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Obstetrical outcomes and follow-up for patients with asymptomatic COVID-19 at delivery: A multicenter prospective cohort study

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Condensation: The majority of pregnant patients with COVID-19 on hospital admission are asymptomatic, have good maternal and obstetrical outcomes, and rarely go on to develop clinically significant disease after discharge.

Short Title: Asymptomatic COVID-19 in pregnancy

AJOG at a Glance

1. Why was the study conducted?

   This study was conducted to determine the clinical course of asymptomatic parturients with coronavirus disease 2019 (COVID-19) and track their outcomes after discharge.

2. What are the key findings?

   In this multicenter prospective cohort study, the majority of pregnant patients who tested positive for COVID-19 during their delivery admissions were asymptomatic. Compared to pregnant patients who tested negative for COVID-19, these asymptomatic patients were not at increased risk for adverse maternal and neonatal outcomes. Postpartum follow-up via telephone surveys revealed that these patients remained asymptomatic and had low rates of family contacts acquiring the disease, but their adherence to social distancing guidelines waned in the two weeks postpartum. Review of inpatient and emergency department records revealed that these patients had low rates of hospital readmission.

3. What does this study add to what is already known?

   This study demonstrated that the majority of pregnant patients who screened positive for COVID-19 are asymptomatic and do not go on to develop clinically significant disease after delivery. These patients do not appear to be at increased risk for decompensation in the postpartum period, suggesting that routine postpartum surveillance is appropriate.

Abstract

Background: Universal testing for coronavirus disease (COVID-19) on labor and delivery identifies asymptomatic patients. Whether or not these patients are at increased risk for adverse outcomes and go on to develop clinically significant disease is uncertain.

Objective: To assess the prevalence of asymptomatic COVID-19 among pregnant patients admitted for delivery and to determine if these patients become symptomatic or require hospital readmission after discharge.

Methods: We performed a multicenter prospective cohort study of pregnant patients between $20^{0/7}$ and $41^{6/7}$ weeks gestation who were found to have COVID-19 based on universal screening on delivery admission at four medical centers in New Jersey (exposed group). The unexposed group comprised of patients who tested negative for COVID-19 were identified from the primary study site. The primary outcomes were the asymptomatic positive COVID-19 rate and the development of symptoms in the asymptomatic positive patients and hospital readmission in the two weeks following discharge. We compared the frequency distribution of risk factors and outcomes in relation to COVID-19 status, with COVID-19 positive patients across all centers and COVID-19 negative patients at the primary site. Associations for categorical risk factors with respect to COVID-19 status were expressed as relative risks (RR) with 95% confidence intervals (CI).

Results: Between 10 April 2020 to 15 June 2020, there were 218 COVID-19 positive patients from the four sites and 413 COVID-19 negative patients from the primary site. The majority (188 [83.2%]) of COVID-19 positive patients were asymptomatic. Compared to negative controls, these asymptomatic patients were not at increased risk for obstetric complications

that may increase the risk for COVID-19, including gestational diabetes (8.2% versus 11.4%, RR 0.72, 95% CI 0.24-2.01) and gestational hypertension (6.1% versus 7.0%, RR 0.88, 95% CI 0.29-2.67). Postpartum follow-up via telephone surveys revealed that these patients remained asymptomatic and had low rates of family contacts acquiring the disease, but their adherence with social distancing guidelines waned during the two weeks postpartum. Review of inpatient and emergency department records revealed low rates of hospital readmission.

Conclusions: The majority of pregnant patients who screened positive for COVID-19 are asymptomatic and do not go on to develop clinically significant infection after delivery. Routine surveillance of these patients after hospital discharge appears sufficient.

Key words

COVID-19; SARS-CoV-2; Pregnancy; Asymptomatic disease; Multicenter prospective cohort study

Introduction

Pregnancy is a risk factor for severe coronavirus disease 2019 (COVID-19) (1-3), but a significant percentage of obstetrical patients who test positive are asymptomatic (4). In one hospital system that performed universal COVID-19 testing on admission (22 March to 4 April 2020), 87.9% of patients who tested positive were asymptomatic (5). In another institution, the rate was 54.1% (6). Although lower asymptomatic carrier rates have been reported in some areas (7), these patients can spread COVID-19, contributing to the difficulty encountered in containing the disease (8, 9). Some of these positive patients may actually be pre-symptomatic (10) and develop clinically significant disease after hospital discharge.

The follow-up strategy for asymptomatic patients with COVID-19 should contain the disease and monitor for development of symptoms. Various follow-up strategies exist for patients who have recovered from symptomatic disease, ranging from self-imposed quarantine to repeat testing (11). However, the optimal follow-up strategy for asymptomatic patients with COVID-19 is uncertain.

Currently, limited studies have evaluated the course of asymptomatic COVID-19 in pregnancy (12-14) and the majority of COVID-19 research in pregnancy has focused on severe and critical disease (15, 16). Therefore, we undertook a multicenter prospective cohort study of obstetrical patients with COVID-19 to assess the prevalence of asymptomatic disease and to determine if these patients become symptomatic or require hospital readmission after discharge. In order to achieve these objectives, we implemented a new clinical program that allowed for tracking and

monitoring of COVID-19 patients after discharge. We hypothesized that the majority of pregnant patients who are found to have COVID-19 during their delivery hospitalizations would be asymptomatic and that the risk of developing symptoms or requiring hospital readmission for COVID-19 symptoms in the first two weeks postpartum would be small.

Materials and Methods

This was a multicenter prospective cohort study of obstetrical patients with COVID-19 that was conducted within the Robert Wood Johnson Barnabas Health System in Central and Northern New Jersey from 10 April 2020 to 15 June 2020. Patient recruitment occurred at four sites: the Robert Wood Johnson University Hospital (RWJUH) in New Brunswick, Saint Barnabas Medical Center (SBMC) in Livingston, Monmouth Medical Center (MMC) in Long Branch, and Clara Maass Medical Center (CMMC) in Belleville. RWJUH, SBMC, and MMC are designated by the state as Regional Perinatal Centers, and CMMC is a community hospital with a level II neonatal intensive care unit (NICU). The Institutional Review Boards of the Rutgers Robert Wood Johnson Medical School, NJ as well as SMBC, MMC and CCMC granted ethics approval under a waiver of informed consent (IRB numbers: PRO2020000940, 20-38, 20-035, and R2020-02cmmc).

All patients that delivered between $20^{0/7}$ and $41^{6/7}$ weeks gestation at the RWJUH from 10 April 2020 through 15 June 2020 were included in the study. The start date corresponds with the initiation of universal COVID-19 testing at RWJUH. The remaining three sites contributed consecutive patients that also delivered between $20^{0/7}$ and $41^{6/7}$ weeks gestation and who tested positive for COVID-19 after initiation of universal testing at each institution (6 April 2020 at

SBMC, 13 April 2020 at CMMC, and 17 April 2020 at MMC) through 15 June 2020. Patients at these sites were not included if they tested positive prior to initiation of universal testing or if they did not deliver during the hospital admission in which testing was performed. Patients under 20 weeks were excluded from the study because these patients would not present to labor and delivery and the emergency departments at each institution were not tracking pregnant COVID-19 positive patients in the same manner.

All patients had COVID-19 testing to detect severe acute respiratory syndrome coronavirus 2 infection by nasopharyngeal swab and quantitative polymerase chain reaction. Each study site used the Cepheid Xpert Xpress rapid COVID-19 test, which has a 99.4% sensitivity, 96.8% specificity, 77% positive predictive value and 100% negative predictive value (17).

We had two primary outcomes. The first primary outcome was the asymptomatic positivity rate for COVID-19. The second primary outcome was the rate of development of self-reported COVID-19 symptoms in the asymptomatic positive patients or hospital readmission for manifestations of COVID-19 in the first two weeks after their positive test on labor and delivery.

Maternal outcomes were collected for a descriptive analysis including intensive care unit [ICU] admission, need for mechanical ventilation, need for supplemental oxygen, and death. Neonatal outcomes collected were intrauterine fetal demise, neonatal demise, neonatal respiratory distress syndrome, neonatal intraventricular hemorrhage, and necrotizing enterocolitis. Other variables collected included baseline maternal demographic and clinical

outcomes such as pregnancy complications (gestational diabetes, gestational hypertension, and preeclampsia), preterm delivery, mode of delivery (spontaneous vaginal, operative vaginal, vaginal birth after cesarean, primary cesarean, and repeat cesarean), and delivery complications (preterm labor, chorioamnionitis, venous thromboembolism, abnormal biophysical profile, and category 2 fetal heart rate tracing despite intrauterine resuscitation). These outcomes and clinical characteristics were defined clinically, and a patient was considered to have an outcome if it was documented in the electronic medical record and if the outcome was not documented, it was assumed to be negative.

As part of a clinical program to monitor the wellbeing of patients with COVID-19 after hospital discharge, a team of physicians and clinical nurses performed follow-up telephone calls during the 2 weeks after hospital discharge. At RWJUH, the primary site, patients were contacted regardless of the results of their COVID-19 testing as it was believed that some of these patients would be found to have COVID-19 following hospitalization. Members of this team attempted to call each patient twice per week for two weeks with the first phone call within 3 days of discharge. At the secondary sites, the follow-up phone calls were made to COVID-19 positive patients. Patients with COVID-19 were administered a questionnaire inquiring about the presence of any symptoms, the development of new symptoms, any additional doctor's visits or visits to the emergency room, readmissions, compliance with CDC recommended isolation precautions (18), household contacts developing symptoms, and household contacts testing positive. At RWJUH, patients with negative COVID-19 testing were administered a questionnaire inquiring about development of COVID-19 symptoms, testing for COVID-19, and

any unscheduled physician visits. Given that we anticipated difficulties in contacting some postpartum patients, we also planned to review inpatient and emergency department records at each institution for patients who could not be contacted to determine if they had hospital readmissions or emergency department visits with COVID-19 related symptoms or complaints. We only had access to patient records within our hospital system and could not account for hospital admissions or emergency department visits at outside institutions.

Statistical Analysis

We performed descriptive statistics to calculate the rate of asymptomatic positive COVID-19 and the rate of symptom development in the asymptomatic positive patients, including means (standard deviations) for normally distributed data and medians (interquartile ranges) for non-normally distributed data.

We compared the frequency distribution of risk factors and outcomes in relation to COVID-19 status, with COVID-19 positive patients across all 4 centers, and COVID-19 negative patients at RWJUH. Since there was substantial heterogeneity (**Supplementary Table 1)** in these distributions across the 4 centers (for COVID-19 positive patients), we also compared demographic characteristics and outcomes of COVID-19 positive patients versus negative patients restricted to the RWJUH site. Associations between risk factors for COVID-19 and COVID-19 status were expressed as relative risks (RR) with 95% confidence intervals (CI). The RRs were estimated from fitting log-linear regression models with a Poisson error structure and log-link function. All analyses were performed in SAS (version 9.4; SAS Institute, Cary, NC).

Results

During the study period (10 April to 15 June 2020), there were 218 COVID-19 positive patients across the four sites (49 at RWJUH, 61 at SBMC, 70 at MMC and 38 at CMMC) and 413 negative patients from the primary site RWJUH. Only 21 of the 218 COVID-19 positive patients had tested positive prior to admission. 14 of those 21 patients were still symptomatic on presentation to labor and delivery. The majority of COVID-19 positive patients were asymptomatic at the time of testing (188 [86.2%]). Demographic characteristics for the COVID-19 positive patients are depicted in **Table 1** and **Supplementary Table 1**. The COVID-19 patients were predominantly White, obese, and had no medical problems. There was a nearly even distribution of commercial and public insurances.

Data from the follow-up phone calls is noted in **Table 2**. About a third (81 [37.2%]) of the patients who tested positive, including 74 of the asymptomatic positive patients, and 145 (35.1%) patients who tested negative were reached at least once. Most of the asymptomatic COVID-19 positive patients adhered to isolation precautions, although adherence waned over the 2 week follow-up period. There were low rates of reported transmission to family members for asymptomatic positive patients. Only one asymptomatic COVID-19 positive patient reportedly developed any symptoms after discharge, and these symptoms were mild. No asymptomatic COVID-19 required COVID-19 readmission, though two COVID-19 negative patients required readmission for non-COVID related issues.

In order to clarify risk factors for COVID-19, we compared the demographics of patients with COVID-19 to negative controls at RWJUH (**Table 1**). The demographic characteristics were similar between the groups and there was not a significant difference in pregnancy complications, including gestational diabetes (8.2% versus 11.4%, RR 0.72, 95% CI 0.24-2.01) and gestational hypertension (6.1% versus 7.0%, RR 0.88, 95% CI 0.29-2.67).

The obstetrical and neonatal outcomes based on COVID-19 status are depicted in **Table 3**. Maternal adverse outcomes were uncommon in both the COVID-19 positive and negative groups. Compared to COVID-19 negative patients at RWJUH, positive patients at RWJUH were more likely to require supplemental oxygen (4.1% versus 0.5%, RR 4.87, 95% CI 1.76-13.47). There was one maternal death during the study period, which occurred in a COVID-19 negative patient with an underlying cardiac condition. In the early stages of the COVID-19 pandemic, all neonates delivered to COVID-19 positive mothers were admitted to the NICU, leading to increased risk for NICU admissions for neonates exposed to COVID-19 positive mothers (83.7% versus 15.7%, RR 17.21, 95% CI 8.33-35.57).

In addition to reaching out to patients by telephone, inpatient and emergency department records were assessed for all patients who did not respond to the follow-up phone calls to determine if they had any COVID-19 related complaints that required evaluation within the healthcare system. Among COVID-19 positive and negative patients, there were 7 patients who presented to the emergency department after discharge. The reasons for visiting the emergency department included bleeding after IUD placement (n=1), superficial phlebitis (n=1),

constipation (n=1), abdominal trauma (n=1), hypertension (n=1), leg swelling (n=1), and vaginal bleeding (n=1). None of these patients presented to the hospital for evaluation of COVID-19 symptoms.

Comment

Principal Findings

In this multicenter prospective cohort study of pregnant patients who were found to have COVID-19 at hospital admission in four New Jersey hospitals, the majority of patients with COVID-19 were asymptomatic. Compared to pregnant patients who tested negative for COVID-19, these asymptomatic patients were not at increased risk for adverse maternal and neonatal outcomes. Postpartum follow-up via telephone surveys and review of inpatient and emergency department records revealed that the majority of asymptomatic patients remained asymptomatic, did not spread the disease to their immediate family, and had low rates of hospital readmission including no readmissions for COVID-19 symptoms.

Results of the Study in Context

The majority of patients who were found to have COVID-19 on hospital admission were asymptomatic. This is potentially important as asymptomatic patients are thought to be major contributors to the spread of disease (19) and screening for COVID-19 with symptom questionnaires and temperature checks may not be an effective way to identify many patients with the potential to spread the disease. Although there is some debate about the utility of universal testing when the prevalence of COVID-19 is low in a community (7), we believe that

this policy is justified as it protects healthcare workers and other patients (including their neonates) and can be an instrument to monitor local infections (20).

In contrast to some studies (21-23), the patients in our study who tested positive for COVID-19—asymptomatic and symptomatic patients alike—rarely required treatment for the disease. Testing positive for COVID-19 was not associated with adverse maternal or neonatal outcomes, which has also been found in other studies (24). Indeed, we found a trend towards lower rates of maternal morbidity and preterm birth in our COVID-19 positive group. This may be secondary to the overall lower rate of medical co-morbidities in the COVID-19 positive group, which reflects the population that our hospitals serve. The primary center, RWJUH, serves predominantly non-Hispanic White and Hispanic patients. The three additional hospitals have a high volume of non-Hispanic White patients. Patients who tested positive for COVID-19 were primarily White without any significant underlying medical comorbidities, which is in contrast to other studies (25). However, another explanation is that patients with asymptomatic disease are healthier than patients with severe forms of the disease, and a healthier baseline status confers some protection from developing symptomatic COVID-19.

Clinical Implications

In the two weeks after a positive test, postpartum patients who were asymptomatic at the time of their positive COVID-19 test rarely developed symptoms or required readmission or an unscheduled physician visit among the patients with post-discharge follow-up. There were 12 unscheduled healthcare visits for typical postpartum complications and no visits for COVID-19

related issues. Underlying maternal comorbidities seem to be a far greater risk for adverse outcomes than asymptomatic COVID-19 positive status.

Asymptomatic patients with COVID-19 reported adherence to guidelines for social distancing, although adherence waned during the two weeks postpartum. They also reported low rates of immediate family members requiring medical evaluation or hospitalization for COVID-19 symptoms. Review of inpatient and emergency room records corroborated these survey results, and indicated that these asymptomatic patients did not develop severe features of COVID-19 or require hospital evaluation or admission. Although some patients may have sought care outside of the Robert Wood Johnson Barnabas Health Network, the study's results suggest that asymptomatic patients remain at low risk for developing significant COVID-19 after hospital discharge.

One neonate tested positive in our study prior to hospital discharge. Although rates of vertical and neonatal transmission are considered to be low (26-28), effective communication between the obstetrics and pediatrics providers is essential to ensure that the newborn's provider is aware of maternal infection. This is especially true as self-reported adherence to social distancing guidelines wane for asymptomatic positive patients who need interact with the medical system to obtain pediatric care in the first two weeks postpartum.

Strengths and Limitations

As patients with symptomatic disease have largely been the focus of COVID-19 research in pregnancy, this study provides information to fill an important knowledge gap. Strengths of the study include multicenter design, pregnant control patients, and postpartum follow-up. This was a multicenter study that included patients from four hospitals in New Jersey, covering patients from across northern and central New Jersey, which improves the generalizability of our findings. Although many studies that have looked at pregnancy outcomes for patients with COVID-19 made comparisons to non-pregnant patients (22, 29), we made comparisons with pregnant patients who tested negative for COVID-19. We also followed patients with postpartum questionnaires during the 2 weeks postpartum, but ensured follow-up by reviewing hospital records of all included patients so as to be able to determine if these patients went on to develop clinically significant COVID-19.

The study has some limitations. Some patients with COVID-19 may test positive for prolonged periods of time, even after convalescing. In our study, the majority of patients with COVID-19 were found to be positive for the first time and 21 (9.6%) tested positive prior to admission. This may have introduced bias that could have impacted the results. Also, the study is underpowered for rare outcomes. In addition, we had a low response rate to the follow-up phone calls. We reached only a third (37.2%) of COVID-19 positive patients and 35.1% of COVID-19 negative patients. Although the low telephone response rate could introduce some bias, we contacted similar numbers of patients with and without COVID-19. Moreover, to combat the anticipated low rate of patients' responses, we performed a system-wide hospital chart review for all patients that were not reached. As a result, we believe the results of our

study are valid. However, we cannot account for patients who sought care or evaluation at hospitals that were not within our hospital system.

Conclusions

In this multicenter prospective cohort study, we found that the majority of pregnant patients who tested positive for COVID-19 at the time of delivery admission are asymptomatic and are unlikely to develop symptoms or require hospital readmission for COVID-19 related complications. Compared to pregnant patients with negative testing for COVID-19, asymptomatic COVID-19 patients were not at increased risk for adverse obstetrical outcomes. After delivery, these asymptomatic positive patients were adherent with isolation precautions, but this adherence waned in the first two weeks postpartum. These asymptomatic patients also reported low rates of household contacts acquiring the disease and had low rates of hospital readmission for COVID-19 symptoms. Given that these patients have low risk of decompensation due to severe COVID-19, routine surveillance is sufficient in this low-risk group.

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References

1. Phoswa WN, Khaliq OP. Is pregnancy a risk factor of COVID-19? Eur J Obstet Gynecol Reprod Biol. 2020;252:605-9.

2. Hanna N, Hanna M, Sharma S. Is pregnancy an immunological contributor to severe or controlled COVID-19 disease? Am J Reprod Immunol. 2020;84(5):e13317.

3. Narang K, Enninga EAL, Gunaratne M, Ibirogba ER, Trad ATA, Elrefaei A, et al. SARS-CoV-2 Infection and COVID-19 During Pregnancy: A Multidisciplinary Review. Mayo Clin Proc. 2020;95(8):1750-65.

4. Bai Y, Yao L, Wei T, Tian F, Jin DY, Chen L, et al. Presumed Asymptomatic Carrier Transmission of COVID-19. JAMA. 2020;323(14):1406-7.

5. Sutton D, Fuchs K, D'Alton M, Goffman D. Universal Screening for SARS-CoV-2 in Women Admitted for Delivery. N Engl J Med. 2020;382(22):2163-4.

6. Brandt JS, Hill J, Reddy A, Schuster M, Patrick HS, Rosen T, et al. Epidemiology of coronavirus disease 2019 in pregnancy: risk factors and associations with adverse maternal and neonatal outcomes. Am J Obstet Gynecol. 2020.

7. LaCourse SM, Kachikis A, Blain M, Simmons LE, Mays JA, Pattison AD, et al. Low prevalence of SARS-CoV-2 among pregnant and postpartum patients with universal screening in Seattle, Washington. Clin Infect Dis. 2020.

8. Zhang J, Wu S, Xu L. Asymptomatic carriers of COVID-19 as a concern for disease prevention and control: more testing, more follow-up. Biosci Trends. 2020;14(3):206-8.

9. Lee M, Eun Y, Park K, Heo J, Son H. Follow-up investigation of asymptomatic COVID-19 cases at diagnosis in Busan, Korea. Epidemiol Health. 2020;42:e2020046.

10. Zhou X, Li Y, Li T, Zhang W. Follow-up of asymptomatic patients with SARS-CoV-2 infection. Clin Microbiol Infect. 2020;26(7):957-9.

11. Zheng Z, Yao Z, Wu K, Zheng J. Patient follow-up after discharge after COVID-19 pneumonia: Considerations for infectious control. J Med Virol. 2020.

12. Tanacan A, Erol SA, Turgay B, Anuk AT, Secen EI, Yegin GF, et al. The rate of SARS-CoV-2 positivity in asymptomatic pregnant women admitted to hospital for delivery: Experience of a pandemic center in Turkey. Eur J Obstet Gynecol Reprod Biol. 2020;253:31-4.

13. Mayor S. Covid-19: Nine in 10 pregnant women with infection when admitted for delivery are asymptomatic, small study finds. BMJ. 2020;369:m1485.

14. Muhidin S, Vizheh M, Behboodi Moghadam Z. Asymptomatic coronavirus infection among pregnant women: a necessity for universal screening of COVID-19 in pregnant women admitted to labor. J Matern Fetal Neonatal Med. 2020:1-2.

15. Pierce-Williams RAM, Burd J, Felder L, Khoury R, Bernstein PS, Avila K, et al. Clinical course of severe and critical coronavirus disease 2019 in hospitalized pregnancies: a United States cohort study. Am J Obstet Gynecol MFM. 2020;2(3):100134.

16. Chen L, Jiang H, Zhao Y. Pregnancy with COVID-19: Management considerations for care of severe and critically ill cases. Am J Reprod Immunol. 2020;84(5):e13299.

17. Dinnes J, Deeks JJ, Adriano A, Berhane S, Davenport C, Dittrich S, et al. Rapid, point-of-care antigen and molecular-based tests for diagnosis of SARS-CoV-2 infection. Cochrane Database Syst Rev. 2020;8:CD013705.

18. Centers for Disease C. Interim Infection Control Guidance for Public Health Personnel Evaluating Persons Under Investigation (PUIs) and Asymptomatic Close Contacts of Confirmed

Cases at Their Home or Non-Home Residential Settings 2020 [Available from: https://www.cdc.gov/coronavirus/2019-ncov/php/guidance-evaluating-pui.html.

19. Yanes-Lane M, Winters N, Fregonese F, Bastos M, Perlman-Arrow S, Campbell JR, et al. Proportion of asymptomatic infection among COVID-19 positive persons and their transmission potential: A systematic review and meta-analysis. PLoS One. 2020;15(11):e0241536.

20. Brandt JS, Fell DB. SARS-CoV-2 infection in pregnancy: Lessons learned from the first pandemic wave. Paediatr Perinat Epidemiol. 2021;35(1):34-6.

21. Allotey J, Stallings E, Bonet M, Yap M, Chatterjee S, Kew T, et al. Clinical manifestations, risk factors, and maternal and perinatal outcomes of coronavirus disease 2019 in pregnancy: living systematic review and meta-analysis. BMJ. 2020;370:m3320.

22. Zambrano LD, Ellington S, Strid P, Galang RR, Oduyebo T, Tong VT, et al. Update: Characteristics of Symptomatic Women of Reproductive Age with Laboratory-Confirmed SARS-CoV-2 Infection by Pregnancy Status - United States, January 22-October 3, 2020. MMWR Morb Mortal Wkly Rep. 2020;69(44):1641-7.

23. Lokken EM, Walker CL, Delaney S, Kachikis A, Kretzer NM, Erickson A, et al. Clinical characteristics of 46 pregnant women with a severe acute respiratory syndrome coronavirus 2 infection in Washington State. Am J Obstet Gynecol. 2020.

24. Adhikari EH, Moreno W, Zofkie AC, MacDonald L, McIntire DD, Collins RRJ, et al. Pregnancy Outcomes Among Women With and Without Severe Acute Respiratory Syndrome Coronavirus 2 Infection. JAMA Netw Open. 2020;3(11):e2029256.

25. Reale SC, Lumbreras-Marquez MI, King CH, Burns SL, Fields KG, Diouf K, et al. Patient characteristics associated with SARS-CoV-2 infection in parturients admitted for labour and

delivery in Massachusetts during the spring 2020 surge: A prospective cohort study. Paediatr Perinat Epidemiol. 2021;35(1):24-33.

26. Chen H, Guo J, Wang C, Luo F, Yu X, Zhang W, 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):809-15.

27. Ashraf MA, Keshavarz P, Hosseinpour P, Erfani A, Roshanshad A, Pourdast A, et al. Coronavirus Disease 2019 (COVID-19): A Systematic Review of Pregnancy and the Possibility of Vertical Transmission. J Reprod Infertil. 2020;21(3):157-68.

28. Dumitriu D, Emeruwa UN, Hanft E, Liao GV, Ludwig E, Walzer L, et al. Outcomes of Neonates Born to Mothers With Severe Acute Respiratory Syndrome Coronavirus 2 Infection at a Large Medical Center in New York City. JAMA Pediatr. 2020.

29. Woodworth KR, Olsen EO, Neelam V, Lewis EL, Galang RR, Oduyebo T, et al. Birth and Infant Outcomes Following Laboratory-Confirmed SARS-CoV-2 Infection in Pregnancy - SET-NET, 16 Jurisdictions, March 29-October 14, 2020. MMWR Morb Mortal Wkly Rep. 2020;69(44):1635-40.

Table 1
Demographic characteristics of all patients and comparison of Robert Wood Johnson University Hospital COVID-19 positive patients versus COVID-19 negative patients

	COVID-19 positive (n=218)	RWJUH COVID-19 positive (n=49)	COVID-19 negative (n=413)	Relative risk (95% confidence interval)*
Asymptomatic	188 (86.2)	35 (71.4)	—	—
Maternal age (years)[†]	29.7 (5.9)	30.1 (6.0)	30.9 (5.9)	—
Gravidity[‡]	3 (1-5)	3 (2-4)	2 (1-4)	—
Parity[‡]	2 (1-4)	2 (1-4)	2 (1-3)	—
Body-mass index at delivery (kg/m^2)[†]	30.3 (5.6)	30.5 (6.6)	30.7 (6.5)	—
Maternal race/ethnicity				
Non-Hispanic White	115 (53.7)	30 (61.2)	179 (43.3)	1.00 (Reference)
Non-Hispanic Black	30 (14.0)	1 (2.0)	37 (9.0)	0.18 (0.03, 1.30)
Hispanic	24 (11.2)	16 (32.6)	94 (22.8)	1.01 (0.58, 1.78)
Asian/Indian	3 (1.4)	2 (4.1)	75 (18.2)	0.18 (0.04, 0.74)
Other	42 (19.6)	0 (0)	28 (6.8)	—
Maternal insurance status				
Private	93 (44.3)	30 (61.2)	269 (65.1)	
Medicaid/Charity Care	101 (48.1)	19 (38.8)	144 (34.9)	
Self-pay	7 (3.3)	0 (0)	0 (0)	—
Other	9 (4.3)	0 (0)	0 (0)	—
No past medical history	154 (71.6)	24 (49.0)	197 (47.7)	
Medical comorbidities	61 (28.4)	25 (51.0)	216 (52.3)	0.96 (0.56, 1.62)
Pre-gestational diabetes	0 (0)	0 (0)	11 (2.7)	—
Chronic hypertension	3 (1.4)	0 (0)	23 (5.6)	—
Renal disease	0 (0)	0 (0)	3 (0.7)	—
Immuno-compromised	4 (1.9)	2 (4.1)	4 (1.0)	3.23 (1.01, 10.35)
Asthma	7 (3.3)	2 (4.1)	11 (2.7)	1.47 (0.40, 5.41)
Anemia	10 (4.7)	1 (2.0)	16 (3.9)	0.55 (0.08, 3.72)
Twins	6 (2.8)	0 (0)	16 (3.9)	—
Obstetrical clinical characteristics				
Gestational diabetes	9 (4.2)	4 (8.2)	47 (11.4)	0.72 (0.24, 2.01)
Gestational hypertension	7 (3.3)	3 (6.1)	29 (7.0)	0.88 (0.29, 2.67)
Preeclampsia	9 (4.2)	5 (10.2)	43 (10.4)	0.98 (0.41, 2.35)

Data presented as n (percent)
*Relative risk for RWJUH COVID-19 positive versus COVID-19 negative patients
[†]Data presented as mean (standard deviation)
[‡]Data presented as median (interquartile range)

Table 2
Follow-up phone calls

	COVID-19 positive (n=218)	Asymptomatic COVID-19 positive (n=188)	COVID-19 negative (n=413)
Patient reached			
One time	81 (37.2)	74 (39.4)	145 (35.1)
Two times	37 (17.0)	36 (19.1)	103 (24.9)
Three times	20 (9.2)	19 (10.1)	60 (14.5)
Four times	11 (5.0)	11 (5.9)	22 (5.3)
Patient developed symptoms after discharge	1 (1.3)	1 (1.4)	0 (0)
Tested after discharge	0 (0)	0 (0)	7 (1.7)
Patient required unscheduled emergency room or doctor's visit after discharge	1 (1.3)	1 (1.4)	4 (2.8)
Patient readmitted	0 (0)	0 (0)	2 (1.4)†
Patient practicing isolation precautions			
First call	71 (87.7)	64 (86.5)	0 (0)
Fourth call	5 (45.5)	5 (45.5)	0 (0)
Household contacts developed symptoms	3 (3.7)	3 (4.1)	0 (0)
Household contacts tested positive	6 (7.4)	2 (2.7)	4 (1.0)

Data presented as n (percent).
†All readmissions were unrelated to COVID-19.

Table 3
Obstetric and neonatal outcomes in relation to COVID-19 status

	All 4 centers COVID-19 positive (n=218)	RWJUH COVID-19 positive (n=49)	RWJUH COVID-19 negative (n=413)	RWJUH COVID-19 positive vs negative: Relative risk (95% confidence interval)
Site of recruitment				
Robert Wood Johnson University Hospital	49 (22.5)	49 (100.0)	413 (100.0)	—
Saint Barnabas Medical Center	61 (28.0)	—	—	—
Monmouth Medical Center	70 (32.1)	—	—	—
Clara Maass Medical Center	38 (17.4)	—	—	—
Gestational age at delivery[†]	38.9 (2.5)	39.1 (2.8)	38.5 (2.7)	—
Mode of delivery				
Spontaneous vaginal	164 (75.6)	38 (77.6)	266 (64.4)	1.00 (Reference)
Operative vaginal	9 (4.2)	0 (0)	11 (2.7)	—
Vaginal birth after c-section	3 (1.4)	2 (4.1)	8 (1.9)	1.60 (0.45, 5.72)
Primary c-section	18 (8.3)	7 (14.3)	65 (15.7)	0.78 (0.36, 1.67)
Repeat c-section	23 (10.6)	2 (4.1)	62 (15.0)	0.25 (0.06, 1.01)
Delivery complications				
Preterm delivery	50 (2.3)	2 (4.0)	48 (11.4)	0.35 (0.09, 1.40)
Spontaneous preterm delivery	9 (4.2)	1 (2.0)	32 (7.8)	0.27 (0.04, 1.90)
Chorioamnionitis	7 (3.2)	2 (4.1)	8 (1.9)	1.92 (0.54, 6.84)
Abnormal biophysical profile	4 (1.8)	2 (4.1)	8 (1.9)	1.92 (0.54, 6.84)
Persistent category 2 tracing	16 (7.4)	4 (8.2)	38 (9.2)	0.89 (0.34, 2.35)
Development of symptoms during admission	7 (3.2)	2 (4.1)	0 (0)	—
Maternal outcomes				
Venous thromboembolism	0 (0)	0 (0)	1 (0.2)	—
Intensive care unit admission	0 (0)	0 (0)	3 (0.7)	—
Supplemental oxygen	3 (1.4)	2 (4.1)	2 (0.5)	4.87 (1.76, 13.47)
Mechanical ventilation	0 (0)	0 (0)	3 (0.7)	—
Death	0 (0)	0 (0)	1 (0.2)	—
Neonatal outcomes				
Birth weight (g)[†]	3249 (568)	3228 (566)	3191 (624)	
Neonatal intensive care unit admission	56 (25.8)	41 (83.7)	65 (15.7)	17.21 (8.33, 35.57)
Positive COVID-19 PCR	1 (0.7)	0 (0)	0 (0)	—
Respiratory distress syndrome	8 (3.7)	2 (4.1)	20 (4.8)	0.85 (0.22, 3.28)
Intraventricular hemorrhage	1 (0.5)	0 (0)	1 (0.2)	—
Necrotizing enterocolitis	1 (0.5)	0 (0)	0 (0)	—
Death	1 (0.5)	1 (2.0)	4 (1.0)	1.90 (0.32, 11.22)

Data presented as n (percent).
[†]Data presented as mean (standard deviation)