Received: 7 July 2023 | Revised: 8 October 2023 | Accepted: 9 October 2023

DOI: 10.1111/aogs.14704

AOGS Acta Obstetricia et Gynecologica Scandinavica

ORIGINAL RESEARCH ARTICLE

Association of maternal SARS-CoV-2 infection at the time of admission for delivery with labor process and outcomes of vaginal birth: A cohort study

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Funding information
Natural Science Research Project of Universities of Anhui Province, Grant/Award Number: KJ2020A1219; School-level quality engineering project of University of Science and Technology of China in 2022, Grant/Award Number: 2022xjyxm091

Abstract

Introduction: This study aimed to investigate the impact of maternal SARS-CoV-2 infection at the time of admission for delivery on labor process and outcomes of vaginal birth.

Material and methods: A cohort study was carried out at the Obstetrics Department of Anhui Provincial Hospital, China, where universal reverse transcriptase polymerase chain reaction (RT-PCR) testing for SARS-CoV-2 infection was introduced for all women admitted for labor and delivery from December 1–31, 2022. Women were divided into positive and negative groups based on the test result. All women having a singleton vaginal birth were included in final analysis. The effect of SARS-CoV-2 positivity on labor process and outcomes of vaginal birth was estimated by regression analyses.

Results: Among a total of 360 women included, 87 had a positive SARS-CoV-2 test and 273 a negative test. Women in the positive group had an increased likelihood of having longer labor (median 9.3 vs 8.3 hours; sB [log-transformed] 0.19; 95% confidence interval [CI] 0.09–0.28), episiotomy (39.1% vs 23.8%; adjusted odds ratio [aOR] 2.31; 95% CI 1.27–4.21), grade III meconium-stained amniotic fluid (19.5% vs 7.0%; aOR 2.52; 95% CI 1.15–5.54) and postpartum hospital stay exceeding 37 hours (58.6% vs 46.5%; aOR 1.71; 95% CI 1.00–2.91). They had reduced rates exclusive breastfeeding (26.7% vs 39%; aOR 0.21; 95% CI 0.09–0.46) as well as mixed feeding (46.5% vs 52.2%; aOR 0.28; 95% CI 0.13–0.60) at 1 week postpartum. No significant differences were observed in other aspects of labor process and birth outcomes, including the uptake of labor analgesia, postpartum hemorrhage (>500 mL) or neonatal outcomes.

Conclusions: A positive maternal SARS-CoV-2 test in labor among women having vaginal birth was associated with a slightly longer duration of labor, increased likelihood

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; COVID-19, coronavirus disease 2019; EMR, electronic medical records; GLM, generalized linear model; NICU, neonatal intensive care unit; OR, odds ratio; SARS-CoV-2, the severe acute respiratory syndrome coronavirus 2; sB, standardization beta; VIFs, variance inflation factors.

Guizhi Cheng, Lai Jiang and Qianqian Ni contributed equally to this study.

of episiotomy, increased incidence of grade III meconium-stained amniotic fluid, a longer postpartum hospital stay and a lower rate of breastfeeding 1 week postpartum. However, it did not have an adverse impact on other birth outcomes.

KEYWORDS
birth outcomes, cohort study, COVID-19, labor process, SARS-CoV-2, vaginal birth

1 | INTRODUCTION

On May 5, 2023, World Health Organization (WHO) declared the end of coronavirus disease 2019 (COVID-19) as a public health emergency of international concern.[1] However, the severe acute respiratory syndrome virus 2 (SARS-CoV-2) continues to maintain a global presence, characterized by ever-mutating variants, with an uncertain future disease trajectory. The SARS-CoV-2 infection during pregnancy and childbirth is reported to be associated with a higher risk of preterm birth, low birthweight infants, neonatal intensive care unit admissions and neonatal mortality.[2]

The mode of birth is an important consideration in the management of pregnant women affected by SARS-CoV-2 infection, particularly at the time of admission for labor and delivery. In accordance with WHO consensus guidelines, decisions on the mode of birth should be primarily guided by obstetric indications, with COVID-19 not being considered an automatic indication for cesarean section.[3] However, published data on the consequences of different delivery modes are scarce, especially with regard to process of labor and outcomes of vaginal birth among women infected with SARS-CoV-2.[4] The majority of studies have focused on the delivery modes and maternal–infant health outcomes following COVID-19 infection that occurred during pregnancy[5,6] but not specifically at the time of labor.[4,7,8] Ferrazzi et al. (2020) investigated the consequences of different modes of delivery among women diagnosed with COVID-19 during labor, including Apgar scores, neonatal infection and breastfeeding.[8] While extant studies have consistently indicated that vertical transmission is rare and the risk of neonatal SARS-CoV-2 infection after vaginal birth is low,[7] the potential for other adverse outcomes cannot be ignored. For instance, fever is the most common symptom of COVID-19 and there is evidence that intrapartum fever may lead to unfavorable neonatal outcomes.[9,10] Moreover, ongoing mutations and evolution of SARS-CoV-2 underscore the need for updated knowledge. Thus, the aim of our study was to investigate the impact of intrapartum SARS-CoV-2 infection on the process of labor and outcomes of vaginal birth.

Key message

Among women having vaginal birth, SARS-CoV-2 infection during labor was not associated with poor maternal or neonatal outcomes compared with uninfected women, except for longer length of labor and hospital stay, and lower rates of breastfeeding.

2 | MATERIAL AND METHODS

2.1 | Study setting, design and participants

In December 2022, amidst the challenges posed by various Omicron subvariants,[11] China rolled back its hard-liner anti-COVID-19 policies, easing many restrictions. Subsequently, vaginal birth started to be available to infected women. However, there is a dearth of published studies presenting data on pregnancy and childbirth-related practices, experience and outcomes associated with this unique phase of the COVID-19 pandemic in China.

In this single-center historical cohort study, all women having singleton vaginal birth from December 1 to 31, 2022, in the First Affiliated Hospital of University of Science and Technology of China (USTC), a province-level tertiary referral hospital with approximately 4000 deliveries per year (vaginal birth: ~50%), were included. Starting on December 1, 2022, universal reverse transcriptase polymerase chain reaction (RT-PCR) testing was introduced in the hospital for all women admitted for labor and delivery regardless of the presence of symptoms. This universal testing practice concluded on January 1, 2023, as it was deemed redundant due to the high prevalence of infection among women presenting for childbirth. The test results were documented in the electronic medical records (EMR). All women delivering vaginally, and their newborns, were followed up until 1 week postpartum as a part of standard routine care. Given that all eligible individuals from this specific research site during this defined timeframe were planned to be included in the study, pre-study sample size calculation was deemed unnecessary. Nevertheless, we estimated the minimum sample size based on a commonly applied rule that for regression analysis the sample size must exceed 10 times the number of independent variables.[12] In addition, we conducted post-hoc statistical power analyses for each outcome variable using G.POWER software.

2.2 | Outcome measures

Data on labor process was retrieved from the hospital EMR. This encompassed information on the utilization of labor analgesia, the duration of labor (first stage and second stage of labor combined, ie

time from the onset/diagnosis of active labor defined as presence of regular uterine contractions and cervical dilation of ≥4 cm to the birth of the neonate), the rate of episiotomy, postpartum hemorrhage (blood loss ≥500 mL), grade III meconium-stained amniotic fluid, neonatal birthweight, Apgar scores, admission to neonatal intensive care unit (NICU), perinatal death and the length of postpartum hospital stay. The information on neonatal feeding practices (exclusive breastfeeding, mixed feeding or formula feeding) at discharge and at 1 week postpartum was collected by a midwife at the postnatal follow up.

2.3 | Baseline clinical characteristics and identification of confounders

The following variables, representing baseline clinical characteristics of women available in the hospital EMR, were identified as potential confounding factors that could exert an influence on the labor process and birth outcomes based on previous studies, and were adjusted for statistical analyses: age (years),[13] parity (primipara/multipara),[14] history of spontaneous or induced abortion(s) (no/yes),[15] body mass index (BMI) at the admission for birth,[16] gestational hypertensive disorders (no/yes),[17] gestational diabetes mellitus (no/yes),[18] Group B streptococci (GBS) positive(no/yes),[19] other preexisting maternal chronic illness and pregnancy complications (no/yes) such as thyroid disease,[20] oligohydramnios,[21] ovarian cyst,[22] hepatitis B seropositivity[23] and polyhydramnios,[24] intrapartum fever (no/yes),[25] gestational age at birth (<28 weeks/28–34 weeks/<37 weeks/37+ weeks),[26] premature rupture of membranes (no/yes)[27] and induction of labor (no/yes).[28] An additional confounding variable considered in this study was birthweight ≥4 kg (no/yes), as the size of baby may affect the vaginal birth process and outcomes.[29]

2.4 | Data collection

All routinely collected data were extracted from the maternity EMR of the hospital. Information regarding neonatal feeding practices at 1 week postpartum was reported by women themselves via follow-up phone calls and recorded by nurses in EMR, which was conducted as a standard part of routine postpartum care. There were two research nurses working in data collection process, with one responsible for collecting the data and the other for reviewing and checking the data.

2.5 | Statistical analyses

Descriptive statistics were calculated and baseline clinical characteristics between the SARS-CoV-2 positive and negative groups were compared using appropriate parametric and nonparametric tests. To assess the strength of associations between a positive COVID-19 test and adverse birth outcomes, odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) were calculated. For categorical outcome variables, logistic regression models were applied to calculate ORs, while for continuous outcome variables, linear regression models were applied to determine standardized regression coefficients (standardized beta, sB). Log-transformation was undertaken to address non-normal distribution of some continuous outcome variables and generalized linear models employing a log link function were used for regression analyses. Continuous outcome variables that did not achieve a normal distribution were dichotomized into binary categorical variables via median split.[30,31] In all multivariate regression models designed to investigate the effect of SARS-CoV-2 positivity on labor process and outcomes of vaginal birth, baseline demographic and clinical characteristics were adjusted.

The normality of distribution of continuous variables in the dataset was assessed by the Kolmogorov–Smirnov test. Several independent variables as well as the outcome variables in this study, including age, BMI, length of labor (hours) and length of postpartum hospital stay (hours) did not satisfy assumption of normality (Table S1). Thus, prior to conducting regression analyses, we conducted multicollinearity analyses among independent variables by calculating variance inflation factors (VIFs). No evidence of multicollinearity among the independent variables was identified (Table S2). Statistical significance was defined as a P-value <0.05. All analytical procedures were executed using IBM SPSS Statistics (version 22.0).

2.6 | Ethics Statement

This study received approval from the Ethical Committee of USTC (Ethical Approval Number: 2023-RE-182) on May 30, 2023. Patient consent was waived, as the research exclusively employed routinely collected clinical data. There was no public or patient involvement in the planning, conducting or reporting of this study.

3 | RESULTS

3.1 | Sample characteristics

Among a total of 390 women with singleton pregnancy admitted for labor and delivery during the study period who planned to deliver vaginally, 99 (25.4%) had a positive SARS-CoV-2 RT-PCR test result and 291 (74.6%) a negative result. No tests yielded an inconclusive result. Thirteen pregnant women in the test-negative group and 12 in the test-positive group underwent an emergency cesarean section. The reasons for emergency cesarean section were fetal distress ($n=7$: 3 from the positive and 4 from the negative group), lack of progress in labor ($n=12$: 5 from the positive and 7 from the negative group) and chorioamnionitis ($n=6$: 4 from the positive and 2 from the negative group). These women were excluded from further analyses. Additionally, five women (all in the COVID-19-negative group) missed follow-up. Thus, data from a total of 360 women (87 with a

positive COVID-19 test result and 273 with a negative result) were included in the final analysis. Figure 1 displays the flow chart of the study population. The baseline characteristics of study groups are detailed in Table 1. No statistically significant differences were observed between the COVID-19 positive and negative test groups, except for the occurrence of intrapartum fever.

3.2 | Impact of COVID-19 infection on labor process and birth outcomes

Table 2 provides an overview of the findings pertaining to labor process and maternal–infant outcomes for both study groups. Only one woman had an instrumental (forceps) vaginal delivery. No maternal death occurred during the study period, but two infants died of severe asphyxia: one in the positive group, born at 27+0 weeks of gestation with an Apgar score of 3, died 5 days postpartum at NICU; the other in the negative group, born at 33+1 weeks of gestation with an Apgar score of 1, died soon after birth.

Women in the COVID-19-positive group had a longer duration of labor compared with their counterparts in the COVID-19-negative group (median, 9.3 vs 8.3 hours; sB, 0.19; 95% confidence interval [CI] 0.09–0.28). To assess the impact of a positive COVID-19 test on the duration of vaginal labor, we employed a generalized linear model with a log link function. The adjusted sB of 0.19 indicated that COVID-19-positive status was associated with an approximate increase of 1.2 hours in the duration of labor. Women in the COVID-19-positive group also had a higher likelihood of undergoing an episiotomy during vaginal birth (39.1% vs 23.8%; adjusted odds ratio [aOR] 2.31; 95% CI 1.27–4.21) and a higher likelihood of having grade III meconium-stained amniotic fluid (19.5% vs 7.0%; aOR 2.52; 95% CI 1.15–5.54). Additionally, women in the positive group were more likely to have a postpartum hospital stay exceeding 37 hours (median) (58.6% vs 46.5%; aOR 1.71; 95% CI 1.00–2.91). At 1 week postpartum, women in the COVID-19-positive group had a reduced likelihood of exclusively breastfeeding their babies (26.7% vs 39%; aOR 0.21; 95% CI 0.09–0.46) or employing mixed feeding practices (46.5% vs 52.2%; aOR 0.28; 95% CI 0.13–0.60). No significant differences were observed between the two groups with regard to other outcomes, including the use of labor analgesia, postpartum hemorrhage (>500 mL), Apgar scores and the rate of breastfeeding at discharge both before and after adjusting for potential confounding factors.

4 | DISCUSSION

In this cohort study, we investigated the labor process and outcomes of vaginal birth among women who tested positive for SARS-CoV-2 at the time of admission for labor and delivery and compared them with those who tested negative. We found that women in the positive group were more likely to have a longer labor, an increased risk of episiotomy, a higher rate of grade III meconium-stained amniotic fluid, a longer postpartum hospital stay and lower rates of breastfeeding at 1 week postpartum; there were no other significant differences between the groups. As no significant association was observed between maternal SARS-CoV-2 positivity in labor and serious adverse maternal or neonatal outcomes after vaginal birth, our findings align with the prevailing consensus that supports the provision of vaginal birth as a viable option for women diagnosed with COVID-19 infection.[32]

However, as the process of labor and some clinical outcomes were modified by SARS-CoV-2, it is important to recognize the potential risks of unfavorable outcomes in women affected by COVID-19 delivering vaginally. Our study showed increased likelihood of slightly prolonged labor as well as higher rates of episiotomy and grade III meconium-stained amniotic fluid among SARS-CoV-2 infected women delivering vaginally. Prolonged labor is shown to be associated with increased maternal morbidity, increased rates of operative deliveries and neonatal infection.[33,34] Similarly, episiotomy is known to be associated with perineal lacerations, infections and negative birth experiences,[35,36] and meconium-stained amniotic fluid increases the likelihood of neonatal meconium aspiration syndrome.[3,37] Whereas most previous studies have reported a substantial shortening in the length of postpartum hospital stay during the COVID-19 pandemic, attributed mainly to the implementation of early postpartum discharge

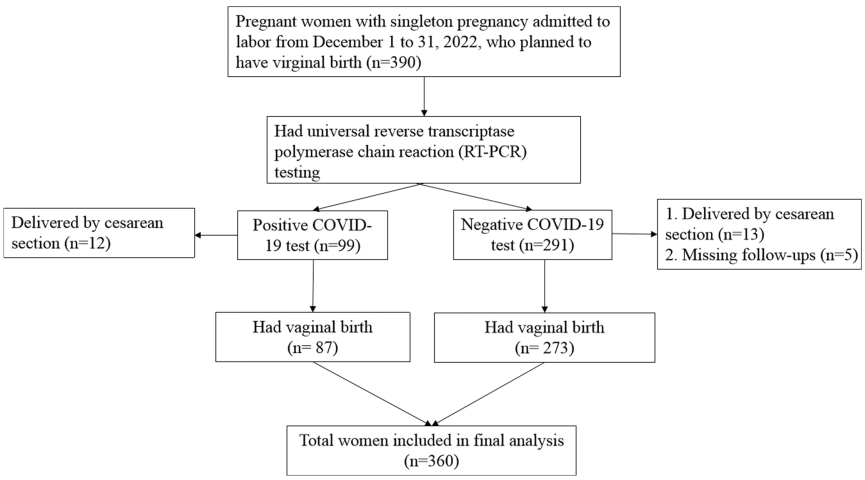

FIGURE 1 Flowchart of study population included in the cohort.

TABLE 1 Baseline and clinical characteristics of the study population ($n = 360$).

Characteristics	COVID-19 test status, *n* (%)		*P*-value
	Positive ($n = 87$)	Negative ($n = 273$)	
Age, years, *M* (P_{25}, P_{75})]	29 (27, 32)	30 (28, 32)	0.30[a]
Parity			
Primipara	65 (74.7)	194 (71.1)	0.51[b]
Multipara	22 (25.3)	79 (28.9)	
History of spontaneous or induced abortion(s)	28 (32.2)	99 (36.3)	0.49[b]
BMI (kg/m^2) at admission for birth, *M* (P_{25}, P_{75})	26.4 (24.2, 28.1)	26.4 (24.65, 28.3)	0.92[a]
Gestational hypertensive disorders	2 (2.3)	12 (4.4)	0.57[b]
Gestational diabetes mellitus	6 (6.9)	41 (15)	0.05[b]
GBS$^+$	10 (11.5)	26 (9.5)	0.59[b]
Other preexisting maternal chronic illness and pregnancy complications (eg thyroid disease, ovarian cyst, hepatitis B seropositivity, oligohydramnios and polyhydramnios)	17 (19.5)	70 (25.6)	0.25[b]
Intrapartum fever	18 (20.7)	13 (4.8)	<0.01[b]
Gestational age at birth			
<28 weeks	1 (1.1)	0	0.82[c]
28–34 weeks	1 (1.1)	7 (2.6)	
<37 weeks	2 (2.3)	4 (1.5)	
37+ weeks	83 (95.4)	262 (96)	
PROM	22 (25.3)	74 (27.1)	0.65[d]
Induction	42 (48.3)	136 (49.8)	0.80[b]
Birthweight ≥4 kg	0	12 (4.4)	0.10[b]

Abbreviations: BMI, body mass index (calculated as weight in kg divided by height in m squared); COVID-19, coronavirus disease 2019; GBS, Group B streptococci; PROM, premature rupture of membranes.

[a]Mann–Whitney rank test.

[b]Chi-square test.

[c]Kruskal–Wallis H-test.

[d]Fisher's exact test.

aimed at minimizing exposures to infection,[38–40] our study revealed an increased risk of extended postpartum hospitalization among COVID-19-infected women giving birth vaginally. This might be due to infected women requiring more time to recover post-delivery.

Limited empirical evidence exists pertaining to the impact of COVID-19 on breastfeeding practices. We observed a decreased rate of exclusive breastfeeding 1 week after delivery among SARS-CoV-2-positive women. This finding resonates with Arti et al.'s (2022) finding that significantly fewer babies born to COVID-19-positive mothers were on exclusive breastfeeding at 3 months of age compared with the reference group.[41] On the other hand, we found no statistically significant difference in breastfeeding practices at discharge between the two groups. Various factors, including family support, could have influenced the women's breastfeeding decisions. However, we did not have any information on such factors to be able to perform an adjusted analysis. The world has witnessed a reduction in breastfeeding rates during the pandemic.[4,42–44] Whereas the evidence regarding the transmission of SARS-CoV-2 through breast milk remains inconclusive, it has been well recognized that breastfeeding can offer enormous health benefits to both the mother and the child. WHO recommends that mothers with suspected or confirmed COVID-19 should be encouraged to have skin-to-skin contact with their newborns and initiate and continue breastfeeding.[45] Thus, providing comprehensive evidence-based information and appropriate breastfeeding support to parents should be prioritized.

Although our primary focus was to detect the effect of maternal COVID-19 positivity at the time of admission for labor and delivery on the labor process and outcomes of vaginal birth, we recognize the possibility of other factors influencing the labor process and outcomes. For example, parity, induction of labor and use of epidural analgesia may influence the duration of labor (Data S1, p. 1). Therefore, we adjusted our analyses for possible confounders; the full analyses results are presented in Data S1. Additionally, we performed further analyses to identify any potential associations among outcome variables, such as use of labor analgesia, length of labor and grade III meconium-stained amniotic fluid. Data S2 presents some additional analyses. These suggest that the duration of labor might be a strong mediator between COVID-19 positivity in labor and grade III meconium-stained amniotic fluid (Data S2, p. 2). These additional analyses provide valuable insight to guide future research.

TABLE 2 Labor process and maternal–infant outcomes ($n=360$).

	COVID-19 test status, *n* (%)		Unadjusted model		Adjusted model	
	Positive ($n=87$)	Negative ($n=273$)	Crude OR (95% CI) or sB	*P*-value	Adjusted[a] OR (95% CI) or sB	*P*-value
Use of labor analgesia[b]	65 (74.7)	194 (71.3)	1.19 (0.69–2.06)[d]	0.54	1.27 (0.63–2.52)[d]	0.51
Length of labor, hours,[c] *M* (P_{25}, P_{75})]	9.3 (7.3, 12.9)	8.3 (5.8, 10.3)	0.18 (0.08–0.28)[e]	<0.01	0.19 (0.09–0.28)[e]	<0.01
Episiotomy	34 (39.1)	65 (23.8)	2.05 (1.23–3.43)[d]	<0.01	2.31 (1.27–4.21)[d]	<0.01
Postpartum hemorrhage (>500 mL)	4 (4.6)	9 (3.3)	1.41 (0.42–4.71)[d]	0.57	1.10 (0.28–4.38)[d]	0.90
Grade III meconium-stained amniotic fluid	17 (19.5)	19 (7.0)	3.25 (1.60–6.58)[d]	<0.01	2.52 (1.15–5.54)[d]	0.02
Neonatal outcomes						
Apgar ≤7 at 1 minute	4 (4.6)	7 (2.6)	1.83 (0.52–6.41)[d]	0.34	1.86 (0.39–9.02)[d]	0.44
Apgar ≤7 at 5 minutes	3 (3.4)	2 (0.7)	4.84 (0.80–29.45)[d]	0.09	12.31 (0.69–220.18)[d]	0.09
Admission to NICU	15 (17.2)	56 (20.5)	0.81 (0.43–1.51)[d]	0.51	0.83 (0.41–1.70)[d]	0.62
Length of postpartum hospital stay (>37 hours)	51 (58.6)	127 (46.5)	1.63 (1.00–2.65)[d]	0.05	1.71 (1.00–2.91)[d]	0.049
Neonatal feeding at discharge	$n=87$	$n=272$ (1 died)				
Non-breastfeeding	29 (33.3)	65 (23.9)				
Mixed feeding	49 (56.3)	169 (62.1)	0.65 (0.38–1.12)[f]	0.12	0.60 (0.33–1.09)[f]	0.09
Exclusive breastfeeding	9 (10.3)	38 (14)	0.53 (0.23–1.24)[f]	0.14	0.47 (0.19–1.21)[f]	0.12
Neonatal feeding at 1 week	$n=86$ (1 died)	$n=272$				
Non-breastfeeding	23 (26.7)	24 (8.8)				
Mixed feeding	40 (46.5)	142 (52.2)	0.29 (0.15–0.58)[f]	<0.01	0.28 (0.13–0.60)[f]	<0.01
Exclusive breastfeeding	23 (26.7)	106 (39)	0.23 (0.11–0.47)[f]	<0.01	0.21 (0.09–0.46)[f]	<0.01

Abbreviations: NICU, neonatal intensive care unit; OR, odds ratios.

[a]Adjustment factors in the multivariable models were all baseline and clinical variables, including age (continuous), ethnic group, parity, BMI (continuous) at admission to birth, gestational hypertensive disorders, gestational diabetes mellitus, GBS^+, other pregnancy complications, history of termination(s), induction, intrapartum fever, gestational age at birth, PROM, birthweight ≥4 kg.

[b]Labor analgesia: epidural analgesia: (0.08% ropivacaine + 0.5 μg/mL sufentanil)/100 mL.

[c]Length of labor: duration of first stage (from the onset to 10 cm cervix dilation) and second stage (from 10 cm cervix dilation to birth of the baby).

[d]Binary logistics regression model, OR (95% CI).

[e]Generalized linear model with a log link function, standardized regression coefficient (sB) (95% CI).

[f]Multinomial logistics regression model, OR (95% CI).

Previously, only a handful of case reports and small studies (sample size ranging from 21 to 52 pregnant women) have reported on the outcomes of vaginal birth among women infected with SARS-CoV-2 during labor,[4,8,46] without any comparison with a reference group. The universal testing of all pregnant women for SARS-CoV-2 on admission for labor and delivery during December 2022 in our hospital, facilitated the execution of this cohort study by providing laboratory-confirmed cases of SARS-CoV-2 and comparators with negative test results. An additional strength of the study was the comprehensive assessment of the independent effect of SARS-CoV-2 positivity on the outcomes, adjusting for several potential confounding factors in a controlled analysis.

Our study has certain limitations that merit discussion. Data on SARS-CoV-2 infection status were not available for all the neonates, as the testing was only done on newborns transferred to NICU. Generalizability of our findings to other SARS-CoV-2 variants (Omicron variant was the main variant during the study period) as well as other countries and settings with different obstetric care standards and availability of resources can also be questioned. Furthermore, this study did not have the statistical power to assess the strength of association between SARS-CoV-2 positivity and certain outcome variables, due to the limited number of cases. The details of post-hoc power analyses and sample size calculations we conducted are presented in Data S3. Lastly, it is important to acknowledge the potential omission of other pertinent clinical and laboratory data on the severity of COVID-19 at the time of labor and delivery.

5 | CONCLUSION

This study revealed that although maternal SARS-CoV-2 positivity at the time of admission for labor and delivery was not significantly associated with serious adverse maternal and neonatal health outcomes, it was associated with a slightly longer duration of labor, increased likelihood of episiotomy, a higher rate of grade III meconium-stained

amniotic fluid, a longer postpartum hospital stay and a lower rate of breastfeeding 1 week postpartum. These findings support the provision of vaginal birth as a viable option for women diagnosed with COVID-19. However, additional support for COVID-19-infected women in labor, aiming to mitigate adverse outcomes during vaginal birth, improve birth experiences and promote successful breastfeeding initiation and establishment should be considered.

AUTHOR CONTRIBUTIONS

AC: conceptualization, methodology, formal analysis, investigation, data curation, writing – original draft, writing – review & editing, visualization. GA: conceptualization, methodology, formal analysis, investigation, writing – review & editing. MH: conceptualization, investigation, writing – review & editing. XG: conceptualization, methodology, data curation, writing – review & editing. GC: conceptualization, investigation, writing – review & editing, funding acquisition. LJ: conceptualization, methodology, data curation, writing – review & editing. QN: conceptualization, methodology, formal analysis, investigation, data curation, writing – original draft, writing – review & editing, visualization, funding acquisition.

ACKNOWLEDGMENTS

Special gratitude is owed to the staff from the information department of Anhui Provincial Hospital who provided support in data collection and management.

FUNDING INFORMATION

This study is supported by Natural Science Research Project of Universities of Anhui Province (KJ2020A1219) and School-level quality engineering project of University of Science and Technology of China in 2022 (2022xjyxm091).

CONFLICT OF INTEREST STATEMENT

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

DATA AVAILABILITY STATEMENT

Please contact the corresponding author to request original database, codes and other materials.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Chen A, Acharya G, Hu M, et al. Association of maternal SARS-CoV-2 infection at the time of admission for delivery with labor process and outcomes of vaginal birth: A cohort study. *Acta Obstet Gynecol Scand*. 2023;00:1-8. doi:10.1111/aogs.14704