

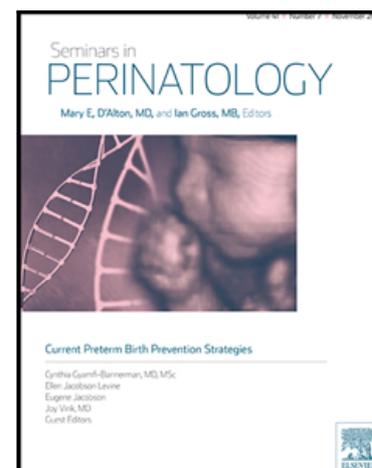


Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Journal Pre-proof

Infection Prevention and Control for Labor and Delivery, Well Baby Nurseries, and Neonatal Intensive Care Units



Lisa Saiman MD MPH , Karen P. Acker MD ,
Dani Dumitru MD PhD , Maria Messina RN BSN CIC ,
Candace Johnson MD , Philip Zachariah MD MS ,
Wanda Abreu MD , Minna Saslaw MD , M. Kathleen Keown MD ,
Erin Hanft MD , Grace Liao MD , Donna Johnson MS, MBA ,
Kenya Robinson MSN RN-BC ,
Svetlana Streltsova MSN, RN, CCRN ,
Natali Valderrama MSN RN RNC-OB ,
Amrita Markan BSN RNC-OB C-EFM CBC CCE ,
Magda Rosado RN MSN , Ganga Krishnamurthy MD ,
Rakesh Sahni MD , Anna A Penn MD PhD , Jean Ju Sheen MD ,
Noelia Zork MD , Janice Aubey MD MPH ,
Corrina Oxford-Horrey MD , Dena Goffman MD

PII: S0146-0005(20)30103-8
DOI: <https://doi.org/10.1016/j.semperi.2020.151320>
Reference: YSPER 151320

To appear in: *Seminars in Perinatology*

Please cite this article as: Lisa Saiman MD MPH , Karen P. Acker MD , Dani Dumitru MD PhD , Maria Messina RN BSN CIC , Candace Johnson MD , Philip Zachariah MD MS , Wanda Abreu MD , Minna Saslaw MD , M. Kathleen Keown MD , Erin Hanft MD , Grace Liao MD , Donna Johnson MS, MBA , Kenya Robinson MSN RN-BC , Svetlana Streltsova MSN, RN, CCRN , Natali Valderrama MSN RN RNC-OB , Amrita Markan BSN RNC-OB C-EFM CBC CCE , Magda Rosado RN MSN , Ganga Krishnamurthy MD , Rakesh Sahni MD , Anna A Penn MD PhD , Jean Ju Sheen MD , Noelia Zork MD , Janice Aubey MD MPH , Corrina Oxford-Horrey MD , Dena Goffman MD , Infection Prevention and Control for Labor and Delivery, Well Baby Nurseries, and Neonatal Intensive Care Units, *Seminars in Perinatology* (2020), doi: <https://doi.org/10.1016/j.semperi.2020.151320>

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Infection Prevention and Control for Labor and Delivery, Well Baby Nurseries, and Neonatal Intensive Care Units

Lisa Saiman MD MPH^{1,2}, Karen P. Acker MD^{2,3}, Dani Dumitru MD PhD¹, Maria Messina RN BSN CIC², Candace Johnson MD^{1,2}, Philip Zachariah MD MS^{1,2}, Wanda Abreu MD¹, Minna Saslaw MD¹, M. Kathleen Keown MD¹, Erin Hanft MD¹, Grace Liao MD¹, Donna Johnson MS, MBA⁴, Kenya Robinson MSN RN-BC⁴, Svetlana Streltsova MSN, RN, CCRN⁴, Natali Valderrama MSN RN RNC-OB⁴, Amrita Markan BSN RNC-OB C-EFM CBC CCE⁴, Magda Rosado RN MSN⁴, Ganga Krishnamurthy MD¹, Rakesh Sahni MD¹, Anna A Penn MD PhD¹, Jean Ju Sheen MD⁵, Noelia Zork MD⁵, Janice Aubey MD MPH⁵, Corrina Oxford-Horrey MD⁶, Dena Goffman MD⁵

¹ Department of Pediatrics, Columbia University Irving Medical Center, New York

² Department of Infection Prevention & Control, NewYork-Presbyterian Hospital, New York, New York

³ Department of Pediatrics, Weill Cornell Medicine, New York

⁴ Department of Nursing, NewYork-Presbyterian Hospital, New York, New York

⁵ Department of Obstetrics and Gynecology, Columbia University Irving Medical Center, New York

⁶ Department of Obstetrics and Gynecology, Weill Cornell Medicine, New York

Introduction

As of this writing, the COVID-19 pandemic is widespread throughout the United States (U.S.), with New York City (NYC), where our hospital is located, being the epicenter. In mid-March 2020, the nursing and physician care teams for maternal care on the obstetric units and newborn infant care in the Well Baby Nurseries (WBN) and neonatal intensive care units (NICUs) partnered with the infection prevention and control (IP&C) teams due to the pressing need to develop specific IP&C policies and practices for these unique patient populations. At the start of the pandemic in the U.S., the risk of severe disease in pregnant women was unknown, but of great concern given the known vulnerability of this patient population to other respiratory viral infections¹. Other IP&C considerations focused on *in utero*, perinatal and postnatal transmission of SARS-CoV-2 (the viral etiology of COVID-19) to the fetus or to newborns. An additional concern was the potential risk of an outbreak of SARS-CoV-2 in the NICU as respiratory outbreaks are well described in this population. Thus, our interventions were developed to minimize these risks and protect the safety of our front-line healthcare teams.

This chapter describes the IP&C policies and practices for women in labor, during delivery, and postpartum, and for newborns born to SARS-CoV-2 positive mothers who were cared for in the WBN, NICU, and after hospital discharge that were implemented during the early weeks of the first wave of the COVID-19 pandemic in NYC, i.e., mid-March through the mid-May. These policies and practices were implemented across a large multi-campus system with ~20,000 annual deliveries, including ~2,000 deliveries during the first six weeks of universal testing of women in labor for SARS-CoV-2 was implemented. To create our interim guidance recommendations, we reviewed the recommendations of the Centers for Disease Control, the World Health Organization, the American Academy of Pediatrics, and the American College of Obstetricians and Gynecologists as described in Table 1. Additionally, the NYS Department of Health issued executive orders on March 28 and on April 29 that informed our visitor policies⁵. Importantly, we reviewed relevant clinical and basic science reports emerging in the literature to inform our recommendations using a shared decision making model among the multidisciplinary team members.

Staff Self-monitoring for COVID-19 Symptoms

Staff were asked to self-monitor for symptoms consistent with COVID-19 including subjective fever or measured fever 100.0 degrees Fahrenheit or higher. The list of compatible COVID-19 symptoms expanded during the first few months of the pandemic in the U.S., i.e., January to April 2020, initially focusing on lower respiratory tract symptoms (e.g., cough and shortness of breath), then including gastrointestinal and systemic manifestations (e.g., diarrhea, myalgia), and then expanding to neurologic manifestations (headache and loss of taste or smell)⁶. At the

time of this writing COVID-19 symptoms include: subjective or measured fever, cough, shortness of breath, sore throat, myalgias, diarrhea, headache, chills or shaking chills, or loss of taste or smell. Staff who developed symptoms self-isolated at home and were cleared to return to work by Workforce Health and Safety based on the following criteria: 1) at least 7 (which increased to 10) days since onset of symptoms, 2) at least 72 hours without fever without use of antipyretic medications, and 3) marked improvement in symptoms.

Screening Patients for COVID-19 Symptoms

Patients and their support persons were screened by nursing staff for the above symptoms and fever upon arrival to the hospital, upon admission to the L&D unit, upon admission to the postpartum unit, and every 12 hours until discharge. When feasible, support persons were screened before arrival to the hospital, e.g., prior to elective caesarean section or induction of labor. Upon arrival to L&D, patients with symptoms or fever were placed in a single room with the door closed. Support persons with symptoms or fever were asked to leave the facility.

SARS-CoV-2 Testing for Obstetrical Patients

Universal SARS-CoV-2 testing was implemented for all obstetrical patients being admitted to L&D units starting on March 22, 2020. This guidance was developed in response to the identification of several women who initially presented to L&D without symptoms, but subsequently developed symptoms during labor or postpartum⁷. Additionally, it was recognized that COVID-19 can mimic symptoms observed during L&D including fever, shortness of breath, and diarrhea, making a symptom-based approach unreliable. Furthermore, as the pandemic progressed, it became clear that transmission of SARS-CoV-2 could occur from asymptomatic or pre-symptomatic individuals. SARS-CoV-2 testing was done by sending a nasopharyngeal swab for RT-PCR. The Cepheid RT-PCR SARS-CoV-2 assay was utilized due to its rapid turnaround time, i.e., ~90 minutes. Testing of newborns born to SARS-CoV-2 positive mothers is described below.

Understanding Transmission of SARS-CoV-2 to Inform Personal Protective Equipment

A comparison of the recommended PPE for care of patients with confirmed or suspected COVID-19 who were not undergoing and who were undergoing aerosol-generating procedures is shown in Table 2. An N95 respirator was required when caring for patients undergoing aerosol-generating procedures. However, we do not yet have a complete understanding of the relative contributions of different factors involved in SARS-CoV-2 transmission which help to guide PPE use as described in Table 3. Furthermore, the optimal use of PPE in healthcare settings during the COVID-19 pandemic has also been hindered by PPE supply issues and rapidly evolving guidance, as described in the following chapter: *Personal Protective Equipment*.

A comparison of the characteristics of droplet versus airborne transmission is shown in Table 4.¹⁹ The primary mode of transmission of coronaviruses, including SARS-CoV-2, is large respiratory droplets produced by coughing, sneezing, singing, and even normal speech.^{9, 10} SARS-CoV-2 virus has been isolated from the naso/oropharynx, sputum, and lower respiratory tract; most studies demonstrated higher viral loads in the upper airway compared to the lower respiratory tract which supports the role of respiratory droplets.^{20, 21} Thus, surgical facemasks and eye protection, consistent with Droplet Precautions, are clearly indicated to prevent transmission of SARS-CoV-2 to healthcare workers during care of patients with COVID-19. Additionally, all staff wore surgical facemasks once they entered the hospital and throughout their workday, unless a higher level of PPE was needed to care for patients as described below.

Airborne transmission of SARS-CoV-2 is thought to occur during aerosol-generating procedures performed in healthcare settings. An experimental model evaluated the aerosol and surface stability of SARS-CoV-1 and SARS-CoV-2; both viruses remained viable in aerosols for as long as three hours.¹¹ Additionally, the recovery of viral RNA from air and air vents in a patient room suggested the potential for airborne transmission.¹² However, at this time, it is unclear if N95 respirators offer superior protection to healthcare providers compared to surgical facemasks during routine hospital care of SARS-CoV-2 positive patients. Thus, N95 respirators are currently prioritized for care of patients undergoing aerosol-generating procedures, e.g., aerosolized medication administration, cardiopulmonary resuscitation, intubation, bronchoscopy, or endoscopy.

As with other respiratory viruses, transmission of SARS-CoV-2 could occur by direct contact with the secretions of an infected person and/or indirect contact with infectious secretions contaminating environmental surfaces. Both direct and indirect contact transmission imply that the hands of a susceptible individual become contaminated with SARS-CoV-2 and the individual subsequently self-inoculates their mucous membranes by touching their eyes, nose, or mouth. In an experimental model using standardized viral inoculum and conditions, SARS-CoV-2 adhered to multiple surface types and remained viable for as long as 72 hours.^{11, 12} SARS-CoV-2 viral RNA was recovered from multiple sites within the hospital room of patient with COVID-19, although viral viability was not evaluated. Thus, current evidence also supports the use of gowns and gloves when caring for SARS-CoV-2 patients.

Staffing

Many strategies were implemented to reduce staff exposures and PPE use. The number of providers for patients with confirmed or suspected COVID-19 was limited to as few individuals as possible to care safely for the patient. Core staff, such as nurses and physicians, also developed strategies to cluster care to minimize the number of times they entered and exited

the rooms of SARS-CoV-2 positive patients. For example, nurses (rather than the nutrition service) brought food trays to patients at the time of medication administrations or during vital sign checks. Ancillary care providers, such as nutrition and social work, interacted with patients via telephone or other remote technology.

On the postpartum unit, nursing assignments were made based on SARS-CoV-2 status; nurses caring for SARS-CoV-2 positive patients were not assigned to SARS-CoV-2 negative patients. A designated “COVID-19” attending cared for newborns of SARS-CoV-2 positive mothers or an attending examined these newborns last.

In the NICU, a designated medical team cared for the neonates of SARS-CoV-2-positive mothers. The number of health care providers entering the NICU was reduced by virtual interdisciplinary meetings and rounding in a separate room, with social distancing implemented, as feasible.

Clearing Mothers from COVID-19 Precautions

As described above, all admitted patients were tested for SARS-CoV-2. As the pandemic continued, some patients were SARS-CoV-2 positive prior to admission. Algorithms were developed to clear such patients from COVID-19 precautions when hospitalized on L&D and postpartum units that included both time and test-based criteria as described in Table 5. SARS-CoV-2 mothers could not visit the NICU until cleared by IP&C. Similarly, prior to discontinuing transmission precautions, all cases were discussed with IP&C.

Visitor Guidelines for L&D and for Postpartum Units

Starting March 28, one consistent, asymptomatic support person was permitted for each pregnant woman admitted for anticipated delivery in labor, scheduled cesarean section, or induction of labor. Starting April 29th, one consistent asymptomatic support person and/or one asymptomatic trained doula was permitted for each pregnant woman admitted for anticipated delivery in labor, scheduled cesarean section, or induction of labor. Support persons could not have been diagnosed with COVID-19 within the past 14 days. All support persons were screened for symptoms and fever every 12 hours and if symptoms developed they were asked to leave, but could be replaced by another support person.

Upon entry to the hospital, patients and their accompanying asymptomatic support person were provided surgical face masks which they wore continually throughout the hospital and in the patients’ room. Support persons had to remain in the patients’ rooms and were provided guest food trays to facilitate this. Hand hygiene was emphasized. Support persons of SARS-CoV-2 patients also wore a gown and gloves while in the patient’s room.

Transporting COVID-19-positive Mothers and their Newborns

At least two healthcare personnel (HCP) transported patients. All newborns born to SARS-CoV-2 mothers were transported in isolettes. The person moving the patient wore an isolation gown, gloves, eye protection, and a surgical mask. Another person “the sweeper” wore a surgical mask and eye protection and interacted with the environment, cleared the hallways, and pushed elevator buttons. This individual kept a distance of at least six feet from the patient. Optimal routes were chosen to minimize potential exposures to other staff, patients, and visitors.

Cohorting Patients on Postpartum Units

The infection prevention and control recommendations for postpartum units are described in Table 6. Women with known or suspected COVID-19 were preferentially placed in negative pressure rooms, as available. When negative pressure rooms were unavailable, patients were placed in single rooms on droplet and contact precautions and the door was kept closed. The rooms of patients with known or suspected COVID-19 were cohorted into separate “sections” on the postpartum units. When available, SARS-CoV-2 negative patients were placed on a separate postpartum unit.

Obstetrical care

No changes in obstetrical care were routinely implemented for SARS-CoV-2 positive mothers, including most with severe COVID-19 illness. This included no changes in the standard indications for cesarean delivery, which have been advocated in other countries²². Given the time needed to don PPE, simulated drills of time sensitive emergencies on L&D were performed so staff could practice appropriate donning, doffing, and the best transport procedures to the operating room. Furthermore, to reduce the risk of transmission of SARS-CoV-2 during hospitalization, SARS-CoV-2 negative mothers and their well newborns were discharged, on average, one day earlier than patients were discharged prior to the COVID-19 pandemic. If mother and baby were deemed medically stable and socially cleared, on average, mothers with vaginal deliveries were discharged on postpartum day 1 and mothers with cesarean deliveries on postoperative day 2.

Managing Newborns in the Well Baby Nursery

Infants born to SARS-CoV-2-positive mothers or infants whose mother’s test was pending, were considered persons under investigation (PUIs). While the risk of *in utero* transmission appears to be very low¹, the risk of perinatal and postnatal transmission is feasible due to contact with maternal secretions and excretions. These factors coupled with high numbers of SARS-CoV-2 positive mothers and the lack of alternative space to sequester PUI infants informed our IP&C

strategies for the postpartum units and WBNs. Rooming in for well newborns and mothers able to care for the newborn was based on shared decision making and became nearly universal among SARS-CoV-2 negative and SARS-CoV-2 positive patients. SARS-CoV-2 positive mothers practiced social distancing from their newborns; newborns were remained in isolettes unless feeding. Isolettes were placed at least six feet from their mothers' beds and mothers wore facemasks. Only newborns whose mothers were unable to care for them or newborns who required nursery care were placed in the PUI nursery separated from other newborns; remote monitoring capabilities were put in place that allowed staff to hear and see these newborns while decreasing staff exposures and PPE use. A detailed description of outcomes in newborn infants born to SARS-CoV-2 positive mothers is found in the chapter: *Review of Neonatal Outcomes during the COVID-19 Pandemic*.

Testing Newborns for SARS-CoV-2

Since infants born to SARS-CoV-2 mothers were PUIs, they required testing for SARS-CoV-2 to resolve their status. Thus, all infants in the WBN or in the NICU born to SARS-CoV-2 positive mothers had an NP swab specimen for SARS-CoV-2 obtained at 24 hours of age to assess *in utero* transmission, regardless of when in pregnancy a mother was diagnosed with COVID-19^{3,4}. NP swabs were preferred to oropharyngeal swabs due to increased sensitivity of NP swabs as per the Roche **cobas**[®] RT-PCR assay, but oropharyngeal swabs were occasionally obtained for premature infants. The turnaround time for this assay was ~8 hours, but well newborns could be discharged home prior to available test results.

Follow-up testing was recommended until day of life 14 because of the concern for perinatal transmission of SARS-CoV-2 and because the SARS-CoV-2 incubation period can be as long as 14 days (range, 2-14 days, mean 4-5 days)^{3, 6}. Given our concern not only for vertical transmission, but also for perinatal transmission, we decided on a strategy in which testing was done at 24 hours of life and the baby was treated as a PUI for the full 14-day incubation period. Repeat testing was performed on a case-by-case basis due to limited testing capacity (particularly during the early weeks of the pandemic), parental preference, and the development of symptoms consistent with COVID-19. Different scenarios for potential management of newborns after discharge are shown in Table 6. After discharge from the WBN, if infants were evaluated in healthcare settings during the first 14 days of life (DOL), they were placed on contact and droplet precautions as described below.

Managing Newborns in the Neonatal Intensive Care Unit

Room placement and Transmission Precautions

Newborns born to SARS-CoV-2 positive mothers who required admission to the NICU, on the basis of standard medical indications for neonatal intensive care, were placed in isolettes on

Contact and droplet precautions until day of life 14, presuming their initial SARS-CoV-2 tests were negative. These newborns were preferentially admitted to negative pressure rooms, as available. Those requiring aerosol-generating procedures, such as nasal CPAP, intubation, or open-line suctioning, were placed on airborne precautions in addition to droplet and contact precautions. When negative pressure rooms were unavailable, neonates born to SARS-CoV-2 positive mothers who did not require aerosol-generating procedures were cohorted in isolettes at least six feet apart in the NICU after consultation with IP&C.

Visitors to the NICU

One designated parent or guardian was permitted for each newborn (multiple gestations were only permitted one parent or guardian) and wore a mask, gown and gloves while at their newborn's bedside. This individual could not have been diagnosed with COVID-19 within the past 14 days. If they had previously been SARS-CoV-2 positive or had symptoms consistent with COVID-19, they could visit if at least 14 days had passed since onset of symptoms or at least 14 days had passed since the date of their positive test, if they were afebrile for at least 72 hours without antipyretic medications, and their symptoms had resolved (if previously symptomatic). As described above, parents/visitors were screened for symptoms and fever upon entry to the hospital, prior to entering the NICU, and every 12 hours. If they became ill or experienced a personal issue, the designated parent or guardian could be replaced.

Breastfeeding

Initial studies did not detect SARS-CoV-2 virus in breast milk, although a recent case report described recovery of viral RNA from breast milk²³. To date, no transmission of SARS-CoV-2 from breast milk has been described. Risks and benefits of breastfeeding were discussed with SARS-CoV-2 positive mothers who were considering breastfeeding; breastfeeding was encouraged based on the strong evidence of benefit and lack of evidence for harm. Those who desired to breastfeed directly wore a mask and performed hand hygiene and breast hygiene with soap and water prior to breastfeeding. Alternatively, mothers who preferred to express breast milk, did so after performing appropriate breast and hand hygiene. Mothers or designated asymptomatic support persons could feed the breast milk to the infant. The breast pump and components were cleaned between pumping sessions as per hospital protocol. For neonates admitted to the NICU, mothers were encouraged to express milk and expressed milk was fed to the neonate as available. Donor milk was available for mothers who could not breastfeed because they were receiving investigational antiviral therapy for COVID-19.

Bathing Newborns

Early bathing of newborns born to SARS-CoV-2 positive mothers has been advocated by some professional organizations to reduce the risk of SARS-CoV-2 transmission from maternal

secretions or excretions during delivery (Table 1). Therefore, early bathing was briefly implemented between March 27 and April 6, 2020. However, early bathing was discontinued on April 6, 2020 due to 1) the lack of evidence for perinatal SARS-CoV-2 transmission to newborns in our hospital and in the literature, 2) the observation that the majority of infected newborns reported in the literature had been born by cesarean section²², and 3) strong evidence for the benefits of delayed bathing for newborns.

COVID-19 Newborn Follow up Clinic

Given limited testing capacity and concern not only for vertical transmission²⁵⁻²⁸, but also for perinatal transmission, we decided on a strategy in which testing was done at 24 hours of life and the baby was treated as a PUI for the full 14-day incubation period as described above. Newborns born to SARS-CoV-2 positive mothers discharged from the WBN or NICU were closely followed for the first two to four weeks of life.

We describe two models of post-discharge care. At one site, for infants with community pediatricians, the WBN attending confirmed their ability to accommodate PUIs. If families did not have medical homes able to see PUIs, they were offered follow-up in a COVID-19 Nursery Follow-up Clinic established at the Children's Hospital on March 23, 2020. This clinic provided care from hospital discharge during the first 14 days of life. The COVID-19 Nursery Follow-up Clinic was in a separate location from the existing Newborn Clinic to minimize inadvertent exposure of patients in our primary care site to SARS-CoV-2. Because SARS-CoV-2 positive mothers were still on home isolation during their newborns' first week of life, a telehealth visit with mothers was conducted one day prior to the in-person visit. An asymptomatic caregiver wearing a mask brought the newborn to the brief in-person well-child care visit during which the newborn was placed on contact and droplet precautions and SARS-CoV-2 testing for the newborn was offered to the families. To minimize possible exposure of the newborn, caregiver and staff to SARS-CoV-2, appointment times were spaced to allow only one patient to be seen in the clinic at a time.

At another site, discharged newborns were followed up in-person and offered repeat testing at 5-7 days and 14 days of life, followed by a video visit at 1 month of life. These visits were used as an opportunity to assess the infants for concerning symptoms or signs and to reinforce infection control recommendations for the infants, parents, and other household members.

Communication and Education

As case counts increased and as new information became available, IP&C continually issued new guidance recommendations that were posted on the hospital's infonet. Frequent and clear communications were needed with leadership and front-line staff to address concerns and

questions. The OB, WBN, and NICU teams had conference calls once or twice each week to discuss new guidance recommendations, new information, and to review our data. Videos for PPE donning and doffing, infographics for PPE recommendations, written guidance, memos, and small group huddles were implemented to facilitate staff understanding of PPE use. Visitor policies, postpartum discharge instructions for SARS-CoV-2 women, and letters for obstetrical patients were available on the infonet in multiple languages that described the COVID-19 precautions and visitor policies. We also established a Pediatric COVID-19 clinical service.

Summary and Conclusions

Thus far, it does not appear that pregnant women in the U.S. are at increased risk of severe disease compared with the general population. Additionally, the risk of *in utero* transmission of SARS-CoV-2 appears to be low and affected newborns have generally been well as described in the chapter *Review of Neonatal Outcomes during the COVID-19 Pandemic*. Currently, these observations support implementation of the IP&C practices described above which included universal testing of women in labor, social distancing of SARS-CoV-2 mothers and newborns, but due to the well described benefits of breastfeeding²⁹, allowing direct breastfeeding with careful hand hygiene and mask-wearing. However, it is crucial to collect additional maternal and neonatal outcome data, including long-term outcomes. Given the ongoing burden of the COVID-19 pandemic, optimizing evidence-based IP&C practices, including PPE use and implementation of appropriate transmission precautions, remain crucial to prevent transmission of SARS-CoV-2 to healthcare workers or patients. It is likely that as more data become available, IP&C practices will continue to be refined.

References

1. <https://www.acog.org/clinical/clinical-guidance/practice-advisory/articles/2020/03/novel-coronavirus-2019> accessed May 14, 2020
2. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/q-a-on-covid-19-and-breastfeeding> accessed May 7, 2020
3. <https://www.cdc.gov/coronavirus/2019-ncov/hcp/inpatient-obstetric-healthcare-guidance.html> accessed May 7, 2020
4. <https://services.aap.org/en/pages/2019-novel-coronavirus-covid-19-infections/faqs-management-of-infants-born-to-covid-19-mothers/>, accessed May 7, 2020
5. www.governor.ny.gov/executiveorders] accessed May 7, 2020
6. <https://www.cdc.gov/coronavirus/2019-ncov/index.html> accessed May 7, 2020
7. Breslin N, Baptiste C, Gyamfi-Bannerman C, et al. COVID-19 infection among asymptomatic and symptomatic pregnant women: Two weeks of confirmed presentations to an affiliated pair of New York City hospitals. *Am J Obstet Gynecol MFM* 2020 Apr 9:100118. doi: 10.1016/j.ajogmf.2020.100118. [Epub ahead of print]
8. He X, Lau EHY, Wu P, et al. Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nat Med*. 2020;26:672–675.
9. Asadi S, Wexler AS, Cappa CD, Barreda S, Bouvier NM, Ristenpart WD. Aerosol emission and superemission during human speech increase with voice loudness. *Sci Rep*. 2019;9:2348.
10. Lynch JB, Davitkov P, Anderson DJ, et al. Infectious Diseases Society of America Guidelines on Infection Prevention in patients with suspected or known COVID-19. <https://www.idsociety.org/practice-guideline/covid-19-guideline-infection-prevention/> accessed May 15, 2020
11. Van Doremalen N, Bushmaker T, Morris DH, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N Engl J Med*. 2020;382:1564-1567.
12. Ong SWX, Tan YK, Chia PY, et al. Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. *JAMA*. 2020 Mar 4. doi: 10.1001/jama.2020.3227. [Epub ahead of print]
13. Pan Y, Zhang D, Yang P, Poon LLM, Wang Q. Viral load of SARS-CoV-2 in clinical samples. *Lancet Infect Dis*. 2020;20:411-412.
14. Liu Y, Yan LM, Wan L, et al. Viral dynamics in mild and severe cases of COVID-19. *Lancet Infect Dis*. 2020 Mar 19. pii: S1473-3099(20)30232-2. doi: 10.1016/S1473-3099(20)30232-2. [Epub ahead of print]
15. To KK, Tsang OT, Leung WS, et al. Temporal profiles of viral load in posterior oropharyngeal saliva samples and serum antibody responses during infection by SARS-CoV-2: an observational cohort study. *Lancet Infect Dis*. 2020;20(5):565-574

16. Bai Y, Yao L, Wei T, et al. Presumed asymptomatic carrier transmission of COVID-19. *JAMA*. 2020;323:1406-1407.
17. Wei WE LZ, Chiew CJ, Yong SE, Toh MP, Lee VJ. Pre-symptomatic transmission of SARS-CoV-2 — Singapore, January 23–March 16, 2020. *MMWR Morb Mortal Wkly Rep* 2020:411-415.
18. Arons MM, Hatfield KM, Reddy SC, et al. Pre-symptomatic SARS-CoV-2 infections and transmission in a skilled nursing facility. *New Eng J Med*. 2020 Apr 24. doi: 10.1056/NEJMoa2008457. [Epub ahead of print].
19. Shiu EYC, Leung NHL, Cowling BJ. Controversy around airborne versus droplet transmission of respiratory viruses: implication for infection prevention. *Curr Opin Infect Dis* 2019;32:372-379.
20. Wang W, Xu Y, Gao R, et al. Detection of SARS-CoV-2 in different types of clinical specimens. *JAMA*. 2020 Mar 11. doi: 10.1001/jama.2020.3786. [Epub ahead of print]
21. Zou L, Ruan F, Huang M, et al. SARS-CoV-2 viral load in upper respiratory specimens of infected patients. *New Eng J Med*. 2020;382:1177-1179.
22. Chen L, Li Q, Zheng D, et al. Clinical characteristics of pregnant women with Covid-19 in Wuhan, China. *New Eng J Med*. 2020 Apr 17. doi: 10.1056/NEJMc2009226. [Epub ahead of print]
23. Wu Y, Liu C, Zhang C, et al. Coronavirus disease 2019 among pregnant Chinese women: Case series data on the safety of vaginal birth and breastfeeding. *BJOG*. 2020 May 5. doi: 10.1111/1471-0528.16276. [Epub ahead of print]
24. Alzamora MC, Paredes T, Caceres D, Webb CM, Valdez LM, La Rosa M. Severe COVID-19 during pregnancy and possible vertical transmission. *Am J Perinatol*. 2020 Apr 18. doi: 10.1055/s-0040-1710050. [Epub ahead of print]
25. Zeng L, Xia S, Yuan W, et al. Neonatal early-onset infection With SARS-CoV-2 in 33 NEONATES BORN TO MOTHERS WITH COVID-19 in Wuhan, China. *JAMA Pediatr*. 2020 Mar 26. doi: 10.1001/jamapediatrics.2020.0878. [Epub ahead of print]
26. Wang S, Guo L, Chen L, et al. A case report of neonatal COVID-19 infection in China. *Clin Infect Dis*. 2020 Mar 12. pii: ciaa225. doi: 10.1093/cid/ciaa225. [Epub ahead of print]
27. Zhang ZJ, Yu XJ, Fu T, et al. Novel coronavirus infection in newborn babies under 28 Days in China. *Europ Resp J*. 2020 Apr 8. pii: 2000697. doi: 10.1183/13993003.00697-2020. [Epub ahead of print]
28. Hu X, Gao J, Luo X, et al. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) vertical transmission in neonates born to mothers with coronavirus disease 2019 (COVID-19) pneumonia. *Obstet Gynecol*. 2020 pr 24. doi: 10.1097/AOG.0000000000003926. [Epub ahead of print] No abstract
29. World Health Organization. WHO Guidelines Approved by the Guidelines Review Committee. In: WHO Recommendations on Postnatal Care of the Mother and Newborn. Geneva: World Health Organization; 2013

https://www.who.int/maternal_child_adolescent/documents/postnatal-care-recommendations/en/ accessed May 15, 2020

Journal Pre-proof

Table 1: Comparison of Recommendations for SARS-CoV-2-positive Mothers and Newborns

Organization Date issued	Recommendations
World Health Organization (WHO) April 28 2020 ²	Hand hygiene Wear a facemask Breastfeed, with good respiratory hygiene Skin-to-skin Room-in Keep surfaces clean
Centers for Disease Control and Prevention (CDC) April 4, 2020 ³	Separation of mother and newborn made on case-by-case basis using shared decision making If separation and breastfeeding <ul style="list-style-type: none"> • Express breast milk If separation not undertaken: <ul style="list-style-type: none"> • Use physical barriers, e.g., curtain If direct breastfeeding, wear facemask and practice hand hygiene
American Academy of Pediatrics (AAP) April 2, 2020 ⁴	Temporary separation of mothers and newborns If mother chooses to room-in despite recommendations OR if facility cannot provide newborns a separate area: <ul style="list-style-type: none"> • Place infants \geq 6 feet from mother • Use curtain or isolette to facilitate separation Advocated expressing breast milk If mother chooses direct breastfeeding, use mask, breast and hand hygiene Early bathing suggested
American College of Obstetricians and Gynecologists (ACOG) April 23, 2020 ¹	Consider temporary separation of mothers from their newborns until the patient's transmission-based precautions are discontinued. Decision to separate mothers and newborns should be made on a case-by-case basis, using shared decision-making between the patient and the clinical team.

Table 2: PPE for Direct Care of Patient with Suspected or Confirmed COVID-19

Direct patient care <u>without</u> aerosol-generating Procedure	<ul style="list-style-type: none"> • Surgical mask or N95 respirator^{a, b} • Gown • Gloves • Eye protection (goggles or face shield)
Direct Patient care <u>with</u> aerosol-generating procedure	<ul style="list-style-type: none"> • N95 respirator <u>required</u>^{a, b} • Gown • Gloves • Eye protection (goggles or face shield)

^a Protect N95 respirator for reuse or extended use with surgical face mask or face shield

^b Fit check (user-seal check) prior to each use

Table 3: Factors involved in transmission of SARS-CoV-2

Mode of respiratory transmission ^{9,10} – droplet vs airborne
Role of fomites ^{11, 12}
Survival in environment ^{11, 12}
Viral viability
Viral quantities over course of illness ¹³⁻¹⁵
Role of symptoms in transmission - symptomatic vs asymptomatic vs pre-symptomatic ¹⁶⁻¹⁸

Table 4: Comparing Droplet and Airborne Transmission¹⁹

Characteristics	Droplet transmission	Airborne Transmission
Size	>5 um	≤5 um
Distance travel	3-6 feet	travel further distances
Susceptible individual route of infection	Infect mucus membranes of the nose, mouth, and eyes	Infect via inhalation to lower respiratory tract ⁸
Type of PPE	Surgical face mask	N95 respirator that filters 95% of particles

Table 5. Postpartum Room Placement and Isolation Precautions for Mother-Newborn Dyads based on SARS-CoV-2 Test Results

Maternal SARS-CoV-2 Results	Room Placement and Transmission Precautions ^a
Asymptomatic mother SARS-CoV-2 positive more than 6 weeks prior to delivery , SARS-CoV-2 negative at delivery	<ul style="list-style-type: none"> • Mother and newborn in single room on Contact and Droplet Precautions • Newborn tested at 24 HOL for SARS-CoV-2 • If newborn SARS-CoV-2 is negative at 24 HOL, newborn no longer PUI • Discontinue Contact and Droplet Precautions for mother and newborn
Asymptomatic mother SARS-CoV-2 positive between 14 days and 6 weeks prior to delivery , SARS-CoV-2 negative at delivery	<ul style="list-style-type: none"> • Mother and newborn in single room on Contact and Droplet Precautions • Newborn tested at 24 HOL for SARS-CoV-2 • Mother retested 24 hours after the first SARS-CoV-2 negative test • If mother SARS-CoV-2 negative on both tests and newborn SARS-CoV-2 negative at 24 HOL, newborn no longer PUI • Discontinue Contact and Droplet Precautions for mother and newborn
Asymptomatic or symptomatic mother SARS-CoV-2 positive less than 14 days prior to delivery , with negative or positive SARS-CoV-2 test at delivery	<ul style="list-style-type: none"> • Mother and newborn in single room on Contact and Droplet Precautions throughout hospitalization • Newborn tested at 24 HOL for SARS-CoV-2 • At discharge, mother provided SARS-CoV-2 Discharge Instructions for Postpartum Patients
Asymptomatic or symptomatic mother SARS-CoV-2 positive or indeterminate at delivery	<ul style="list-style-type: none"> • Mother and newborn in a single room on Contact and Droplet Precautions throughout hospitalization • Newborn tested at 24 HOL for SARS-CoV-2 • At discharge, mother provided SARS-CoV-2 Discharge Instructions for Postpartum Patients
Asymptomatic mother SARS-CoV-2 negative at delivery <i>plus</i> no history of previous positive test within past 6 weeks	<ul style="list-style-type: none"> • Mother can be cohorted in semi-private room with another COVID-19-negative mother • Standard precautions for mother and newborn • Newborns should preferentially room in • Privacy curtain pulled closed throughout hospital stay • If mother or infant develop symptoms, place mother and newborn on Contact and Droplet Precautions and retest for SARS-CoV-2

^a Abbreviations used in Table. HOL – hours of life, PUI – person under investigation

Table 6: Infection Prevention and Control Recommendations for Postpartum Units

IP&C Strategy	SARS-CoV-2 positive Mother	SARS-CoV-2 negative Mother
Isolation precautions	Contact and Droplet Precautions Airborne if aerosol-generating procedure performed	Standard Precautions
Room type	Single room, negative pressure room if available	Semi-private if single rooms unavailable
Mother PPE	Mask throughout hospital stay, including within patient room	Mask throughout hospital stay, including within patient room
Social distancing between mother and newborn	Infant in isolette unless feeding Infant and mother at least 6 feet apart unless feeding	NA
Breastfeeding	Encouraged direct breastfeeding In addition to mask, and hand and breast hygiene prior to breastfeeding If mother prefers, can express breast milk and clean breast pump and components between pumping sessions	Encouraged direct breastfeeding Hand hygiene and breast hygiene prior to breastfeeding
Bathing	As per usual WBN practices and parental preference	As per usual WBN practices and parental preference

Table 7. Follow-up SARS-CoV-2 Testing and Person under Investigation Clearance for Infants born to SARS-CoV-2 Positive Mothers

SARS-CoV-2 at 24 hours of life	Symptomatic within 14 days of birth	Follow-up and Testing
Negative	NO	PUI status cleared at DOL14 days. Repeat testing performed on a case-by-case basis according to local testing resources, e.g., ~ DOL5 and DOL14
Negative	YES	<ul style="list-style-type: none"> - In NICU: assess symptoms as per usual care. Perform repeat testing if concern symptoms due to COVID-19 - In Clinic: assess symptoms as per usual. Perform repeat testing, according to testing resources - In Emergency Department: alert ED that infant is PUI so transmission precautions can be implemented and testing performed
Positive	NO	Repeat testing and duration of transmission precautions determined on a case-by-case basis according to testing resources, e.g., DOL14, and in consultation with infection prevention and control
Positive	YES	<ul style="list-style-type: none"> - In NICU: assess symptoms as per usual care. Perform repeat testing if concern symptoms due to COVID-19 - In Clinic: assess symptoms as per usual. Perform repeat testing, according to testing resources - In Emergency Department: alert ED that infant is PUI so transmission precautions can be implemented and repeat testing performed. <p>Discontinue of transmission precautions on a case-by-case basis, in consultation with infection prevention and control</p>