





Review

Transmission of SARS-CoV-2 through breast milk and breastfeeding: a living systematic review

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The pandemic of coronavirus disease 2019 (COVID-19) is caused by infection with a novel coronavirus strain, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). At present, there is limited information on potential transmission of the infection from mother to child, particularly through breast milk and breastfeeding. Here, we provide a living systematic review to capture information that might necessitate changes in the guidance on breast milk and breastfeeding given the uncertainty in this area. Our search retrieved 19,414 total records; 605 were considered for full-text eligibility and no ongoing trials were identified. Our review includes 340 records, 37 with breast milk samples and 303 without. The 37 articles with analyzed breast milk samples reported on 77 mothers who were breastfeeding their children; among them, 19 of 77 children were confirmed COVID-19 cases based on RT-PCR assays, including 14 neonates and five older infants. Nine of the 68 analyzed breast milk samples from mothers with COVID-19 were positive for SARS-CoV-2 RNA; of the exposed infants, four were positive and two were negative for COVID-19. Currently, there is no evidence of SARS-CoV-2 transmission through breast milk. Studies are needed with longer follow-up periods that collect data on infant feeding practices and on viral presence in breast milk.

Keywords: COVID-19; SARS-CoV-2; novel coronavirus; 2019 nCoV; severe acute respiratory syndrome; vertical transmission; perinatal transmission; mother-to-child transmission; breast milk; breastfeeding

Introduction

On March 11, 2020, the World Health Organization (WHO) declared the coronavirus disease (COVID-19) outbreak a pandemic, with more than 600,000 cases globally.¹ Infection with a novel coronavirus strain, SARS-CoV-2, causes COVID-19. Clinical manifestation of SARS-CoV-2 infection varies; most infections are asymptomatic or present

with mild symptoms, such as fatigue, fever, and cough.² Severe cases may progress to viral pneumonia and require oxygen therapy, intensive care, and mechanical ventilation.³

There is limited but increasing evidence of SARS-CoV-2 infection during pregnancy. As initial reports on infections have been primarily from pregnant women confirmed or suspected with COVID-19 who were infected in either the third or late second trimester of pregnancy, it is not yet entirely clear if pregnant women are at greater risk of becoming infected or if SARS-CoV-2 can be

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transmitted from mother to infant during pregnancy, delivery, or breastfeeding.^{4,5} Similarly, information on COVID-19 during infancy or in childhood remains sparse.

On May 27, 2020, WHO updated Interim Guidance on Clinical Management of COVID-19, recommending exclusive breastfeeding for at least the first 6 months and breastfeeding alongside complementary foods until 2 years of age while using necessary precautions for infection prevention and control in infants born to mothers with suspected or confirmed COVID-19 (WHO 2020a)^b. This recommendation is based on the health benefits associated with breastfeeding for both the mother and the child and the relatively mild or asymptomatic illness experienced by infants reported so far. Infant feeding practices are an area of concern for families and health personnel, particularly during such outbreaks and high uncertainty of associated risks, such as its impact on food and nutrition security.

The objective of this review is to assess available evidence related to the possible transmission of SARS-CoV-2 through breast milk and breastfeeding (i.e., related bodily fluids, such as blood, sweat, and respiratory droplets) or droplet transmission due to close contact with the infant or young child via skin-to-skin exposure or airborne transmission. The review aims to support policymakers in making evidence-informed global, regional, and national guidelines on infant feeding in the context of the ongoing pandemic.

Methods

We designed and piloted a structured search strategy. The search was carried out on July 07, 2020, in the following electronic databases: MEDLINE (PubMed), the WHO COVID-19 Global literature on coronavirus disease (<https://search.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/>), Cochrane Library, Web of Science Core Collection, and Embase (May 15, 2020). We also searched the COVID-19 subset of the WHO International Clinical Trials Registry Platform (ICTRP)

(July 07, 2020) to identify ongoing and unpublished studies. The WHO COVID-19 global literature database is a comprehensive multilingual database on COVID-19 updated daily (Monday through Friday) from searches of bibliographic databases, hand searching, and the addition of other expert-referred scientific articles.

Living systematic review guidelines employ a continual approach to searching the literature on rapidly emerging research topics, to ensure greater currency and validity, and to increase the benefits to end users.⁶ We used standard reporting methods described elsewhere.⁷ Updated searches are planned to be performed as needed to keep the results up to date as the COVID-19 research base grows over time. Keywords used in the search strategy will be updated every week, incorporating new terminology for the virus as it comes into use. A detailed presentation of the number of studies retrieved, deduplicated, excluded during screening, and included in findings as of the third iteration of the search update is given in Figure 1 (PRISMA flow diagram). The protocol for this review is registered in PROSPERO, an international prospective register of systematic reviews: CRD42020178664.⁸

Type of studies

We aimed to consider any study design, including case reports, case series, and a report of family clusters, which are part of the epidemiological data from the ongoing outbreak investigations. Other study designs, such as cohort studies, were considered for inclusion, but none were identified with the search strategy.

Types of participants

Pregnant or lactating women with suspected, probable, or confirmed SARS-CoV-2 infection as well as their infants or young children (0–24 months of age) regardless of breastfeeding status, with suspected or confirmed SARS-CoV-2 infection, were eligible for inclusion. Case definitions are based on WHO Global surveillance interim guidance for COVID-19 (WHO 2020c)^c.

^bWHO. Clinical management of severe acute respiratory infection (SARI) when COVID-19 disease is suspected: interim guidance. 3 March 2020. World Health Organization; 2020.

^cWHO. Global surveillance for COVID-19 caused by human infection with COVID-19 virus. Interim guidance. 20 March 2020.: World Health Organization; 2020.

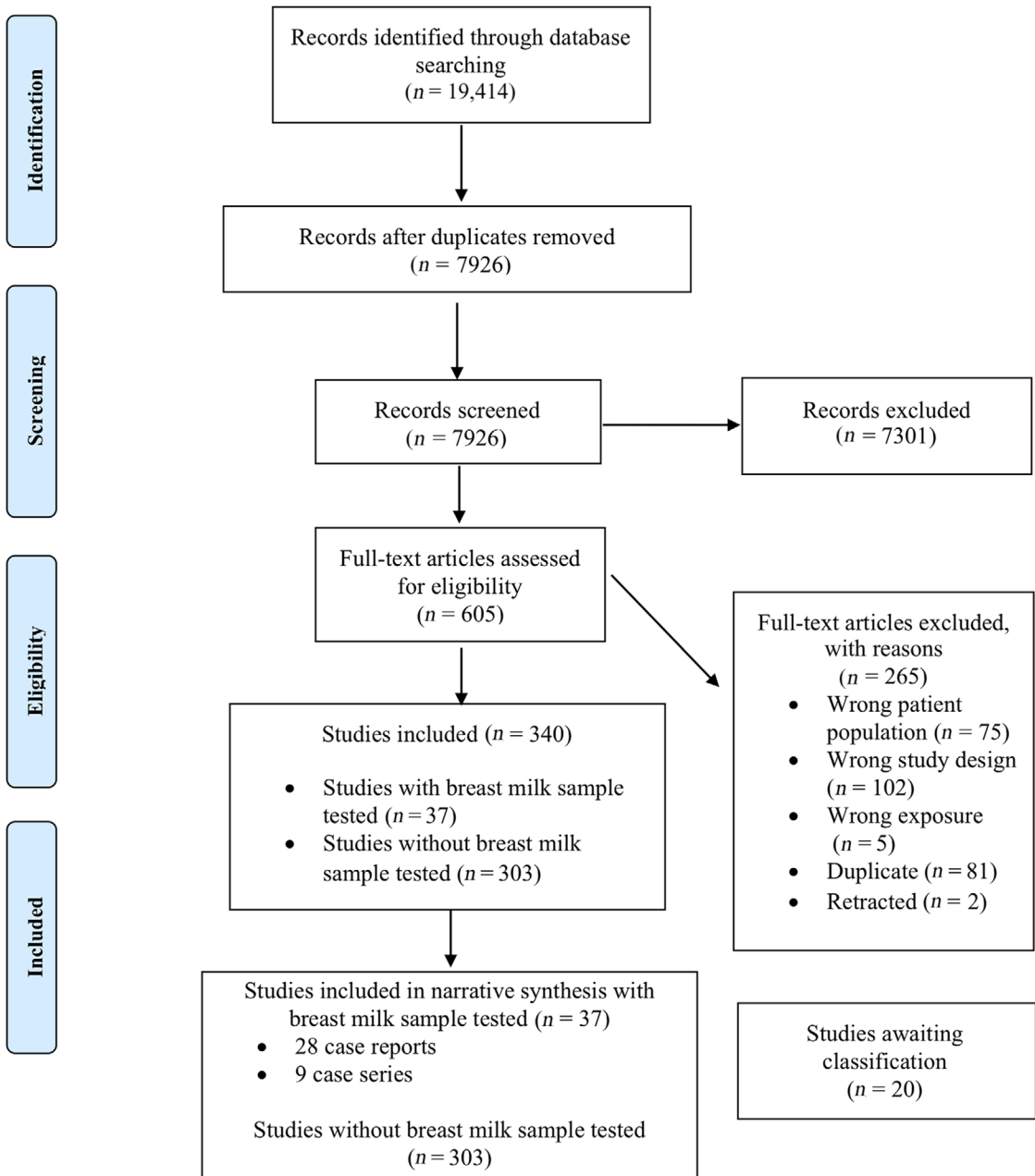


Figure 1. PRISMA chart (as of July 07, 2020).

Types of exposure

Apparently healthy infants or young children consuming breast milk directly from the breast or expressed breast milk from a woman with confirmed SARS-CoV-2 infection were considered exposed.

Types of outcomes

The primary outcome was any infant with suspected, probable, or confirmed SARS-CoV-2 infection within 30 days of breastfeeding or receiving expressed breast milk from a woman with a suspected, probable, or confirmed SARS-CoV-2 infection. The secondary outcomes include the presence

of SARS-CoV-2 RNA in breast milk by RT-PCR, infant adverse effects, and neonatal mortality or morbidity.

Search strategy

A comprehensive search strategy was designed to identify all available research pertaining to COVID-19 and breastfeeding practices. An initial search was conducted (March 10 and 17, 2020) as part of rapid assessment of the evidence. On the second search (April 10, 2020), we included all known variations of terms to describe COVID-19 at the time of searching (i.e., severe acute respiratory syndrome coronavirus 2, 2019nCoV, and SARS COV 2). Another iteration of the search was performed (July 07, 2020), and incorporated search terms for breastfeeding OR pregnancy OR mothers OR infants OR vertical transmission, to provide a more focused set of search results as the literature base on COVID-19 rapidly grows in scope and volume. This latest version of the search strategy will be performed as needed going forward, and a 1-week date filter will be applied to capture all new available literature that meets search criteria within the previous weeks' time. The full search strategy in all its variations for the databases used is presented in the Supplementary Materials (online only). We plan to consider the following sources prior to each search of the literature, and updates to the search strategies will be made accordingly.

- The National Library of Medicine's Technical Bulletin: regular announcements regarding new Medical Subject Headings and synonyms for COVID-19. (https://www.nlm.nih.gov/pubs/techbull/jf20/brief/jf20_mesh_novel_coronavirus_disease.html)
- The Medical Library Association's crowd-sourced compilation of COVID-19 search strategies (<https://www.mlanet.org/p/cm/ld/fid=1713>)
- The Australian Library and Information Association's database of live COVID-19 literature searches (<https://www.alia.org.au/groups/HLA/covid-19-live-literature-searches>).

Study selection

The references captured by the search strategy were screened using the Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org). Two

authors independently screened titles and abstracts according to the inclusion criteria; any discrepancies were resolved through discussion with a third author. The included full-text articles were retrieved and managed using EndNote X9 (Thomson Reuters Corporation).

Data extraction and management

Two authors independently extracted data from the included studies, using a piloted data extraction form. Since all the included studies were case reports or case series, it was not possible to calculate effect estimates, such as risk or odds ratio. For each study, information pertaining to exposure, diagnosis, symptoms, and infant feeding practices is described in the Results section.

Quality of the evidence

The GRADE approach was followed for rating the quality of the evidence.⁹ Data on primary and secondary outcomes were considered: SARS-CoV-2 infection in infants and children breastfeeding from mothers with confirmed SARS-CoV-2 infection, and detection of SARS-CoV-2 in breast milk from mothers with confirmed SARS-CoV-2 infection. The GRADE approach included risk of bias, directness of evidence, inconsistency (heterogeneity), precision of effect estimates, and risk of publication bias across the included studies. We downgraded the certainty of the evidence according to study limitations (i.e., risk of bias, consistency, and directness of measurements of effects) and possible risk of publication bias, dose-response gradient, large effect, and other confounders. Serious or very serious limitations in any of these aspects led to a one- or two-level downgrade in certainty. All the included reports are observational studies, which provide low-quality evidence according to the GRADE approach. Therefore, the quality assessment is being presented in a narrative way instead of using summary of findings tables, which will be used in future updates, as more evidence becomes available.

Results

Our search initially identified 19,414 records, of which, 7926 titles and abstracts were screened after removing duplicates. A total of 605 full-text articles were assessed for eligibility, of which 265 were excluded. A total of 340 reports were included,

of which 37 included the analysis of breast milk samples and 303 described lactating women or infants and children 0–24 months of age without collection or SARS-CoV-2 testing of breast milk samples. There were 20 records where the full text could not be located and are thus awaiting assessment.

Among the 303 reports without breast milk sample collection, there were 73 included reports that did not contribute data to inform the results of this review due to lack of breast milk or outcomes of interest: 36 reports presented pooled data of children of breastfeeding age and older; 27 other reports included pregnancy outcomes but not neonatal or breast milk outcomes; in three reports, neonates were not tested; six studies described ongoing pregnancies; and two reported a spontaneous abortion or pregnancy termination. References to these studies can be found in Table 2.

Study designs

Twenty-eight case reports,^{10–26,32–34,36–40,42,43,45} and nine retrospective case series.^{27–31,35,41,44,46} These report articles were included for narrative analysis.

Settings

The included studies were reports from Australia ($n = 1$),³² Belgium ($n = 1$),³³ Canada ($n = 1$),³⁴ China ($n = 21$),^{12,13,18–20,22–31,41–46} Germany ($n = 2$),^{14,35} Italy ($n = 6$),^{10,11,21,36–38} Jordan ($n = 1$),³⁹ Singapore ($n = 1$),¹⁷ Turkey ($n = 2$),^{16,40} and the Republic of Korea ($n = 1$).¹⁵ No additional information was available on the setting characteristics of the cases described.

Among the studies without breast milk samples, there were reports from Australia ($n = 1$), Belgium ($n = 1$), Brazil ($n = 1$), China ($n = 122$), France ($n = 8$), Germany ($n = 5$), Honduras ($n = 1$), India ($n = 3$), Iran ($n = 7$), Iraq ($n = 2$), Ireland ($n = 1$), Israel ($n = 1$), Italy ($n = 26$), Japan ($n = 1$), Jordan ($n = 1$), Lebanon ($n = 1$), Malaysia ($n = 1$), Mexico ($n = 2$), Morocco ($n = 2$), Netherlands ($n = 3$), Pakistan ($n = 1$), Peru ($n = 1$), Portugal ($n = 1$), Republic of Korea ($n = 3$), Spain ($n = 17$), Sweden ($n = 3$), Switzerland ($n = 2$), Thailand ($n = 1$), Turkey ($n = 5$), United Kingdom ($n = 12$), United States of America ($n = 67$), Venezuela ($n = 1$), and Vietnam ($n = 1$).

Participants

The 37 reviewed studies reported on a total of 77 infants whose mothers were diagnosed with COVID-19 and were able to provide a breast milk specimen for analysis. In these reports, there were 19 confirmed cases that included infants 2 years of age or younger. Among these cases, one newborn was diagnosed by the detection of anti-SARS-CoV-2-specific antibodies in serum.¹² All the other cases were diagnosed by the detection of viral RNA by RT-PCR from nasal or nasopharyngeal swabs or anal swabs (two cases).³⁵ One study assessed breast milk samples for viral infection from five women with COVID-19 but did not report on infant health outcomes or feeding practices for the corresponding five infants.⁴¹

Of the 19 positive children, 10 cases were reported to be breastfed and four mix-fed from a woman with COVID-19,^{10,14,15,17,19,21,24,25,33–35} two cases^{12,22,32,40} were described to be fed with a breast milk substitute (infant formula), and two cases that did not provide a description of infant feeding practices.^{11,14}

Infection outcomes are summarized in Tables 1 and 2. Cases are presented as neonates (≤ 28 days old) and infants and young children (> 28 days old to 24 months old) as these age groups potentially represent different exposure to breast milk and case management. Many neonates are tested regardless of symptoms due to maternal symptoms during pregnancy or the peripartum period, while older infants are less likely to be tested in the absence of severe symptoms.

Among the included studies with laboratory-confirmed breast milk samples from 77 mothers, the breastfed group composed of eight COVID-19-positive neonates (≤ 28 days old),^{10,14,15,21,33–35} 15 neonates without COVID-19,¹⁶ and two confirmed COVID-19-positive infants 3 and 6 months old;^{17,25} the mix-fed group had two COVID-19-positive neonate,^{10,40} two negative neonates,^{10,39} and three infants of 55 days and 8 and 14 months old;^{19,24,32} in the formula group, which includes infants separated from their mothers after birth, there were two positive infected neonates, 16 negative neonates,^{13,20,26,30,36,42} and no infants.^{12,22} Infant feeding practices were not reported for two positive neonates^{11,14} and 25 neonates who were negative for COVID-19.^{13,18,23,27–29,31,43–46}

Table 1. Children infection outcomes among articles with breast milk samples tested for SARS-CoV-2 RNA

Articles with breast milk samples available: 37				
Neonates ≤28 days old				
	Confirmed COVID-19 ^a	Negative COVID-19 ^b	Total	Studies
Breastfeeding ^c	8	15	23	Positive cases ^{14,15,21,33–35} Negative cases ^{16,35,37,38}
Breast milk substitute (infant formula) ^d	2	16	18	Positive cases ^{12,22} Negative cases ^{13,20,26,30,36,42}
Mix-feeding	2	2	4	Positive cases ^{10,40} Negative cases ^{10,39}
Not reported feeding practice	2	25	27	Positive cases ^{11,14} Negative cases ^{13,18,23,27–29,31,43–45}
Infants >28 days old				
Breastfeeding ^c	2	0	2	17, 25
Breast milk substitute (infant formula) ^d	0	0	0	
Mix-feeding	3	0	3	24,19,32
Not reported feeding practice	0	0	0	
Total	19	58	77	

^a Confirmed cases are defined as individuals with a positive RT-PCR test for SARS-CoV-2 RNA.

^b Negative COVID-19 are individuals with a negative RT-PCR test for SARS-CoV-2 RNA.

^c The frequency of exclusivity of breastfeeding before infection is not clear among these studies.

^d In one case,¹² the newborn was isolated from the mother and, therefore, presumably fed with a breast milk substitute.

Three of the eight breastfed neonates with COVID-19 developed signs and symptoms of respiratory illness,^{14,15,21} and one newborn required ventilation therapy and tube feeding.¹⁴ Two positive newborns²¹ were exclusively breastfed at the breast, the two mothers had positive nasopharyngeal swabs for COVID-19 and presented mild symptoms. One of these neonates presented with cough, fever, diarrhea, and poor feeding and the other one was asymptomatic. In the case reported by Ref. 15, the 27-day-old neonate developed nasal stuffiness, fever, tachycardia, and jaundice during hospitalization. This child was breastfed from birth and her mother presented mild symptoms 1 day earlier; the grandparents who live in the same house showed symptoms a couple of days earlier and they were all positive for COVID-19.

One case report²² described a neonate diagnosed with SARS-CoV-2 by RT-PCR from a nasopharyngeal sample collected 36 h after birth; this neonate was never breastfed as a preventive measure to avoid transmission. The mother used a N95 mask (i.e., a particulate-filtering facepiece respirator that filters at least 95% of airborne particles) during delivery

and the neonate was separated 10 min after birth. The neonate did not have fever, difficulty breathing, or coughing; however, at 5 days of age, a chest computed tomography showed a high-density nodular shadow under the pleura and lower lobe of the right lung. Six days later, there were small patchy shadows in the right lung, and after 5 more days, there were smaller pieces of patchy shadows. Both the mother and neonate recovered and were discharged without any other complications.²²

Repeated elevated IgM and IgG levels were found in a neonate born to a mother diagnosed 23 days before birth with COVID-19, the infant was delivered by cesarean section, the mother wore a N95 mask and did not hold the infant who was immediately quarantined.¹² The infant was asymptomatic and there were no complications at birth. At birth, the infant's IgM level was 45.83 AU/mL and IgG 279.72 AU/mL and 14 days later, IgM levels were still elevated at 69.94 AU/mL and IgG 11.75 AU/mL suggesting *in utero* infection. Samples from the placenta or amniotic fluid were not analyzed and maternal vaginal secretions were negative by RT-PCR test, as were five RT-PCR tests of

Table 2. Children infection outcomes among articles without breast milk samples tested

Articles without breast milk samples available: 303				
Neonates (0 to 28 days old)				
	Confirmed COVID-19 ^a	Negative COVID-19 ^b	Total	Studies
Breastfeeding ^c	16	137	153	Positive cases ^{60–69} Negative cases ^{68,70–79}
Breast milk substitute (infant formula) ^d	15	67	82	Positive cases ^{62,63,80–87} Negative cases ^{4,68,79,81,88–103}
Mix-feeding	3	7	10	Positive cases ^{104–106} Negative cases ¹⁰⁷
Not reported feeding practice	76	596	672	Positive cases ^{63,67,108–136} Negative cases ^{5,10,47,75,111,114,119,120,122,137–188}
Infants (>28 days old)				
Breastfeeding ^c	12	0	12	Positive cases ^{69,189–198}
Breast milk substitute (infant formula) ^d	6	0	6	Positive cases ^{83,193,199,200}
Mix-feeding	3	0	3	Positive cases ^{193,201}
Not reported ^e feeding practice	125	2	127	Positive cases ^{48,59,85,126,202–254} Negative cases ^{155,255}
Total	256	808	1065	
Articles not included in the analysis				3,102,115,136,178,225,256–355

^a Confirmed cases are defined as individuals with a positive RT-PCR tests for SARS-CoV-2 RNA.

^b Negative COVID-19 are individuals with a negative RT-PCR test for SARS-CoV-2 RNA.

^c The frequency of exclusivity of breastfeeding before infection is not clear among these studies.

^d There were 35 cases where authors clearly stated not breastfeeding, in 16 cases, authors advised not to breastfed, and 30 newborns were isolated at birth.

^e Among the cases with not reported feeding practices, there were 46 positive and 1 negative cases <1-year-old. There were 15 positive and 2 negative cases >1- to 2-year-old.

neonatal nasopharyngeal swabs taken between 2 and 13 days of life. The other 27 infants described in the included studies were negative for SARS-CoV-2 infection. The studies are briefly described in Table S1 (online only).

Of the eight breastfed infants, one 6-month-old infant did not develop any symptoms. Infants 3- and 14-months of age developed mild symptoms and recovered completely.^{19,25} In both cases, the infant's parents were positive for SARS-CoV-2. A 55-day-old infant²⁴ presented with rhinorrhea and dry cough; during hospitalization, the chest computed tomography scan showed progressive pneumonia and laboratory results indicated alterations in hepatic function and abnormal myocardial zymogram. This infant was receiving mixed feeding before illness, and both parents and other family members were diagnosed with COVID-19 2 days after infant symptoms onset. One neonate³³ with

confirmed COVID-19 was born prematurely by cesarean section and transferred to a closed incubator. The mother presented symptoms on the day of birth and the infant's test was positive at 14 days of life. The infant was fed expressed breast milk and the infant did not present respiratory or gastrointestinal symptoms and continued in stable condition.

A total of 82 women provided breast milk samples for analysis. Nine out of 68 breast milk samples, collected from different mothers and assessed by an RT-PCR assay, had detectable levels of SARS-CoV-2 RNA. Fourteen breast milk samples, from different women, were only assessed for the presence of specific antibodies, with one sample having specific IgG antibodies for SARS-CoV-2. The remaining 59 breast milk samples were negative. Of the six infants exposed to positive breast milk samples, two neonates were negative

for viral RNA,^{10,31} three neonates^{14,34,40} and one infant³² were positive for SARS-CoV-2 infection by RT-PCR analysis. There were no infant outcomes reported for one mother with a positive breast milk sample.⁴¹

In one case report,¹⁰ a series of breast milk samples from the same women tested positive the day of delivery and on days 2 and 4 postpartum, and was negative on days 14–17. In the same case, viral RNA was also detected in placenta tissues and umbilical cord. The neonate nasopharyngeal swabs were negative at days 1, 3, 18, and 24 of life and the infant was clinically well.

Groß and collaborators¹⁴ described a neonate diagnosed with COVID-19 who was exposed to breast milk with detectable SARS-CoV-2 by RT-PCR, the breast milk samples tested positive during a 4-day period, while the mother was symptomatic. Maternal symptoms initiated during the postpartum period and viral RNA was detected at day 8 postpartum, the neonate tested positive at day 11 and was also positive for syncytial virus infection, he presented with severe respiratory problems.¹⁴ The mother used a mask during the symptomatic period and followed hygiene recommendations while feeding and handling the neonate. There is no information about the infection status of other close relatives, the suspected close contact was a different mother–child pair with COVID-19 sharing the same hospital room during the pre and postdelivery period.

In another study,³¹ SARS-CoV-2 RNA was detected in one of three breast milk samples from an asymptomatic mother. The mother was diagnosed with COVID-19 the same day of delivery, the newborn was negative for viral infection by throat and anal swabs that were assessed on the first and third days after delivery. The infant feeding practices were not described.

In another case report,³² two out of six consecutively collected breast milk samples were positive for SARS-CoV-2 RNA, the positive samples were collected at 5 and 15 days after maternal symptoms. Maternal urine and saliva samples were negative for viral RNA. The 8-month-old infant had confirmed COVID-19 with mild coryza symptoms and cough; breastfeeding was interrupted during the first 5 days of maternal symptoms and continued after the infant's diagnosis.

The time between maternal or infant symptoms and when breast milk samples were tested for SARS-CoV-2 RNA varied among the different studies. Most of the cases were tested during the acute phase, 1–5 days after maternal symptoms^{14,18,22,26,29,31,34,36,38–41,45} or between 5 and 8 days after onset of maternal symptoms.^{10,13,16,20,32,33,37} Other samples were collected during the convalescent phase at 14–19 days after maternal^{17,24,29,42} or infant onset of symptoms.²⁵ The time between maternal symptoms and breast milk sample collection was not reported in four neonates with COVID-19^{21,35} and other 25 neonates without infection.^{28,35,44}

In another case,¹² maternal symptoms occurred during pregnancy, at 34 gestational weeks, and the breast milk sample was collected 23 days later after delivery. Similarly, another pregnant woman was diagnosed with COVID-19 during the 33rd gestational week, and a breast milk sample was tested on the day of delivery at 38 gestational weeks.²³

The overall certainty of the evidence was very low for all included studies. The studies were all observational and included case reports and case series. All studies had a high risk of bias due to lack of a control group, short follow-up time, and lack of control for other possible confounders. All of the included studies also had a high risk of imprecision since case reports and case series document outcomes on few cases. Additionally, the description of feeding practices was incomplete. We consider that a high risk of publication bias is plausible given that COVID-19–positive cases of infants and breast milk are most likely to be reported and published. Additionally, the sample could also be biased by only testing infants who seek care and present with severe symptoms.

Studies without breast milk sample assessment

A total of 303 reports on infants and young children 0–24 months of age did not test breast milk samples for SARS-CoV-2. We grouped these reports by the infant feeding practices (Table 2).

We identified 153 breastfeeding neonates, which included 16 positive SARS-CoV-2 infections and 137 negative cases, based on the lack of viral RNA detection by RT-PCR tests in throat or nasopharyngeal samples. There were 82 neonate cases who

were reportedly fed with a breast milk substitute or presumably so since some of the newborns were isolated from their mothers or the authors recommended stopping breastfeeding practices during hospital stay. Among these neonates, there were 15 positive cases and 67 negatives by RT-PCR tests from throat or nasopharyngeal swabs. There were 10 cases of reportedly mix-feeding practices: three of these neonates were positive and seven were negative for SARS-CoV-2 infection according to the lack of viral RNA detection by RT-PCR test on oral or nasopharyngeal samples. A total of 672 neonate cases did not report on infant feedings. These included 76 positive neonates and 596 negative neonates for SARS-CoV-2 infection; neonate diagnosis was based on viral RNA detection in nasal or nasopharyngeal samples, except 19 neonates⁴⁷ who were diagnosed as negative COVID-19 cases based on clinical diagnosis. The references to these studies are listed in Table 2.

There were also 12 breastfeeding infants (of 28 days to 2 years of age) who were positive for SARS-CoV-2 infection, as well as other six infants fed with a breast milk substitute and three cases who were mix-fed. There were no negative cases among these feeding categories. Infant feeding practices were not reported in 127 cases of infants, which included 112 infants with a positive diagnosis for COVID-19 and two were negative cases (Table 2). Infant cases of COVID-19 were determined by viral RNA detection with RT-PCR assays from nasal or nasopharyngeal swabs, except by one infant who was diagnosed by clinical presentation.⁴⁸

Discussion

In this review, we assess the evidence on transmission of SARS-CoV-2 from the mother to her child through breast milk and breastfeeding (i.e., related bodily fluids, such as blood, sweat, and respiratory droplets) or droplet transmission due to close contact with the infant or young child via skin-to-skin exposure or airborne transmission. We also summarize outcomes for infants and children with suspected or confirmed SARS-CoV-2 infection according to breastfeeding practices, as reported by the authors.

Among the 37 included studies with breast milk samples, nine out of 84 analyzed breast milk samples were reported to be positive for SARS-CoV-2 RNA via RT-PCR analysis^{10,14,31} and one sample

had specific IgG.³⁵ Among the cases with viral RNA detected in breast milk samples, one healthy neonate¹⁰ had negative nasopharyngeal and anal test results for COVID-19, while maternal breast milk samples had detectable viral RNA. However, this neonate was fed with a breast milk substitute, while maternal breast milk was positive and thus, it is not possible to ascertain the risk of infection by exposure to breast milk. In another case, the infant tested negative to the virus and exposure through breast milk could not be confirmed because infant feeding practices were not reported.³¹ In a different case, a neonate was found to be positive for COVID-19 based on viral RNA detected by RT-PCR, while exposed to maternal breast milk that tested positive for SARS-CoV-2 RNA.¹⁴ The mother breastfed the neonate while using surgical masks and following hygiene recommendations. In this particular case, before showing symptoms, both mother and newborn shared a hospital room with another mother–infant pair diagnosed with COVID-19. Thus, it is not clear whether the newborn became exposed due to close contact with the other confirmed COVID-19 patients, contact with the confirmed COVID-19–positive mother, or through the exposure to her SARS-CoV-2 RNA–positive breast milk. Moreover, this newborn was also coinfecting with respiratory syncytial virus and it is possible that the coinfection could have increased the neonate’s vulnerability to COVID-19 or worsened the symptoms of the infection. In the case of an 8-month-old infant with COVID-19,³² it is not possible to determine if transmission occurred through breast milk intake or breastfeeding, since it was interrupted during the maternal symptomatic phase, and the infant had symptoms 1 day after the mother’s symptoms; additionally, mother and infant were staying in an area with ongoing COVID-19 community transmission for 2 months.

Even though viral RNA has been detected in breast milk samples, among the included studies there were no attempts to culture the SARS-CoV-2 from breast milk isolates, adding to the uncertainty about potential infectious capacity of breast milk. One preprint study⁴⁹ found no culturable virus from one breast milk sample with viral RNA and from control breast milk samples spiked with SARS-CoV-2.

From the two reports that described breastfeeding practices, it is not possible to conclude

if SARS-CoV-2 infection was due to mother-to-child transmission, which can include but is not limited to specific breastfeeding practices or to feeding young children with breast milk from a COVID-19-positive woman. For the latter, the evidence gathered also includes another 79 breast milk samples, belonging to different women with confirmed COVID-19, which had no traces of SARS-CoV-2 RNA, and this may suggest a low risk of transmission by ingesting breast milk. Interestingly, there were several confirmed COVID-19 infants by RT-PCR tests who received SARS-CoV-2 negative breast milk; these included two newborns exclusively breastfed,²¹ one 27-day-old neonate who was breastfed,¹⁵ and infants aged 3 and 6 months old.^{17,25} Therefore, it seems plausible that these infants might have been exposed to SARS-CoV-2 through close contacts with infected family members, especially considering that in all these cases, both parents, relatives, and individuals in their communities were diagnosed with COVID-19. Notably, infant feeding practices were scarcely reported in most of the included studies.

From the evidence reported in articles without breast milk samples tested, it is not possible to ascertain if there is an increased risk of viral infection among breastfeeding children via breast milk. Most breastfeeding neonates did not have evidence of COVID-19 (28 out of 33) based on negative RT-PCR tests. Similarly, among infants who were fed with a breast milk substitute, 63 out of 77 did not have COVID-19 based on negative RT-PCR tests. However, infant feeding practices were not accurately reported. From all these studies, the frequency or exclusivity of breastfeeding is unclear, especially in relation to onset of maternal symptoms or viral load.

Most neonates born to mothers diagnosed with COVID-19 by RT-PCR tests during their pregnancy were negative for viral infection. One neonate was reported to be negative for COVID-19 by RT-PCR tests in throat swabs but had elevated IgM and IgG levels at birth.¹² These findings may suggest that vertical transmission does not appear to occur during the peripartum period. It is possible that passive immunity from the mother to the infant could be protective against infection. This was also suggested in the context of severe acute respiratory syndrome coronavirus (SARS-CoV) infection.⁵⁰ Given that all maternal infections reported in the included studies

occurred shortly before delivery, the consequences of infection during earlier stages of pregnancy are not clear. Additionally, the majority of included studies did not assess the presence of SARS-CoV-2-specific antibodies in neonates, breast milk, placenta, or other tissues and hence, the significance of finding anti-SARS-CoV-2 IgM immediately after birth in serum samples from the neonates, as reported by Ref. 12, remains to be defined. It is also important to understand the potential of passive immunity from mother to child during pregnancy and by breast milk intake. Specific IgA antibodies have been found in 12 of 15 breast milk samples, for example, from different women who had COVID-19,⁵¹ and further research is needed to ascertain the protective capacity and the duration of these antibodies.

It is also important to understand if the risk of transmission through breast milk changes in different stages of maternal disease progression or in asymptomatic cases. The three breast milk samples with detectable viral RNA were collected during the maternal symptomatic phase.^{10,14,31} But the 43 breast milk samples without detectable viral RNA were collected during either the symptomatic or convalescent phase. This might suggest that SARS-CoV-2 does not always cross the alveolus or milk-secreting unit during the acute phase, when maternal viremia is expected to be higher, or during the convalescent phase. Even after 4–5 weeks of maternal infection, viral RNA was not detected in breast milk, possibly indicating that the alveolus does not act as a reservoir for SARS-CoV-2.

Breast milk is not homogenous and its composition changes through the lactation period. In the future studies, it will be important to determine if the risk of transmission changes with the stage of lactation. In this review, most of the breast milk samples (43 out of 46) were negative for SARS-CoV-2 RNA presence, and the majority were tested during the first 48 h postpartum. This early period usually has a higher concentration of immune factors in milk compared with the composition of mature milk after the first month postpartum. There were few samples at different stages indicating the need to further characterize the risk of SARS-CoV-2 transmission in the context of breast milk composition, especially considering the immunomodulating components of breast milk, including antibodies, growth factors, and other

proteins, with critical roles in sustaining healthy neonatal intestinal epithelium and with antimicrobial properties.⁵² Lactoferrin, an iron-binding protein present in breast milk, for example, has been found to inhibit SARS-coronavirus infection in cell culture conditions.⁵³

What is known from SARS-CoV

When we consider the past experience with SARS-CoV, the viral agent that caused a major outbreak in 2003, it is important to note that it is genetically similar to SARS-CoV-2.⁵⁴ We identified two case reports where SARS-CoV was tested in breast milk.⁵⁵ In one case,⁵⁶ the breast milk sample collected at birth was positive for SARS-CoV. The infant was exclusively breastfed and did not show any symptoms of the disease at 5 days of age. The mother was diagnosed with SARS-CoV infection at 20 gestational weeks, and she required intensive care. In a second case report,⁵⁵ the mother presented with serious symptoms of SARS-CoV infection at 20 gestational weeks, and the infant was born healthy at 38 gestational weeks by cesarean section. Viral RNA was not detected in maternal samples of serum, whole blood, nasopharyngeal, and rectal swabs, or postdelivery, in the placenta, cord blood, amniotic fluid, and breast milk. However, antibodies to SARS-CoV were detected in maternal serum, cord blood, and breast milk, suggesting that the newborn might have acquired passive immunity from the mother. Curiously, in both cases, the mothers developed gestational diabetes.^{55,56}

Another case series⁵⁷ reported five infants born to mothers with SARS-CoV infection and pneumonia. All five infants tested negative for the presence of SARS-CoV RNA in samples of serum, throat swab, and urine. They also had negative cultures, but serum samples indicated the presence of SARS-CoV antibodies. The antibody titres did not increase in paired samples between the acute (1–9 days) and convalescent phases (21–23 days), suggesting passive immune transfer during pregnancy.⁵⁷ It is possible that the vertical transmission of SARS-CoV may be prevented by the presence of antibodies in cord blood and breast milk, as previously described.^{55,57} In summary, we reviewed the evidence for the transmission of the related SARS coronavirus (SARS-CoV) and found that most studies reporting on infection status of mothers and their children did not describe breastfeeding behaviors

or test breast milk samples. This evidence from the SARS-CoV outbreak in 2003 can be useful in the interpretation of the results from this review on COVID-19.

Limitations

Findings from this review are limited by the scarcity of information of infant feeding practices and breast milk samples tested, there was very limited information on skin-to-skin contact, rooming-in, and exclusive breastfeeding. In most cases, there was not clear information on the breast milk sample collection and analysis procedure. We also identified several studies from diverse countries that reported infant infection outcomes, but the reporting of feeding practices was heterogeneous or not available. Additionally, there could be a high risk of publication and sample bias, given that the most severe cases are the ones that seek care, are tested, and most commonly only those with a positive diagnosis are most likely to be reported. Moreover, there could be duplication of reported cases as case reports become part of a larger body of evidence. We plan to update these review findings as the evidence continues to grow with upcoming results from cohort studies and other case reports.

Implications for future research

More evidence about the intake of breast milk directly from the breast or expressed, as well as infants being breastfed exclusively, or formula fed will further the understanding of SARS-CoV-2 transmission. Despite the rapidly increasing literature around SARS-COV-2 transmission routes, the evidence of possible transmission through breast milk is still limited. Most of the reported cases are symptomatic infants or symptomatic pregnant women and their newborns, the information on older infants with or without symptoms is scarce. In most cases, only one breast milk sample was tested and with no information on maternal viremia. Breast milk samples were only tested by RT-PCR assays, and it is possible that viral RNA detection in breast milk was affected by the component of breast milk tested, as it has been shown to affect the assay sensitivity in other contexts.⁵⁸ It is important to note that viral RNA detection in breast milk does not necessarily indicate viral infectivity, and other assays will be necessary to determine if there are

viral particles in the breast milk that can be infectious once ingested by children.

This systematic review included findings from 37 studies; 19 infants out of 77 were diagnosed with COVID-19 by viral RNA detection and one by serology; 59 breast milk samples that were collected from COVID-19-positive mothers tested negative for SARS-CoV-2 via RT-PCR. As new evidence emerges from the current SARS-CoV-2 outbreak, additional research is warranted to explore the possible dynamic of breastfeeding transmission or protection against SARS-CoV-2. Specifically, studies focused on defining the timing of maternal and infant exposure, breast milk viral load, duration of infection, and the presence of protective antibodies in breast milk might aid in determining the risks of SARS-CoV-2 transmission when a breastfeeding woman is infected. We suggest that investigators working with breastfeeding mothers and their children collect the following data, where feasible, to better inform this review and the consequent guidelines: (1) confirmation and clinical characteristics of maternal and infant infection; (2) analyze and report on the presence of virus and viral infectious particles in breast milk, potentially with serial samples; and (3) record data on infant feeding practices and any contact precautions observed, such as wearing a mask and isolation.

The review authors are uncertain whether SARS-CoV-2 transmission via breast milk is possible as the certainty of the evidence has been assessed as very low. Nonetheless, the possible transmission through other breastfeeding-related bodily fluids, such as blood, sweat, respiratory droplets, or droplet transmission due to close contact with the infant or young child via skin-to-skin exposure or airborne transmission cannot be disregarded.

Note adding in proof. Since this work was completed and accepted, Chambers *et al.* report that although SARS-CoV-2 RNA was detectable in 1 breast milk sample from 18 infected woman, this did not represent replication-competent virus; the authors concluded that breast milk may not be a source of infection for infants. *JAMA*. Published online August 19, 2020. <https://doi:10.1001/jama.2020.15580>

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Disclaimer

The authors alone are responsible for the views expressed in this review and they do not necessarily represent the views, decisions, or policies of the institutions with which they are affiliated.

Author contributions

S.M., P.R.S., J.L.F., and J.P.P.R. conceptualized the study. E.C.T., M.M.R., J.L.F., P.R.S., M.N.G.C., L.R., J.P.P.R., and S.M. designed the protocol. K.G.K. and E.C.T. designed, updated, and translated the search strategy. E.C.T., M.M.R., and P.R. screened and extracted data from articles. E.C.T., M.M.R., J.L.F., P.R.S., M.N.G.C., L.R., P.R., J.P.P.R., and S.M. interpreted the findings. E.C.T. and M.M.R. wrote the first draft, which all authors revised for critical content. E.C.T. and M.M.R. contributed equally to this study. All authors approved the final manuscript. S.M. is the guarantor. The corresponding authors attest that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Supporting information

Additional supporting information may be found in the online version of this article.

References

1. WHO. 2020. Coronavirus disease 2019 (COVID-19): situation report-70. World Health Organization. Accessed March 30, 2020. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200330-sitrep-70-covid-19.pdf?sfvrsn=7e0fe3f8_2.
2. Hu, Z., C. Song, C. Xu, *et al.* 2020. Clinical characteristics of 24 asymptomatic infections with COVID-19 screened among close contacts in Nanjing, China. *Sci. China Life Sci.* **63**: 706–711.
3. Guan, W.-J., Z.-Y. Ni, Y. Hu, *et al.* 2020. Clinical characteristics of coronavirus disease 2019 in China. *N. Engl. J. Med.* **382**: 1708–1720.

4. Chen, Y., H. Peng, L. Wang, *et al.* 2020. Infants born to mothers with a new coronavirus (COVID-19). *Front. Pediatr.* **8**. <https://doi.org/10.3389/fped.2020.00104>.
5. Zhu, H., L. Wang, C. Fang, *et al.* 2020. Clinical analysis of 10 neonates born to mothers with 2019-nCoV pneumonia. *Transl. Pediatr.* **9**: 51–60.
6. Elliott, J.H., A. Synnot, T. Turner, *et al.* 2017. Living systematic review: 1. Introduction—the why, what, when, and how. *J. Clin. Epidemiol.* **91**: 23–30.
7. Moher, D., A. Liberati, J. Tetzlaff & D.G. Altman. 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med.* **6**: e1000097.
8. Centeno-Tablante, E., M. Medina-Rivera, J.L. Finkelstein, *et al.* 2009. Transmission of novel coronavirus-19 through breast milk and breastfeeding. A living systematic review of the evidence. PROSPERO 2020 CRD42020178664 2020. Accessed April 22, 2020. https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=178664.
9. GRADEpro. 2015. GRADEproGDT: GRADEpro Guideline Development Tool [Software]. McMaster University. [Developed by Evidence Prime, Inc.]. Accessed August 12, 2020. <https://www.gradepro.org>.
10. Buonsenso, D., S. Costa, M. Sanguinetti, *et al.* 2020. Neonatal late onset infection with severe acute respiratory syndrome coronavirus 2. *Am. J. Perinatol.* **37**: 869–872.
11. Carosso, A., S. Cosma, F. Borella, *et al.* 2020. Pre-labor anorectal swab for SARS-CoV-2 in COVID-19 pregnant patients: is it time to think about it? *Eur. J. Obstet. Gynecol. Reprod. Biol.* **249**: 98–99.
12. Dong, L., J. Tian, S. He, *et al.* 2020. Possible vertical transmission of SARS-CoV-2 from an infected mother to her newborn. *JAMA* **323**: 1846–1848.
13. Fan, C., D. Lei, C. Fang, *et al.* 2020. Perinatal transmission of COVID-19 associated SARS-CoV-2: should we worry? *Clin. Infect. Dis.* <https://doi.org/10.1093/cid/ciaa226>.
14. Groß, R., C. Conzelmann, J.A. Müller, *et al.* 2020. Detection of SARS-CoV-2 in human breastmilk. *Lancet* **395**: 1757–1758.
15. Han, M.S., M.-W. Seong, E.Y. Heo, *et al.* 2020. Sequential analysis of viral load in a neonate and her mother infected with SARS-CoV-2. *Clin. Infect. Dis.* <https://doi.org/10.1093/cid/ciaa447>.
16. Kalafat, E., E. Yaprak, G. Cinar, *et al.* 2020. Lung ultrasound and computed tomographic findings in pregnant woman with COVID-19. *Ultrasound Obstet. Gynecol.* **55**: 835–837.
17. Kam, K.Q., C.F. Yung, L. Cui, *et al.* 2020. A well infant with coronavirus disease 2019 (COVID-19) with high viral load. *Clin. Infect. Dis.* **71**: 847–849.
18. Li, Y., R. Zhao, S. Zheng, *et al.* 2020. Lack of vertical transmission of severe acute respiratory syndrome coronavirus 2, China. *Emerg. Infect. Dis.* **26**: 1335–1336.
19. Mao, L.-J., J. Xu, Z.-H. Xu, *et al.* 2020. A child with household transmitted COVID-19. *BMC Infect. Dis.* **20**: 329.
20. Peng, Z., J. Wang, Y. Mo, *et al.* 2020. Unlikely SARS-CoV-2 vertical transmission from mother to child: a case report. *J. Infect. Public Health* **13**: 818–820.
21. Salvatori, G., D.U. De Rose, C. Concato, *et al.* 2020. Managing COVID-19-positive maternal-infant dyads: an Italian experience. *Breastfeed. Med.* **15**: 347–348.
22. Wang, S., L. Guo, L. Chen, *et al.* 2020. A case report of neonatal COVID-19 infection in China. *Clin. Infect. Dis.* **71**: 853–857.
23. Xiong, X., H. Wei, Z. Zhang, *et al.* 2020. Vaginal delivery report of a healthy neonate born to a convalescent mother with COVID-19. *J. Med. Virol.* <https://doi.org/10.1002/jmv.25857>.
24. Cui, Y., M. Tian, D. Huang, *et al.* 2020. A 55-day-old female infant infected with COVID 19: presenting with pneumonia, liver injury, and heart damage. *J. Infect. Dis.* **221**: 1775–1781.
25. Zhang, Y.H., D.J. Lin, M.F. Xiao, *et al.* 2020. 2019-novel coronavirus infection in a three-month-old baby. *Chin. J. Pediatr.* **58**: E006.
26. Siying, Z., G. Juanjuan, C. Yuming, *et al.* 2020. A case of perinatal new coronavirus infection. *Chin. J. Perinat. Med.* **02**: 85–90.
27. Chen, H., J. Guo, C. Wang, *et al.* 2020. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. *Lancet* **395**: 809–815.
28. Chen, L., Q. Li, D. Zheng, *et al.* 2020. Clinical characteristics of pregnant women with Covid-19 in Wuhan, China. *N. Engl. J. Med.* **382**: e100.
29. Di, L., W. Chen, L. Chunyan, *et al.* 2020. Clinical characteristics of COVID-19 in pregnancy: analysis of nine cases. *Chin. J. Perinat. Med.* **23**: 222–228.
30. Liu, W., J. Wang, W. Li, *et al.* 2020. Clinical characteristics of 19 neonates born to mothers with COVID-19. *Front. Med.* <https://doi.org/10.1007/s11684-020-0772-y>
31. Wu, Y., C. Liu, L. Dong, *et al.* 2020. Coronavirus disease 2019 among pregnant Chinese women: case series data on the safety of vaginal birth and breastfeeding. *BJOG* **127**: 1109–1115.
32. Tam, P.C.K., K.M. Ly, M.L. Kernich, *et al.* 2020. Detectable severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in human breast milk of a mildly symptomatic patient with coronavirus disease 2019 (COVID-19). *Clin. Infect. Dis.* <https://doi.org/10.1093/cid/ciaa673>.
33. Piersigilli, F., K. Carkeek, C. Hocq, *et al.* 2020. COVID-19 in a 26-week preterm neonate. *Lancet Child Adolesc. Health* **4**: 476–478.
34. Kirtsman, M., Y. Diambomba, S.M. Poutanen, *et al.* 2020. Probable congenital SARS-CoV-2 infection in a neonate born to a woman with active. *CMAJ* **192**: E647–E650.
35. Preßler, J., S. Fill Malfertheiner, M. Kabisch, *et al.* 2020. Postnatal SARS-CoV-2 infection and immunological reaction: a prospective family cohort study. *Pediatr. Allergy Immunol.* <https://doi.org/10.1111/pai.13302>.
36. Costa, S., B. Posteraro, S. Marchetti, *et al.* 2020. Excretion of SARS-CoV-2 in human breast milk. *Clin. Microbiol. Infect.* <https://doi.org/10.1016/j.cmi.2020.05.027>
37. De Socio, G.V., L. Malincarne, S. Arena, *et al.* 2020. Delivery in asymptomatic Italian woman with

- SARS-CoV-2 infection. *Mediterr. J. Hematol. Infect. Dis.* **12**: e2020033.
38. Perrone, S., M. Giordano, A. Meoli, et al. 2020. Lack of viral transmission to preterm newborn from a COVID-19 positive breastfeeding mother at 11 days postpartum. *J. Med. Virol.* <https://doi.org/10.1002/jmv.26037>.
 39. AlZaghal, L.A., N. AlZaghal, S.O. Alomari, et al. 2020. Multidisciplinary team management and cesarean delivery for a Jordanian woman infected with SARS-COV-2: a case report. *Case Rep. Womens Health* **27**: e00212.
 40. Bastug, A., A. Hanifehnezhad, C. Tayman, et al. 2020. Viro-lactia in an asymptomatic mother with COVID-19. *Breast-feed. Med.* <https://doi.org/10.1089/bfm.2020.0161>.
 41. Zhu, C., W. Liu, H. Su, et al. 2020. Breastfeeding risk from detectable severe acute respiratory syndrome coronavirus 2 in breastmilk. *J. Infect.* <https://doi.org/10.1016/j.jinf.2020.06.001>.
 42. Dong, Y., X. Chi, H. Huang, et al. 2020. Antibodies in the breast milk of a maternal woman with COVID-19. *Emerg. Microbes Infect.* **9**: 1467–1469.
 43. Chen, X., Y. Li, J. Wang, et al. 2020. [Pregnant women complicated with COVID-19: a clinical analysis of 3 cases]. *Zhejiang Da Xue Xue Bao Yi Xue Ban* **49**: 240–244.
 44. Deng, G., F. Zeng, L. Zhang, et al. 2020. Characteristics of pregnant COVID-19 patients with liver injury. *J. Hepatol.* <https://doi.org/10.1016/j.jhep.2020.06.022>.
 45. Lang, G.-J. & H. Zhao. 2020. Can SARS-CoV-2-infected women breastfeed after viral clearance? *J. Zhejiang Univ. Sci. B* **21**: 405–407.
 46. Wang, X., Y. Zhou, N. Jiang, et al. 2020. Persistence of intestinal SARS-CoV-2 infection in patients with COVID-19 leads to re-admission after pneumonia resolved. *Int. J. Infect. Dis.* **95**: 433–435.
 47. Wu, X., R. Sun, J. Chen, et al. 2020. Radiological findings and clinical characteristics of pregnant women with COVID-19 pneumonia. *Int. J. Gynaecol. Obstet.* **150**: 58–63.
 48. Jiang, J., L. Duan, D. Xiong, et al. 2020. Epidemiological and clinical characteristics of novel coronavirus infection in children: thoughts on the diagnostic criteria of suspected cases outside Hubei Province. *Chin. Pediatr. Emerg. Med.* **27**: E003.
 49. Chambers, C.D., P. Krogstad, K. Bertrand, et al. 2020. Evaluation of SARS-CoV-2 in breastmilk from 18 infected women. <https://doi.org/10.1101/2020.06.12.20127944>.
 50. Rebmann, T. 2005. Severe acute respiratory syndrome: implications for perinatal and neonatal nurses. *J. Perinat. Neonat. Nurs.* **19**: 332–345; quiz 46–7.
 51. Fox, A., J. Marino, F. Amanat, et al. 2020. Evidence of a significant secretory-IgA-dominant SARS-CoV-2 immune response in human milk following recovery from COVID-19. <https://doi.org/10.1101/2020.05.04.20089995>.
 52. Nolan, L.S., O.B. Parks & M. Good. 2019. A review of the immunomodulating components of maternal breast milk and protection against necrotizing enterocolitis. *Nutrients* **12**. <https://doi.org/10.3390/nu12010014>.
 53. Lang, J., N. Yang, J. Deng, et al. 2011. Inhibition of SARS pseudovirus cell entry by lactoferrin binding to heparan sulfate proteoglycans. *PLoS One* **6**: e23710.
 54. Lu, H., C.W. Stratton & Y.W. Tang. 2020. Outbreak of pneumonia of unknown etiology in Wuhan, China: the mystery and the miracle. *J. Med. Virol.* **92**: 401–402.
 55. Robertson, C.A., S.A. Lowther, T. Birch, et al. 2004. SARS and pregnancy: a case report. *Emerg. Infect. Dis.* **10**: 345–348.
 56. Schneider, E., D. Duncan, M. Reiken, et al. 2004. SARS in pregnancy. *AWHONN Lifelines* **8**: 122–128.
 57. Shek, C.C., P.C. Ng, G.P. Fung, et al. 2003. Infants born to mothers with severe acute respiratory syndrome. *Pediatrics* **112**: e254.
 58. Hoffman, I.F., F.E. Martinson, P.W. Stewart, et al. 2003. Human immunodeficiency virus type 1 RNA in breast-milk components. *J. Infect. Dis.* **188**: 1209–1212.
 59. Liu, H., F. Liu, J. Li, et al. 2020. Clinical and CT imaging features of the COVID-19 pneumonia: focus on pregnant women and children. *J. Infect.* **80**: e7–e13.
 60. Chacón-Aguilar, R., J.M. Osorio-Cámara, I. Sanjurjo-Jimenez, et al. 2020. COVID-19: fever syndrome and neurological symptoms in a neonate. *An. Pediatr. (Engl. Ed.)* **92**: 373–374.
 61. Sinelli, M.T., G. Paterlini, M. Citterio, et al. 2020. Early neonatal SARS-CoV-2 infection manifesting with hypoxemia requiring respiratory support. *Pediatrics* **146**: e20201121.
 62. Ferrazzi, E., L. Frigerio, V. Savasi, et al. 2020. Vaginal delivery in SARS-CoV-2 infected pregnant women in Northern Italy: a retrospective analysis. *BJOG.* <https://doi.org/10.1111/1471-0528.16278>.
 63. Zhang, Z.-J., X.-J. Yu, T. Fu, et al. 2020. Novel coronavirus infection in newborn babies aged < 28 days in China. *Eur. Respir. J.* **55**. <https://doi.org/10.1183/13993003.00697-2020>
 64. Dumpa, V., R. Kamity, A.N. Vinci, et al. 2020. Neonatal coronavirus 2019 (COVID-19) infection: a case report and review of literature. *Cureus* **12**: e8165.
 65. Gonzalez Brabin, A., M.I. Iglesias-Bouzas, M. Nieto-Moro, et al. 2020. Neonatal apnea as initial manifestation of SARS-CoV-2 infection. *An. Pediatr.* <https://doi.org/10.1016/j.anpedi.2020.05.008>
 66. Ng, K.F., S. Bandi, P.W. Bird & J. Wei-Tze Tang. 2020. COVID-19 in neonates and infants: progression and recovery. *Pediatr. Infect. Dis. J.* **39**: e140–e142.
 67. Patanè, L., D. Morotti, M.R. Giunta, et al. 2020. Vertical transmission of COVID-19: SARS-CoV-2 RNA on the fetal side of the placenta in pregnancies with COVID-19 positive mothers and neonates at birth. *Am. J. Obstet. Gynecol. MFM* <https://doi.org/10.1016/j.ajogmf.2020.100145>.
 68. Savasi, V.M., F. Parisi, L. Patanè, et al. 2020. Clinical findings and disease severity in hospitalized pregnant women with coronavirus disease 2019 (COVID-19). *Obstet. Gynecol.* **136**: 252–258.
 69. White, A., P. Mukherjee, J. Stremming, et al. 2020. Neonates hospitalized with community-acquired SARS-CoV-2 in a Colorado Neonatal Intensive Care Unit. *Neonatology.* <https://doi.org/10.1159/000508962>.
 70. Breslin, N., C. Baptiste, C. Gyamfi-Bannerman, et al. 2020. 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* **2**. <https://doi.org/10.1016/j.ajogmf.2020.100118>.
71. Lowe, B. & B. Bopp. 2020. COVID-19 vaginal delivery – a case report. *Aust. N. Z. J. Obstet. Gynaecol.* **60**: 465–466.
 72. Kuhrt, K., J. McMicking, S. Nanda, et al. 2020. Placental abruption in a twin pregnancy at 32 weeks' gestation complicated by COVID-19, without vertical transmission to the babies. *Am. J. Obstet. Gynecol. MFM* <https://doi.org/10.1016/j.ajogmf.2020.100135>.
 73. Al-Kuraishy, H., T. Al-Maiyah, A. Al-Gareeb, et al. 2020. COVID-19 pneumonia in an Iraqi pregnant woman with preterm delivery. *Asian Pac. J. Reprod.* **9**: 156–158.
 74. Chhabra, A., T. Rao, M. Kumar, et al. 2020. Anaesthetic management of a COVID-19 parturient for caesarean section — case report and lessons learnt. *Indian J. Anaesth.* **64**(14 Suppl. 2): S141–S143.
 75. Griffin, I., F. Benarba, C. Peters, et al. 2020. The impact of COVID-19 infection on labor and delivery, newborn nursery, and neonatal intensive care unit: prospective observational data from a single hospital system. *Am. J. Perinatol.* **37**: 1022–1030.
 76. Lyra, J., R. Valente, M. Rosário & M. Guimarães. 2020. Cesarean section in a pregnant woman with COVID-19: first case in Portugal. *Acta Med. Port.* **33**: 429–431.
 77. Pereira, A., S. Cruz-Melguizo, M. Adrien, et al. 2020. Clinical course of coronavirus disease-2019 (COVID-19) in pregnancy. *Acta Obstet. Gynecol. Scand.* **99**: 839–847.
 78. Perrone, S., M. Deolmi, M. Giordano, et al. 2020. Report of a series of healthy term newborns from convalescent mothers with COVID-19. *Acta Biomed.* **91**: 251–255.
 79. Qadri, F. & F. Mariona. 2020. Pregnancy affected by SARS-CoV-2 infection: a flash report from Michigan. *J. Matern. Fetal Neonat. Med.* <https://doi.org/10.1080/14767058.2020.1765334>.
 80. Alzamora, M.C., T. Paredes, D. Caceres, et al. 2020. Severe COVID-19 during pregnancy and possible vertical transmission. *Am. J. Perinatol.* **37**: 861–865.
 81. Hu, X., J. Gao, X. Luo, et al. 2020. 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.* **136**: 65–67.
 82. Lorenz, N., A. Treptow, S. Schmidt, et al. 2020. Neonatal early-onset infection with SARS-CoV-2 in a newborn presenting with encephalitic symptoms. *Pediatr. Infect. Dis. J.* **39**: e212.
 83. Meslin, P., C. Guiomard, M. Chouakria, et al. 2020. Coronavirus disease 2019 in newborns and very young infants: a series of six patients in France. *Pediatr. Infect. Dis. J.* **39**: e145–e147.
 84. Zamaniyan, M., A. Ebadi, S. Aghajanoor Mir, et al. 2020. Preterm delivery in pregnant woman with critical COVID-19 pneumonia and vertical transmission. *Prenat. Diagn.* <https://doi.org/10.1002/pd.5713>.
 85. Zheng, F., C. Liao, Q.H. Fan, et al. 2020. Clinical characteristics of children with coronavirus disease 2019 in Hubei, China. *Curr. Med. Sci.* **40**: 275–280.
 86. Li, M., M. Xu, W. Zhan, et al. 2020. Report of the first cases of mother and infant infections with 2019 novel coronavirus in Xinyang City Henan Province. *Chin. J. Infect. Dis.* **38**: E007.
 87. Zheng, L.K., X.W. Tao, W.H. Yuan, et al. 2020. [First case of neonate with COVID-19 in China]. *Chin. J. Pediatr.* **58**: 279–280.
 88. Chen, S., E. Liao & Y. Shao. 2020. Clinical analysis of pregnant women with 2019 novel coronavirus pneumonia. *J. Med. Virol.* <https://doi.org/10.1002/jmv.25789>.
 89. Lee, D.H., J. Lee, E. Kim, et al. 2020. Emergency cesarean section on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) confirmed patient. *Korean J. Anesthesiol.* **73**: 347–351.
 90. Lu, D., L. Sang, S. Du, et al. 2020. Asymptomatic COVID-19 infection in late pregnancy indicated no vertical transmission. *J. Med. Virol.* <https://doi.org/10.1002/jmv.25927>.
 91. Vallejo, V. & J.G. Ilagan. 2020. A postpartum death due to coronavirus disease 2019 (COVID-19) in the United States. *Obstet. Gynecol.* **136**: 52–55.
 92. Wang, X., Z. Zhou, J. Zhang, et al. 2020. A case of 2019 novel coronavirus in a pregnant woman with preterm delivery. *Clin. Infect. Dis.* **71**: 844–846.
 93. Xia, H., S. Zhao, Z. Wu, et al. 2020. Emergency caesarean delivery in a patient with confirmed COVID-19 under spinal anaesthesia. *Br. J. Anaesth.* **124**: e216–e8.
 94. Xu, L., Q. Yang, H. Shi, et al. 2020. Clinical presentations and outcomes of SARS-CoV-2 infected pneumonia in pregnant women and health status of their neonates. *Sci. Bull. (Beijing)* **65**: 1537–1542.
 95. Yang, H., G. Sun, F. Tang, et al. 2020. Clinical features and outcomes of pregnant women suspected of coronavirus disease 2019. *J. Infect.* **81**: e40–e44.
 96. Yao, L., J. Wang, J. Zhao, et al. 2020. Asymptomatic COVID-19 infection in pregnant woman in the third trimester: a case report. *Chin. J. Perinat. Med.* **23**: 229–231.
 97. Zeng, H., C. Xu, J. Fan, et al. 2020. Antibodies in infants born to mothers with COVID-19 pneumonia. *JAMA* **323**: 1848–1849.
 98. Zhang, L., Y. Jiang, M. Wei, et al. 2020. [Analysis of the pregnancy outcomes in pregnant women with COVID-19 in Hubei Province]. *Zhonghua Fu Chan Ke Za Zhi* **55**: E009.
 99. Zhao, Y., L. Zou, M.-H. Dong, et al. 2020. Challenges for obstetricians and the countermeasures of COVID-19 epidemic. *Matern. Fetal Med.* **2**: 68–71.
 100. Zhou, R., Y. Chen, C. Lin, et al. 2020. Asymptomatic COVID-19 in pregnant woman with typical chest CT manifestation: a case report. *Chin. J. Perinat. Med.* **23**: E006.
 101. Grimminck, K., L.A.M. Santegoets, F.C. Siemens, et al. 2020. No evidence of vertical transmission of SARS-CoV-2 after induction of labour in an immune-suppressed SARS-CoV-2-positive patient. *BMJ Case Rep.* **13**: e235581
 102. Liu, P., J. Zheng, P. Yang, et al. 2020. The immunologic status of newborns born to SARS-CoV2-infected mothers in Wuhan, China. *J. Allergy Clin. Immunol.* **146**: 101–109.e1.
 103. Silverstein, J.S., M.A. Limaye, S.G. Brubaker, et al. 2020. Acute respiratory decompensation requiring intubation in

- pregnant women with SARS-CoV-2 (COVID-19). *AJP Rep.* **10**: e169–e75.
104. Diaz, C.A., M.L. Maestro, M.T.M. Pumarega, et al. 2020. First case of neonatal infection due to COVID 19 in Spain. *An. Pediatr. (Engl. Ed.)* **92**: 237–238.
 105. Wang, J., D. Wang, G.C. Chen, et al. 2020. [SARS-CoV-2 infection with gastrointestinal symptoms as the first manifestation in a neonate]. *Zhongguo Dang Dai Er Ke Za Zhi* **22**: 211–214.
 106. de Carvalho, W.B., M.A.C., Gibelli, V.L.J. Krebs, et al. 2020. Neonatal SARS-CoV-2 infection. *Clinics (Sao Paulo)* **75**: e1996.
 107. Liao, J., X. He, Q. Gong, et al. 2020. Analysis of vaginal delivery outcomes among pregnant women in Wuhan, China during the COVID-19 pandemic. *Int. J. Gynaecol. Obstet.* **150**: 53–57.
 108. Baud, D., G. Greub, G. Favre, et al. 2020. Second-trimester miscarriage in a pregnant woman with SARS-CoV-2 infection. *JAMA* **323**: 2198–2200.
 109. Coronado Munoz, A., U. Nawaratne, D. McMann, et al. 2020. Late-onset neonatal sepsis in a patient with Covid-19. *N. Engl. J. Med.* **382**: e49.
 110. Kamali Aghdam, M., N. Jafari & K. Eftekhari. 2020. Novel coronavirus in a 15-day-old neonate with clinical signs of sepsis, a case report. *Infect. Dis.* **52**: 427–429.
 111. Khan, S., L. Jun, Nawsherwan, et al. 2020. Association of COVID-19 infection with pregnancy outcomes in healthcare workers and general women. *Clin. Microbiol. Infect.* **26**: 788–790.
 112. Kim, J.-H., N. Shrestha & M. Girshin. 2020. Unexpected severe thrombocytopenia in the COVID-19 positive parturient. *Anesth. Analg.* <https://doi.org/10.1213/ANE.0000000000004948>.
 113. Paret, M., J. Lighter, R. Pellett Madan, et al. 2020. SARS-CoV-2 infection (COVID-19) in febrile infants without respiratory distress. *Clin. Infect. Dis.* <https://doi.org/10.1093/cid/ciaa452>.
 114. Pierce-Williams, R.A.M., J. Burd, L. Felder, et al. 2020. Clinical course of severe and critical COVID-19 in hospitalized pregnancies: a US cohort study. *Am. J. Obstet. Gynecol. MFM* <https://doi.org/10.1016/j.ajogmf.2020.100134>.
 115. Yu, N., W. Li, Q. Kang, et al. 2020. Clinical features and obstetric and neonatal outcomes of pregnant patients with COVID-19 in Wuhan, China: a retrospective, single-centre, descriptive study. *Lancet Infect. Dis.* **20**: P559–564.
 116. Zeng, L., S. Xia, W. Yuan, et al. 2020. Neonatal early-onset infection with SARS-CoV-2 in 33 neonates born to mothers with COVID-19 in Wuhan, China. *JAMA Pediatr.* **174**: 722–725.
 117. Zhiqiang, Z., S.U.N. Xingxing, L.I. Shiyong, et al. 2020. Anesthesia management for cesarean section during novel coronavirus epidemic. *Chin. J. Anesthesiol.* E006.
 118. Feng, X., X. Tao, L. Zeng, et al. 2020. Application of pulmonary ultrasound in the diagnosis of COVID-19 pneumonia in neonates. *Chin. J. Pediatr.* **58**: E013.
 119. Govind, A., S. Essien, A. Karthikeyan, et al. 2020. Re: novel coronavirus COVID-19 in late pregnancy: outcomes of first nine cases in an inner city London hospital. *Eur. J. Obstet. Gynecol. Reprod. Biol.* **251**: 272–274.
 120. Hantoushzadeh, S., A.A. Shamshirsaz, A. Aleyasin, et al. 2020. Maternal death due to COVID-19 disease. *Am. J. Obstet. Gynecol.* **223**: 109.e1–109.e16.
 121. Knight, M., K. Bunch, N. Vousden, et al. 2020. Characteristics and outcomes of pregnant women admitted to hospital with confirmed SARS-CoV-2 infection in UK: national population based. *BMJ* **369**: m2107.
 122. Mehta, H., S. Ivanovic, A. Cronin, et al. 2020. Novel coronavirus-related acute respiratory distress syndrome in a patient with twin pregnancy: a case report. *Case Rep. Womens Health* **2020**: e00220.
 123. Precit, M.R., R. Yee, V. Anand, et al. 2020. A case report of neonatal acute respiratory failure due to SARS-CoV-2. *J. Pediatr. Infect. Dis. Soc.* **9**. <https://doi.org/10.1093/jpids/piaa064>.
 124. Salik, I. & B. Mehta. 2020. Tetralogy of Fallot palliation in a COVID-19 positive neonate. *J. Clin. Anesth.* **66**. <https://doi.org/10.1016/j.jclinane.2020.109914>.
 125. Sun, M., G. Xu, Y. Yang, et al. 2020. Evidence of mother-to-newborn infection with COVID-19. *Br. J. Anaesth.* **125**: e245–e247.
 126. Venturini, E., G. Palmas, C. Montagnani, et al. 2020. Severe neutropenia in infants with severe acute respiratory syndrome caused by the novel coronavirus 2019 infection. *J. Pediatr.* **222**: 259–261.
 127. De Rose, D.U., C. Auriti, F. Landolfo, et al. 2020. Reshaping of neonatal intensive care units to avoid the spread of COVID-19 to high-risk infants. *Infect. Control Hosp. Epidemiol.* <https://doi.org/10.1017/ice.2020.310>.
 128. Futterman, I., M. Toaff, L. Navi & C.A. Clare. 2020. COVID-19 and HELLP: overlapping clinical pictures in two gravid patients. *AJP Rep.* **10**: e179–e82.
 129. Gao, J., W. Li, X. Hu, et al. 2020. Disappearance of SARS-CoV-2 antibodies in infants born to women with COVID-19, Wuhan, China. *Emerg. Infect. Dis.* **26**. <https://doi.org/10.3201/eid2610.202328>.
 130. Gregorio-Hernández, R., A.B. Escobar-Izquierdo, J. Cobas-Pazos & A. Martínez-Gimeno. 2020. Point-of-care lung ultrasound in three neonates with COVID-19. *Eur. J. Pediatr.* <https://doi.org/10.1007/s00431-020-03706-4>.
 131. Kanburoglu, M.K., O. Altuntas & A.C. Cicek. 2020. The challenges of contact tracing in a case of early neonatal sepsis with COVID-19. *Indian J. Pediatr.* <https://doi.org/10.1007/s12098-020-03400-1>.
 132. Kayem, G., V. Alessandrini, E. Azria, et al. 2020. A snapshot of the Covid-19 pandemic among pregnant women in France. *J. Gynecol. Obstet. Hum. Reprod.* <https://doi.org/10.1016/j.jogoh.2020.101826>.
 133. Khoury, R., P.S. Bernstein, C. Debolt, et al. 2020. Characteristics and outcomes of 241 births to women with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection at five New York City Medical Centers. *Obstet. Gynecol.* **136**: 273–282.
 134. McDevitt, K.E.M., N. Ganjoo, D. Mlangeni & S. Pathak. 2020. Outcome of universal screening of asymptomatic neonates for COVID-19 from asymptomatic mothers. *J. Infect.* **81**: 452–482.

135. Xiong, Y., Q. Zhang, L. Zhao, *et al.* 2020. Clinical and imaging features of COVID-19 in a neonate. *Chest* **158**: e5–e7.
136. McLaren, R.A., Jr., V. London, F. Atallah, *et al.* 2020. Delivery for respiratory compromise among pregnant women with COVID-19. *Am. J. Obstet. Gynecol.* <https://doi.org/10.1016/j.ajog.2020.05.035>.
137. An, P., B.J. Wood, W. Li, *et al.* 2020. Postpartum exacerbation of antenatal COVID-19 pneumonia in 3 women. *CMAJ* **192**: E603–E606.
138. Blauvelt, C.A., C. Chiu, A.L. Donovan, *et al.* 2020. Acute respiratory distress syndrome in a preterm pregnant patient with coronavirus disease 2019 (COVID-19). *Obstet. Gynecol.* **136**: 46–51.
139. Breslin, N., C. Baptiste, R. Miller, *et al.* 2020. COVID-19 in pregnancy: early lessons. *Am. J. Obstet. Gynecol. MFM* **2**. <https://doi.org/10.1016/j.ajogmf.2020.100111>.
140. Cao, D., H. Yin, J. Chen, *et al.* 2020. Clinical analysis of ten pregnant women with COVID-19 in Wuhan, China: a retrospective study. *Int. J. Infect. Dis.* **95**: 294–300.
141. Chen, R., Y. Zhang, L. Huang, *et al.* 2020. Safety and efficacy of different anesthetic regimens for parturients with COVID-19 undergoing cesarean delivery: a case series of 17 patients. *Can. J. Anesth.* **67**: 655–663.
142. Chen, S., B. Huang, D. Luo, *et al.* 2020. Pregnant women with new coronavirus infection: a clinical characteristics and placental pathological analysis of three cases. *Chin. J. Pathol.* **49**: E005.
143. Hirshberg, A., A.R. Kern-Goldberger, L.D. Levine, *et al.* 2020. Care of critically ill pregnant patients with COVID-19: a case series. *Am. J. Obstet. Gynecol.* **223**: 286–290.
144. Khan, S., L. Peng, R. Siddique, *et al.* 2020. Impact of COVID-19 infection on pregnancy outcomes and the risk of maternal-to-neonatal intrapartum transmission of COVID-19 during natural birth. *Infect. Control Hosp. Epidemiol.* <https://doi.org/10.1017/ice.2020.84>.
145. Liao, X., H. Yang, J. Kong & H. Yang. 2020. Chest CT findings in a pregnant patient with 2019 novel coronavirus disease. *Balkan Med. J.* **37**: 226–228.
146. Li, N., L. Han, M. Peng, *et al.* 2020. Maternal and neonatal outcomes of pregnant women with COVID-19 pneumonia: a case-control study. *Clin. Infect. Dis.* <https://doi.org/10.1093/cid/ciaa352>.
147. Liu, D., L. Li, X. Wu, *et al.* 2020. Pregnancy and perinatal outcomes of women with coronavirus disease (COVID-19) pneumonia: a preliminary analysis. *AJR Am. J. Roentgenol.* **215**: 127–132.
148. Liu, Y., H. Chen, K. Tang & Y. Guo. 2020. Clinical manifestations and outcome of SARS-CoV-2 infection during pregnancy. *J. Infect.* <https://doi.org/10.1016/j.jinf.2020.02.028>.
149. Penfield, C.A., S.G. Brubaker, M.A. Limaye, *et al.* 2020. Detection of SARS-CoV-2 in placental and fetal membrane samples. *Am. J. Obstet. Gynecol. MFM* <https://doi.org/10.1016/j.ajogmf.2020.100133>.
150. Qiancheng, X., S. Jian, P. Lingling, *et al.* 2020. Coronavirus disease 2019 in pregnancy. *Int. J. Infect. Dis.* **95**: 376–383.
151. Taghizadieh, A., H. Mikaeili, M. Ahmadi & H. Valizadeh. 2020. Acute kidney injury in pregnant women following SARS-CoV-2 infection: a case report from Iran. *Respir. Med. Case Rep.* <https://doi.org/10.1016/j.rmcr.2020.101090>.
152. Vintzileos, W.S., J. Muscat, E. Hoffmann, *et al.* 2020. Screening all pregnant women admitted to labor and delivery for the virus responsible for COVID-19. *Am. J. Obstet. Gynecol.* **223**: 284–286.
153. Yang, P., X. Wang, P. Liu, *et al.* 2020. Clinical characteristics and risk assessment of newborns born to mothers with COVID-19. *J. Clin. Virol.* **127**. <https://doi.org/10.1016/j.jcv.2020.104356>.
154. Zambrano, L.I., I.C. Fuentes-Barahona, D.A. Bejarano-Torres, *et al.* 2020. A pregnant woman with COVID-19 in Central America. *Travel Med. Infect. Dis.* <https://doi.org/10.1016/j.tmaid.2020.101639>.
155. Zhang, W., S. Tian, Y. Wang, *et al.* 2020. Analysis of family cluster infection with novel coronavirus pneumonia. *Chin. J. Emerg. Med.* **29**: E019.
156. Ahmed, I., A. Azhar, N. Eltoweel & B.K. Tan. 2020. First Covid-19 maternal mortality in the UK associated with thrombotic complications. *Br. J. Haematol.* **190**: e37–e38.
157. Baergen, R.N. & D.S. Heller. 2020. Placental pathology in Covid-19 positive mothers: preliminary findings. *Pediatr. Dev. Pathol.* **23**: 177–180.
158. Bianco, A., A.B. Buckley, J. Overbey, *et al.* 2020. Testing of patients and support persons for coronavirus disease 2019 (COVID-19) infection before scheduled deliveries. *Obstet. Gynecol.* **136**: 283–287.
159. Cooke, W.R., A. Billett, S. Gleeson, *et al.* 2020. SARS-CoV-2 infection in very preterm pregnancy: experiences from two cases. *Eur. J. Obstet. Gynecol. Reprod. Biol.* **250**: 259–260.
160. Dória, M., C. Peixinho, M. Laranjo, *et al.* 2020. Covid-19 during pregnancy: a case series from an universally tested population from the north of Portugal. *Eur. J. Obstet. Gynecol. Reprod. Biol.* **250**: 261–262.
161. Du, Y., L. Wang, G. Wu, *et al.* 2020. Anesthesia and protection in an emergency cesarean section for pregnant woman infected with a novel coronavirus: case report and literature review. *J. Anesth.* <https://doi.org/10.1007/s00540-020-02796-6>.
162. Huang, W., Z. Zhao, Z. He, *et al.* 2020. Unfavorable outcomes in pregnant patients with COVID-19 outside Wuhan, China. *J. Infect.* **81**: e99–e101.
163. London, V., R. McLaren, Jr., F. Atallah, *et al.* 2020. The relationship between status at presentation and outcomes among pregnant women with COVID-19. *Am. J. Perinatol.* **37**: 991–994.
164. Ochiai, D., Y. Kasuga, M. Iida, *et al.* 2020. Universal screening for SARS-CoV-2 in asymptomatic obstetric patients in Tokyo, Japan. *Int. J. Gynaecol. Obstet.* **150**: 268–269.
165. Perlman, J., C. Oxford, C. Chang, *et al.* 2020. Delivery room preparedness and early neonatal outcomes during COVID-19 pandemic in New York City. *Pediatrics* **146**: e20201567.
166. Schnettler, W.T., Y. Al Ahwel & A. Suhag. 2020. Severe ARDS in COVID-19-infected pregnancy: obstetric and intensive care considerations. *Am. J. Obstet. Gynecol. MFM.* <https://doi.org/10.1016/j.ajogmf.2020.100120>.

167. Shanes, E.D., L.B. Mithal, S. Otero, *et al.* 2020. Placental pathology in COVID-19. *Am. J. Clin. Pathol.* **154**: 23–32.
168. Yang, H., B. Hu, S. Zhan, *et al.* 2020. Effects of SARS-CoV-2 infection on pregnant women and their infants: a retrospective study in Wuhan, China. *Arch. Pathol. Lab. Med.* <https://doi.org/10.5858/arpa.2020-0232-SA>.
169. Yu, Y., C. Fan, J. Bian & Y. Shen. 2020. Severe COVID-19 in a pregnant patient admitted to hospital in Wuhan. *Int. J. Gynaecol. Obstet.* **150**: 262–263.
170. Bani Hani, D.A., I. Alsharaydeh, A.M. Bataineh, *et al.* 2020. Successful anesthetic management in cesarean section for pregnant woman with COVID-19. *Am. J. Case Rep.* **21**: e925512.
171. Blitz, M.J., B. Rochelson, H. Minkoff, *et al.* 2020. Maternal mortality among women with COVID-19 admitted to the intensive care unit. *Am. J. Obstet. Gynecol.* <https://doi.org/10.1016/j.ajog.2020.06.020>.
172. Campbell, K.H., J.M. Tornatore, K.E. Lawrence, *et al.* 2020. Prevalence of SARS-CoV-2 among patients admitted for childbirth in Southern Connecticut. *JAMA* **323**: 2520–2522.
173. Ferraiolo, A., F. Barra, C. Kratochwila, *et al.* 2020. Report of positive placental swabs for SARS-CoV-2 in an asymptomatic pregnant woman with COVID-19. *Medicina (Kaunas)* **56**: 306.
174. Forero-Peña, D.A., M.I. Rodríguez, D.M. Flora-Noda, *et al.* 2020. The first pregnant woman with COVID-19 in Venezuela: pre-symptomatic transmission. *Travel Med. Infect. Dis.* <https://doi.org/10.1016/j.tmaid.2020.101805>.
175. Jain, P., A. Thakur, N. Kler & P. Garg. 2020. Manifestations in neonates born to COVID-19 positive mothers. *Indian J. Pediatr.* <https://doi.org/10.1007/s12098-020-03369-x>.
176. Jung, J., M.J. Hong, E.O. Kim, *et al.* 2020. Investigation of a nosocomial outbreak of COVID-19 in a pediatric ward in South Korea: successful control by early detection and extensive contact tracing with testing. *Clin. Microbiol. Infect.* <https://doi.org/10.1016/j.cmi.2020.06.021>.
177. Nawsherwan S., Khan, G. Nabi, *et al.* 2020. Impact of COVID-19 pneumonia on neonatal birth outcomes. *Indian J. Pediatr.* <https://doi.org/10.1007/s12098-020-03372-2>.
178. Oh, J., E. Kim, H. Kim, *et al.* 2020. Infection control of operating room and anesthesia for cesarean section during pandemic coronavirus disease-19 (COVID-19) outbreak in Daegu, the Republic of Korea — 8 cases report. *Korean J. Anesthesiol.* <https://doi.org/10.4097/kja.20204>.
179. San-Juan, R., P. Barbero, M. Fernandez-Ruiz, *et al.* 2020. Incidence and clinical profiles of COVID-19 pneumonia in pregnant women: a single-centre cohort study from Spain. *EclinicalMedicine* **23**: 100407.
180. Yassa, M., P. Birol, A.M. Mutlu, *et al.* 2020. Lung ultrasound can influence the clinical treatment of pregnant women with COVID-19. *J. Ultrasound Med.* <https://doi.org/10.1002/jum.15367>.
181. Yilmaz, R., F. Kilic, S. Arican, *et al.* 2020. Anesthetic management for cesarean birth in pregnancy with the novel coronavirus (COVID-19). *J. Clin. Anesth.* **66**. <https://doi.org/10.1016/j.jclinane.2020.109921>.
182. Fassett, M.J., L.D. Lurvey, L. Yasumura, *et al.* 2020. Universal SARS-Cov-2 screening in women admitted for delivery in a large managed care organization. *Am. J. Perinatol.* <https://doi.org/10.1055/s-0040-1714060>.
183. Gong, X., L. Song, H. Li, *et al.* 2020. CT characteristics and diagnostic value of COVID-19 in pregnancy. *PLoS One* **15**: e0235134.
184. Sentilhes, L., F. De Marcillac, C. Jouffrieau, *et al.* 2020. COVID-19 in pregnancy was associated with maternal morbidity and preterm birth. *Am. J. Obstet. Gynecol.* <https://doi.org/10.1016/j.ajog.2020.06.022>.
185. Wang, Y., F. Zhu, C. Wang, *et al.* 2020. Children hospitalized with severe COVID-19 in Wuhan. *Pediatr. Infect. Dis. J.* **39**: e91–e4.
186. Zeng, Q.-L., G.-M. Li, F. Ji, *et al.* 2020. Clinical course and treatment efficacy of COVID-19 near Hubei Province, China: a multicentre, retrospective study. *Transbound. Emerg. Dis.* <https://doi.org/10.1111/tbed.13674>.
187. Wang, Z. & G. Xiong. 2020. Clinical characteristics and laboratory results of pregnant women with COVID-19 in Wuhan, China. *Int. J. Gynaecol. Obstet.* <https://doi.org/10.1002/ijgo.13265>.
188. Buonsenso, D., F. Raffaelli, E. Tamburrini, *et al.* 2020. Clinical role of lung ultrasound for the diagnosis and monitoring of COVID-19 pneumonia in pregnant women. *Ultrasound Obstet. Gynecol.* **56**: 106–109.
189. Canarutto, D., A. Priolo, G. Russo, *et al.* 2020. COVID-19 infection in a paucisymptomatic infant: raising the index of suspicion in epidemic settings. *Pediatr. Pulmonol.* **55**: E4–E5.
190. Kan, M.J., L.M.C. Grant, M.A. Muña & T.L. Greenhow. 2020. Fever without a source in a young infant due to SARS-CoV-2. *J. Pediatr. Infect. Dis. Soc.* <https://doi.org/10.1093/jpids/piaa044>.
191. Lahfaoui M., M. Azizi, M. Elbakkaoui, *et al.* 2020. Acute respiratory distress syndrome secondary to SARS-CoV-2 infection in an infant. *Rev. Mal. Respir.* **37**: 502–504.
192. Le, H.T., L.V. Nguyen, D.M. Tran, *et al.* 2020. The first infant case of COVID-19 acquired from a secondary transmission in Vietnam. *Lancet Child Adolesc. Health* **4**: 405–406.
193. Nathan, N., B. Prevost & H. Corvol. 2020. Atypical presentation of COVID-19 in young infants. *Lancet* **395**: 1481.
194. Acharyya, B.C., S. Acharyya & D. Das. 2020. Novel coronavirus mimicking Kawasaki disease in an infant. *Indian Pediatr.* S097475591600184.
195. Calderaro, A., M.C. Arcangeletti, F. De Conto, *et al.* 2020. SARS-CoV-2 infection diagnosed only by cell culture isolation before the local outbreak in an Italian seven-week-old suckling baby. *Int. J. Infect. Dis.* **46**: 387–389.
196. Cook, J., K. Harman, B. Zoica, *et al.* 2020. Horizontal transmission of severe acute respiratory syndrome coronavirus 2 to a premature infant: multiple organ injury and association with markers of inflammation. *Lancet Child Adolesc. Health* **4**: 548–551.
197. Jafari, R., L. Cegolon, M. Torkaman, *et al.* 2020. A 6 months old infant with fever, dyspnea and poor feeding, diagnosed with COVID-19. *Travel Med. Infect. Dis.* <https://doi.org/10.1016/j.tmaid.2020.101789>.
198. Nyholm, S., A. Edner, Å. Myreliid, *et al.* 1992. Invasive mechanical ventilation in a former preterm infant

- with COVID-19. *Acta Paediatr.* <https://doi.org/10.1111/apa.15437>.
199. Del Barba, P., D. Canarutto, E. Sala, *et al.* 2020. COVID-19 cardiac involvement in a 38-day old infant. *Pediatr. Pulmonol.* **55**: 1879–1881.
 200. Tchidjou, H.K. & B. Romeo. 2020. Infant case of co-infection with SARS-CoV-2 and *Citrobacter koseri* urinary infection. *J. Trop. Pediatr.* <https://doi.org/10.1093/tropej/fmaa032>.
 201. Zhang, G.X., A.M. Zhang, L. Huang, *et al.* 2020. [Twin girls infected with SARS-CoV-2]. *Zhongguo Dang Dai Er Ke Za Zhi* **22**: 221–225.
 202. Cai, J., J. Xu, D. Lin, *et al.* 2020. A case series of children with 2019 novel coronavirus infection: clinical and epidemiological features. *Clin. infect. Dis.* <https://doi.org/10.1093/cid/ciaa198>.
 203. Carrabba, G., L. Tariciotti, S. Guez, *et al.* 2020. Neurosurgery in an infant with COVID-19. *Lancet* **395**: e76.
 204. Chang, D., M. Lin, L. Wei, *et al.* 2020. Epidemiologic and clinical characteristics of novel coronavirus infections involving 13 patients outside Wuhan, China. *JAMA.* <https://doi.org/10.1001/jama.2020.1623>.
 205. Chen, F., Z.S. Liu, F.R. Zhang, *et al.* 2020. First case of severe childhood novel coronavirus pneumonia in China. *Chin. J. Pediatr.* **58**: E005.
 206. Dona, D., C. Minotti, P. Costenaro, *et al.* 2020. Fecal-oral transmission of SARS-COV-2 in children: is it time to change our approach? *Pediatr. Infect. Dis. J.* **39**: e133–e134.
 207. Fan, Q., Y. Pan, Q. Wu, *et al.* 2020. Anal swab findings in an infant with COVID-19. *Pediatr. Investig.* **4**: 48–50.
 208. Feld, L., J. Belfer, R. Kabra, *et al.* 2020. A case series of the 2019 novel coronavirus (SARS-CoV-2) in three febrile infants in New York. *Pediatrics.* <https://doi.org/10.1542/peds.2020-1056>.
 209. Qian, G., N. Yang, A.H.Y. Ma, *et al.* 2020. COVID-19 transmission within a family cluster by presymptomatic infectors in China. *Clin. Infect. Dis.* **71**: 861–862.
 210. Jiang, X.-L., X.-L. Zhang, X.-N. Zhao, *et al.* 2020. Transmission potential of asymptomatic and paucisymptomatic SARS-CoV-2 infections: a three-family cluster study in China. *J. Infect. Dis.* **221**: 1948–1952.
 211. Li, J., J. Feng, T.-H. Liu, *et al.* 2020. An infant with a mild SARS-CoV-2 infection detected only by anal swabs: a case report. *Braz. J. Infect. Dis.* **24**: 247–249.
 212. Li, W., H. Cui, K. Li, *et al.* 2020. Chest computed tomography in children with COVID-19 respiratory infection. *Pediatr. Radiol.* <https://doi.org/10.1007/s00247-020>.
 213. Liu, M., Z. Song & K. Xiao. 2020. High-resolution computed tomography manifestations of 5 pediatric patients with 2019 novel coronavirus. *J. Comput. Assist. Tomogr.* **44**: 311–313.
 214. Lou, X.X., C.X. Shi, C.C. Zhou & Y.S. Tian. 2020. Three children who recovered from novel coronavirus 2019 pneumonia. *J. Paediatr. Child Health.* <https://doi.org/10.1111/jpc.14871>.
 215. Mansour, A., R. Atoui, K. Kanso, *et al.* 2020. First case of an infant with COVID-19 in the Middle East. *Cureus* **12**: e7520.
 216. Mogharab, V., A.M.K. Pasha, F. Javdani & N. Hatami. 2020. The first case of COVID-19 infection in a 75-day-old infant in Jahrom City, south of Iran. *J. Formos. Med. Assoc.* **119**: 995–997.
 217. Poli, P., S. Timpano, M. Goffredo, *et al.* 2020. Asymptomatic case of Covid-19 in an infant with cystic fibrosis. *J. Cyst. Fibros.* **19**: e18.
 218. Qian, G., N. Yang, A.H.Y. Ma, *et al.* 2020. A COVID-19 transmission within a family cluster by presymptomatic infectors in China. *Clin. Infect. Dis.* **71**: 861–862.
 219. Qiu, L., R. Jiao, A. Zhang, *et al.* 2020. A typical case of critically ill infant of coronavirus disease 2019 with persistent reduction of T lymphocytes. *Pediatr. Infect. Dis. J.* **39**: e87–e90.
 220. Robbins, E., Z. Ilahi & P. Roth. 2020. Febrile infant: COVID-19 in addition to the usual suspects. *Pediatr. Infect. Dis. J.* **39**: e81–e82.
 221. See, K.C., S.M. Liew, D.C.E. Ng, *et al.* 2020. COVID-19: four paediatric cases in Malaysia. *Int. J. Infect. Dis.* **94**: 125–127.
 222. Shen, Q., W. Guo, T. Guo, *et al.* 2020. Novel coronavirus infection in children outside of Wuhan, China. *Pediatr. Pulmonol.* **55**: 1424–1429.
 223. Su, L., X. Ma, H. Yu, *et al.* 2020. The different clinical characteristics of corona virus disease cases between children and their families in China — the character of children with COVID-19. *Emerg. Microbes Infect.* **9**: 707–713.
 224. Sun, D., H. Li, X.-X. Lu, *et al.* 2020. Clinical features of severe pediatric patients with coronavirus disease 2019 in Wuhan: a single center's observational study. *World J. Pediatr.* **16**: 251–259.
 225. Wang, Y., Y. Liu, L. Liu, *et al.* 2020. Clinical outcome of 55 asymptomatic cases at the time of hospital admission infected with SARS-Coronavirus-2 in Shenzhen, China. *J. Infect. Dis.* **221**: 1770–1774.
 226. Wei, M., J. Yuan, Y. Liu, *et al.* 2020. Novel coronavirus infection in hospitalized infants under 1 year of age in China. *JAMA.* <https://doi.org/10.1001/jama.2020.131>.
 227. Wehl, G., M. Laible & M. Rauchenzauner. 2020. Co-infection of SARS CoV-2 and influenza A in a pediatric patient in Germany. *Klin. Padiatr.* **232**: 217–218.
 228. Xing, Y.-H., W. Ni, Q. Wu, *et al.* 2020. Prolonged viral shedding in feces of pediatric patients with coronavirus disease 2019. *J. Microbiol. Immunol. Infect.* **53**: 473–480.
 229. Xu, Y., X. Li, B. Zhu, *et al.* 2020. Characteristics of pediatric SARS-CoV-2 infection and potential evidence for persistent fecal viral shedding. *Nat. Med.* **26**: 502–505.
 230. Zhou, Y., G.D. Yang, K. Feng, *et al.* 2020. [Clinical features and chest CT findings of coronavirus disease 2019 in infants and young children]. *Chin. J. Contemp. Pediatr.* **22**: 215–220.
 231. Zhu, L., J. Wang, R. Huang, *et al.* 2020. Clinical characteristics of a case series of children with coronavirus disease 2019. *Pediatr. Pulmonol.* **55**: 1430–1432.
 232. Song, W., J. Li, N. Zou, *et al.* 2020. Clinical features of pediatric patients with coronavirus disease (COVID-19). *J. Clin. Virol.* **127**. <https://doi.org/10.1016/j.jcv.2020.104377>.

233. Cai, X., Y. Ma, S. Li, *et al.* 2020. Clinical characteristics of 5 COVID-19 cases with non-respiratory symptoms as the first manifestation in children. *Front. Pediatr.* **8**: 258.
234. Danley, K. & P. Kent. 2020. 4-month-old boy coinfecting with COVID-19 and adenovirus. *BMJ Case Rep.* **13**: e236264.
235. de Rojas, T., A. Pérez-Martínez, E. Cela, *et al.* 2020. COVID-19 infection in children and adolescents with cancer in Madrid. *Pediatr. Blood Cancer* **67**: e28397.
236. Farber, K., P. Stabler, T. Getzinger & T. Uhlig. 2020. Suspected sepsis in a 10-week-old infant and SARS-CoV-2 detection in cerebrospinal fluid and pharynx. *Monatschr. Kinderheilkd.* <https://doi.org/10.1007/s00112-020-00942-8>.
237. Frauenfelder, C., J. Brierley, E. Whittaker, *et al.* 2020. Infant with SARS-CoV-2 infection causing severe lung disease treated with Remdesivir. *Pediatrics* e20201701. <https://doi.org/10.1542/peds.2020-1701>.
238. Heinz, N., A. Griesemer, J. Kinney, *et al.* 2020. A case of an infant with SARS-CoV-2 hepatitis early after liver transplantation. *Pediatr. Transplant.* **2020**: e13778.
239. Li, C., F. Luo & B. Wu. 2020. A 3-month-old child with COVID-19: a case report. *Medicine (Baltimore)* **99**: e20661.
240. Li, D., D. Wang, J. Dong, *et al.* 2020. False-negative results of real-time reverse-transcriptase polymerase chain reaction for severe acute respiratory syndrome coronavirus 2: role of deep-learning-based CT diagnosis and insights from two cases testing the repatriated for SARS-Cov2: should laboratory-based quarantine replace traditional quarantine? *Korean J. Radiol.* **21**: 505–508.
241. Martínez-Castaño, I., E. Calabuig-Barbero, J. González-Piñera & J.M. López-Ayala. 2020. COVID-19 infection is a diagnostic challenge in infants with ileocecal intussusception. *Pediatr. Emerg. Care* **36**: e368.
242. McLaren, S.H., P.S. Dayan, D.B. Fenster, *et al.* 2020. Novel coronavirus infection in febrile infants aged 60 days and younger. *Pediatrics*. <https://doi.org/10.1542/peds.2020-1550>.
243. Mithal, L.B., K.Z. Machut, W.J. Muller & L.K. Kociolek. 2020. SARS-CoV-2 infection in infants less than 90 days old. *J. Pediatr.* <https://doi.org/10.1016/j.jpeds.2020.06.047>.
244. Lu, Y., H. Wen, D. Rong, *et al.* 2020. Clinical characteristics and radiological features of children infected with the 2019 novel coronavirus. *Clin. Radiol.* **75**: 520–525.
245. Moazzam, Z., A. Salim, A. Ashraf, *et al.* 2020. Intussusception in an infant as a manifestation of COVID-19. *J. Pediatr. Surg. Case Rep.* **59**: 101533.
246. Nieto-Moro, M., F.G. Ecclesia, I. Tomé-Masa, *et al.* 2020. SARS-CoV-2 and *Streptococcus pneumoniae* coinfection as a cause of severe pneumonia in an infant. *Pediatr. Pulmonol.* <https://doi.org/10.1002/ppul.24916>.
247. Shi, B., Z. Xia, S. Xiao, *et al.* 2020. Severe pneumonia due to SARS-CoV-2 and respiratory syncytial virus infection: a case report. *Clin. Pediatr. (Phila.)* **59**: 823–826.
248. Climent, F.J., C. Calvo, L. García-Guereta, *et al.* 2020. Fatal outcome of COVID-19 disease in a 5-month infant with comorbidities. *Rev. Esp. Cardiol. (Engl. Ed.)* **73**: 667–669.
249. Dugue, R., K.C. Cay-Martínez, K.T. Thakur, *et al.* 2020. Neurologic manifestations in an infant with COVID-19. *Neurology* **94**: 1100–1102.
250. Giacomet, V., V.A. Manfredini, G. Meraviglia, *et al.* 2020. Acute inflammation and elevated cardiac markers in a two-month-old infant with severe acute respiratory syndrome coronavirus 2 infection presenting with cardiac symptoms. *Pediatr. Infect. Dis. J.* **39**: e149–e151.
251. Kesici, S., H.H. Aykan, D. Orhan & B. Bayrakci. 2020. Fulminant COVID-19-related myocarditis in an infant. *Eur. Heart J.* <https://doi.org/10.1093/eurheartj/ehaa515>.
252. Nassih, H., K. El Fakiri & I.A. Sab. 2020. Absence of evidence of transmission of coronavirus disease 2019 from a young child to mother despite prolonged contact. *Indian J. Pediatr.* <https://doi.org/10.1007/s12098-020-03382-0>.
253. Sieni, E., F. Pegoraro, T. Casini, *et al.* 2020. Favourable outcome of coronavirus-19 in a 1-year-old girl with acute myeloid leukaemia and severe treatment-induced immunosuppression. *Br. J. Haematol.* **189**: e222–e224.
254. Tan, Y.-P., B.-Y. Tan, J. Pan, *et al.* 2020. Epidemiologic and clinical characteristics of 10 children with coronavirus disease 2019 in Changsha, China. *J. Clin. Virol.* **127**: 104353.
255. Bai, S.L., J.Y. Wang, Y.Q. Zhou, *et al.* 2020. Analysis of the first cluster of cases in a family of novel coronavirus pneumonia in Gansu Province. *Zhonghua Yu Fang Yi Xue Za Zhi* **54**: E005.
256. Browne, P.C., J.B. Linfert & E. Perez-Jorge. 2020. Successful treatment of preterm labor in association with acute COVID-19 infection. *Am. J. Perinatol.* **37**: 866–868.
257. Chen, L., H.G. Liu, W. Liu, *et al.* 2020. Analysis of clinical features of 29 patients with 2019 novel coronavirus pneumonia. *Zhonghua Jie He He Hu Xi Za Zhi* **43**: E005.
258. Collin, J., E. Byström, A. Carnahan & M. Ahrne. 2020. Pregnant and postpartum women with SARS-CoV-2 infection in intensive care in Sweden. *Acta Obstet. Gynecol. Scand.* <https://doi.org/10.1111/aogs.13901>.
259. Dong, Y., X. Mo, Y. Hu, *et al.* 2020. Epidemiology of COVID-19 among children in China. *Pediatrics* **145**. <https://doi.org/10.1542/peds.2020-0702>.
260. Easom, N., P. Moss, G. Barlow, *et al.* 2020. Sixty-eight consecutive patients assessed for COVID-19 infection: experience from a UK Regional Infectious Diseases Unit. *Influenza Other Respir. Viruses* **14**: 374–379.
261. Gagliardi, L., R. Danieli, G. Suriano, *et al.* 2020. Universal SARS-CoV-2 testing of pregnant women admitted for delivery in two Italian regions. *Am. J. Obstet. Gynecol.* **223**: 291–292.
262. González Romero, D., J. Ocampo Pérez, L. González Bautista & L. Santana-Cabrera. 2020. [Pregnancy and perinatal outcome of a woman with COVID-19 infection]. *Rev. Clin. Esp.* <https://doi.org/10.1016/j.rceng.2020.04.005>.
263. Guan, C.S., Z.B. Lv, S. Yan, *et al.* 2020. Imaging features of coronavirus disease 2019 (COVID-19): evaluation on thin-section CT. *Acad. Radiol.* **27**: 609–613.
264. Han, Y.-N., Z.-W. Feng, L.-N. Sun, *et al.* 2020. A comparative-descriptive analysis of clinical characteristics in 2019-coronavirus-infected children and adults. *J. Med. Virol.* <https://doi.org/10.1002/jmv.25835>.

265. Indraccolo, U. 2020. A pregnant woman and the SARS-CoV-2 infection: how are barriers easily crossed? *Recenti Prog. Med.* **111**: 259–260.
266. Juusela, A., M. Nazir & M. Gimovsky. 2020. Two cases of COVID-19 related cardiomyopathy in pregnancy. *Am. J. Obstet. Gynecol. MFM* **2**: 100113.
267. Kleinwechter, H. & K. Laubner. 2020. Coronavirus disease 2019 (COVID-19) and pregnancy: overview and report of the first German case with COVID-19 and gestational diabetes. *Diabetologie* **3**: 242–246.
268. Li, C., F. Ji, L. Wang, et al. 2020. Asymptomatic and human-to-human transmission of SARS-CoV-2 in a 2-family cluster, Xuzhou, China. *Emerg. Infect. Dis.* **26**: 1626–1628.
269. Li, J., Y. Wang, Y. Zeng, et al. 2020. Critically ill pregnant patient with COVID-19 and neonatal death within two hours of birth. *Int. J. Gynaecol. Obstet.* **150**: 126–128.
270. Li, L., D. Liu & L. Yang. 2020. Follow-up information about the four pregnant patients with coronavirus disease (COVID-19) pneumonia who were still in the hospital at the end of our study. *AJR Am. J. Roentgenol.* **215**: W1–W2.
271. Liu, W., Q. Zhang, J. Chen, et al. 2020. Detection of Covid-19 in children in early january 2020 in Wuhan, China. *N. Engl. J. Med.* <https://doi.org/10.1056/NEJMc2003717-10.1056/NEJMc>.
272. Lu, X., L. Zhang, H. Du, et al. 2020. SARS-CoV-2 infection in children. *N. Engl. J. Med.* **382**: 1663–1665.
273. Ma, H., J. Shao, Y. Wang, et al. 2020. High resolution CT features of novel coronavirus pneumonia in children. *Chin. J. Radiol.* **54**: E002.
274. Martinelli, I., E. Ferrazzi, A. Ciavarella, et al. 2020. Pulmonary embolism in a young pregnant woman with COVID-19. *Thromb. Res.* **191**: 36–37.
275. Paolino, G., V. Canti, S. Raffaele Mercuri, et al. 2020. Diffuse cutaneous manifestation in a new mother with COVID-19 (SARS-Cov-2). *Int. J. Dermatol.* **59**: 874–875.
276. Qiu, H., J. Wu, L. Hong, et al. 2020. Clinical and epidemiological features of 36 children with coronavirus disease 2019 (COVID-19) in Zhejiang, China: an observational cohort study. *Lancet Infect. Dis.* **20**: 689–696.
277. Rosen, M.H., J. Axelrad, D. Hudesman, et al. 2020. Management of acute severe ulcerative colitis in a pregnant woman with COVID-19 infection: a case report and review of the literature. *Inflamm. Bowel Dis.* **26**: 971–973.
278. Tagarro, A., C. Epalza, M. Santos, et al. 2020. Screening and severity of coronavirus disease 2019 (COVID-19) in children in Madrid, Spain. *JAMA Pediatr.* <https://doi.org/10.1001/jamapediatrics.2020.1346>.
279. Vibert, F., M. Kretz, V. Thuét, et al. 2020. Prone positioning and high-flow oxygen improved respiratory function in a 25-week pregnant woman with COVID-19. *Eur. J. Obstet. Gynecol. Reprod. Biol.* **250**: 257–258.
280. Wang, D., X.L. Ju, F. Xie, et al. 2020. Clinical analysis of 31 cases of 2019 novel coronavirus infection in children from six provinces (autonomous region) of northern China. *Zhonghua Er Ke Za Zhi* **58**: E011.
281. Wen, R., P. Sun & Q.-S. Xing. 2020. A patient with SARS-CoV-2 infection during pregnancy in Qingdao, China. *J. Microbiol. Immunol. Infect.* **53**: 499–500.
282. Wu, C., W. Yang, X. Wu, et al. 2020. Clinical manifestation and laboratory characteristics of SARS-CoV-2 infection in pregnant women. *Virolog. Sin.* **35**: 305–310.
283. Xia, W., J. Shao, Y. Guo, et al. 2020. Clinical and CT features in pediatric patients with COVID-19 infection: different points from adults. *Pediatr. Pulmonol.* **55**: 1169–1174.
284. Yu, N., W. Li, Q. Kang, et al. 2020. No SARS-CoV-2 detected in amniotic fluid in mid-pregnancy. *Lancet Infect. Dis.* [https://doi.org/10.1016/S1473-3099\(20\)30320-0](https://doi.org/10.1016/S1473-3099(20)30320-0).
285. Cohen, J., O. Vignaux & F. Jacquemard. 2020. Covid-19 in pregnant women: general data from a French National Survey. *Eur. J. Obstet. Gynecol. Reprod. Biol.* **251**: 267–268.
286. Emeruwa, U.N., S. Ona, J.L. Shaman, et al. 2020. Associations between built environment, neighborhood socioeconomic status, and SARS-CoV-2 infection among pregnant women in New York City. *JAMA* **324**: 390–392.
287. Gulersen, M., M.J. Blitz, B. Rochelson, et al. 2020. Clinical implications of SARS-CoV-2 infection in the viable preterm period. *Am. J. Perinatol.* <https://doi.org/10.1055/s-0040-1713851>.
288. Hosier, H., S.F. Farhadian, R.A. Morotti, et al. 2020. SARS-CoV-2 infection of the placenta. *J. Clin. Invest.* <https://doi.org/10.1172/JCI139569>.
289. Mohr-Sasson, A., J. Chayo, Y. Bart, et al. 2020. Laboratory characteristics of pregnant compared to non-pregnant women infected with SARS-CoV-2. *Arch. Gynecol. Obstet.* <https://doi.org/10.1007/s00404-020-05655-7>.
290. Rabice, S.R., P.C. Altshuler, C. Bovet, et al. 2020. COVID-19 infection presenting as pancreatitis in a pregnant woman: a case report. *Case Rep. Women's Health* **27**: e00228.
291. Andrikopoulou, M., N. Madden, T. Wen, et al. 2020. Symptoms and critical illness among obstetric patients with coronavirus disease 2019 (COVID-19) infection. *Obstet. Gynecol.* **136**: 291–299.
292. Chen, J., X.-F. Wang & P.-F. Zhang. 2020. [Asymptomatic SARS-CoV-2 infection in children: a clinical analysis of 20 cases]. *Zhongguo Dang Dai Er Ke Za Zhi* **22**: 414–418.
293. Fox, N.S. & S. Melka. 2020. COVID-19 in pregnant women: case series from one large New York City Obstetrical Practice. *Am. J. Perinatol.* **37**: 1002–1004.
294. Garazzino, S., C. Montagnani, D. Donà, et al. 2020. Multicentre Italian study of SARS-CoV-2 infection in children and adolescents, preliminary data as at 10 April 2020. *Euro Surveill.* **25**. <https://doi.org/10.2807/1560-7917.ES.2020.25.18.2000600>.
295. Khalil, A., R. Hill, S. Ladhani, et al. 2020. SARS-CoV-2 in pregnancy: symptomatic pregnant women are only the tip of the iceberg. *Am. J. Obstet. Gynecol.* **223**: 296–297.
296. Li, B., J. Shen, L. Li & C. Yu. 2020. Radiographic and clinical features of children with 2019 novel coronavirus (COVID-19) pneumonia. *Indian Pediatr.* **57**: 423–426.
297. Lokken, E.M., C.L. Walker, S. Delaney, et al. 2020. Clinical characteristics of 46 pregnant women with a SARS-CoV-2 infection in Washington State. *Am. J. Obstet. Gynecol.* <https://doi.org/10.1016/j.ajog.2020.05.031>.
298. Parri, N., A.M. Magistà, F. Marchetti, et al. 2020. Characteristic of COVID-19 infection in pediatric patients: early

- findings from two Italian Pediatric Research Networks. *Eur. J. Pediatr.* **179**: 1315–1323.
299. Peng, H., P. Gao, Q. Xu, et al. 2020. Coronavirus disease 2019 in children: characteristics, antimicrobial treatment, and outcomes. *J. Clin. Virol.* **128**: 104425.
 300. Zachariah, P., C.L. Johnson, K.C. Halabi, et al. 2020. Epidemiology, clinical features, and disease severity in patients with coronavirus disease 2019 (COVID-19) in a Children's Hospital in New York City, New York. *JAMA Pediatr.* **2020**: e202430.
 301. LaCourse, S.M., A. Kachikis, M. Blain, et al. 2020. Low prevalence of SARS-CoV-2 among pregnant and postpartum patients with universal screening in Seattle, Washington. *Clin. Infect. Dis.* <https://doi.org/10.1093/cid/ciaa675>.
 302. Oh, T.T., E. Lew & B.L. Sng. 2020. Management of maternal resuscitation and category 1 cesarean delivery in a Covid-19 suspect parturient. *J. Clin. Anesth.* **66**: 109909.
 303. Pan, A., L. Liu, C. Wang, et al. 2020. Association of public health interventions with the epidemiology of the COVID-19 outbreak in Wuhan, China. *JAMA* **323**: 1915–1923.
 304. Sun, D., X. Chen, H. Li, et al. 2020. SARS-CoV-2 infection in infants under 1 year of age in Wuhan City, China. *World J. Pediatr.* **16**: 260–266.
 305. Wu, H., H. Zhu, C. Yuan, et al. 2020. Clinical and immune features of hospitalized pediatric patients with coronavirus disease 2019 (COVID-19) in Wuhan, China. *JAMA Netw. Open* **3**: e2010895.
 306. Cui, N., X. Zou & L. Xu. 2020. Preliminary CT findings of coronavirus disease 2019 (COVID-19). *Clin. Imaging* **65**: 124–132.
 307. Mannheim, J., S. Gretsche, J.E. Layden & M.J. Fricchione. 2020. Characteristics of hospitalized pediatric COVID-19 cases — Chicago, Illinois, March–April 2020. *J. Pediatr. Infect. Dis. Soc.* <https://doi.org/10.1093/jpids/piaa070>.
 308. Richardson, S., J.S. Hirsch, M. Narasimhan, et al. 2020. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City Area. *JAMA* **323**: 2052–2059.
 309. Shen, N., Y. Zhu, X. Wang, et al. 2020. Characteristics and diagnosis rate of 5630 subjects receiving SARS-CoV-2 nucleic acid tests from Wuhan, China. *JCI Insight* **5**: e137662.
 310. Yue, L., L. Han, Q. Li, et al. 2020. Anesthesia and infection control in cesarean section of pregnant women with COVID-19 infection: a descriptive study. *J. Clin. Anesth.* **66**: 109908.
 311. Zachariah, P., K.C. Halabi, C.L. Johnson, et al. 2020. Symptomatic infants have higher nasopharyngeal SARS-CoV-2 viral loads but less severe disease than older children. *Clin. Infect. Dis.* <https://doi.org/10.1093/cid/ciaa608>.
 312. Inchingolo, R., A. Smargiassi, F. Moro, et al. 2020. The diagnosis of pneumonia in a pregnant woman with coronavirus disease 2019 using maternal lung ultrasound. *Am. J. Obstet. Gynecol.* **223**: 9–11.
 313. Lucarelli, E., C. Behn, S. Lashley, et al. 2020. Mechanical ventilation in pregnancy due to COVID-19: a cohort of three cases. *Am. J. Perinatol.* <https://doi.org/10.1055/s-0040-1713664>.
 314. Naqvi, M., P. Zakowski, L. Glucksman, et al. 2020. Tocilizumab and Remdesivir in a pregnant patient with coronavirus disease 2019 (COVID-19). *Obstet. Gynecol.* <https://doi.org/10.1097/AOG.0000000000004050>.
 315. Rubin, E.S., S.A. Sansone, A. Hirshberg, et al. 2020. Detection of COVID-19 in a vulvar lesion. *Am. J. Perinatol.* <https://doi.org/10.1055/s-0040-1713665>.
 316. Chen, Z., L. Tong, Y. Zhou, et al. 2020. Childhood COVID-19: a multi-center retrospective study. *Clin. Microbiol. Infect.* <https://doi.org/10.1016/j.cmi.2020.06.015>
 317. Fernandez-Nieto, D., J. Jimenez-Cauhe, A. Suarez-Valle, et al. 2020. Characterization of acute acral skin lesions in nonhospitalized patients: a case series of 132 patients during the COVID-19 outbreak. *J. Am. Acad. Dermatol.* **83**: e61–e3.
 318. Göttinger, F., B. Santiago-García, A. Noguera-Julián, et al. 2020. COVID-19 in children and adolescents in Europe: a multinational, multicentre cohort study. *Lancet Child Adolesc. Health.* [https://doi.org/10.1016/S2352-4642\(20\)30177-2](https://doi.org/10.1016/S2352-4642(20)30177-2).
 319. Korkmaz, M.F., E. Türe, B.A. Dorum & Z.B. Kılıç. 2020. The epidemiological and clinical characteristics of 81 children with COVID-19 in a pandemic hospital in Turkey: an observational cohort study. *J. Korean Med. Sci.* **35**: e236.
 320. L'Huillier, A.G., G. Torriani, F. Pigny, et al. 2020. Culture-competent SARS-CoV-2 in nasopharynx of symptomatic neonates, children, and adolescents. *Emerg. Infect. Dis.* **26**. <https://doi.org/10.3201/eid2610.202403>.
 321. Liu, L., X. Lei, X. Xiao, et al. 2020. Epidemiological and clinical characteristics of patients with coronavirus disease-2019 in Shiyuan City, China. *Front. Cell. Infect. Microbiol.* **10**: 284.
 322. Lu, L., W. Xiong, D. Liu, et al. 2020. New onset acute symptomatic seizure and risk factors in coronavirus disease 2019: a retrospective multicenter study. *Epilepsia*. **61**: e49–e53.
 323. Ornelas-Aguirre, J.M. 2020. El nuevo coronavirus que llegó de Oriente: análisis de la epidemia inicial en México. *Gac. Med. Mex.* **156**: 208–216.
 324. Randhawa, A.K., L.H. Fisher, A.L. Greninger, et al. 2020. Changes in SARS-CoV-2 positivity rate in outpatients in Seattle and Washington State, March 1–April 16, 2020. *JAMA* **323**: 2334–2336.
 325. Reisinger, E.C., R. von Possel, P. Warnke, et al. 2020. [Screening of mothers in a COVID-19 low-prevalence region: determination of SARS-CoV-2 antibodies in 401 mothers from Rostock by ELISA and confirmation by immunofluorescence]. *Dtsch. Med. Wochenschr.* <https://doi.org/10.1055/a-1197-4293>.
 326. Zhang, C., J. Gu, Q. Chen, et al. 2020. Clinical and epidemiological characteristics of pediatric SARS-CoV-2 infections in China: a multicenter case series. *PLoS Med.* **17**: e1003130.
 327. Bai, K., W. Liu, C. Liu, et al. 2020. Clinical analysis of 25 COVID-19 infections in children. *Pediatr. Infect. Dis. J.* **39**: e100–e3.
 328. Lu, Y., Y. Li, W. Deng, et al. 2020. Symptomatic infection is associated with prolonged duration of viral shedding in mild coronavirus disease 2019: a retrospective

- study of 110 children in Wuhan. *Pediatr. Infect. Dis. J.* **39**: e95–e9.
329. Melgosa, M., A. Madrid, O. Alvarez, *et al.* 2020. SARS-CoV-2 infection in Spanish children with chronic kidney pathologies. *Pediatr. Nephrol.* **35**: 1521–1524.
 330. Oualha, M., M. Bendavid, L. Berteloot, *et al.* 2020. Severe and fatal forms of COVID-19 in children. *Arch. Pediatr.* **27**: 235–238.
 331. Xu, P.P., R.H. Tian, S. Luo, *et al.* 2020. Risk factors for adverse clinical outcomes with COVID-19 in China: a multicenter, retrospective, observational study. *Theranostics* **10**: 6372–6383.
 332. Liu, Z., L. Ding, G. Chen, *et al.* 2020. Clinical time features and chest imaging of 85 patients with COVID-19 in Zhuhai, China. *Front. Med.* **7**: 209.
 333. Nicoletti, A., V. Talarico, L. Sabetta, *et al.* 2020. Screening of COVID-19 in children admitted to the hospital for acute problems: preliminary data. *Acta Biomed.* **91**: 75–79.
 334. Ceulemans, D., I. Thijs, A. Schreurs, *et al.* 2020. Screening for COVID-19 at childbirth: does it deliver? *Ultrasound Obstet. Gynecol.* **56**: 113–114.
 335. Fontanella, F., S. Hannes, N. Keating, *et al.* 2020. COVID-19 infection during the third trimester of pregnancy: current clinical dilemmas. *Eur. J. Obstet. Gynecol. Reprod. Biol.* **251**: 268–271.
 336. Goldfarb, I.T., M.A. Clapp, M.D. Soffer, *et al.* 2020. Prevalence and severity of coronavirus disease 2019 (COVID-19) illness in symptomatic pregnant and postpartum women stratified by Hispanic ethnicity. *Obstet. Gynecol.* **136**: 300–302.
 337. Hong, L., N. Smith, M. Keerthy, *et al.* 2020. Severe COVID-19 infection in pregnancy requiring intubation without preterm delivery: a case report. *Case Rep. Womens Health* **2020**: e00217.
 338. Lumbreras-Marquez, M.I., M. Campos-Zamora, H. Lizaola-Diaz de Leon & M.K. Farber. 2020. Maternal mortality from COVID-19 in Mexico. *Int. J. Gynaecol. Obstet.* **50**: 266–267.
 339. Miller, E.S., W.A. Grobman, A. Sakowicz, *et al.* 2020. Clinical implications of universal severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) testing in pregnancy. *Obstet. Gynecol.* **136**: 232–234.
 340. Sutton, D., K. Fuchs, M. D'Alton & D. Goffman. 2020. Universal screening for SARS-CoV-2 in women admitted for delivery. *N. Engl. J. Med.* **382**: 2163–2164.
 341. Tang, M.W., E. Nur & B.J. Biemond. 2020. Immune thrombocytopenia during pregnancy due to COVID-19. *Am. J. Hematol.* <https://doi.org/10.1002/ajh.25877>.
 342. Tekbali, A., A. Grünebaum, A. Saraya, *et al.* 2020. Pregnant vs nonpregnant severe acute respiratory syndrome coronavirus 2 and coronavirus disease 2019 hospital admissions: the first 4 weeks in New York. *Am. J. Obstet. Gynecol.* **223**: 126–127.
 343. Anderson, J., J. Schauer, S. Bryant & C.R. Graves. 2020. The use of convalescent plasma therapy and remdesivir in the successful management of a critically ill obstetric patient with novel coronavirus 2019 infection: a case report. *Case Rep. Womens Health* **2020**: e00221.
 344. Damiani, G.R., A. Biffi, G. Del Boca & F. Arezzo. 2020. Abdominal pregnancy during the COVID-19 pandemic. *Int. J. Gynaecol. Obstet.* **150**: 270–271.
 345. Hijona Elósegui, J.J., A.L. Carballo García, A.C. Fernández Risquez, *et al.* 2020. ¿existe transmisión materno-fetal del SARS-CoV-2 durante la gestación? *Rev. Clin. Esp.* <https://doi.org/10.1016/j.rce.2020.06.001>
 346. Mohammadi, S., M. Abouzaripour, N. Hesam Shariati & M.B. Hesam Shariati. 2020. Ovarian vein thrombosis after coronavirus disease (COVID-19) infection in a pregnant woman: case report. *J. Thromb. Thrombolysis.* <https://doi.org/10.1007/s11239-020-02177-6>.
 347. Nesr, G., C. Garnett, C. Bailey & S. Arami. 2020. ITP flare with mild COVID-19 infection in pregnancy: a case report. *Br. J. Haematol.* <https://doi.org/10.1111/bjh.16928>.
 348. Liu, P., J. Cai, R. Jia, *et al.* 2020. Dynamic surveillance of SARS-CoV-2 shedding and neutralizing antibody in children with COVID-19. *Emerg. Microbes Infect.* **9**: 1254–1258.
 349. Panichaya, P., W. Thaweerat & J. Uthaisan. 2020. Prolonged viral persistence in COVID-19 second trimester pregnant patient. *Eur. J. Obstet. Gynecol. Reprod. Biol.* **250**: 263.
 350. Ellington, S., P. Strid, V.T. Tong, *et al.* 2020. Characteristics of women of reproductive age with laboratory-confirmed SARS-CoV-2 infection by pregnancy status — United States, January 22–June 7, 2020. *MMWR Morb. Mortal. Wkly. Rep.* **69**: 769–775.
 351. Li, H., S. Wang, F. Zhong, *et al.* 2020. Age-dependent risks of incidence and mortality of COVID-19 in Hubei Province and other parts of China. *Front. Med.* **7**: 190.
 352. Martínez-Perez, O., M. Vouga, S. Cruz Melguizo, *et al.* 2020. Association between mode of delivery among pregnant women with COVID-19 and maternal and neonatal outcomes in Spain. *JAMA.* <https://doi.org/10.1001/jama.2020.10125>.
 353. Mendoza, M., I. Garcia-Ruiz, N. Maiz, *et al.* 2020. Preeclampsia-like syndrome induced by severe COVID-19: a prospective observational study. *BJOG* <https://doi.org/10.1111/1471-0528.16339>.
 354. Blitz, M.J., A. Grünebaum, A. Tekbali, *et al.* 2020. Intensive care unit admissions for pregnant and non-pregnant women with COVID-19. *Am. J. Obstet. Gynecol.* **223**: 290–291.
 355. Ma, Y., Q.-N. Xu, F.-L. Wang, *et al.* 2020. Characteristics of asymptomatic patients with SARS-CoV-2 infection in Jinan, China. *Microbes Infect.* **22**: 212–217.