SARS-CoV-2 genome and antibodies in breastmilk: a systematic review and meta-analysis

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ABSTRACT

Objective To systematically review and meta-analyse the rate of SARS-CoV-2 genome identification and the presence of SARS-CoV-2 antibodies in breastmilk of mothers with COVID-19.

Design A systematic review of studies published between January 2019 and October 2020 without study design or language restrictions.


Patients Mothers with confirmed COVID-19 and breastmilk tested for SARS-CoV-2 by RT-PCR or for anti-SARS-CoV-2 antibodies.

Main outcome measures Presence of SARS-CoV-2 genome and antibodies in breastmilk.

Results We included 50 articles. Twelve out of 183 women from 48 studies were positive for SARS-CoV-2 genome in their breastmilk (pooled proportion 5% (95% CI 2% to 15%; I²=48%)). Six infants (50%) of these 12 mothers tested positive for SARS-CoV-2, with one requiring respiratory support. Sixty-one out of 89 women from 10 studies had anti-SARS-CoV-2 antibody in their breastmilk (pooled proportion 83% (95% CI 32% to 98%; I²=88%)). The predominant antibody detected was IgA.

Conclusions SARS-CoV-2 genome presence in breastmilk is uncommon and is associated with mild symptoms in infants. Anti-SARS-CoV-2 antibodies may be a more common finding. Considering the low proportion of SARS-CoV-2 genome detected in breastmilk and its lower virulence, mothers with COVID-19 should be supported to breastfeed.

INTRODUCTION

SARS-CoV-2 is transmitted by respiratory droplets from close contact between individuals and is the cause of the current COVID-19 pandemic. The possibility of maternal–neonatal transmission via breast feeding or breastmilk consumption is uncertain. Current guidance on breast feeding for neonates born to women with suspected or confirmed COVID-19 remains controversial, and international recommendations vary. The WHO, UNICEF, Canadian Pediatric Society and UK Royal College of Paediatrics and Child Health recommend that mothers with suspected or proven COVID-19 can safely continue breast feeding.1,4 However, the Union of European Neonatal and Perinatal Societies supports the separation of symptomatic mothers from their newborns and interruption of breast feeding, and the Association of Chinese Neonatologists advises against the use of breast milk or breast feeding.5,6 Up until 22 July 2020, the American Academy of Pediatrics recommended separating baby from mother, but new guidance now supports rooming-in and the use of breast milk.7 Meanwhile, the Centers for Disease Control and Prevention supports the use of expressed breast milk but advises further discussion with the mother and families to determine whether breast feeding should be initiated or continued.8 These divisive recommendations are the result of initial reactions based on a lack of evidence regarding transmission of SARS-CoV-2 via breast milk and breast feeding. Given the increasing concerns relating to maternal depression and anxiety during the current pandemic, the decision to separate mothers from babies should not be taken lightly.9 Concerns regarding the potential presence of SARS-CoV-2 in breastmilk affect the postnatal health and well-being of both mother and baby and the potential availability of donor breast milk for preterm neonates in the neonatal intensive care unit.10

Reports of SARS-CoV-2 in breastmilk have caused families and healthcare professionals to be concerned about the potential for transmission.11 Conversely, anti-SARS-CoV-2 antibodies in

What is already known on this topic?

- Breast feeding is the optimal nutrition for infants.
- Evidence is limited on whether SARS-CoV-2 is transmitted via breastmilk, but some guidelines recommend women with COVID-19 refraining from breast feeding.
- Transmission of anti-SARS-CoV-2 antibodies in breastmilk may be beneficial.

What this study adds?

- The presence of SARS-CoV-2 genome in breastmilk is uncommon (5%), and when it occurs, it is associated with mild symptoms in infants.
- Anti-SARS-CoV-2 antibodies are more prevalent in breastmilk of COVID-19 positive women (83%).
- Breast feeding should be recommended and encouraged for women with COVID-19.
breastmilk may confer potential benefits to infants. Hence, a detailed examination of the literature is needed. Our primary objective was to systematically review and meta-analyse the available evidence for the presence of SARS-CoV-2 genome in the breastmilk of mothers who tested positive for COVID-19. Our secondary objective was to review the literature reporting on the presence of antibodies to SARS-CoV-2 in breastmilk.

METHODS

The study was conducted according to the Meta-analysis of Observational Studies in Epidemiology guidelines and reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Our institution did not require ethics approval for systematic reviews, and this study was not registered on PROSPERO as their operations during this pandemic were halted.

Search strategy

We searched bibliographic databases of Ovid Medline, Ovid Embase Classic+Embase, PubMed, Web of Science and Scopus for articles published between 1 January 2019 and 7 October 2020 using a search developed by an information specialist (CDC). No limits on language were imposed. The detailed search strategy is reported in the online supplemental eTable 1. An additional search from bibliographies of relevant articles and the John Hopkins University COVID-19 database was conducted. Two reviewers (FZ and CZ) screened the search results independently and selected articles for full-text review, and conflicts were resolved by a third reviewer (PSS).

Eligibility criteria

All study designs were included in the systematic review. Studies were included if they met the following criteria: (1) mother with confirmed SARS-CoV-2 genome detected by RT-PCR in any sample and (2) breastmilk was tested either for the presence of SARS-CoV-2 RNA using RT-PCR or for the presence of antibodies to SARS-CoV-2. Studies were excluded if information on maternal infection during pregnancy was not confirmed. ‘Case series’ was defined as a report of more than one mother.

Data collection

Data on maternal characteristics, infant characteristics, test characteristics, results and any other relevant information on the follow-up of the child were extracted. An infant’s day of birth was considered day of life 1, and the day of maternal symptom onset was considered day 1 of infection.

Risk of bias assessment

The risk of bias within each included study was evaluated using the Joanna Briggs Institute Critical Appraisal Tool for case reports and case series. Studies were assessed for their inclusion criteria, methods, reporting of demographics, clinical history and follow-up. For case series, an additional assessment of consecutive or complete inclusion of cases was performed. Studies were deemed ‘low risk’ if they fulfilled all the available criteria, and ‘intermediate risk’ or ‘high risk’ when 1 or ≥2 criteria, respectively, were unmet.

Statistical analysis

We summarised data from all included studies in a table format to provide the complete context of the available evidence, types of studies, locations of studies, methods of detection and results. Meta-analyses of the proportion of mothers with breastmilk positivity for SARS-CoV-2 genome and presence of antibodies were performed, and the pooled proportions were reported as effect size with 95% CI. A generalised mixed linear model was used to derive the pooled proportion as we expected a high number of reports of zero cases of positivity. Statistical heterogeneity was calculated as I² values, and an a priori decision was made to use a random effects model. Analyses were conducted using the ‘metaprop’ command in the programme R (V.4.0.2; available at https://www.r-project.org/).

RESULTS

Detailed search results are reported in figure 1. One hundred and four articles were excluded (28 were review articles, 64 studies did not test breastmilk, 6 studies included a mix of confirmed and suspected COVID-19 mothers, with no clear distinction between the groups, 4 were duplicate articles, 1 study did not provide breastmilk results and 1 study considered a mother positive based on SARS-CoV-2 antibodies, but she was negative on RT-PCR testing). A total of 50 studies (nine preprints) from 15 countries were included in the qualitative synthesis, which comprised 27 case reports, 18 case series, 4 cohort studies and 1 case control study (figure 1). There were 46 articles published in English and 4 in Chinese language. A total of 183 mothers had SARS-CoV-2 genome testing of their breastmilk, and 89 mothers had antibody testing of their breastmilk. Thirty mothers had antibody testing without SARS-CoV-2 genome testing of their breastmilk. The maternal and infant characteristics are summarised in online supplemental eTable 2. Fifteen studies had low risk of bias, 19 had intermediate risk of bias and 16 had high risk of bias (online supplemental eTable 3).

A total of 12 mothers’ breastmilk samples were identified to contain SARS-CoV-2 genome. Further details of these studies are summarised in table 1. These studies reported testing of different genes, including surface glycoprotein gene (table 1). Meta-analyses identified that the pooled breastmilk positivity rate for SARS-CoV-2 was 5% (95% CI 2% to 15%; I²=48%).
Table 1 Characteristics of studies with SARS-CoV-2 genome detected in breastmilk

<table>
<thead>
<tr>
<th>Author</th>
<th>Maternal characteristics</th>
<th>Time interval between maternal symptoms onset and BM positive</th>
<th>Time interval between maternal symptoms onset and BM negative</th>
<th>Type of test</th>
<th>Infants of mothers with BM-positive characteristics</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bautug et al[16]</td>
<td># mothers BM RT-PCR positive: 1.</td>
<td>0 days (asymptomatic)</td>
<td>Asymptomatic/confirmed negative samples</td>
<td>Genes tested: S-gene. Cycle threshold: 28.65–32.28.</td>
<td>Type of feeding: EBM. Symptoms: no. Infant positive: no. If yes, for how long: ≤14 days.</td>
<td>Infant separated from mother at birth and tested negative at birth. Was exposed to EBM on DoL 1. Repeat infant PCR positive at 96 hours. BM continued to test positive on DoL 4 and 5.</td>
</tr>
<tr>
<td>Bertino et al[17]</td>
<td># mothers BM RT-PCR positive: 1.</td>
<td>3 days</td>
<td>28 days</td>
<td>Genes tested: ORF1ab, E-gene, N-gene and RdRp. Cycle threshold: NK.</td>
<td>Type of feeding: BF. Symptoms: no. Infant positive: no. If yes, for how long: ≤14 days.</td>
<td>Mother symptomatic at time of positive BM test. Infant only retested 14 days after first test. BM negative on day 15 but positive on day 26 of maternal symptoms. BM negative from day 28 onwards.</td>
</tr>
<tr>
<td>Buonsenso et al*[18]</td>
<td># mothers BM RT-PCR positive: 1.</td>
<td>9 days</td>
<td>13 days</td>
<td>Genes tested: E-gene, N-gene and RdRp. Cycle threshold: 34.3–38.3.</td>
<td>Type of feeding: EBM. Symptoms: no. Infant positive: no.</td>
<td>BM PCR negative on day 11 but positive on day 12 of maternal symptoms. Repeat on day 13 and after remained negative.</td>
</tr>
<tr>
<td>Chambers et al[19]</td>
<td># mothers BM RT-PCR positive: 1.</td>
<td>1 day (collected at the day of symptoms onset)</td>
<td>12 days</td>
<td>Genes tested: RdRp and N-gene. Cycle threshold: NK.</td>
<td>Type of feeding: NK. Symptoms: no. Infant positive: not tested.</td>
<td>Mother symptomatic at time of BM testing. Infant (9 months) had fever (1 day). BM PCR was positive 14 days before maternal test. Repeat testing negative. BM also negative by infectivity assay.</td>
</tr>
<tr>
<td>Groš et al[21]</td>
<td># mothers BM RT-PCR positive: 1.</td>
<td>5 days</td>
<td>9 days</td>
<td>Genes tested: N-gene and ORF1b-nsp14. Cycle threshold: 29.8 (peak, whole milk), 30.4 (peak, skimmed milk).</td>
<td>Type of feeding: BF. Symptoms: yes. Infant positive: yes. If yes, for how long: 15 days.</td>
<td>Mother symptomatic at time of positive BM test. Repeat BM sample negative (9 days after maternal symptoms). Baby also was positive for RSV.</td>
</tr>
<tr>
<td>Hinojosa-Velasco et al*[22]</td>
<td># mothers BM RT-PCR positive: 1.</td>
<td>6 days</td>
<td>15 days</td>
<td>Genes tested: N-gene and ORF1b. Cycle threshold: NK.</td>
<td>Type of feeding: BMS and BF. Symptoms: no. Infant positive: yes. If yes, for how long: 13 days.</td>
<td></td>
</tr>
<tr>
<td>Tam et al*[25]</td>
<td># mothers BM RT-PCR positive: 1.</td>
<td>5 days</td>
<td>9 days (became positive again at 15 days)</td>
<td>Genes tested: E-gene. Cycle threshold: 20–35.1</td>
<td>Type of feeding: BF. Symptoms: yes. Infant positive: yes. If yes, for how long: 11 days.</td>
<td>4 negative BM samples in between both positive samples. Last sample positive on day 15 of symptoms.</td>
</tr>
</tbody>
</table>

*Information collated from both Buonsenso et al and Costa et al: same cases were reported in two separate papers.

1No exact cycle threshold values given.

* number of; BF, breast feeding; BM, breastmilk; DoL, day of life; EBM, expressed breastmilk; E-gene, envelope protein gene; NA, not applicable; N-gene, nucleocapsid protein gene; NK, not known; ORF1b-nsp14, Open Reading Frame 1b-non-structural protein 14; RdRp, RNA dependent RNA polymerase gene; RT-PCR, real time-PCR; S-gene, surface glycoprotein gene.
figure 2). Among the infants of these 12 mothers with positive breastmilk RT-PCR testing, 50% (6/12) tested positive for SARS-CoV-2 via nasopharyngeal swab and 33% (4/12) were symptomatic (three confirmed positive). Only one of these four symptomatic infants required respiratory support; this infant was found to have concurrent infection with respiratory syncytial virus. The time interval between maternal symptoms and positive test results for SARS-CoV-2 in the breastmilk was 1–9 days. In studies that performed repeat testing, the time interval between maternal symptom onset and subsequent negative RT-PCR test results in the breastmilk was 9–28 days.

A total of 214 infants (one set of twins) were born, of which 32 infants (15%) tested positive for SARS-CoV-2 viral genome in the nasopharyngeal swab and one tested positive for anti-SARS-CoV-2 antibodies in serum.27 Of these, 25% (8/32) were preterm (<37 weeks’ gestational age) and 41% (13/32) tested positive at ≥7 days of age. Among the 171 mothers who tested negative for SARS-CoV-2 in the breastmilk, 24 (14%) infants had a positive SARS-CoV-2 genome result. All infants survived to discharge.

Ten studies reported anti-SARS-CoV-2 antibody testing in the breastmilk of 89 mothers.14 15 20 28–34 Of these mothers, 61 (69%) had antibodies detected in their breastmilk (pooled proportion 83% (95% CI 32% to 98%; I²=88%; figure 3). Time intervals between maternal symptom onset and antibody detection ranged from 3 to 79 days. Of the 61 mothers with anti-SARS-CoV-2 antibodies, only three (5%) infants had a positive nasopharyngeal swab confirming SARS-CoV-2 genome and two infants (one confirmed positive) were symptomatic. The characteristics of these studies including the types of antibodies are reported in table 2.

DISCUSSION
Main findings
In this systematic review and meta-analysis of 50 studies and 213 mothers, we identified that 1 in 20 mothers who had

![Figure 2](https://example.com/figure2.png) Meta-analysis of proportion of SARS-CoV-2 genome detection in breastmilk. Chen 1 (reference #7); Chen 2 (reference #8); Dong 1 (reference #11); Dong 2 (reference #12); Peng 1 (reference #34); Peng 2 (reference #35). All reference numbers are from the supplemental references in the online supplemental material.

![Figure 3](https://example.com/figure3.png) Meta-analysis of proportion of anti-SARS-CoV-2 genome detection in breastmilk. Dong 2 (reference #12); Peng 2 (reference #35). All reference numbers are from the supplemental references in the online supplemental material.
Table 2  Characteristics of studies with anti-SARS-CoV-2 antibodies detected in breastmilk

<table>
<thead>
<tr>
<th>Author</th>
<th>Maternal characteristics</th>
<th>Time interval between maternal symptoms onset and Ig positive</th>
<th>Assay and immunoglobulin characteristics</th>
<th>Infant characteristics</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dong et al</td>
<td># mothers BM Ig positive: 1. # positive samples: 6.</td>
<td>26 days</td>
<td>Assay method: ELISA. Antigen used: S-protein. Type of Ig: IgA and IgG.</td>
<td>Type of feeding: NK. Symptoms: no. Infant RT-PCR positive: no.</td>
<td>BM IgG remained positive for 58 days after symptom onset. Maternal serum IgG positive at 26 days and remained positive 58 days after symptom onset. Infant serum IgG positive at DoL 25 but negative at DoL 44.</td>
</tr>
<tr>
<td>Fenizia et al</td>
<td># mothers BM Ig positive: 1. # positive samples: 1.</td>
<td>NK</td>
<td>Assay method: chemiluminescence immunoassay. Antigen used: nucleocapsid and S-protein. Type of Ig: IgG and IgM.</td>
<td>Type of feeding: NK. Symptoms: NK. Infant RT-PCR positive: no.</td>
<td>BM positive for both virus RNA and antibodies.</td>
</tr>
<tr>
<td>Gao et al</td>
<td># mothers BM Ig positive: 2. # positive samples: 2.</td>
<td>17–22 days</td>
<td>Assay method: chemiluminescence immunoassay. Antigen used: nucleocapsid and S-protein. Type of Ig: IgG and IgM.</td>
<td>Type of feeding: BMS1 and EBM.1 Symptoms: NK. Infant RT-PCR positive: no.</td>
<td>Both infants had positive serum IgG, one also had positive serum IgM. (Third mother with positive IgM in BM not included, had negative RT-PCR in throat swab but positive serum IgM.)</td>
</tr>
<tr>
<td>Luo et al</td>
<td># mothers BM Ig positive: 4. # positive samples: 4.</td>
<td>13–45 days</td>
<td>Assay method: ELISA. Antigen used: NK. Type of Ig: IgM.</td>
<td>Type of feeding: BMS. Symptoms: no. Infant RT-PCR positive: no.</td>
<td>BM RT-PCR negative All four mothers had serum IgG and IgM positive after delivery. All four mothers had negative PCR at time of BM sampling.</td>
</tr>
<tr>
<td>Pace et al</td>
<td># mothers BM Ig positive: 18. # positive samples: 37.</td>
<td>0–20 days (three asymptomatic)</td>
<td>Assay method: ELISA. Antigen used: spike (S2 and RBD) and nucleocapsid. Type of Ig: IgA and IgG.</td>
<td>Type of feeding: BF5 and MF.13 Symptoms: yes.2</td>
<td>BM-RT-PCR negative, one breast swab RT-PCR positive. Serum Ig not tested. All mothers had positive PCR before first BM sample, two had negative PCR before second sample and one had negative PCR before third sample.</td>
</tr>
<tr>
<td>Peng et al</td>
<td># mothers BM Ig positive: 8. # positive samples: 21.</td>
<td>3–79 days</td>
<td>Assay method: ELISA. Antigen used: NK. Type of Ig: IgM.</td>
<td>Type of feeding: NK. Symptoms: yes.* Infant RT-PCR: NK.</td>
<td>BM RT-PCR negative. Serum Ig not tested. Three mothers had IgM negative at 47–72 days. IgM positive samples collected at 31±19 days and IgM negative samples at 43±21 days after symptom onset.†</td>
</tr>
<tr>
<td>Van Keulen et al</td>
<td># mothers BM Ig positive: 24. # positive samples: 24.</td>
<td>Mean 5.9 (SD 2.6 weeks)</td>
<td>Assay method: ELISA and bridging ELISA. Antigen used: S-protein, RBD and N protein. Type of Ig: IgA (S-protein) and total Ig (RBD and N protein).</td>
<td>Type of feeding: NK. Symptoms: NK. Infant RT-PCR: NK.</td>
<td>BM-RT-PCR not tested. IgA present for at least 13 weeks from symptom onset.</td>
</tr>
<tr>
<td>Walczak et al</td>
<td># mothers BM Ig positive: 1. # positive samples: 2 (for IgG, negative for IgM).</td>
<td>10 days</td>
<td>Assay method: ELISA. Antigen used: NK. Type of Ig: IgG and IgM.</td>
<td>Type of feeding: BF. Symptoms: yes. Infant RT-PCR positive: yes. If yes: for how long: 13 days.</td>
<td>BM RT-PCR negative. Repeat BM IgG remained positive on day 26 postsymptom onset. Maternal serum IgG positive on days 15 and 19. Infant serum IgG and IgM positive on day 13.</td>
</tr>
</tbody>
</table>

*Unable to distinguish feeding practices of those who tested IgG positive and IgM negative.
†No statistical difference found (Mann-Whitney U test, p=0.052).
# number of: BF, breast feeding; BM, breastmilk; BMS, breastmilk substitute; DoL, day of life; Ig, immunoglobulin; NK, not known; RT-PCR, real time polymerase chain reaction; PCR, S-protein, spike protein.
SARS-CoV-2 infection had a positive test for SARS-CoV-2 genome in the breastmilk. Meta-analyses revealed that this proportion could be as low as 1 in 50 and as high as 1 in 7. Although the presence of antibodies against SARS-CoV-2 was assessed in few studies, they were identified in the majority of mothers who were tested. Our results may be explained by the timing of tests performed, as the majority of mothers with positive SARS-CoV-2 antibodies detected in breastmilk were tested after the first week of symptom onset compared with those with positive genome detected who were tested within the first week. Infants of mothers with positive viral genome testing in the breastmilk were mostly asymptomatic; only one infant who had another concurrent viral infection required respiratory support.

Well-established examples of infection transmitted through breastmilk include HIV, cytomegalovirus (CMV), human T cell lymphotropic virus type 1 (HTLV-1) and Ebola virus. In the cases of HIV and HTLV-1, breastmilk viral levels correlate with systemic viral load. Although there have been no studies demonstrating maternal SARS-CoV-2 systemic viral load and shedding patterns in breastmilk, it is interesting to note that 4 out of 12 (33.3%) mothers in our study were reported to be symptomatic during the time their breastmilk tested positive for SARS-CoV-2. For primary HIV infection, elevated viral load in plasma, and presumably in breastmilk, were associated with an almost 30% postnatal transmission rate. The mother-to-infant transmission rate for CMV via breastmilk has been reported to be 66%–96% among CMV-IgG positive mothers, with subsequent CMV positivity in 5.7%–58.6% of the infants. These transmission rates are in stark contrast to our current estimates of a very low rate of SARS-CoV-2 RNA in breastmilk.

Coronaviruses typically cause the common cold in humans. However, within the last two decades, more virulent strains have emerged: initially SARS-CoV-1 in 2003, followed by Middle Eastern Respiratory Syndrome (MERS-CoV) in 2012 and SARS-CoV-2 in 2019. Although transmission of SARS-CoV-1 or MERS-CoV via breastmilk has not been reported, this is likely due to a lack of testing. There are only two reports in which breastmilk was tested for SARS-CoV-1 and two reports of breastmilk testing for SARS-CoV-1 antibodies, with one positive SARS-CoV-1 detected and one positive antibody result. To the best of our knowledge, there have been no reports of MERS-CoV in human breastmilk; however, this virus has been reported in the milk of dromedary camels resulting in a case of likely direct zoonosis through consumption of unpasteurised camel milk.

Oligosaccharides, lactoferrin and immunoglobulins in breastmilk are some of the known protective agents against infection. Infants who are not breast fed have a threefold increase in developing severe respiratory tract illnesses requiring hospitalisation compared with those who are exclusively breast fed for 4 months. Antibodies may play an immune-protective role as they are present in milk (IgA, IgG and IgM), with IgA most abundant. Breastmilk IgA and secretory IgA, which acts on the mucosal surfaces, have been linked to both decreased episodes of respiratory illness in infants of mothers who receive antenatal influenza vaccine and reduced maternal-to-child transmission of HIV-1 from infected mothers. Anti-SARS-CoV-2 IgA antibodies have also demonstrated virus-neutralising properties in vitro. Thus, in our review, where the presence of anti-SARS-CoV-2 antibodies in breastmilk are more commonly identified, with a predominance of IgA, there is a likelihood of potential immune protection of infants. However, the clinical impact of anti-SARS-CoV-2 antibodies in breastmilk is yet to be determined and further studies are required.

In nursing mothers, delineating the mode of transmission between intrapartum or postpartum infection through droplet or close contact proves challenging. Bastug et al reported a case of an infant who was separated immediately after birth from a mother asymptomatic for COVID-19. This infant initially tested negative for SARS-CoV-2 genome on nasopharyngeal swab in the first 8 hours after birth and received breastmilk for the first 2 days. However, following positive testing for SARS-CoV-2 in the breastmilk, the infant was subsequently retested and found to be positive on day 4. Possible transmission via breastmilk may be considered in this case; however, transmission through other personnel contact cannot be ruled out. Although the detection of SARS-CoV-2 RNA in the breastmilk is most commonly used to establish potential transmission of the virus via breastmilk, its significance relating to infectivity is not well understood. Chambers and colleagues evaluated the replication competency of SARS-CoV-2 in breastmilk using viral culture methods. Of all samples tested, including one that was positive on RT-PCR testing, none showed evidence of cytopathic effects in culture, suggesting that the presence of RNA may not represent replication-competent virus in breastmilk.

Strengths and limitations

To the best of our knowledge, this is the most comprehensive systematic review and meta-analysis on the detection of SARS-CoV-2 and its antibodies in breastmilk. To maximise the scope of our review, no languages were excluded, and studies published in languages other than English were all reviewed by native speakers trained in paediatrics. Although the majority of cases in our review were case reports and case series, this was due to the nature of the current pandemic situation; more robust studies require longer time to complete. Another limitation of this review could be publication bias as negative results may not be reported. Thus, our results could be an overestimation of the true positive rate.

A restrictive approach to breast feeding can significantly affect the type of feeding for infants in hospital and following discharge home. Popofsky and colleagues demonstrated increased formula feeding in hospital in separated versus unseparated mothers (81.6% vs 27.8%, respectively), which continued at home (34.7% vs 8.3%, respectively). In line with this, Patil and colleagues found rooming-in and breast feeding for infants of women with SARS-CoV-2 did not result in adverse neonatal outcomes. According to one estimate, 5%, 10%, 25% or 50% relative reductions in the prevalence of breast feeding due to the COVID-19 pandemic can result in 16,469, 32,139, or 50% relative reductions in the prevalence of breast feeding and the findings of this review could be publication bias as negative results may not be reported. Thus, our results could be an overestimation of the true positive rate.
CONCLUSION

The presence of SARS-CoV-2 genome in breastmilk is uncommon in mothers with confirmed SARS-CoV-2 infection while the presence of antibodies in breastmilk is more prevalent, especially beyond the first week of maternal symptom onset. However, the role of SARS-CoV-2 antibodies in neonatal protection is unclear. With low viral prevalence and virulence, breast feeding should be recommended in mothers with SARS-CoV-2 after counselling and education regarding safe hygiene practices.

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Contributors

FZ performed an independent literature search, selected studies for inclusion, extracted and interpreted the data, assessed the risk of bias of included studies and wrote the first draft of the manuscript. CZ performed an independent literature search, selected studies for inclusion, verified the extracted data, assessed risk of bias, interpreted data, translated studies in Spanish, reviewed the manuscript and provided critical feedback. QZ participated in extracting data from studies in Chinese, assessed the risk of bias of included studies and reviewed the manuscript. CDC was the information specialist who developed the search strategy, performed the database search and reviewed the manuscript. PSS conceptualised and designed the study, interpreted the data, overwaw the meta-analysis and revised the final draft of the manuscript.

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Competing interests

None declared.

Patient consent for publication

Not required.

Provenance and peer review

Not commissioned; internally peer reviewed.

Data availability statement

All data relevant to the study are included in the article or uploaded as supplementary information. As this was a systematic review and meta-analysis, all included data were publicly available from published research articles. A complete reference list of included studies is provided in the supplemental references in the supplemental material.

Supplemental material

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3 Canadian Paediatric Society. Breastfeeding when mothers have suspected or proven COVID-19, 2020.


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Supplemental Material

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<th>Search Strategy</th>
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<tbody>
<tr>
<td>Ovid Medline(R ALL)</td>
<td>1 exp Coronavirus/</td>
</tr>
<tr>
<td></td>
<td>2 exp Coronavirus Infections/</td>
</tr>
<tr>
<td></td>
<td>3 (coronavirus* or corona virus* or corona virinae* or coronavirinae* or OC43 or NL63 or 229E or HKU1 or HCoV* or covid* or ncov* or coV or sars-cov* or sarscov* or Sars-coronavirus* or Severe Acute Respiratory Syndrome Coronavirus* or 2019-ncov or 2019-novel CoV or SARS-like coronavirus*).mp.</td>
</tr>
<tr>
<td></td>
<td>4 ((novel or new or nouveau) adj2 pandemi*).mp.</td>
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<tr>
<td></td>
<td>5 ((pneumonia or sars*).mp. or exp pneumonia/) and Wuhan.mp.</td>
</tr>
<tr>
<td></td>
<td>6 (COVID-19 or severe acute respiratory syndrome coronavirus 2).os,ps,ox,px,rx,nm.</td>
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<td>7 or/1-6</td>
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<tr>
<td></td>
<td>8 exp Pregnancy/</td>
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<td></td>
<td>9 exp Pregnancy Complications/</td>
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<td>10 exp Pregnancy Outcome/</td>
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<td>11 exp Obstetrics/</td>
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<td>12 exp Breast Feeding/</td>
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<td>13 exp Maternal Health Services/</td>
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<td>15 exp Fetal Therapies/</td>
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<td>16 exp Fetal Monitoring/</td>
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<td>17 exp Prenatal Diagnosis/</td>
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<td>18 exp Infant, Newborn/</td>
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<td>19 Pregnant Women/</td>
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<td>20 Infectious Disease Transmission, Vertical/</td>
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<td></td>
<td>21 Intensive Care Units, Neonatal/</td>
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<tr>
<td></td>
<td>22 Intensive Care, Neonatal/</td>
</tr>
<tr>
<td></td>
<td>23 (pregn* or gestation* or parturition or neonatal* or neo natal* or neonate* or ante natal* or antenatal* or pre natal* or prenat al* or puerper* or postnatal* or postpartum or post partum or post natal* or peripartum or peri partum or intrapartum or intra partum or prepgnancy or pre pregnancy or preconception* or pre conception* or periconception* or peri conception* or preterm or premature or labo?r or eclamp* or preeclamps* or preeclampsia or amniocentesis or chorion* vill* or breastfe* or breast f* or lactation* or cesarean or caesarean or cesarian or caesarian or caesarien or newborn* or new born* or tocoly* or fetal or foetal or fetus or foetus or miscarriage* or obstetric*).tw,kf,kw.</td>
</tr>
<tr>
<td></td>
<td>24 ((Vertical or Fetomaternal or Foetomaternal or Maternal-Fetal or Maternal Fetal or Maternal-Foetal or Maternal-Foetal or Mother-To-Child or Mother to child) adj2 transmission*).tw,kf,kw.</td>
</tr>
<tr>
<td></td>
<td>25 or/8-24</td>
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<tr>
<td></td>
<td>26 antibodies/ or antibodies, viral/</td>
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<tr>
<td></td>
<td>27 immunoglobulins/ or Immunoglobulin G/ or Immunoglobulin M/</td>
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<tr>
<td></td>
<td>28 Oligosaccharides/</td>
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<td></td>
<td>29 Reverse Transcriptase Polymerase Chain Reaction/</td>
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<td>30 (antibod* or immunoglobulin* or oligosaccharide* or reverse transcription-polymerase chain reaction or RT-PCR).tw,kf,kw.</td>
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<td>31 or/26-30</td>
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<tr>
<td></td>
<td>32 7 and 25 and 31</td>
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<tr>
<td></td>
<td>33 breast feeding/ or breast milk expression/ or Milk, Human/</td>
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<td></td>
<td>34 (breastfe* or breast f* or lactation* or breastmilk or milk).tw,kf,kw.</td>
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<tr>
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<td>35 33 or 34</td>
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<td></td>
<td>36 7 and 35</td>
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<td>37 32 or 36</td>
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<td>Embase Classic + Embase</td>
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</table>
| Pubmed (non-Medline) | Supplemental material

33  breast feeding/ or breast milk expression/ or breast milk/
34  (breast* or breast fe* or lactation* or breastmilk or milk).tw,kw.
35  33 or 34
36  7 and 35
37  32 or 36
38  limit 37 to dc=20190101-20301231

### References

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<th>Set</th>
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<th>Indexes</th>
<th>Timespan</th>
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<td>SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI</td>
<td>All years</td>
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<td>#15 AND #6</td>
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<td>#14 OR #13</td>
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<td>All years</td>
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<tr>
<td>#14</td>
<td>TS=(breastfe* or breast feed* or breast fed or lactation* or breastfeeding) OR breast feeding OR breast expression OR milk OR (pubstatusaheadofprint OR publisher[sb] OR in process[sb] OR pubmednotmedline[sb])) AND &quot;2019/01/01&quot;[CRDT] : &quot;3000&quot;[CRDT] OR (*2019/01/01&quot;[EDAT] : &quot;3000&quot;[EDAT]) OR &quot;2019/01/01&quot;[MHDA] : &quot;3000&quot;[MHDA]</td>
<td>SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI</td>
<td>All years</td>
</tr>
<tr>
<td>#13</td>
<td>TS=(&quot;breast feeding&quot; OR &quot;breast milk expression&quot; OR &quot;Human Milk&quot;)</td>
<td>SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI</td>
<td>All years</td>
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<tr>
<td>#12</td>
<td>#11 AND #10 AND #6</td>
<td>SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI</td>
<td>All years</td>
</tr>
<tr>
<td>#11</td>
<td>TS=(Antibod* OR Immunoglobulin* OR Oligosaccharide* OR &quot;Reverse Transcriptase Polymerase Chain Reaction&quot;)</td>
<td>SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI</td>
<td>All years</td>
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<td>#9 OR #8 OR #7</td>
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<td>All years</td>
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<tr>
<td>#9</td>
<td>TS=((Vertical or Fetomaternal or Foetomaternal or Maternal-Fetal or &quot;Maternal Fetal&quot; or Maternal Foetal or Mother-To-Child or &quot;Mother to child&quot;) NEAR/1 transmission*)</td>
<td>SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI</td>
<td>All years</td>
</tr>
<tr>
<td>#8</td>
<td>TS=(pregnan* or gestation* or parturition or neonatal* or neonate* or antenatal* or prenatal* or puerper* or postnatal* or postpartum or post partum or post natal* or peripartum or peri partum or intrapartum or intra partum or pre pregnancy or pre pregnancy or preconception* or preconception* or peri conception* or preterm or premature or labo?r or eclamp* or preeclamps* or anmniocentesis* or chorion* vill* or breastfe* or breast fed or lactation* or cesarean or cesarean or cesarean birth or cesarean birth or cesarean birth or cesarean birth or cesarean birth or cesarean birth or cesarean birth or cesarean birth or cesarean birth)</td>
<td>SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI</td>
<td>All years</td>
</tr>
<tr>
<td>#7</td>
<td>TS=(Pregnancy OR &quot;Pregnancy Complications&quot; OR &quot;Pregnancy Outcome&quot; OR Obstetrics OR &quot;Breast Feeding&quot; OR &quot;Maternal Health Services&quot; OR Fetus OR &quot;Fetal Therapies&quot; OR &quot;Fetal Monitoring&quot; OR &quot;Prenatal Diagnosis&quot; OR Newborn OR Pregnant Women OR &quot;Vertical Transmission&quot;)</td>
<td>SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI</td>
<td>All years</td>
</tr>
<tr>
<td>#6</td>
<td>#5 OR #4 OR #3 OR #2 OR #1</td>
<td>SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI</td>
<td>All years</td>
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</tbody>
</table>
This table outlines the literature search strategy we used in our systematic review to assess the presence of SARS-CoV-2 virus and antibodies in breast milk. Search strategies are listed. 

There were no restrictions to publication status or language. 

All searches were run from inception to October 7, 2020, and filtered to articles since January 2019.
### eTable 2. Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Author Type of Publication Country</th>
<th>Maternal Characteristics</th>
<th>Infant Characteristics</th>
<th>Type of Feed Given</th>
<th>Testing of Breast Milk</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>AlZaghal et al (1) Case report Jordan</td>
<td>Number of confirmed mothers: 1</td>
<td>Number of infants: 1</td>
<td>BMS &amp; BM</td>
<td>Number of mothers tested: 1</td>
<td>Infant received BMS until breast milk RT-PCR was negative.</td>
</tr>
<tr>
<td></td>
<td>Trimester of infection: 3rd</td>
<td>BW: 2500g</td>
<td></td>
<td>Number of milk samples tested: 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Symptomatic at birth: Yes</td>
<td>GA: 36(^{+3})</td>
<td></td>
<td>DoL at test: NK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Detected by: RT-PCR</td>
<td>Symptomatic: No</td>
<td></td>
<td>Type of test: RT-PCR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mode of birth: CS</td>
<td>RT-PCR: Negative</td>
<td></td>
<td>Results: Negative</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antiviral medication: No</td>
<td>Immunoglobulin: ND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bastug et al (2) Case report Turkey</td>
<td>Number of confirmed mothers: 1</td>
<td>Number of infants: 1</td>
<td>EBM &amp; BF as of DoL 6</td>
<td>Number of mothers tested: 1</td>
<td>Asymptomatic mother. Infant tested negative at 8 hours of age, separated from mother at birth, but received EBM until DoL 2. Infant repeat test on DoL 4 positive. See table 1 for more details</td>
</tr>
<tr>
<td></td>
<td>Trimester of infection: 3rd</td>
<td>BW: 2980g</td>
<td></td>
<td>Number of milk samples tested: 3</td>
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</tr>
<tr>
<td></td>
<td>Symptomatic at birth: No</td>
<td>GA: 39 weeks</td>
<td></td>
<td>DoL at test: 1 (8 hours), 4 &amp; 5</td>
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<td>Detected by: RT-PCR</td>
<td>Symptomatic: No</td>
<td></td>
<td>Type of test: RT-PCR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mode of birth: VB</td>
<td>RT-PCR: Positive</td>
<td></td>
<td>Results: All 3 samples positive</td>
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<tr>
<td></td>
<td>Antiviral medication: No</td>
<td>Immunoglobulin: ND</td>
<td></td>
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<tr>
<td>Bertino et al (3) Case series (Preprint) Italy</td>
<td>Number of confirmed mothers: 12</td>
<td>Number of infants: 12</td>
<td>BF (11), BMS (1)</td>
<td>Number of mothers tested: 12 (1 mother tested positive)</td>
<td>See table 1 for more details</td>
</tr>
<tr>
<td></td>
<td>Trimester of infection: 3rd trimester (9), PN (3)</td>
<td>BW: NK</td>
<td></td>
<td>Number of milk samples tested: NK</td>
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</tr>
<tr>
<td></td>
<td>Symptomatic at birth: Yes in 10</td>
<td>GA: 30-41 weeks</td>
<td></td>
<td>DoL at test: NK</td>
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</tr>
<tr>
<td></td>
<td>Detected by: RT-PCR</td>
<td>Symptomatic: No</td>
<td></td>
<td>Type of test: RT-PCR</td>
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</tr>
<tr>
<td></td>
<td>Mode of birth: CS (7), VB (5)</td>
<td>RT-PCR: Positive in 4</td>
<td></td>
<td>Results: Positive (3/6 samples)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antiviral medication NK</td>
<td>Immunoglobulin: ND</td>
<td></td>
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<tr>
<td>Author Type of Publication Country</td>
<td>Maternal Characteristics</td>
<td>Infant Characteristics</td>
<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
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<tr>
<td>Buonsenso et al (4, 5) Case series Italy</td>
<td>Number of confirmed mothers: 7 Trimester of infection: 3rd trimester (2) Symptomatic at birth: NK Detected by: RT-PCR Mode of birth: CS Antiviral medication: Yes</td>
<td>Number of infants: 2 BW: 2300-3390g GA: 35-38 weeks Symptomatic: No RT-PCR: Positive in 1 Immunoglobulin: ND</td>
<td>Both BMS in hospital, BF (1), EBM (1) at home</td>
<td>Number of mothers tested: 2 (1 mother tested positive) Number of milk samples tested: 20 DoL at test: 1-17 Type of test: RT-PCR Results: Positive (3/20 samples)</td>
<td>Only 2/7 mothers delivered during study period, one spontaneous abortion at 8 weeks. Both infants tested negative at birth. Infant 1 received BMS in hospital and BF at home had positive test on DoL 15. BM for this infant tested negative. Infant 2 tested negative throughout, received BMS in hospital and after discharge home, EBM was given. BM initially tested positive but negative from DoL 5. EBM given after negative tests.</td>
</tr>
<tr>
<td>Chambers et al (6) Case series USA</td>
<td>Number of confirmed mothers: 18 Trimester of infection: NK Symptomatic at birth: NK Detected by: RT-PCR Mode of birth: NK Antiviral medication: NK</td>
<td>Number of infants: 18 BW: NK GA: NK Symptomatic: Yes in 13 RT-PCR: Positive in 2 Immunoglobulin: ND</td>
<td>NK</td>
<td>Number of mothers tested: 18 (1 mother tested positive) Number of milk samples tested: 64 DoL at test: NA Type of test: RT-PCR Results of test: Positive (1/64 samples)</td>
<td>Infants’ age at sample collection between &lt;1 and 25 months. BM tested negative for infants who tested positive. BM RT-PCR positive before maternal test confirmed. Viral cultures (26 samples from 9 mothers) all negative.</td>
</tr>
<tr>
<td>Author</td>
<td>Type of Publication</td>
<td>Country</td>
<td>Maternal Characteristics</td>
<td>Infant Characteristics</td>
<td>Type of Feed Given</td>
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<tr>
<td>Chen et al(7)</td>
<td>Case series</td>
<td>China</td>
<td>Number of confirmed mothers: 9</td>
<td>Number of infants: 9</td>
<td>NK</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Trimester of infection: 3rd</td>
<td>BW: 1880-3730g GA: 36(^{0})- 39(^{4}) weeks</td>
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<td>Symptomatic: No</td>
<td>RT-PCR: All negative</td>
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<td>Immunoglobulin: ND</td>
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<td></td>
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<td>Antiviral medication: NK</td>
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<tr>
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<td>Number of infants: 1</td>
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<td></td>
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<td>Trimester of infection: 3rd (1)</td>
<td>BW: 2670g GA: 35(^{4})</td>
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<td>RT-PCR: Negative</td>
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<td>Immunoglobulin: ND</td>
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<td>Mode of birth: CS</td>
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<td>Antiviral medication: Yes</td>
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<tr>
<td>Cui et al(9)</td>
<td>Case report</td>
<td>China</td>
<td>Number of confirmed mothers: 1</td>
<td>Number of infants: 1</td>
<td>MF</td>
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<td>Trimester of infection: PN</td>
<td>BW: NA GA: NA Symptomatic: Yes</td>
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<td>RT-PCR: Positive</td>
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<td>Immunoglobulin: Positive</td>
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<td>Antiviral medication: NA</td>
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<td>De Socio et al(10)</td>
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<td>Italy</td>
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<td>Number of infants: 1</td>
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<td>Trimester of infection: 3rd</td>
<td>BW: NK GA: NK Symptomatic: No</td>
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<td>Symptomatic at birth: No</td>
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<td></td>
<td>Detected by: RT-PCR</td>
<td></td>
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</tr>
<tr>
<td>Author Type of Publication</td>
<td>Maternal Characteristics</td>
<td>Infant Characteristics</td>
<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
</tr>
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</tr>
<tr>
<td>Dong et al (11) Case report China</td>
<td>Number of confirmed mothers: 1 Trimester of infection: 3rd Symptomatic at birth: NK Detected by: RT-PCR Mode of birth: VB Antiviral medication: No</td>
<td>Number of infants: 1 BW: 3120g GA: 37(^{+6}) weeks Symptomatic: No RT-PCR: Negative Immunoglobulin: ND</td>
<td>NK</td>
<td>Number of mothers tested: 1 Number of milk samples tested: 1 DoL at test: 7 Type of test: RT-PCR Results: Negative</td>
<td>Mother tested positive 23 days before delivery. Infant IgG and IgM levels positive at 2 hours of age, with negative PCR.</td>
</tr>
<tr>
<td>Dong et al (12) Case report China</td>
<td>Number of confirmed mothers: 1 Trimester of infection: 3rd Symptomatic at birth: NK Detected by: RT-PCR Mode of birth: CS Antiviral medication: Yes</td>
<td>Number of infants: 1 BW: 2950g GA: 38(^{+2}) weeks Symptomatic: No RT-PCR: Negative Immunoglobulin: Yes</td>
<td>NK</td>
<td>Number of mothers tested: 1 Number of milk samples tested: 6 DoL at test: 12 Type of test: RT-PCR and antibody assay Results of test: PCR negative, Positive IgG (6/6), Positive IgA (4/6)</td>
<td>Infant serum IgG antibody positive. See table 2 for more details</td>
</tr>
<tr>
<td>Fan et al (13) Case series China</td>
<td>Number of confirmed mothers: 2 Trimester of infection: 3rd Symptomatic at birth: 1 Detected by: RT-PCR Mode of birth: CS</td>
<td>Number of infants: 2 BW: 2890-3400g GA: 36(^{+5})-38(^{+1}) weeks Symptomatic: Yes RT-PCR: All negative Immunoglobulin: ND</td>
<td>NK</td>
<td>Number of mothers tested: 2 Number of milk samples tested: NK DoL at test: 2 Type of test: RT-PCR Results: All negative</td>
<td>Both infants had respiratory symptoms and lymphopenia, one had low-grade fever.</td>
</tr>
<tr>
<td>Author Type of Publication</td>
<td>Maternal Characteristics</td>
<td>Infant Characteristics</td>
<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
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<tr>
<td>Fenizia et al (14) Case series Italy</td>
<td>Antiviral medication: Yes</td>
<td>Number of confirmed mothers: 31 Trimester of infection: 3rd Symptomatic at birth: NK Detected by: RT-PCR Mode of birth: VB (25), CS (6)</td>
<td>Number of infants: 31 BW: 2180-4165g GA: NK (1 preterm) Symptomatic: RT-PCR: Positive in 2 Immunoglobulin: IgG in 12, IgM in 1 (cord blood)</td>
<td>Number of mothers tested: 11 for RT-PCR, 10 for IgG &amp; IgM (1 mother positive) Number of milk samples tested: RT-PCR (11), IgG (10), IgM (10) DoL at test: 5 Type of test: RT-PCR, IgG, IgM Results: Positive both RT-PCR and IgM. Negative IgG</td>
<td>One mother tested positive for both RT-PCR and IgM in BM. IgG was negative. Infant tested negative. All infants reported to be healthy</td>
</tr>
<tr>
<td>Gao et al (15) Case series China</td>
<td>Antiviral medication: NK</td>
<td>Number of confirmed mothers: 12 Trimester of infection: 3rd Symptomatic at birth: NK Detected by: RT-PCR Mode of birth: VB (2), CS (12)</td>
<td>Number of infants: 14 BW: 2700-4120g GA: 364-411 weeks RT-PCR: All negative Immunoglobulin: IgG in 4 (1 cord blood), IgM in 1</td>
<td>BMS, EBM, BF</td>
<td>Number of mothers tested: 10 Number of milk samples tested: 10 DoL at test: NK Type of test: RT-PCR, IgG, IgM Results: RT-PCR all negative and IgG positive (2/10), IgM positive in (2/10)</td>
</tr>
<tr>
<td>Groβ et al (16) Case series Germany</td>
<td></td>
<td>Number of confirmed mothers: 2 Trimester of infection: PN Symptomatic at birth: No</td>
<td>Number of infants: 2 BW: NK GA: NK Symptomatic: Yes (2)</td>
<td>BF</td>
<td>Number of mothers tested: 2 (1 mother tested positive) Number of milk samples tested: 11</td>
</tr>
<tr>
<td>Author, Type of Publication, Country</td>
<td>Maternal Characteristics</td>
<td>Infant Characteristics</td>
<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
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<tr>
<td>Han et al (17), Case report, South Korea</td>
<td>Number of confirmed mothers: 1</td>
<td>Number of infants: 1</td>
<td>BF</td>
<td>Number of mothers tested: 1, Number of milk samples tested: 1</td>
<td>Infant was 27 days old, had fever, tachycardia and vomiting. No respiratory distress or need for oxygen.</td>
</tr>
<tr>
<td>Hinojosa-Velasco et al (18), Case report, Mexico</td>
<td>Number of confirmed mothers: 1</td>
<td>Number of infants: 1</td>
<td>BMS, BF</td>
<td>Number of mothers tested: 1, Number of milk samples tested: 2</td>
<td>Maternal BM given only after infant tested positive</td>
</tr>
<tr>
<td>Kalafat et al (19), Case report, Turkey</td>
<td>Number of confirmed mothers: 1</td>
<td>Number of infants: 1</td>
<td>NK</td>
<td>Number of mothers tested: 1, Number of milk samples tested: 1</td>
<td></td>
</tr>
<tr>
<td>Author Type of Publication</td>
<td>Maternal Characteristics</td>
<td>Infant Characteristics</td>
<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
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<tr>
<td>Kam et al(20) Case report Singapore</td>
<td>Number of confirmed mothers: 1 Trimester of infection: PN Symptomatic at birth: NA Detected by: RT-PCR Mode of birth: NK Antiviral medication: NA</td>
<td>Number of infants: 1 BW: NA GA: NA Symptomatic: Yes RT-PCR: Positive Immunoglobulin: Positive</td>
<td>NK</td>
<td>Number of mothers tested: 1 Number of milk samples tested: NK DoL at test: 6 months Type of test: RT-PCR Results: Negative</td>
<td>6 month age infant with one episode of fever at time of positive testing. No respiratory support required.</td>
</tr>
<tr>
<td>Kirtsman et al(21) Case report Canada</td>
<td>Number of confirmed mothers: 1 Trimester of infection: 3rd Symptomatic at birth: Yes Detected by: RT-PCR Mode of birth: CS Antiviral medication: No</td>
<td>Number of infants: 1 BW: 2930g GA: 35+5 weeks Symptomatic: Yes RT-PCR: Positive Immunoglobulin: ND</td>
<td>BF</td>
<td>Number of mothers tested: 1 Number of milk samples tested: 1 DoL at test: 2 &amp; 7 Type of test: RT-PCR Results: Positive (1/2 samples)</td>
<td>Infant was neutropenic and had mild hypothermia and feeding difficulties. Required NICU stay for management of hypoglycaemia. See table 1 for more details</td>
</tr>
<tr>
<td>Lang et al(22) Case report China</td>
<td>Number of confirmed mothers: 1 Trimester of infection: 3rd Symptomatic at birth: Yes Detected by: RT-PCR Mode of birth: CS Antiviral medication: Yes</td>
<td>Number of infants: 1 BW: NK GA: 35+4 weeks Symptomatic: No RT-PCR: Negative Immunoglobulin: ND</td>
<td>NK</td>
<td>Number of mothers tested: 1 Number of milk samples tested: NK DoL at test: 2 Type of test: RT-PCR Results: Negative</td>
<td></td>
</tr>
<tr>
<td>Lei et al(23) Case series China</td>
<td>Number of confirmed mothers: 9 Trimester of infection: 2nd trimester (4), 3rd trimester</td>
<td>Number of infants: 4 BW: 2350-3400g GA: 34+2 – 37 weeks Symptomatic: No</td>
<td>NK</td>
<td>Number of mothers tested: 4 Number of milk samples tested: 4 DoL at test: NK Type of test: RT-PCR</td>
<td>Only 4/9 mothers delivered during the study period. One pregnancy was terminated.</td>
</tr>
<tr>
<td>Author Type of Publication Country</td>
<td>Maternal Characteristics</td>
<td>Infant Characteristics</td>
<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
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<tr>
<td>Li et al (24) Case report, China</td>
<td>Number of confirmed mothers: 1 &lt;br&gt; Trimester of infection: 3&lt;sup&gt;rd&lt;/sup&gt; &lt;br&gt; Symptomatic at birth: No &lt;br&gt; Detected by: RT-PCR &lt;br&gt; Mode of birth: CS (3), VB (1) &lt;br&gt; Antiviral medication: Yes</td>
<td>Number of infants: 1 &lt;br&gt; BW: NK &lt;br&gt; GA: 35±2 weeks &lt;br&gt; Symptomatic: No</td>
<td>RT-PCR: All negative Immunoglobulin: ND</td>
<td>Results: All negative</td>
<td></td>
</tr>
<tr>
<td>Liu et al (25) Case series (Preprint), China</td>
<td>Number of confirmed mothers: 3 &lt;br&gt; Trimester of infection: 3&lt;sup&gt;rd&lt;/sup&gt; &lt;br&gt; Symptomatic at birth: Yes (2), No (1) &lt;br&gt; Detected by: RT-PCR &lt;br&gt; Mode of birth: CS (2), VB (1) &lt;br&gt; Antiviral medication: Yes (PN)</td>
<td>Number of infants: 3 &lt;br&gt; BW: 3250-3670g &lt;br&gt; GA: 38±4 – 40 weeks &lt;br&gt; Symptomatic: No</td>
<td>RT-PCR: All negative Immunoglobulin: ND</td>
<td>Number of mothers tested: 1 &lt;br&gt; Number of milk samples tested: 3 &lt;br&gt; DoL at test: 1-3 &lt;br&gt; Type of test: RT-PCR &lt;br&gt; Results: Negative</td>
<td>Mothers received postpartum antiviral medication</td>
</tr>
<tr>
<td>Lugli et al (26) Case report</td>
<td>Number of confirmed mothers: 1 &lt;br&gt; Trimester of infection: PN &lt;br&gt; Symptomatic at birth: No</td>
<td>Number of infants: 1 &lt;br&gt; BW: 1614g &lt;br&gt; GA: 32 weeks &lt;br&gt; Symptomatic: No</td>
<td>EBM</td>
<td>Number of mothers tested: 1 &lt;br&gt; Number of milk samples tested: 2 &lt;br&gt; DoL at test: 9 &lt;br&gt; Type of test: RT-PCR</td>
<td>First sample taken without any precautions, second taken with strict precautions</td>
</tr>
<tr>
<td>Author</td>
<td>Maternal Characteristics</td>
<td>Infant Characteristics</td>
<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
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</tr>
<tr>
<td>Luo et al (27)</td>
<td>Number of confirmed mothers: 14</td>
<td>Number of infants: 14</td>
<td>BF (1), AF (13)</td>
<td>Number of mothers tested: 14</td>
<td>Four confirmed mothers had both serum and BM antibody testing. 3/4 had positive serum IgG and IgM before delivery and 4/4 had positive serum IgM post-delivery. See table 2 for details.</td>
</tr>
<tr>
<td></td>
<td>Trimester of infection: 3rd trimester (12), PN (2)</td>
<td>BW: NK</td>
<td>RT-PCR, 4 antibodies</td>
<td>Number of milk samples tested: 14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Symptomatic at birth: NK</td>
<td>GA: NK (3 preterm)</td>
<td>Number of milk samples tested: 14</td>
<td>DoL at test: 1-15 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Detected by: RT-PCR</td>
<td>RT-PCR: Positive</td>
<td>Type of test: RT-PCR and ELISA</td>
<td>Results: PCR all Negative, IgG Negative, IgM Positive (4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mode of birth: CS (12), VB (2)</td>
<td>Immunoglobulin: ND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antiviral medication: Yes (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mao et al (28)</td>
<td>Number of confirmed mothers: 1</td>
<td>Number of infants: 1</td>
<td>BF</td>
<td>Number of mothers tested: 1</td>
<td>14 month old child with fever and coryza</td>
</tr>
<tr>
<td></td>
<td>Trimester of infection: PN</td>
<td>BW: NK</td>
<td></td>
<td>Number of milk samples tested: NK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Symptomatic at birth: NA</td>
<td>GA: NK</td>
<td></td>
<td>DoL at test: 14 months</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Detected by: RT-PCR</td>
<td>RT-PCR: Positive</td>
<td>Type of test: RT-PCR</td>
<td>Results: Negative</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mode of birth: NA</td>
<td>Immunoglobulin: ND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antiviral medication: NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marín Gabriel et al (29)</td>
<td>Number of confirmed mothers: 7</td>
<td>Number of infants: 7</td>
<td>NK</td>
<td>Number of mothers tested: 7</td>
<td>Samples collected were colostrum</td>
</tr>
<tr>
<td></td>
<td>Trimester of infection: 3rd trimester</td>
<td>BW: 2866-4574g</td>
<td></td>
<td>Number of milk samples tested: 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Symptomatic at birth: Yes (1)</td>
<td>GA: 38<em>3 – 41</em>2 weeks</td>
<td>Type of test: RT-PCR</td>
<td>DoL at test: 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Detected by: RT-PCR</td>
<td>RT-PCR: All negative</td>
<td>Results: Negative</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Immunoglobulin: ND</td>
<td></td>
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</tr>
</tbody>
</table>

Results: PCR all Negative, IgG Negative, IgM Positive (4)

Four confirmed mothers had both serum and BM antibody testing. 3/4 had positive serum IgG and IgM before delivery and 4/4 had positive serum IgM post-delivery. See table 2 for details.

Samples collected were colostrum
<table>
<thead>
<tr>
<th>Author Type of Publication</th>
<th>Maternal Characteristics</th>
<th>Infant Characteristics</th>
<th>Type of Feed Given</th>
<th>Testing of Breast Milk</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menter et al (30) Case series Switzerland</td>
<td>Mode of birth: VB (6), CS (1) Antiviral medication: No</td>
<td></td>
<td></td>
<td></td>
<td>One infant had hypothermia</td>
</tr>
<tr>
<td>Number of confirmed mothers: 5</td>
<td></td>
<td>Number of infants: 5</td>
<td>BF (2) MF (3)</td>
<td>Number of mothers tested: 5</td>
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</tr>
<tr>
<td>Trimester of infection: 3rd</td>
<td></td>
<td>BW: 2790-3500g</td>
<td>Number of milk samples tested: 5</td>
<td>Number of milk samples tested: 5</td>
<td></td>
</tr>
<tr>
<td>Symptomatic at birth: Yes</td>
<td>GA: 39^{10} – 40^{15} weeks</td>
<td>RT-PCR: NK</td>
<td>DoL at test: NK</td>
<td>Antiviral medication: No</td>
<td></td>
</tr>
<tr>
<td>Detected by: RT-PCR</td>
<td>Symptomatic: Yes (1)</td>
<td>Immunoglobulin: ND</td>
<td>Type of test: RT-PCR</td>
<td>Mode of birth: VB (3), CS (2)</td>
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</tr>
<tr>
<td>Mode of birth: VB</td>
<td></td>
<td>RT-PCR: Negative</td>
<td>Results: Negative</td>
<td>Antiviral medication: No</td>
<td></td>
</tr>
<tr>
<td>Number of mothers tested: 5</td>
<td></td>
<td>Immunoglobulin: Yes</td>
<td></td>
<td>Number of infants tested: 5</td>
<td></td>
</tr>
<tr>
<td>Number of milk samples tested: 5</td>
<td></td>
<td>DoL at test: NK</td>
<td></td>
<td>Antiviral medication: No</td>
<td></td>
</tr>
<tr>
<td>Molina et al (31) Case report USA</td>
<td></td>
<td>Number of mothers tested: 1</td>
<td>NK</td>
<td>First maternal positive PCR</td>
<td></td>
</tr>
<tr>
<td>Number of confirmed mothers: 1</td>
<td></td>
<td>BW: 3810g</td>
<td>Number of milk samples tested: 1</td>
<td>and symptoms at 28^{12} weeks,</td>
<td></td>
</tr>
<tr>
<td>Trimester of infection: 3rd</td>
<td></td>
<td>GA: 38^{11} weeks</td>
<td>NK</td>
<td>and remained positive for 104</td>
<td></td>
</tr>
<tr>
<td>Symptomatic at birth: No</td>
<td></td>
<td>Symptomatic: No</td>
<td>DoL at test: NK</td>
<td>days. Cord blood positive for IgG</td>
<td></td>
</tr>
<tr>
<td>Detected by: RT-PCR</td>
<td></td>
<td>RT-PCR: Negative</td>
<td>Type of test: RT-PCR</td>
<td>antibodies.</td>
<td></td>
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<tr>
<td>Mode of birth: VB</td>
<td></td>
<td>Immunoglobulin: Yes</td>
<td>Results of test: Negative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antiviral medication: No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of mothers tested: 1</td>
<td></td>
<td>Number of milk samples tested: 1</td>
<td>NK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of milk samples tested: 1</td>
<td></td>
<td>DoL at test: NK</td>
<td>Type of test: RT-PCR</td>
<td></td>
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<tr>
<td>DoL at test: NK</td>
<td></td>
<td>Results of test: Negative</td>
<td></td>
<td></td>
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<tr>
<td>Oncel et al (32) Cohort study Turkey</td>
<td></td>
<td>Number of mothers tested: 125</td>
<td>BF (9), EBM (45), BMS (71)</td>
<td>Positive test on 3/4 infants on</td>
<td></td>
</tr>
<tr>
<td>Number of confirmed mothers: 125</td>
<td></td>
<td>BW: 1480-3415g</td>
<td>Number of milk samples tested: 6</td>
<td>DoL 2-5, 1/4 infant positive on</td>
<td></td>
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<tr>
<td>Trimester of infection: NK</td>
<td></td>
<td>GA: 26-39 weeks</td>
<td>DoL at test: NK</td>
<td>DoL 1. Three infants required</td>
<td></td>
</tr>
<tr>
<td>Symptomatic at birth: NK</td>
<td></td>
<td>Symptomatic: Yes in 3</td>
<td>Type of test: RT-PCR</td>
<td>CPAP. All 4 became negative</td>
<td></td>
</tr>
<tr>
<td>Detected by: RT-PCR</td>
<td></td>
<td>RT-PCR: Positive in 4</td>
<td>Results of test: Negative</td>
<td>on DoL 6-11. None of these 4</td>
<td></td>
</tr>
<tr>
<td>Mode of birth: CS (89), VB</td>
<td></td>
<td>Immunoglobulin: ND</td>
<td></td>
<td>infants received BF/EBM.</td>
<td></td>
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<tr>
<td>Author</td>
<td>Maternal Characteristics</td>
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<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
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<tr>
<td>Author</td>
<td>Maternal Characteristics</td>
<td>Infant Characteristics</td>
<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
</tr>
<tr>
<td>Pace et al(33)</td>
<td>Number of confirmed mothers: 18</td>
<td>Number of infants: 18</td>
<td>BF (5), MF (13)</td>
<td>Number of mothers tested: 18</td>
<td>See table 2 for more details.</td>
</tr>
<tr>
<td>Case series</td>
<td>Trimester of infection: NK</td>
<td>BW: 3372 ± 560g</td>
<td></td>
<td>Number of milk samples tested: 37</td>
<td></td>
</tr>
<tr>
<td>(Preprint)</td>
<td>Symptomatic at birth: NK</td>
<td>GA: 38.6 ± 1.7 weeks</td>
<td></td>
<td>DoL at test: NK</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>Detected by: RT-PCR</td>
<td>Symptomatic: NK</td>
<td></td>
<td>Type of test: RT-PCR, IgA, IgG</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mode of birth: CS</td>
<td>RT-PCR: Positive in 2</td>
<td>Number of milk</td>
<td>Results: PCR Negative, IgA Positive (37/37 samples), IgM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Antiviral medication: NK</td>
<td>Immunoglobulin: ND</td>
<td>samples tested:</td>
<td>Positive (37/37 samples)</td>
<td></td>
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<tr>
<td></td>
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<td>37</td>
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<td>DoL at test: 2-14</td>
<td>Type of test:</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td>RT-PCR</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Results: Negative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peng et al(34)</td>
<td>Number of confirmed mothers: 1</td>
<td>Number of infants: 1</td>
<td>NK</td>
<td>Number of mothers tested: 1</td>
<td>Infant presented with respiratory distress after birth requiring CPAP</td>
</tr>
<tr>
<td>Case report</td>
<td>Trimester of infection: 3rd</td>
<td>BW: 2600g</td>
<td></td>
<td>Number of milk samples tested: 8</td>
<td>and surfactant.</td>
</tr>
<tr>
<td>China</td>
<td>Symptomatic at birth: NK</td>
<td>GA: 35\textsuperscript{+} weeks</td>
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<td>Mode of birth: CS</td>
<td>RT-PCR: Negative</td>
<td>Number of milk</td>
<td>Results: Negative</td>
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<tr>
<td></td>
<td>Antiviral medication: Yes</td>
<td>Immunoglobulin: ND</td>
<td>samples tested:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td></td>
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</tr>
<tr>
<td>Peng et al(35)</td>
<td>Number of confirmed mothers: 24</td>
<td>Number of infants: 25</td>
<td>BF (1), BMS (10),</td>
<td>Number of mothers tested: 16</td>
<td>Milk samples were collected from confirmed cases. Total 44 samples were</td>
</tr>
<tr>
<td>Cohort study</td>
<td>Trimester of infection: 3rd</td>
<td>BW: 3000 ± 500g</td>
<td>MF (13)</td>
<td>Number of milk samples tested: 44</td>
<td>tested but only 38 samples underwent both RT-PCR and ELISA tests.</td>
</tr>
<tr>
<td>(Preprint)</td>
<td>Symptomatic at birth: Yes in</td>
<td>GA: 38.2 ± 2.1 weeks</td>
<td>(RT-PCR), 38 (antibodies)</td>
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<tr>
<td>China</td>
<td></td>
<td>Symptomatic: No</td>
<td></td>
<td></td>
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</tr>
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<td></td>
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<td>RT-PCR: NK</td>
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<td>Infant Characteristics</td>
<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
</tr>
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<td>15</td>
<td></td>
<td>Immunoglobulin: ND</td>
<td>DoL at test: 3-70 days</td>
<td>Type of test: RT-PCR, ELISA</td>
<td>See table 2 for more details</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Results: Negative, IgM Positive (21/38 samples)</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Perrone et al(36)</td>
<td>Case report</td>
<td>Number of confirmed mothers: 1</td>
<td>Number of infants: 1</td>
<td>EBM &amp; BF</td>
<td>Mother developed symptoms 11 days postpartum. Infant was premature and required 24 hours of CPAP at birth.</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td>Trimester of infection: PN</td>
<td>BW: NK, GA: 32 weeks</td>
<td>Number of mothers tested: 1</td>
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<td>Symptomatic: NK</td>
<td>Number of milk samples tested: 1</td>
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<tr>
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<td>RT-PCR: Negative</td>
<td>DoL at test: 13</td>
<td></td>
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<td>Mode of birth: NK</td>
<td>Immunoglobulin: ND</td>
<td>Type of test: RT-PCR</td>
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<td>Antiviral medication: NA</td>
<td></td>
<td>Results: Negative</td>
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<tr>
<td>Piersigilli et al(37)</td>
<td>Case report</td>
<td>Number of confirmed mothers: 1</td>
<td>Number of infants: 1</td>
<td>EBM</td>
<td>First neonatal test at DoL 7, positive on repeat on DoL 14 but negative at DoL 21. Infant had leucopenia and lymphopenia.</td>
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<tr>
<td>Belgium</td>
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<td>Trimester of infection: PN</td>
<td>BW: 960g, GA: 26^{4} weeks</td>
<td>Number of mothers tested: 1</td>
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<tr>
<td>Preßler et al(38)</td>
<td>Case series</td>
<td>Number of confirmed mothers: 5</td>
<td>Number of infants: 5</td>
<td>NK</td>
<td>Mother with BM IgG positive had symptomatic infant but negative RT-PCR test. One symptomatic infant with positive RT-PCR had positive serum IgA at 4-5 weeks. The</td>
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<tr>
<td>Germany</td>
<td></td>
<td>Trimester of infection: PN</td>
<td>BW: NK, GA: NK</td>
<td>Number of mothers tested: NK</td>
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<td>Symptomatic: Yes in 3</td>
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<td>RT-PCR: Positive in 2</td>
<td>DoL at test: NK</td>
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<td></td>
<td></td>
<td>Mode of birth: NK</td>
<td>Immunoglobulin:</td>
<td>Type of test: antibody assay</td>
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<td></td>
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<td>Results: Positive IgG in 1 mother</td>
<td></td>
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</tbody>
</table>

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**Arch Dis Child Fetal Neonatal Ed**

**doi: 10.1136/archdischild-2020-321074–8.**

**Arch Dis Child Fetal Neonatal Ed, et al. Zhu F**
<table>
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<tr>
<th>Author Type of Publication Country</th>
<th>Maternal Characteristics</th>
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<td>Sahin et al(39) Cohort study Turkey</td>
<td>Antiviral medication: NK</td>
<td>Positive in 1</td>
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<td></td>
<td>GA: 31-40 weeks</td>
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<td>RT-PCR: All negative</td>
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<td>Number of mothers tested: 10</td>
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<td>Number of milk samples tested: NK</td>
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<td>Results: Negative</td>
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<tr>
<td></td>
<td>Only 10/29 mothers delivered during study period.</td>
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<td>Detected by: RT-PCR</td>
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<tr>
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<td>Mode of birth: NK</td>
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<tr>
<td></td>
<td>Antiviral medication: NK</td>
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<td>Number of infants: 2</td>
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<td>BW: 3120-4440g</td>
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<td>GA: 39-41&lt;sup&gt;±2&lt;/sup&gt; weeks</td>
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<td>RT-PCR: Positive in both</td>
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<td>Immunoglobulin: ND</td>
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<tr>
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<td>Number of milk samples tested: NK</td>
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<td>DoL at test: NK</td>
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<td>Type of test: RT-PCR</td>
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<tr>
<td></td>
<td>Results: All negative</td>
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<tr>
<td></td>
<td>Infants were admitted on DoL 10-18</td>
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<tr>
<td></td>
<td>One infant had diarrhoea and required intravenous fluids until day 5 of admission.</td>
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<tr>
<td>Schoenmakers et al(41) Case report Netherlands</td>
<td>Number of confirmed mothers: 1</td>
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<td>Trimester of infection: 3&lt;sup&gt;rd&lt;/sup&gt;</td>
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<td></td>
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<tr>
<td></td>
<td>Number of infants: 1</td>
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</tr>
<tr>
<td></td>
<td>BW: NK</td>
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<tr>
<td></td>
<td>GA: NK</td>
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<td>Symptomatic: Yes</td>
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<tr>
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<td>Number of mothers tested: 1</td>
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<td>DoL at test: 3</td>
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<td>Type of test: RT-PCR</td>
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<tr>
<td></td>
<td>Premature infant, with multi-organ failure, PPHN, and hypotension. Suspected pediatric inflammatory</td>
<td></td>
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<tr>
<td>Author</td>
<td>Maternal Characteristics</td>
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<td>Type of Feed Given</td>
<td>Testing of Breast Milk</td>
<td>Comments</td>
</tr>
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</tbody>
</table>
| Tam et al(42)     | Number of confirmed mothers: 1  
Mode of birth: NA  
Trimester of infection: PN  
Symptomatic at birth: NA  
Detected by: RT-PCR | Number of infants: 1  
BW: NA  
GA: NA  
Symptomatic: Yes  
RT-PCR: Positive  
Immunoglobulin: ND | BF  
Number of mothers tested: 1  
Number of milk samples tested: 7  
DoL at test: NA  
Type of test: RT-PCR  
Results: Positive (2/7 samples from one mother) | Postnatal infection of 8 month old with cough and coryzal symptoms.  
See table 1 for more details |
| Van Keulen et al(43) | Number of confirmed mothers: 29  
Mode of birth: NK  
Trimester of infection: NK  
Symptomatic at birth: NK  
Detected by: RT-PCR | Number of infants: 29  
BW: NK  
GA: 38^{14} – 40^{15} weeks  
Symptomatic: NK  
RT-PCR: NK  
Immunoglobulin: NK | NK  
Number of mothers tested: 29  
Number of milk samples tested: 29  
DoL at test: 12 – 39 weeks  
Type of test: Total Ig and IgA  
Results: Positive (24/29 samples) | BM RT-PCR not tested.  
See table 2 for more details. |
| Walczak et al(44) | Number of confirmed mothers: 1  
Mode of birth: Yes  
Trimester of infection: 3rd  
Symptomatic at birth: Yes  
Detected by: RT-PCR | Number of infants: 1  
BW: 3770g  
GA: 40^{11} weeks  
Symptomatic: NK  
RT-PCR: Negative | NK  
Number of mothers tested: 1  
Number of milk samples tested: NK  
DoL at test: NK  
Type of test: RT-PCR, IgA, IgG, IgM | Authors state immunoassay not validated for sample type.  
Serum immunoglobulin (parent) positive for IgG and IgM |
<table>
<thead>
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<th>Author</th>
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<th>Infant Characteristics</th>
<th>Type of Feed Given</th>
<th>Testing of Breast Milk</th>
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<td>Wang et al(45)</td>
<td>Case report</td>
<td>China</td>
<td>Number of confirmed mothers: 1</td>
<td>Mode of birth: VB</td>
<td>Immunoglobulin: ND</td>
<td>IgM</td>
<td>Results: Negative RT-PCR; Positive IgA, IgG and IgM</td>
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<td>GA: 40^1 weeks</td>
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<td>Immunoglobulin: ND</td>
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<td>Wu et al(46)</td>
<td>Case series</td>
<td>China</td>
<td>Number of confirmed mothers: 13</td>
<td>Mode of birth: CS</td>
<td>BMS</td>
<td>Number of mothers tested: 1</td>
<td>Only 5/13 mothers delivered. Repeat BM test subsequently all negative. See table 1 for more details</td>
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<td>Number of milk samples tested: 1</td>
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<td>Symptomatic at birth: Yes in 1</td>
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<td>GA: 35^5 – 38^4 weeks</td>
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| Zhuang et al(51)  
Case report  
China                     | Mode of birth: CS (4), VB (1)  
Antiviral medication: NK | Number of confirmed mothers: 1  
Trimester of infection: 3rd  
Symptomatic at birth: Yes  
Detected by: RT-PCR  
Mode of birth: CS  
Antiviral medication: Yes | Number of infants: 1  
BW: 2870g  
GA: 37+2  
Symptomatic: No  
RT-PCR: Negative  
Immunoglobulin: ND | BMS | Number of mothers tested: 1  
Number of milk samples tested: 1  
DoL at test: 5  
Type of test: RT-PCR  
Results of test: Negative |

Abbreviations: BF, breastfeeding; BM, breastmilk; BMS, breastmilk substitute; BW, birth weight; CPAP, continuous positive airway pressure; CS, caesarean section; DoL, day of life; EBM, expressed breastmilk; ELISA, enzyme linked immunosorbent assays; GA, gestational age; IQR, interquartile range; MF, mixed breastmilk and breastmilk substitute feeds; NA, not applicable; NICU, neonatal intensive care unit; NK, not done; NK, not known; PN, postnatal; PPHN, persistent pulmonary hypertension of the newborn; RT-PCR, real time polymerase chain reaction; VB, vaginal birth.

* Information collated from 2 papers by Buonsenso et al and Costa et al: same cases were reported in 2 separate papers.
### eTable 3. Risk of Bias for Included Studies

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Abbreviation: NA, not applicable.

*Information collated from 2 papers by Buonsenso et al and Costa et al: same cases were reported in 2 separate papers.

Risk of bias based on Joanna Briggs Institute Critical Appraisal Tool for case reports and case series.

Refer to methods section for details of assessment.
REFERENCES


27. Luo Q, Chen L, Yao D, et al. Safety of Breastfeeding in Mothers with SARS-CoV-2 Infection. medRxiv


