Title

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Journal

American Journal of Perinatology, 38(06)

ISSN

0735-1631

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Publication Date

2021-05-01

DOI

10.1055/s-0041-1726036

Peer reviewed

HHS Public Access

Author manuscript

Am J Perinatol. Author manuscript; available in PMC 2022 May 01.

Published in final edited form as:

Am J Perinatol. 2021 May ; 38(6): 622–631. doi:10.1055/s-0041-1726036.

Management and Early Outcomes of Neonates Born to Women with SARS-CoV-2 in 16 US Hospitals

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Abstract

Objective: There is a paucity of evidence to guide the clinical care of late preterm and term neonates born to women with perinatal SARS-CoV-2 infection. The objective of this case series is to describe early neonatal outcomes and inpatient management in US hospitals.

Study Design—We solicited cases of mother-infant dyads affected by COVID-19 from Better Outcomes through Research for Newborns (BORN) Network members. Using a structured case template, participating sites contributed de-identified, retrospective birth hospitalization data for neonates ≥35 weeks of gestation at birth with mothers who tested positive for SARS-CoV-2 before delivery. We describe demographic and clinical characteristics, clinical management, and neonatal outcomes.

Results—Sixteen US hospitals contributed 70 cases. Birth hospitalizations were uncomplicated for 66 (94%) neonates; 4 (6%) required admission to a neonatal intensive care unit. None required evaluation or treatment for infection, and all who were tested for SARS-CoV-2 were negative (n=57). Half of the dyads were co-located (n=34), and 40% directly breastfed (n=28). Outpatient follow-up data were available for 13 neonates, all of whom remained asymptomatic.

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Conclusion: In this multi-site case series of 70 neonates born to women with SARS-CoV-2 infection, clinical outcomes were overall good, and there we no documented neonatal SARS-CoV-2 infections. Clinical management was largely inconsistent with contemporaneous US COVID-19 guidelines for nursery care, suggesting concerns about the acceptability and feasibility of those recommendations. Longitudinal studies are urgently needed to assess the benefits and harms of current practices to inform evidence-based clinical care and aid shared decision making.

Keywords

COVID-19; SARS CoV-2; newborn; neonate; nursery; mother-infant dyad; breastfeeding

Introduction

There is a paucity of published evidence to guide the early clinical care of neonates born to women with perinatal severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. Prenatal transmission is thought to be unlikely due the absence of virus in placenta, amniotic fluid, and umbilical cord blood.[1–3] However, reports of neonates with early-onset SARS-CoV-2 infection have raised the possibility of intrapartum or postnatal transmission,[3–9] either through exposure to maternal secretions, such as breast milk,[10,11] or through respiratory droplets from infectious mothers.

The limited information about maternal-infant transmission and neonatal outcomes poses challenges for the clinical care of maternal-infant dyads affected by SARS-CoV-2. Developing evidence-based recommendations to guide the care of these infants is further complicated by the fact that women can present with or develop severe illness during the birth hospitalization[12] or may be asymptomatic and identified through universal screening of obstetric patients.[13] At the time of data collection for the present study, the American Academy of Pediatrics (AAP) recommended temporary separation of mothers and neonates and feeding expressed mother's milk, if breastfeeding is desired.[14] The concurrent United States Centers for Disease Control and Prevention (CDC) guidelines similarly suggested strong consideration of these measures— in the context of parental wishes.[15] In contrast, World Health Organization (WHO) recommendations included room-sharing, skin-to-skin contact, and direct breastfeeding with precautions similar to those taken with influenza.[16] Guidelines have since converged, with the AAP most recently recommending co-location and direct breastfeeding with infection control precautions in place.[17]

Children overall appear to be less affected and have less severe disease from acute SARS-CoV-2.[18] However, infants remain a vulnerable population,[3,19–22] as there are reports of serious illness and very rarely, death.[18] More recent reports of Multisystem Inflammatory Syndrome in Children temporally associated with COVID-19 raise concern that the full details of COVID-19 presentation in children are yet to be elucidated,[23–25] and the long term complications of COVID-19 in children are unknown. Case series from China[3] and New York[9,26–28] and a United Kingdom population study[8] suggest neonates generally fare well during the birth hospitalization. To date, very little is known about United States (US) early clinical outcomes and clinical management of neonates at risk for acquiring SARS-CoV-2 from their mothers.

This case series from the Better Outcomes through Research for Newborns (BORN) Network offers a glimpse into US clinical outcomes for late preterm and term infants born to women who test positive for SARS-CoV-2 near the time of delivery. Variation in the hospital care of maternal-infant dyads is described for a geographically diverse US sample.

Methods

We conducted this case series in partnership with the Academic Pediatric Association's BORN Network, which consists of 121 North American academic and community hospital nurseries, representing approximately 415,000 annual births.[29]

We collected de-identified, retrospective clinical data for infants born to women diagnosed with perinatal SARS-CoV-2 infection by reverse transcription polymerase chain reaction (RT-PCR), who were cared for at BORN member hospitals between March and May 2020. We included dyads delivered at 35 weeks of gestation or greater, who comprised the typical nursery patient population. The 16 sites that elected to participate contributed all cases that had been identified to date, or if they were limited in the number of cases they could contribute, submitted their first cases sequentially. Each site representative gathered case data and demographics from electronic health records and shared with BORN using a structured template (Appendix). The template included brief prenatal history, birth outcomes, neonatal hospital course, maternal and infant SARS-CoV-2 studies, feeding practices, and infection control precautions. We additionally requested information about maternal race/ethnicity and early follow-up, when these data were available.

Investigators JC/ML/EN and a research assistant abstracted case descriptions into REDcap[30,31] hosted at the University of California, San Francisco; a second coder verified all abstracted data. Outcomes and hospital practices for infants born to women whose last SARS-CoV-2 test prior to delivery was positive are reported separately from infants whose mothers had a negative repeat study before delivery.

Each nursery site consulted with its local Institutional Review Board prior to participating in this collaborative case series. All data collection and the transmission of deidentified data by site representatives to BORN was in accordance with the local Institutional Review Board requirements.

Results

BORN Network collaborators from 16 hospitals in nine states and Washington, D.C. provided a total of 77 cases. Of the 77 mother-infant dyads, 70 women tested positive for SARS-CoV-2 on the most recent RT-PCR test before delivery and were included in the primary analyses (Table 1). The remaining seven women had an initial positive test and had a repeat negative test before delivery; the results for this subgroup are described separately below.

Maternal Clinical Characteristics.

The 70 women who tested positive on the most recent upper respiratory swab before delivery were first diagnosed an average of 4.9 days prior to delivery (range 29 days before to two days after delivery; Table 1); 9 women who were diagnosed more than 14 days prior to delivery had repeat positive respiratory swabs closer to their delivery date. Serology and cycle threshold values were not collected for any of the included women. Sixty-three percent were symptomatic at some point, and 36% still had symptoms at the time of delivery. The timing and mode of deliveries was most often managed as per usual care, with the exception of one woman who was induced at term due to staffing and SARS-CoV-2 related care coordination, and two women who delivered by cesarean section due to maternal intrapartum clinical decompensation related to SARS-CoV-2 infection.

Neonatal Clinical Characteristics and Outcomes.

Infants were delivered at an average of 39.0 weeks of gestation (range 36.3 – 41.6 weeks, SD=1.3; Table 1). The majority (84%) had birthweights appropriate for gestational age, and 10% were small for gestational age. Delivery room interventions were limited to warm/dry/stimulation and suction for 64 (91%) infants. Five infants required positive pressure ventilation (PPV) and/or continuous positive airway pressure (CPAP) at the delivery, all of whom were ultimately admitted to the well-baby nursery and had otherwise uncomplicated hospital courses (Table 2). One infant required cardiopulmonary resuscitation and intubation in the delivery room, was treated with therapeutic hypothermia, and exhibited signs of hypoxic ischemic encephalopathy. Three other infants required care in a neonatal intensive care unit (NICU; Table 2). One infant was transferred to the NICU on day two for tachypnea, which resolved without need for respiratory support, and no additional evaluation (e.g. for sepsis) was pursued. The other two NICU admissions were due to hypoglycemia (1 large for gestational age, 1 transient hyperinsulinemia of unknown etiology; Table 2).

Of 70 infants, 57 (81%) were tested by upper respiratory RT-PCR due to hospital policy for universal testing of neonates born to women positive for SARS-CoV-2; 13 (19%) were not tested due to hospital policy pertaining to asymptomatic neonates. Most infants were tested close to 24 hours of life (range 2–120 hours, M=30 hours, SD=16.0). Eleven (19% of infants tested) had a repeat upper respiratory swab during the birth hospitalization. All initial and repeat upper respiratory RT-PCR tests in this sample were negative for SARS-CoV-2. Additional testing for one infant included stool RT-PCR and serum IgM and IgG at 24 hours, which were all negative. The mother of this infant developed symptoms 12 days before delivery and tested positive for SARS-CoV-2 10 days before delivery and again at four days before delivery.

Pediatric Provider Delivery Attendance.

Hospital practices varied across and within participating institutions, likely due to evolving protocols over the data collection period. A pediatric provider was present at 50 (72%) of deliveries. The indication for pediatric attendance was noted as maternal SARS-CoV-2 positivity or related maternal clinical status for 32 of these 50 deliveries.

Management Related to Infection Control.

Sixty-six (94%) infants were admitted to a well-baby unit. Of these 66 dyads, 33 (50%) were roomed separately during the birth hospitalization. The decision to separate was cited as hospital COVID-19 rooming policy for 29 dyads and due to shared decision making between parents and providers for four dyads. Most cases of dyads who were separated due to hospital policy were at sites in the US Northeast. Of the 33 (50%) dyads who were co-located, the decision was due to hospital COVID-19 co-location policy for 12 dyads, due to parental preference against hospital separation recommendations for 10 dyads, and due to shared decision making for 11 dyads. Case descriptions revealed that the management of nearly all co-located dyads included additional infection control precautions, such as physical distancing within the shared hospital room, infant placement in an isolette, limited physical contact between mother and infant, use of maternal personal protective equipment, and breast hygiene.

Neonatal Feeding Outcomes.

Another commonly implemented infection control measure relates to infant feeding (Table 3). Forty-two infants (53%) were not provided any feedings at breast and were exclusively fed by bottle or alternative methods. Of these 42 infants, 37 were exclusively fed formula or donor milk, four were fed a combination of expressed maternal colostrum/milk plus supplementation, and one infant was exclusively fed expressed breast milk. Of the 28 dyads who directly breastfed, seven also supplemented with formula or donor milk. Twelve of the 28 women who directly breastfed were at a hospital whose policy at the time was to recommend against direct breastfeeding in women who test positive for SARS-CoV-2.

Management of Discharge and Follow-up.

Length of stay for asymptomatic infants averaged 1.9 days (range 1–4 days, SD=0.8). For the 44 infants with data on their outpatient follow-up plan, the timing of follow-up averaged 1.7 days after discharge (range 1–4 days, SD=0.9). Most (74%) infants followed up at in-person clinic appointments, and 26% had a phone or video tele-health appointment.

Information about COVID-19 related discharge instructions was included with all submitted cases, though the specificity of this data was variable. Case descriptions commonly included the following measures for infection control after discharge: maintaining physical distance between the mother and infant, parental use of personal protective equipment, and hygiene (e.g. hand, breast, home cleaning). Ten cases noted recommendations for ongoing, temporary avoidance of direct breastfeeding.

Post-discharge Clinical Outcomes.

Thirteen of the cases submitted to BORN included post-discharge follow-up information (Table 4). At the time of outpatient follow-up (range four days to one month of life), all infants were asymptomatic, and none had been re-tested for SARS-CoV-2. Seven of these 13 dyads were co-located during the birth hospitalization, of whom five directly breastfed and two were fed formula. Of the six dyads who were separated, three were fed a combination of expressed maternal milk and formula, and three were exclusively fed formula.

Not included in the main results or tables are seven cases in which a repeat maternal SARS-CoV-2 test just before delivery resulted negative. These seven women presented with COVID-19 symptoms during pregnancy and were confirmed positive for SARS-CoV-2 by upper respiratory swab RT-PCR; their symptoms resolved prior to delivery, and repeat tests were negative. From an infection control standpoint, these dyads were managed as per usual without any COVID-19 specific precautions such as separation or avoidance of direct breastfeeding. The neonates did not exhibit any signs of infection during their birth hospitalizations.

Discussion

This case series provides a national sampling of US nurseries' first cases of late preterm and term neonates born to women with perinatal SARS-CoV-2 infection. The majority of infants in this case series were clinically well, and all infants who were tested for SARS-CoV-2 during the birth hospitalization tested negative. These cases also demonstrate variation in infection control practices across participating US hospitals, likely due to the very limited evidence to guide clinical care in the early stages of the pandemic.

Our finding that infants born to women with SARS-CoV-2 infection generally fared well is consistent with reports from China,[2,3] the United Kingdom,[8] and the US.[26–28,32] The variation in length of gestation,[33] rate of small for gestational age (per the most common definition of birth weight <10th percentile), and the rate of infants who required delivery resuscitation[34] in this sample were consistent with that of the typical US nursery patient population, though our modest sample size does not allow statistical power to make these conclusions. We anticipate the publication of data from ongoing larger registry studies to assess the generalizability of these early observations.[35]

Regarding infection control practices, we found that a large proportion of infants were not managed according to AAP and CDC recommendations in place at the time of delivery,[14,15] with half of dyads co-locating and 40% directly breastfeeding. Rates of indirect breastfeeding of expressed maternal milk were exceedingly low in this sample, despite being the recommended practice by both AAP[14] and CDC[15] at the time of data collection in order to preserve breastfeeding during temporary mother-infant separation. These data suggest that indirect breastfeeding in the first days of life may not be feasible or acceptable to parents and/or providers of neonates with mothers who test positive for SARS-CoV-2, raising serious concerns about the unintended consequences of separation on breastfeeding rates.[36] Women who did not initiate direct breastfeeding during the birth hospitalization were not receiving the inpatient sources of support that promote longer breastfeeding durations.[37,38] Studies with post-discharge breastfeeding outcome data are needed to enable careful assessment of this potential consequence of recommendations for temporary separation and avoidance of direct breastfeeding to inform decision making during this pandemic and potential future infectious outbreaks. We anticipate that adherence to AAP recommendations will improve with the latest updates due to likely greater patient acceptance of the recommended practices. We also anticipate greater provider acceptance and confidence in the AAP recommendations, which are now closely aligned with those of other organizations.

This series provides preliminary evidence of the potentially limited direct impact of maternal perinatal SARS-CoV-2 infection on early neonatal outcomes in the US. However, we caution against overgeneralizations based upon this relatively small sample of late preterm and term neonates with outcome data restricted to the birth hospitalization for most cases. Studies with larger samples and longitudinal clinical outcome data will be critical for assessing the effects of COVID-19 on neonates and the associations with various hospital infection control practices. Of note, although the cases reported reflect a geographically diverse sampling of academic and community hospital nurseries, about 40% of cases were from three nurseries that are part of the same hospital system in New Jersey; the policy at these nurseries is to recommend separation and indirect breastfeeding for dyads affected by COVID-19.[39] Therefore, our study should not be considered a representative US sample with regards to clinical management. In addition, data on institutional policies about universal screening of obstetric patients for SARS-CoV-2 were not systematically collected; therefore, symptomatic cases may be overrepresented. The BORN Network has a follow-up study underway to assess the variation in institutional policies across its member nurseries.

Importantly, emerging data show significant racial/ethnic[40–42] and socioeconomic[43,44] disparities in US rates and outcomes of SARS-CoV-2 infection. Consistent with these reports, this series includes predominantly women of color; however, our study design does not permit inferences about the effect of COVID-19 on specific demographic groups. The demographic make-up of this sample is influenced by the demographics at the local sites who opted to contribute and may not be representative of the COVID-19 pandemic in the US.

Assessment of nursery management practices and neonatal outcomes is a critical next step in COVID-19 research. Concrete evidence of the relative benefits and harms are needed to inform evidence-based guidelines and aid shared decision making with parents. More longitudinal studies, such as the one by Salvatore et al (2020), are urgently needed to understand associations among inpatient management, post-discharge infection control precautions, feeding practices, SARS-CoV-2 infection in other caregivers, and infant clinical outcomes. Finally, as clinicians we recognize the large impact of COVID-19 related stressors for new families. The documentation and analysis of caregiver experiences and mental health in the setting of changes in clinical and social supports will provide critical input into the development of best practices.

Conclusions

In this case series, the majority of neonates born to US women with perinatal SARS-CoV-2 infection were asymptomatic during the birth hospitalization and had a length of stay consistent with US norms. Of the neonates who were tested, none tested positive for SARS-CoV-2 during the birth hospitalization. The small subset of neonates for whom post-discharge data were available all remained asymptomatic. Clinical management varied and did not uniformly follow national guidelines in place during data collection. Rates of indirect breastfeeding were low despite being the recommended method of feeding by the AAP and CDC at the time of birth. Larger studies with longitudinal clinical data, including repeat

SARS-CoV-2 testing, readmission rates, breastfeeding rates, and parental mental health are needed to inform the establishment of evidence-based clinical guidelines.

Acknowledgements

The authors acknowledge the contributions of research coordinators, Beth King, Apryl Olarte, Annalisa Watson, and Dennis West.

Funding Source:

Research staff were supported by the Academic Pediatric Association. Dr. Kair's effort was supported by the National Center for Advancing Translational Sciences, National Institutes of Health (through grant UL1 TR001860), and the National Institutes of Health Building Interdisciplinary Research Careers in Women's Health Program (K12HD051958). The contents of this publication are solely the responsibility of the authors and do not represent the official views of the National Institutes of Health.

Appendix

Suggested Template for Submission of Cases of Infants Born to Women with Perinatal SARS-CoV-2 Infection

Patient # is a [sex] [singleton, twin, etc.] [AGA/SGA/LGA] infant born at [ ] weeks of gestation to a [ ] year-old woman with G [ ] P [ ], [any pertinent maternal medical history], and a diagnosis of COVID-19 by [pertinent studies and symptoms, if available] at [ ] days prior to delivery. The mode of delivery was [ ] due to [indication, if induced or cesarean] after a rupture time of [ ] hours. The delivery [was/was not] attended by a pediatric provider due to [ ]. Resuscitation included [ ], and Apgar scores were [ ]. On day [ ] of life, the infant experienced [any signs/symptoms of infection], with [ ] physical exam findings. The hospital course included [any other remarkable hospital course information]. Studies included [imaging, if done], which showed [imaging findings, if done] and the following laboratory tests: [general infectious work-up or other, if done]. [COVID-19 specific tests, if done] were [negative/positive] for SARS-CoV-2 on day [ ] of life. The infant was admitted to the [ ] service due to [e.g., hospital COVID-19 policy, infant or maternal indication]. Feeding included [e.g., direct breastfeeding, indirect breastfeeding pumped colostrum/milk, formula] due to [e.g., infection control precautions, maternal preference]. Infection control precautions included [e.g., complete separation during hospitalization, minimizing physical contact, PPE]. Discharge was at [ ] days of life to [e.g., parents, other healthy caregiver], with instructions to follow-up at [ ] days of life and [any other specific instructions regarding infection control, e.g., feeding or PPE practices].

Abbreviations:

AAP	American Academy of Pediatrics
BORN	Better Outcomes through Research for Newborns
CDC	United States Centers for Disease Control and Prevention
COVID-19	Coronavirus Disease of 2019
NICU	neonatal intensive care unit

RT-PCR	reverse transcription polymerase chain reaction
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
US	United States
WHO	World Health Organization

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Key Points

- Birth hospitalizations were uncomplicated for late preterm and term infants with maternal COVID-19.
- Nursery management of dyads affected by COVID-19 varied between hospitals.
- Adherence to contemporaneous US clinical guidelines for nursery care was low.
- Breastfeeding rates were lower for dyads roomed separately than those who were co-located.

Table 1.

Demographics, clinical characteristics, and hospital management of maternal-infant dyads affected by perinatal SARS-CoV-2 infection (n=70)

	N (%)
Demographic Characteristics	
Maternal age	
<20 years	2 (3%)
20 to <30 years	31 (44%)
30 to <40 years	31 (44%)
>40 years	6 (9%)
Maternal race/ethnicity	
Asian	3 (4%)
Black or African American	14 (20%)
Latinx	32 (46%)
White	13 (19%)
Other/multi-ethnic	1 (1%)
Missing/unknown	7 (10%)
Infant sex	
Female	35 (50%)
Male	35 (50%)
United States region	
Northeast	39 (56%)
Midwest	7 (10%)
South	10 (14%)
West	14 (20%)
Delivery and Birth Characteristics	
Mode of delivery	
Vaginal	45 (64 %)
Cesarean	25 (36%)
Length of gestation	
35 to <37 weeks	4 (6%)
37 to <38 weeks	14 (20%)
38 to <39 weeks	10 (14%)
39 to <40 weeks	21 (30%)
≥40 weeks	21 (30%)
Birthweight	
Appropriate for gestational age	59 (84%)
Small for gestational age	7 (10%)
Large for gestational age	4 (6%)

	N (%)
Delivery room resuscitation	
Routine warm, dry, stimulation and suction	63 (90%)
Positive pressure ventilation (PPV)	3 (4%)
Continuous positive airway pressure (CPAP)	3 (4%)
Cardiopulmonary resuscitation and intubation	1 (1%)
SARS-CoV-2	
Maternal SARS-CoV-2 diagnosis, days before delivery (range, mean [SD]) *	2–29, 7.1 [7.9]
Maternal SARS-CoV-2 symptoms	
Maternal symptoms at any point	42 (63%)
Maternal symptoms at time of delivery	25 (36%)
Maternal symptoms unknown	3 (4%)
Neonate tested for SARS-CoV-2 by upper respiratory swab RT-PCR	57 (81%)
Hours of life at swab #1 (range, mean [SD])	2–120, 30 [16.0]
Hours of life at swab #2 (range, mean [SD])	36–384, 88 [101.0]
SARS-CoV-2 Related Clinical Management	
Pediatric provider attended delivery	50 (72%)
Pediatric provider attended due to maternal SARS-CoV-2	24 (34%)
Service to which infant was admitted	
Well-baby nursery	65 (93%)
Pediatric hospitalist/ward (with separation)	1 (2%)
Intensive care nursery (with separation)	4 (6%)
Co-location of mother and infant	34 (49%)
Length of stay (range, mean [SD])	1– 4, 1.9 [1.8]
Discharge to which caregiver(s)	
Parents	65 (93%)
Other healthy caregiver	5 (7%)
Timing of post-discharge follow-up (range, mean [SD])	1–4, 1.7 [0.9]
Method of post-discharge follow-up	
In person clinic appointment	52 (74%)
Tele-health appointment	18 (26%)

RT-PCR: reverse transcription polymerase chain reaction, SARS-CoV-2: severe acute respiratory syndrome coronavirus 2, SD: standard deviation;

* diagnosis timing per collection date of the first respiratory swab that was positive for SARS-CoV-2 (all by RT-PCR)

Table 2.

Neonates born to women with SARS-CoV-2 infection who required delivery resuscitation and/or had clinical complications during the birth hospitalization (n=9)

Brief ID	Maternal History	Maternal SARS-CoV-2 Status	Delivery and Resuscitation	Neonatal Hospital Course	Neonatal Laboratory and Imaging Studies
41 0/7 AGA female	Gestational hypertension	Symptom onset 12 days before delivery and resolution 6 days before delivery; NP RT-PCR positive 10 days before delivery and again 2 days before delivery	NSVD after ROM 28 hours; emerged with poor tone and respiratory effort requiring PPV for 1 minute and CPAP for 30 minutes; Apgar 3, 8, 9	Uncomplicated; co-located and directly breastfed (see Table 4 for follow-up)	Upper respiratory SARS-CoV-2 RT-PCR negative at 24 and 48 hours; stool RT-PCR negative at 24 hours; IgM, IgG negative at 24 hours
38 0/7 LGA male	Hypertension, GDMA2 not taking prescribed insulin, obesity, persistent asthma, anemia	Asymptomatic at delivery (presence of prior symptoms not documented); NP RT-PCR positive 14 days and 3 days before delivery	Repeat CS with ROM at delivery; required CPAP for 3 hours after delivery for respiratory distress and hypoxemia; Apgar 8, 9	Observed in NICU while on CPAP, then transferred to well-baby unit and had otherwise uncomplicated course; co-located with mother and directly breastfed	Upper respiratory SARS-CoV-2 RT-PCR negative at 24 and 48 hours; no other studies obtained
39 0/7 AGA female	Limited prenatal care	Respiratory symptoms for 7 days before admission; NP RT-PCR positive on day of delivery	Repeat CS with ROM at delivery; required CPAP for 30 minutes due to respiratory distress and hypoxemia; Apgar 8, 9	Uncomplicated; co-located and directly breastfed	Upper respiratory SARS-CoV-2 RT-PCR negative at 24 and 48 hours
40 3/7 AGA male	Uncomplicated	Asymptomatic; NP RT-PCR positive on day of delivery	NSVD after ROM 9 hours; emerged with poor respiratory effort requiring brief PPV; Apgar 6, 8	Uncomplicated; co-located and directly breastfed	Upper respiratory SARS-CoV-2 RT-PCR negative at 35 hours
38 4/7 AGA female	Uncomplicated	Symptoms resolved before admission; NP RT-PCT positive 19 days before and on the day of delivery	CS for fetal malpresentation; emerged with poor respiratory effort and tone requiring brief PPV; Apgar 3, 8	Uncomplicated; admitted to well-baby service and roomed separately	Upper respiratory SARS-CoV-2 RT-PCR negative at 24 hours
38 6/7 AGA male	Obesity	Presented to emergency department 2 days before delivery with fever; NP RT-PCR positive 2 days before delivery	CS after ROM 4 hours due to worsening maternal and fetal tachycardia; no resuscitation needed; Apgar 9, 9	Initially admitted to well-baby service and roomed separately from mother; NICU transfer on day 2 for tachypnea; feeding tube placed, no respiratory support needed; tachypnea resolved and was discharged on day 4	Upper respiratory SARS-CoV-2 RT-PCR negative at 24 hours; chest radiograph on day 2 with increased interstitial markings bilaterally, presumed retained fetal fluid; no other studies obtained
39 1/7 LGA male	Uncomplicated	Symptoms resolved before admission; Upper respiratory RT-PCR positive 23 days and 1 day before delivery	NSVD after ROM 1 hour; shoulder dystocia; required vigorous stimulation and appeared dusky until 3 minutes of life; Apgar 5, 8	NICU admission for hypoglycemia, hospitalization prolonged due to feeding difficulty and therapy for brachial plexus neuropathy (see Table 4 for readmission and follow-up)	Upper respiratory SARS-CoV-2 negative at 2 and 5 days
40 1/7 AGA male	Uncomplicated	Symptoms resolved before delivery; NP RT-PCR positive day after delivery	NSVD with ROM at delivery; no resuscitation needed; Apgar 9, 9	NICU admission for persistent hypoglycemia requiring dextrose-containing fluids for 2 weeks; endocrinology consultants diagnosed transient hyperinsulinemia; otherwise well	Upper respiratory SARS-CoV-2 RT-PCR negative at 3, 4, and 7 days

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Brief ID	Maternal History	Maternal SARS-CoV-2 Status	Delivery and Resuscitation	Neonatal Hospital Course	Neonatal Laboratory and Imaging Studies
40 5/7 SGA male	Preeclampsia	Symptoms resolved before delivery; NP RT-PCR positive on day of delivery	NSVD after ROM 4 hours; emerged without respiratory effort, poor tone, and bradycardia; required CPR and intubation; Apgar 0, 1, 6	NICU admission for therapeutic hypothermia for hypoxic ischemic encephalopathy; discharged at 9 days with close monitoring of neurodevelopmental progression (see Table 4 for follow-up)	Upper respiratory SARS-CoV-2 RT-PCR negative 24 and 50 hours; MRI brain unrevealing, EEG without seizure activity

AGA: appropriate for gestational age, CPAP: continuous positive airway pressure, CS: cesarean section, CPR: cardiopulmonary resuscitation, GDM2: gestational diabetes mellitus, insulin controlled, NICU: neonatal intensive care unit, LGA: large for gestational age, NP: nasopharyngeal, NSVD: normal spontaneous vaginal delivery, PPV: positive pressure ventilation, ROM: rupture of membranes, RT-PCR: reverse transcription polymerase chain reaction, SARS-CoV-2: severe acute respiratory syndrome coronavirus 2; SGA: small for gestational age

Table 3.

Method of feeding for neonates born to women with SARS-CoV-2 Infection (n=70)

Method of Feeding	Full Sample (n=70)	Co-located (n=34)	Roomed Separately (n=36)
Direct breastfeeding exclusively	21 (30%)	21 (64%)	--
Direct breastfeeding + supplementation*	7 (10%)	7 (21%)	--
Expressed breastmilk exclusively	1 (1%)	--	1 (3%)
Expressed breastmilk + supplementation*	4 (6%)	--	4 (11%)
Formula or donor milk exclusively	37 (53%)	6 (18%)	31 (84%)

*Supplementation defined as formula or donor milk

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Table 4.

Neonates born to women with perinatal SARS-CoV-2 infection with post-discharge clinical outcomes (n=13)

Brief ID	Maternal SARS-CoV-2 Status	Newborn SARS-CoV-2 Status	Inpatient Rooming Arrangement	Feeding	Clinical Status at Follow-up
41 0/7 AGA female; required delivery resuscitation; otherwise uncomplicated course (Table 2)	NP RT-PCR positive 10 days before delivery and 2 days before delivery; symptoms had resolved	Upper respiratory RT-PCR negative at 24 and 48 hours; stool RT-PCR negative at 24 hours; IgM, IgG negative at 24 hours	Co-located, in-room physical distancing, parental PPE	Direct breastfeeding	*Asymptomatic at 2 weeks*
39 0/7 AGA male; uncomplicated course	NP RT-PCR positive 2 days after delivery; mild respiratory symptoms present at delivery	Upper respiratory RT-PCR negative at 5 days and 16 days	Co-located, in-room physical distancing, isolette, parental PPE	Formula	*Asymptomatic at 1 month*
40 0/7 AGA female; uncomplicated course	NP RT-PCR positive 1 day before delivery; asymptomatic	Upper respiratory RT-PCR negative at 24 hours	Co-located, in-room physical distancing, isolette, parental PPE	Direct breastfeeding	*Asymptomatic at 1 month*
37 5/7 LGA female; uncomplicated course	NP RT-PCR positive on day before delivery; asymptomatic	Not tested	Co-located, no additional precautions	Direct breastfeeding	*Asymptomatic at 2 weeks*
40 1/7 AGA male; uncomplicated course	NP RT-PCR positive 15 days, 10 days, and 1 day before delivery; symptoms had resolved	Not tested	Co-located, in-room physical distancing, parental PPE	Direct breastfeeding	*Asymptomatic at 4 days*
40 5/7 week AGA male; uncomplicated course	NP RT-PCR positive 2 days before delivery; symptomatic at delivery	Upper respiratory RT-PCR negative at 24 hours	Co-located, in-room physical distancing, parental PPE	Direct breastfeeding	*Asymptomatic at 1 week*
37 0/7 LGA male; uncomplicated course	NP RT-PCR positive 2 days before delivery; mild respiratory symptoms present at delivery	Upper respiratory RT-PCR negative at 24 and 48 hours	Separated for 24 hours, then co-located per maternal request to practice infant care	Formula	*Asymptomatic at 1 month*
40 0/7 AGA male; uncomplicated course	NP RT-PCR positive 2 days before delivery; mild symptoms present	Upper respiratory RT-PCR negative at 24 hours	Separated	Formula	*Asymptomatic at 1 month*
37 2/7 AGA male; uncomplicated course	NP RT-PCR positive on day of delivery; asymptomatic	Not tested	Separated	Expressed breastmilk, formula	*Asymptomatic at 5 days*
40 1/7 AGA male; uncomplicated course	NP RT-PCR positive 4 days before delivery	Upper respiratory RT-PCR negative at 24 hours	Separated	Expressed breastmilk, formula	*Asymptomatic at 2 weeks*
39 0/7 AGA male; uncomplicated course	NP RT-PCR positive 1 day before delivery; respiratory symptoms present at delivery	Not tested	Separated	Expressed breastmilk, formula inpatient; direct breastfeeding after discharge	*Asymptomatic at 1 month*
40 5/7 SGA male; CPR and intubation at delivery, hypoxic	NP RT-PCR positive on day of delivery; symptoms had resolved	Upper respiratory RT-PCR negative at 24 and 50 hours	Separated due to NICU admission	Formula	*Asymptomatic from infection standpoint and with ongoing*

Brief ID	Maternal SARS-CoV-2 Status	Newborn SARS-CoV-2 Status	Inpatient Rooming Arrangement	Feeding	Clinical Status at Follow-up
ischemic encephalopathy (Table 2)					*neurodevelopmental concerns at 1 month*
39 1/7 LGA male; admitted to NICU for hypoglycemia, poor feeding, brachial plexus neuropathy (Table 2)	NP RT-PCR positive 23 days and 1 day before delivery; symptoms had resolved	Upper respiratory RT-PCR negative at 2 days and 5 days	Separated due to NICU admission	Formula	*Readmitted at 17 days for apneic episode during a feed, well appearing in ED, observed 48 hours in NICU, repeat SARS-CoV-2 test negative and no other work-up; otherwise asymptomatic from infection standpoint*

AGA: appropriate for gestational age, CPR: cardiopulmonary resuscitation, NICU: neonatal intensive care unit, LGA: large for gestational age, NP: nasopharyngeal, PPE: personal protective equipment, RT-PCR: reverse transcription polymerase chain reaction, SARS CoV-2: severe acute respiratory syndrome coronavirus 2, SGA: small for gestational age