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The COVID-19 Pandemic and Pregnancy: Impact on Mothers and Newborns

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The severe acute respiratory syndrome coronavirus 2 pandemic has markedly, and likely permanently, changed health care. This includes changing the obstetric and perinatal care of mothers and infants, and by extension, the care of their families. Infection during pregnancy is associated with an increased risk for severe coronavirus disease 2019 illness and related complications that can significantly impact maternal health and the health of the neonate. Viral transmission from mother to fetus is possible, but rare during pregnancy, and current health care policies focusing on maternal masking, and hand washing allows infected mothers to safely care for neonates (including nursing or feeding with expressed breast milk). The newly developed vaccines have been shown to be safe and effective for pregnant and breast-feeding mothers, with measurable antibody levels in cord blood and breast milk potentially providing a level of passive immunity to neonates. While studies looking at short-term outcomes for neonates have been reassuring, it is critical that we continue to work to understand and improve the care of pregnant woman and newborns with coronavirus disease 2019 to optimize long term outcomes. Although the knowledge base continues to evolve, the available evidence influencing the care of pregnant women and their infants is summarized in this focused review.
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Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the worldwide pandemic of symptomatic coronavirus disease 2019 (COVID-19) infection[1] has disrupted our medical, social, and economic spheres in a fashion unprecedented in modern times. The pandemic of symptomatic infection, referred to as COVID-19, has disrupted our medical, social, and economic spheres in a fashion unprecedented in modern times. The initial lack of evidence has been followed by a seemingly endless onslaught of rapidly changing recommendations. This has significantly complicated patient care, including obstetric and perinatal care of mothers and infants, regardless of SARS-CoV-2 infection status. With the acknowledgment that the field is still evolving, the recent available evidence guiding the care of pregnant women and infants impacted or infected by the pandemic is summarized in this focused, point in time review.

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Maternal COVID-19 Infection During Pregnancy

A women's personal health and her pregnancy are placed at risk by COVID-19. Pregnant women with symptomatic COVID-19 infection, when compared to non-pregnant women with COVID-19, (and adjusted for race, age, ethnicity, and underlying medical conditions) are 3 times more likely to be admitted to an intensive care unit (10.5 vs 3.9 per 1000 cases), 2.9 times more likely to require invasive ventilation (2.9 vs 1.1 per 1000 cases), 2.4 times more likely to require extra-corporeal membrane oxygenation (0.7 vs 0.3 per 1000 cases), and 1.7 times more likely to die (1.5 vs 1.2 per 1000 cases).[2] Ko et al., found that in pregnant women with a COVID-19 diagnosis, there was an increased risk of acute respiratory distress syndrome (adjusted relative risk [aRR]= 34.4), sepsis (aRR = 13.6), need for mechanical ventilation (aRR = 12.7) and death (aRR = 17) compared to

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pregnant women without COVID-19 infection. Additionally, increased risk for acute renal failure, adverse cardiac events, and thromboembolic events was recognized in the infected group.[3] Villar et al., further demonstrated that pregnant women with COVID-19 have higher rates of pregnancy-induced hypertension (relative risk [RR], 1.46; 1.05-2.02), preeclampsia/eclampsia (RR, 1.76; 1.27-2.43), are more likely to be admitted to the ICU (RR, 5.04; 3.13-8.10), and are more likely to die (RR, 22.3; 2.88-172).[4]

The increased risk of severe disease during pregnancy is likely secondary to physiologic adaptations in the respiratory, cardiovascular, and immunologic systems. These changes include decreased lung residual volume due to elevation of the diaphragm and potential pulmonary hypertension, which can lead to hyperventilation. Increased maternal metabolic demand, gestational anemia, and fetal oxygen consumption make respiratory compromise and hypoxic respiratory failure more likely.[5] Viral illness can raise metabolic demand and increase pulmonary vascular resistance, further stressing an already taxed system of oxygen delivery.[5] Other factors that independently increase severity of disease are similar to non-pregnant patients, including increased age, higher body mass index, and pre-existing comorbidities including hypertension, chronic lung disease (ie, asthma or chronic obstructive pulmonary disease), and pre-gestational diabetes.[2]

Fetal Complications of Maternal Infection During Pregnancy

Fetal Infection

Transplacental infection of the fetus, also referred to as vertical transmission, can be diagnosed when viral antigen or RNA is identified in fetal-derived placental cells.[6] This finding is rare but has been demonstrated with evidence of virus in villous syncytiotrophoblast, endothelial cells, fibroblasts, and, most notably, fetal intravascular monocytes.[7]

SARS-CoV-2 infects individuals by binding the spike protein on angiotensin-2 converting enzymes receptors and using the proteolytic host serine protease, transmembrane protease serine 2, for entry into the cell.[8] Multiple tissue types in the placenta, including placental syncytiotrophoblast and cytotrophoblast, express these proteins starting at 7 weeks gestation, allowing for SARS-CoV-2 placental infection. These receptors are not highly expressed in fetal lung tissue, and are not present in fetal brain tissue.[9,10]

Despite the presence of the cellular machinery to facilitate placental and transplacental infection, such infection is rare. In a series of 1457 pregnant women with infection in any trimester, SARS-CoV-2 RNA was detected in placental tissue of 13 (0.89%) pregnancies.[11] In another study, placental syncytiotrophoblasts were infected in 12% of pregnant women with COVID-19.[10] Both of these numbers are quite low when compared to other viruses, for instance, CMV infects 35% of fetuses if primary maternal infection occurs during pregnancy.[12] Mechanisms that protect from invasion of fetal tissue by SARS-CoV-2 are yet to be elucidated.

First and Second Trimester Infection

The authors of articles detailing first trimester infections have largely reported uncomplicated deliveries and favorable short term neonatal outcomes.[13-15] The authors of a study of over 3000 pregnant women including 1456 women with SARS-CoV-2 infection in the first trimester found no statistical differences between groups in intrauterine fetal distress, fetal growth restriction, premature delivery or low birth weight.[15]

However, case reports illustrate a spectrum of potential fetal outcomes. In 1 case report, the authors described a mild maternal infection and the uneventful delivery of an asymptomatic, but Reverse Transcription-Polymerase Chain Reaction (RT-PCR) positive neonate with viral particles detected in placental villous syncytiotrophoblast.[16] In contrast, an asymptomatic maternal infection at 8 weeks was followed by fetal hydrops at 10 weeks and fetal demise at 13 weeks, in the context of persistent maternal RT-PCR positivity.[14] Placenta, amniotic fluid and fetal tissues were all positive for virus. The authors of another study described a pregnancy complicated by symptomatic maternal SARS-CoV-2 infection mid first trimester, producing a single neonate born with congenital microphthalmia and optic nerve hypoplasia. Extensive genetic testing, teratogenic exposure history, and investigation for other infectious etiologies was unrevealing, therefore this may demonstrate a potential rare complication of SARS-CoV-2 infection.[14] This range of outcomes illustrates the broad clinical scope of this illness, and highlights the challenges involved in accurately identifying high risk pregnancies.

With a heightened awareness of the potential for complications, the American College of Obstetricians and Gynecologists (ACOG) currently recommends that women with first trimester infection undergo a detailed mid-trimester anatomy ultrasound. For infections in the second or third trimesters, additional third-trimester growth ultrasounds could be considered based on severity of illness and maternal course.[8,17] Going forward, long term follow up is needed to determine the impact of maternal infection on infant development and cognition.

Placental Abnormalities

A SARS-CoV-2 infection during pregnancy can result in variable placental histologic findings ranging from normal to severely abnormal, with intervillositis, accelerated villous maturation, chorioamnionitis, thrombosis, and placental infarction reported.[7] The severity of maternal illness does not necessarily correlate with the severity of pathologic findings in the placenta, and maternal infection can cause an inflammatory response in the placenta without detectable virus in placental tissue.[18,19] There is also increased oxidative damage, decreased mitochondrial function, and altered gene expression in placentas of pregnancies complicated by COVID-19.[20,21] There may be an evolution of pathologic and histologic findings in term-delivered placentas based on the time since infection, but few cases have been directly compared.[22]

In a group of 6 live born neonates with SARS-CoV-2 and 5 fetuses experiencing intrauterine demise, all placentas showed chronic histiocytic intervillositis and trophoblast necrosis.[23] In contrast, the authors of a series of 50 placentas from third trimester COVD-19 infection reported that pathologic findings did not differ from 50 historical controls prior to the pandemic.[24] Chronic histiocytic intervillositis, which can be associated with maternal placental malperfusion, has been described, even in cases with negative placental and fetal/neonatal tissue testing and mild maternal illness.[25] These abnormalities in placental pathology are generally associated with negative neonatal neurodevelopmental outcomes regardless of causative factors,[26] therefore infants born after pregnancies complicated by SARS-CoV-2 infection warrant longitudinal follow up to monitor outcomes.

Neonatal Infection and Complications of Gestational COVID-19

Criteria defining early onset neonatal SARS-CoV-2 infection, including RT-PCR positivity in the first 72 hours of life, have been proposed.[6] An estimated 30% of all neonates who become infected with SARS-CoV-2 are infected either through intrauterine or intrapartum mechanisms, while the 70% majority of neonates are infected through direct contact with aerosolized respiratory secretions or via droplet transmission of the virus.[27]

Third Trimester Infection

Risks to the fetus/newborn likely relate to the timing and severity of maternal infection. Most reports focus on third trimester infection, when a woman is at greatest risk of severe disease. Although only 3% of infants born to infected mothers test positive for SARS-CoV-2,[18,28] neonatal complications can occur, including admission to neonatal intensive care units,[3,4,29] preterm birth, cesarean section and low birth weight.[1,30,31] De Medeiros et al. showed the most prevalent neonatal complication to be neonatal care unit (NICU) admission (28%, confidence interval [CI] 0.17-0.43) with 576 of 2430 neonates requiring NICU admission. Low birth weight was observed in 148 of 1093 neonates (15%, CI 0.10-0.21) in this cohort. Fetal distress was reported in 11% (CI 0.06-0.19) and fetal mortality occurred in 2% (CI 0.01-0.03) of the combined cohort.[30] Alternatively, Wilkinson et al., found no statistically significant differences in perinatal death, birth weight or rate of elective cesarean section. The authors noted, however, that a larger proportion of emergency cesarean sections were performed for maternal SARS-CoV-2 infection (11/46, 23.9%) compared to non-infected pregnant women (2/41, 4.9%) (P= 0.01).[31] The authors of a cohort study from England reported that pregnant women with SARS-CoV-2 infection at the time of birth were at increased risk for premature birth (12.1% vs 5.8%, adjusted odds ratio [aOR], 2.17; 95% CI, 1.96-2.42; P< 0.001) and fetal death (8.5 per 1000 vs 3.4 per 1000, aOR, 2.21; 95% CI, 1.58-3.11; P< 0.001). Pre-eclampsia (aOR 1.55; 95% CI, 1.29-1.85; P< 0.001) and emergency cesarean section (aOR 1.63; 95% CI 1.51-1.76; P< 0.001)[32] were also more common in mothers with laboratory confirmed SARS-CoV-2 infection.[33] Although outcomes vary, the recognized risk of complications indicates that the infant-mother dyad with third trimester infection warrants close observation.

Infection in Infancy

Initially, SARS-CoV-2 infection in children under 18 accounted for 1%-2% of cases, although this was potentially an underestimate due to generally mild or asymptomatic infection in children, and less testing capacity in the early stages of the pandemic. Pediatric infections now represent 25% of all new SARS-CoV-2 infections.[34] Overall short-term outcomes are good with 90% of children less than five years old developing mild to moderate degree of illness. Infants (>7 days and <1 year) with COVID-19 typically experience only rare intubations, have brief hospital stays, and boast more than 99% survival.[35,36]

Work is ongoing to define risk factors for severe disease and determine potential outcomes for these patients, as certain infants may be at higher risk of severe infection than older children. The authors of a study in the United Kingdom demonstrated 2 periods of increased risk for ICU admission for children; under 1 month of age (OR = 3.21, 1.36-7.66; P= 0.008) and between ages 10-14 years (3.23, 1.55-6.99; P= 0.002).[37] Severe disease in neonates and infants can occur, and neonatal multisystem inflammatory syndrome with associated organ dysfunction has been reported. Neonates at greatest risk for severe disease are those with underlying or pre-existing medical conditions, such as cyanotic heart disease, immunodeficiency, extreme prematurity, neonatal multisystem inflammatory syndrome, or co-infection.[35,38,39]

Long-Term Outcomes

Short-term outcomes have overall been reassuring for neonates, however there is a pressing need to characterize the long-term effects of SAR-CoV-2 infection. Although vertical transmission during pregnancy or delivery from mother to the fetus/neonate is low, the consequences of in-utero exposure are unknown. Researchers are presently evaluating neurodevelopmental and multidisciplinary outcomes following in-utero exposure to maternal infection.[40,41] One comprehensive study assessed infants at 3-month intervals, following growth, weight gain, head circumference, neurologic development, immunoglobulin G (IgG) antibody levels, and documenting hearing function (as SARS-CoV-2 can cause sensorineural hearing loss) and ophthalmology examinations. More than 90% of mothers of this cohort contracted the infection in the third trimester, with 2% of neonates testing positive in the first 24 hours, although all were asymptomatic. All children enrolled had normal growth parameters, independent of timing or severity of maternal infection. Of the 20 children who received an

ophthalmologic exam, 3 (15%) had retinal abnormalities but maintained normal fixation, tracking and saccadic movements.[40]

The authors of an ongoing developmental study are comparing infants from infected and non-infected pregnancies to historical healthy controls assessed prior to the pandemic.[41] Preliminary data shows no significant associations between maternal SARS-CoV-2 infection (status, timing or severity) and infant neurodevelopment. No significant differences were identified in communication, gross motor, fine motor, problem solving or personal-social domains when comparing exposed to non-exposed infants. However, growing up in the pandemic seems to be taking a toll. Children born into the pandemic, regardless of exposure to infection, demonstrate lower scores in gross motor (mean difference, −5.63; 95% CI, −8.75 to −2.51; $P < 0.001$), fine motor (mean difference, −6.61; 95% CI, −10.00 to −3.22; $P < .001$), and personal-social (mean difference, −3.71; 95% CI, −6.61 to −0.82; $P = 0.01$) domains compared to children evaluated prior to the pandemic.[41] The authors of another study found a higher proportion of delays in fine motor skills (aOR: 2.50, 95% CI: 1.25-4.99) and communication (aRR: 1.13, 95% CI: 1.02-1.25) in pandemic era infants at 1 year of age.[42]

Although these preliminary studies are being conducted at single centers in areas heavily impacted by COVID-19, they show that although exposure to the infection itself may not alter neurodevelopmental outcomes, the societal changes associated with the pandemic may have underappreciated effects. More developmental time and assessments on children born during the pandemic, ideally in multiple regions, are needed.

Care of Infants of COVID Infected Mothers

Early Pandemic Policies

At the onset of the pandemic, the worldwide emergency state required rapid policy creation to guide the management of pregnancy and delivery. As the risk of perinatal and postnatal transmission of SARS-CoV-2 was not known, strict initial regulations were enacted. In the case of SARS-CoV-2-positive mothers, early recommendations stipulated that woman were to be isolated from their infants and breast feeding or use of expressed breast milk was not recommended due to safety concerns.[43] Concerns were immediately raised regarding the long-term consequences of these strategies, including interference with mother-child bonding and breast-feeding establishment.[8,44]

In many systems, early in the pandemic, partners were excluded from the delivery suite and visitation was severely restricted, even limiting or prohibiting visitation of neonates in the NICU. These changes prevented skin to skin and kangaroo/maternal care (KMC), disrupting the family centered care models that are widely accepted, models that have been proven to reduce morbidity and mortality in low birthweight infants.[38,45] The authors of outcomes research have confirmed increased parental emotional and psychological stress, and speculate increased long-term risks for parental posttraumatic stress disorder and postpartum depression stemming from these early policies.[38,46]

Current Policies and Evidence

Over the course of the progression of the pandemic, pre- and perinatal care policies have shifted. Although variability remains, governing agencies have embraced less restrictive policies based on currently available and evolving evidence. The complications of severe, systemic maternal COVID-19 illness during pregnancy creates inherent risks for the fetuses and infants. However, in mild to moderate maternal COVID-19, infection in utero or during delivery (regardless of mode of delivery) is estimated to occur in 3% of cases[18] as amniotic fluid, cord blood and breast milk are unlikely to carry viral particles.[11,47] As a result, evidence-based recommendations from ACOG now stipulate that management of pregnancy and delivery should be determined based on pregnancy specific factors, and that the presence of mild to moderate COVID symptoms in a mother should not factor in decision-making. This extends to decisions regarding antenatal steroid treatment for women at risk for premature delivery, and choices surrounding timing and mode of delivery.[17]

Safe Rooming-In Practices

The low rate of horizontal transmission of SARS-CoV-2 has largely extinguished policies separating mother-infant dyads, even when the mother is SARS-CoV-2-positive. The estimated post-natal transmission rate of approximately 2% for infants rooming and nursing with an infected mother has allowed for "protected rooming in" (with contact and droplet precautions) to become the accepted practice.[38,48,49] This revision of regulations extends even to the most vulnerable infants. Evidence supports that the survival benefit of KMC in the NICU far outweighs the risk of death due to SARS-CoV-2 infection in premature infants with birth weight <2000 g admitted to the NICU. Modelled scenarios estimate infant lives saved by continuing KMC during the pandemic will be 65 to 630-fold higher than the mortality risk from transmitted SARS-CoV-2 in the NICU population.[50]

Safe Feeding Practices

The safety of direct breastfeeding and using expressed milk from a SARS-CoV-2-positive mother was an initial area of concern. Subsequent work following surveillance testing of serial nasopharyngeal swabs of breastfed infants who roomed in with infected mothers confirmed low rates of infection in the 4 weeks following delivery when safety protocols (maternal masking and hand washing prior to infant cares) were followed.[38,51] There has been a reassuring lack of clinically identified infections spread by breast milk,[38] and no replication-competent or transmissible SARS-CoV-2 viral particles have been found in reliably performed breast milk testing.[48] Finally, although in vivo immunologic impact is not well characterized, testing confirms that breast milk contains immunoglobulin (Ig)A, IgG, and IgM antibodies capable of

Table 1 Key Features of Organizational Guidelines: Care of Neonates Born to Mothers Positive for SARS-CoV-2. (Adapted with permission from guidelines published by the AAP,[49] Barrero-Casti et al,[53] CDC,[54] WHO,[55] and AAFP.[56])

Organization	Safe care and feeding	Infant medical care and considerations	Infant SARS-CoV-2 testing
American Academy of Pediatrics (AAP)	• Mothers should perform hand hygiene and mask prior to cares and breastfeeding • Infant may be fed expressed breast milk by uninfected caregiver	• Mothers and infants may room together, consistent with center standard of care • Use of an isolette may facilitate distancing • Infants requiring NICU admission should be placed in a single room with potential for negative pressure ventilation	• Swab of the nasopharynx or oropharynx then nasopharynx, or 2 swabs of each site (based on institutional policy) • Serial testing at 24 and 48 hours of age • Repeat testing every 48-72 hours until 2 negative tests recorded • If testing is not possible, infants are observed and treated as positive for 14 days
United States' Centers for Disease Control (CDC)	• Mothers should perform hand hygiene and mask prior to cares and breastfeeding • Infant may be fed expressed breast milk by healthy caregiver if possible	• Mothers and infants may room-in, using shared decision making • Physical distancing of $\geq$6 ft or use an isolette when possible • Consider separating neonates at high risk for severe illness*	• RT-PCR test on nasopharyngeal, oropharyngeal or nasal swab samples • Serial testing at 24 and 48 hours of age • infants without testing born to infected or presumed infected mothers treated as positive
World Health Organization (WHO)	• Mothers should perform hand hygiene and mask prior to cares and breastfeeding • Breastfeeding should begin within 1 hour of birth	• Mother/newborn dyads should be not separated • Skin-to-skin contact, and kangaroo care supported regardless of maternal SARS-CoV-2 status	
American Academy of Family Physicians (AAFP)	• Mothers should perform hand hygiene and mask prior to cares and breastfeeding • Consider expressed breast milk fed by uninfected care giver	• Avoid separation of parents and infants when possible • Limit contact with infant when not nursing	

NICU, neonatal care unit; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.
*Infants at risk for severe COVID-19 illness include preterm infants, infants with underlying medical conditions and infants needing specialized or intensive care.[54]

neutralizing SARS-CoV-2 viral infectivity in vitro.[38,52] This evidence has shifted the field to support direct breast feeding and feeding with expressed breast milk (with safety practices) for infected mothers providing infant care in the hospital and at home. Several health organizations have published clinical guidelines, with both unique and shared features, outlining the framework for safely caring for infants born to SARS-CoV-2-positive mothers (Table 1).

Vaccination for SARs-CoV-2

The increased understanding of risks of maternal infection during pregnancy and the associated risks to fetuses and neonates have shaped vaccine recommendations over the course of the pandemic. Original recommendations supported shared decision-making during discussion and consideration of vaccination for pregnant and breastfeeding women. Mounting evidence of vaccine safety has prompted updated formal recommendations from ACOG[17] and European Board and College Obstetrics and Gynaecology.[57] These agencies now recommend vaccinations for all pregnant and recently pregnant and lactating women, prioritizing prevention of disease without trimester specific guidelines.[58]

Vaccine Background

Vaccines against COVID-19 were developed at an unprecedented speed. The Pfizer-BioTech and Moderna messenger RNA (mRNA) vaccines utilize a lipid nano-particle facilitating mRNA entry into the cytoplasm where the mRNA is transcribed, repurposing technology previously tested with the intention of vaccinating against zika virus.[58,59] The Janssen (Johnson & Johnson) vaccine utilizes a replication-incompetent adenovirus vector to insert viral DNA into the cell

nucleus, where mRNA is transcribed. Intracellular mRNA then directs the production of the SARS-CoV-2 spike protein, beginning the cascade of immune response, priming the body to respond when exposed to the native virus.[58,60,61]

Vaccine Safety in Pregnant Women

Although the intention was not to deliberately study vaccines during pregnancy, several pregnancies occurred after women were enrolled and vaccinated in initial trials. There were not notable differences in adverse events or side effects when the vaccinated pregnant group was compared to the non-pregnant group. In the interval since the initial trials, more than 30,000 vaccinated pregnant women have been reported to the v-safe vaccine safety monitoring program, including 275 completed pregnancies and 232 live births.[58] Data reviewed in February 2021 showed pregnancy outcomes and adverse events of vaccinated women have been consistent with baseline pregnancy rates, and "no unexpected pregnancy or infant outcomes have been observed related to COVID-19 vaccination during pregnancy"[62] (Fig. 1). COVID-19 vaccine safety in pregnancy is postulated to be related to their unique mechanisms of action. mRNA vaccines have a short half-life of 8-10 hours and are unable to enter the cell nucleus, therefore cannot be transmitted to a developing fetus.[60] The Janssen viral vector cannot replicate and cannot induce viremia, negating the risk of infection of the fetus during gestation.[58] Recent review of the v-safe website shows that 205,829 women have identified as pregnant at the time of vaccination, and 17,920 have consented to be followed by a v-safe registry to continue to generate useful outcomes data.[63]

Vaccine Safety in Lactating Women

The unique vaccine features postulated to allow safe administration during pregnancy, are also believed to make mRNA and Janssen vaccines safe during lactation. Injected mRNA material and the transcribed protein is briefly present in the mother's body after injection. Although vaccine material is not expected to enter the breast milk, any particles would be broken down into a nonfunctional product during milk digestion. As there is not a viremic state following Janssen vaccine administration,

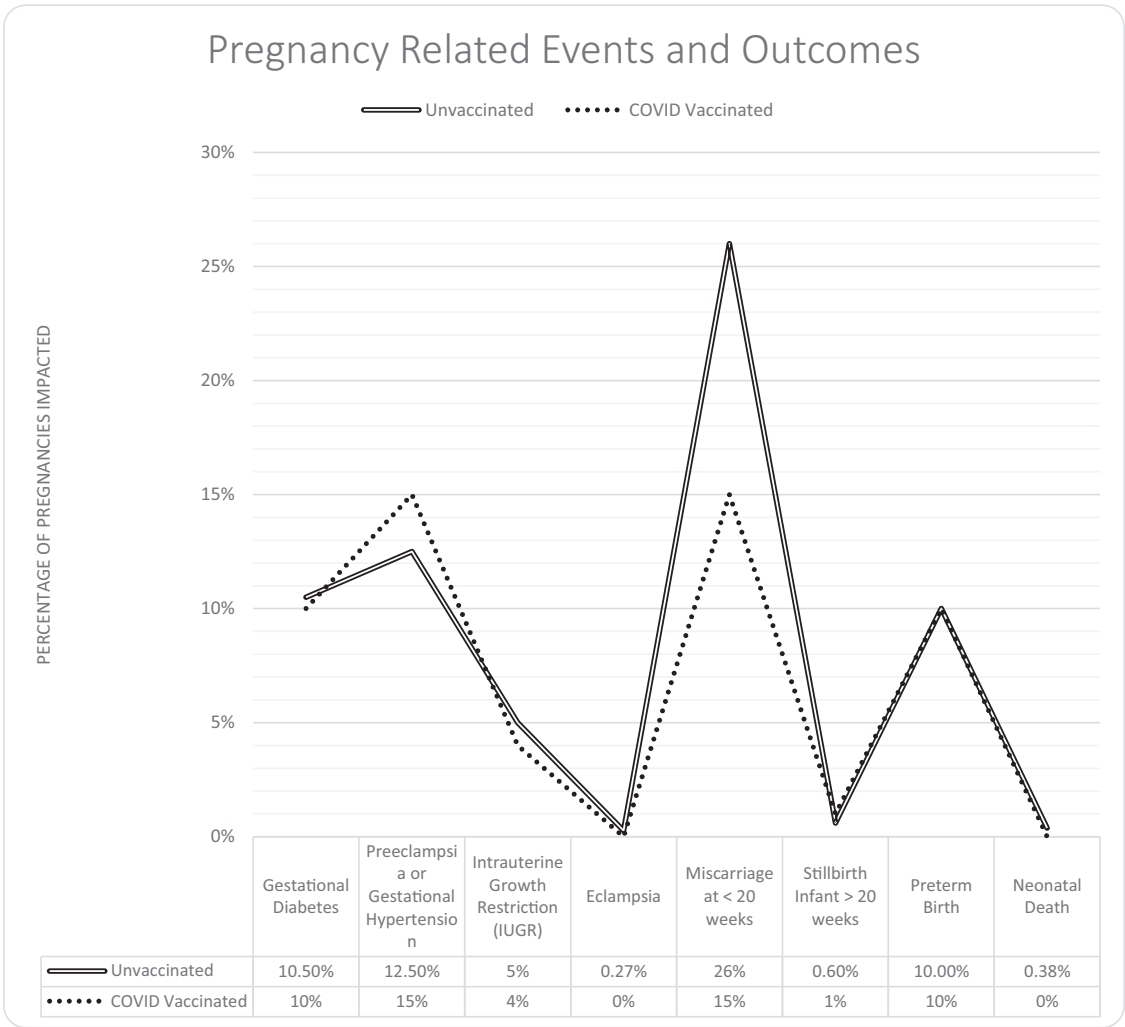

Figure 1 Comparison of pregnancy related events and outcomes comparing pregnant women with and without vaccination for SARS-CoV-2. (Adapted with permission from Blumberg D et al.[58])

there is no opportunity for entry of the adenovirus vector into the milk supply.[58] Breast milk tested from mothers vaccinated during or after pregnancy contains IgA and IgG antibodies. Peak levels of immunoglobulin occur between 4 and 6 weeks after the first vaccine dose.[64,65]

Vaccine Efficacy in Pregnant and Lactating Women

Available follow up of mother-infant dyads vaccinated during pregnancy demonstrates encouraging and interesting vaccine efficacy data. Vaccinated pregnant and lactating mothers have side effect profiles and antibody response similar to non-pregnant/nursing vaccinated women. They also have higher antibody levels than women who acquire natural infection during pregnancy.[64,66]

Cord blood samples from mothers vaccinated during pregnancy have measurable level of binding and neutralizing antibodies, indicative of the potential for transmission of passive immunity to the infant.[65] Review of hospital admissions in infants less than 6 months of age by Halasa et al., found that maternal vaccination with 2 doses of an mRNA vaccine was associated with a decreased risk of COVID-19 related hospitalization for infants. Overall, vaccination during pregnancy was 61% effective (95% CI 31%-78%) in preventing COVID-related hospital admissions for infants. Stratifying the data, vaccination in the first 20 weeks of pregnancy was 32% effective (95% CI 43%-68%), while vaccination after 21 weeks of pregnancy up to 2 weeks prior to delivery was 80% effective in preventing infant hospitalization for COVID-19 (95% CI 55%-91%). This work suggests that completion of maternal vaccination series during pregnancy may offer protection against hospitalization for COVID-19 in infants less than 6 months of age, although the ideal timing of vaccination remains unknown.[67]

Conclusion

Two years into the pandemic, prenatal care, perinatal care, and postnatal care of women and infants has been significantly altered, with unknown long-term ramifications. The impact of the SARS-CoV-2 virus extends beyond the physical effects of the COVID-19 infection itself. Early evidence indicates that the social and emotional changes associated with the pandemic have meaningfully impacted the health of both women and infants. Although there is a growing base of reliable evidence to guide the comprehensive care of pregnant women and their infants in the context of SARS-CoV-2, high quality research continues to be critically necessary to optimize the outcomes of these vulnerable populations.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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