Of course,

### TABLE 3 Comparison of maternal, fetal, and neonatal outcomes in the two groups

| Maternal and neonatal outcomes | Groups | Healthy mothers | Patients with COVID-19 | $P$ value | RR (95% CI) |
|-------------------------------|--------|-----------------|-----------------------|-----------|-------------|
| Pre-eclampsia                 | No     | 87 (65.9)       | 44 (34.1)             | 0.037     | 2.68 (1.10–6.52) |
|                               | Yes    | 7 (7.4)         | 11 (19.8)             |           |             |
| Preterm                       | No     | 82 (87.2)       | 36 (65.5)             | 0.003     | 2.70 (1.42–5.14) |
|                               | Yes    | 12 (12.8)       | 19 (34.5)             |           |             |
| PROM                          | No     | 85 (90.4)       | 53 (94.6)             | 0.632     | 0.75 (0.24–2.35) |
|                               | Yes    | 9 (9.6)         | 4 (7.3)               |           |             |
| Fetal distress                | No     | 90 (95.7)       | 46 (83.6)             | 0.016     | 3.84 (1.24–11.90) |
|                               | Yes    | 4 (4.3)         | 9 (16.1)              |           |             |
| Fetal or neonatal death       | No     | 94 (100)        | 53 (96.4)             | 0.165     | 8.48 (0.41–173.53) |
|                               | Yes    | 0 (0)           | 2 (3.6)               |           |             |
| Admission to NICU             | No     | 74 (78.8)       | 46 (83.6)             | 0.470     | 0.76 (0.37–1.56) |
|                               | Yes    | 20 (21.3)       | 9 (16.4)              |           |             |
| LBW                           | No     | 80 (85.1)       | 44 (80)               | 0.497     | 1.34 (0.65–2.74) |
|                               | Yes    | 14 (14.9)       | 11 (20)               |           |             |

Abbreviations: CI, confidence interval; LBW, low birth weight; NICU, neonatal intensive care unit; PROM, premature rupture of membranes; RR, relative risk.

*Values are given as number (percentage).
early onset of labor and termination of early pregnancy in women with a previous cesarean delivery can be related to stress induced by COVID-19. However, further studies are needed to determine what factors may increase the rate of cesarean delivery in patients with COVID-19.

The risk of adverse maternal outcomes in the exposed group was 2.42 times higher than in the control group. In the New York study,\textsuperscript{17} this difference had not been observed, and the maternal outcomes pointed to the greater vulnerability of mothers with COVID-19 during the postpartum period. Recently, in two meta-analyses, it was found that women with COVID-19 experience adverse pregnancy outcomes,\textsuperscript{25,26} but a systematic review of 33 articles concluded that COVID-19 is not associated with undesirable maternal and neonatal outcomes.\textsuperscript{29} However, this finding has been obtained from case reports and case series that may not be of good quality.

The risk of pre-eclampsia in the exposed group was 2.68 times higher than in the control group, and there was a significant difference between the two groups. Neither of the two cohort studies, investigated the risk of pre-eclampsia, and therefore there is no possibility of comparison. In some case reports and review articles, pre-eclampsia has been reported as one of the most common outcomes in mothers with COVID-19.\textsuperscript{22,25} In several other studies, the rate of pre-eclampsia was almost the same as in healthy pregnant women.\textsuperscript{2,21} However, it is known that during pregnancy, ACE2 plays an important role in regulating arterial blood pressure, and infection caused by COVID-19 can change the expression of ACE2, cause vascular contractions, and induce pre-eclampsia.\textsuperscript{27,28}

The risk of preterm labor in the exposed group was 2.70 times higher than in the control group. The rate of preterm labor in the general population is in the range of 5%-8%. The higher rate of preterm labor in these mothers can be due to the deterioration of the mother’s condition, and the need for preterm delivery or spontaneous delivery after PROM.\textsuperscript{29} It is not clear if COVID-19 infection is a direct cause of preterm labor. Viral infections in pregnancy can induce abnormal responses to opportunistic bacterial infections and may lead to preterm labor and delivery.\textsuperscript{30} This finding is similar to that of the UKOSS study, in which preterm labor was more common in women with COVID-19.\textsuperscript{3} However, in one study, there was no difference between patients with COVID-19 and healthy mothers in terms of preterm labor.\textsuperscript{17} In other case reports and review studies, a large number of patients experienced preterm labor, but due to the lack of a control group, this finding could not be judged,\textsuperscript{2,11,12,19,21,22} and the present study can confirm the results of these studies.

The risk of fetal distress in the exposed group was 3.84 times higher than in the control group. Fetal distress has been reported as one of the consequences of COVID-19 in the case reports and review articles.\textsuperscript{2,20,21} Its cause is not clear, but it may be due to preterm labor or PROM. Therefore, during the acute period of the disease, fetal monitoring is recommended for the early detection of these cases.

The risk of a neonatal Apgar score of 7 or less in the exposed group was 25.4 higher than in the control group, which could be due to higher fetal distress, preterm labor, and prematurity in the group with COVID-19. In one study, there was no difference in the Apgar score of neonates\textsuperscript{27}; however, another study reported a low Apgar score in neonates.\textsuperscript{24} According to the population-based data, it was found that in women with other viral pneumonia, the risk of an Apgar score of 7 or less increases.\textsuperscript{31}

There was no significant difference between the two groups in terms of low birth weight. Meta-analysis studies also showed that if COVID-19 occurs at the end of pregnancy, it does not affect the weight of the newborn.\textsuperscript{32} However, if an infection develops early in the pregnancy or in the chronic hypoxia condition, assessment of fetal growth and development are recommended.\textsuperscript{33}

The rate of admission to the NICU was not significantly different between the two groups, which is consistent with the findings of one study;\textsuperscript{17} however, in the UKOSS study, the rate of admission to the NICU in the COVID-19 group was higher than in the control group.\textsuperscript{3} However, the criteria for admission to the NICU are different among hospitals and resulted in differences in the studies’ findings. It seems that the majority of admissions to the NICU have been performed for the accurate monitoring of status in premature newborns or for isolating newborns from their mothers to prevent transmission of the infection.

The present study has one case of neonatal death and one case of stillbirth. It cannot be determined whether these deaths are related to COVID-19 infection. In several studies, neonatal deaths and stillbirths have been reported, but researchers were not sure if the deaths were related to the disease.\textsuperscript{3,13,21} However, it seems that the risk of maternal and neonatal mortality from this disease is very low.\textsuperscript{32}

In general, the discrepancy in some findings can be due to differences in the course of the disease, symptoms, and severity of the disease, as well as differences in the immune system of the mother and newborn. The immune system response of pregnant women is complex and varies based on gestational age, immune response, duration and severity of infection, and maternal and neonatal consequences of COVID-19.

In the present study, some patients were diagnosed based on chest CT scan, laboratory, and clinical findings. In critical situations during the COVID-19 pandemic, this issue might be acceptable because it is not possible to wait for the qRT-PCR test results for a definitive diagnosis.

The present study is the first cohort study about COVID-19 in pregnant women in Iran, and women who had been diagnosed based on clinical and laboratory findings were enrolled in this cohort. According to the definition by WHO, these cases are classified as suspected cases of COVID-19 and it seems that providing these cases can be useful.

The present study had some limitations. The first limitation was that sampling of the vaginal discharge, amniotic fluid, and placenta was not performed to investigate COVID-19. It is necessary to consider these issues in further studies. The second limitation was that it was not possible to investigate the early pregnancy outcomes such as abortion because the majority of mothers were infected at the end of the second or third trimester of pregnancy.
5 | CONCLUSION

The clinical and laboratory manifestations and radiographic criteria in pregnant women with COVID-19 are similar to those in the general population. The common maternal outcomes in pregnant women with COVID-19 were increased risk of pre-eclampsia, preterm labor, and cesarean delivery. In addition, their fetal and neonatal outcomes were fetal distress, newborn prematurity, and low Apgar score.

ACKNOWLEDGMENTS

This study was derived from the research project (Grant No. 99034) and approved by the Ethics Committee of Kashan University of Medical Sciences with the code of ethics IRKAUMSREC.1399.002. We express our thanks to the deputy of research in Kashan University of Medical Sciences and the midwives and clinicians at the delivery ward of Shahid Beheshti and Shabihkhani Hospitals for their cooperation.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

AUTHOR CONTRIBUTIONS

MAK, MS, and ZV performed the literature review, study design, and manuscript writing. MAK and ZV supervised the research project. MAK, PT, and ZV performed the data collection. MAK and MS analyzed and interpreted the patient data and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

REFERENCES

1. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. The Lancet. 2019;2020(395):497-506.
2. Sahin D, Tanacan A, Erol SA, et al. A pandemic center’s experience of managing pregnant women with COVID-19 infection in Turkey: a prospective cohort study. Int J Gynaecol Obstetr. 2020;151(1):74-82.
3. Knight M, Bunch K, Vousden N, et al. Characteristics and outcomes of pregnant women admitted to hospital with confirmed SARS-CoV-2 infection in the UK: national population based cohort study. BMJ. 2020;369:m2107.
4. Fan C, Lei D, Fang C, et al. Perinatal transmission of COVID-19 associated SARS-CoV-2: should we worry? Clin Infect Dis. 2020; https://doi.org/10.1093/cid/ciaa226.
5. Rasmussen SA, Smulian JC, Lednicky JA, Wen TS, Jamieson DJ. Coronavirus Disease 2019 (COVID-19) and pregnancy: what obstetricians need to know. Am J Obstet Gynecol. 2020;222(5):415-426.
6. Wang X, Zhou Z, Zhang J, Zhu F, Tang Y, Shen X. A case of 2019 novel coronavirus in a pregnant woman with preterm delivery. Clin Infect Dis. 2020;71(15):844-846.
7. Zaiqham M, Andersson O. Maternal and perinatal outcomes with COVID-19: a systematic review of 108 pregnancies. Acta Obstet Gynecol Scand. 2020;97(10):823-829.
8. Mardani M, Pourkahv B. A controversial debate: vertical transmission of COVID-19 in pregnancy. Arch Clin Infect Dis. 2020;15(1):e102286.
9. Alfaraj SH, Al-Tawfiq JA, Memish ZA. Middle East Respiratory Syndrome Coronavirus (MERS-CoV) infection during pregnancy: report of two cases & review of the literature. J Microbial Immunol Infect. 2019;52(3):501-503.
10. Mullins E, Evans D, Viner RM, O’Brien P, Morris E. Coronavirus in pregnancy and delivery: rapid review. Ultrasound Obstet Gynecol. 2020;55(5):586-592.
11. Breslin N, Baptiste C, Gyamfi-Bannerman C, et al. Coronavirus disease 2019 infection among asymptomatic and symptomatic pregnant women: two weeks of confirmed presentations to an affiliated pair of New York City hospitals. Am J Obstetr Gynecol MFM. 2020;2(2, Suppl):100118.
12. Chen H, Guo J, Wang C, et al. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. Lancet. 2020;395(10226):809-815.
13. Zhu H, Wang L, Fang C, et al. Clinical analysis of 10 neonates born to mothers with 2019-nCoV pneumonia. Transl Pediatr. 2020;9(1):51-60.
14. Dong L, Tian J, He S, et al. Possible vertical transmission of SARS-CoV-2 from an infected mother to her newborn. JAMA. 2020;323(18):1846-1848.
15. Yu N, Li W, Kang Q, et al. Clinical features and obstetric and neonatal outcomes of pregnant patients with COVID-19 in Wuhan, China: a retrospective, single-centre, descriptive study. Lancet Infect Dis. 2020;20(5):559-564.
16. Zeng H, Xu C, Fan J, et al. Antibodies in infants born to mothers with COVID-19 pneumonia. JAMA. 2020;323(18):1848-1849.
17. Prabhu M, Cagino K, Matthews K, et al. Pregnancy and postpartum outcomes in a universally tested population for SARS-CoV-2 in New York City: a prospective cohort study. BJOG. 2020;127(12):1548-1556.
18. Cunningham F, Leveno K, Bloom S, et al. Williams Obstetrics: 25th Edition: New York, NY: McGraw-Hill Education; 2018.
19. Elshafeey F, Magdi R, Hindi N, et al. A systematic scoping review of COVID-19 during pregnancy and childbirth. Int J Gynecol Obstetr. 2020;150(1):47-52.
20. Liu Y, Chen H, Tang K, Guo Y. Clinical manifestations and outcome of SARS-CoV-2 infection during pregnancy. J Infect. 2020. https://doi.org/10.1016/j.jinf.2020.02.028.
21. Yan J, Guo J, Fan C, et al. Coronavirus disease 2019 in pregnant women: a report based on 116 cases. Am J Obstet Gynecol. 2020;223(1):e1-111.e14.
22. Antoun L, Taweel NE, Ahmed I, Patni S, Honest H. Maternal COVID-19 infection, clinical characteristics, pregnancy, and neonatal outcome: a prospective cohort study. Eur J Obstet Gynecol Reprod Biol. 2020;252:559-562.
23. Phua J, Weng L, Ling L, et al. Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations. The Lancet Respir Med. 2020;8(5):506-517.
24. Ferrazzi E, Frigerio L, Savasi V, et al. Vaginal delivery in SARS-CoV-2-infected pregnant women in Northern Italy: a retrospective analysis. BJOG. 2020;127(9):1116-1121.
25. Di Mascio D, Khalil A, Saccone G, et al. Outcome of coronavirus spectrum infections (SARS, MERS, COVID-19) during pregnancy: a systematic review and meta-analysis. Am J Obstet Gynecol MFM. 2020;2(2):100107.
26. Kasraei M, Zare M, Vafaee H, et al. COVID-19 pneumonia and pregnancy; a systematic review and meta-analysis. J Mater-Fetal Neonat Med. 2020;1-8. https://doi.org/10.1080/14760580.2017.163952.
27. Ahmed I, Eltaweel N, Antoun L, Rehal A. Severe pre-eclampsia complicated by acute fatty liver disease of pregnancy, HELLP syndrome and acute kidney injury following SARS-CoV-2 infection. BMJ Case Rep. 2020;13(8):e237521.
28. Yan R, Zhang Y, Li Y, Xia L, Guo Y, Zhou Q. Structural basis for the recognition of SARS-CoV-2 by full-length human ACE2. Science. 2020;367(6485):1444-1448.
29. Blencowe H, Cousens S, Oestergaard MZ, et al. National, regional, and worldwide estimates of preterm birth rates in
the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. The Lancet. 2012;379(9832):2162-2172.

30. Mendz G, Kaakoush N, Quinlivan J. Bacterial aetiological agents of intra-amniotic infections and preterm birth in pregnant women. Front Cell Infect Microbiol. 2013;3(58); https://doi.org/10.3389/fcimb.2013.00058

31. Chen Y-H, Keller J, Wang IT, Lin C-C, Lin H-C. Pneumonia and pregnancy outcomes: a nationwide population-based study. Am J Obstet Gynecol. 2012;207(4):288.e1-288.e7.

32. Di Toro F, Gjoka M, Di Lorenzo G, et al. Impact of COVID-19 on maternal and neonatal outcomes: a systematic review and meta-analysis. Clin Microbiol Infect. 2021;27(1):36-46.

33. Poon LC, Yang H, Kapur A, et al. Global interim guidance on coronavirus disease 2019 (COVID-19) during pregnancy and puerperium from FIGO and allied partners: information for healthcare professionals. Int J Gynecol Obstetr. 2020;149(3):273-286.