Recommendations for breastfeeding during Coronavirus Disease 2019 (COVID-19) pandemic

Xiyao Liu†, Haoyue Chen†, Meijing An, Wangxing Yang, Yujie Wen, Zhihuan Cai, Lulu Wang and Qianling Zhou*

Abstract

Background: Coronavirus Disease 2019 (COVID-19) has spread worldwide. The safety of breastfeeding of SARS-CoV-2-positive women has not yet reached a consensus among the scientific community, healthcare providers, experts in lactation care, health organizations and governments. This study was conducted to summarize the latest evidence about the safety of breastfeeding among suspected/confirmed infected mothers and to summarize the recommendations on breastfeeding during COVID-19 from different organizations.

Methods: A comprehensive literature review of publications about the safety of breastfeeding among SARS-CoV-2-infected mothers was conducted. Scientific databases were searched up to 26 May 2021. The evidence was summarized into five perspectives according to a framework proposed by van de Perre et al. with certain modifications. Moreover, websites of different health organizations were visited to gather the recommendations for breastfeeding.

Results: The current evidence demonstrated that the majority of infants breastfed by infected mothers were negative for SARS-CoV-2. Breast milk samples from suspected/infected mothers mainly demonstrated negative results in SARS-CoV-2 viral tests. There was insufficient evidence proving the infectivity of breast milk from infected mothers. Recent studies found other transmission modalities (e.g., milk containers, skin) associated with breastfeeding. Specific antibodies in the breast milk of infected mothers were also found, implying protective effects for their breastfed children. According to van de Perre’s criteria, the breast milk of infected mothers was unlikely to transmit SARS-CoV-2. Owing to the low quality of the current evidence, studies with a more robust design are needed to strengthen the conclusion regarding the safety of breastfeeding. Further studies to follow up the health status of infants who were directly breastfed by their suspected/infected mothers, to collect breast milk samples at multiple time points for viral tests and to examine specific antibodies in breast milk samples are warranted. Current recommendations on breastfeeding during COVID-19 from different organizations are controversial, while direct breastfeeding with contact precautions is generally suggested as the first choice for infected mothers.

Conclusions: This review determined the safety of breastfeeding and identified the focus for further research during the COVID-19 pandemic. Recommendations on breastfeeding are suggested to be updated in a timely manner according to the latest evidence.

Keywords: COVID-19, SARS-CoV-2, Breastfeeding, Safety, Recommendation, Review

Background

Coronavirus Disease 2019 (COVID-19) is a viral infection caused by a novel coronavirus named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) [1].

© The Author(s) 2022. Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated in a credit line to the data.
COVID-19 was characterized as a global pandemic by the World Health Organization (WHO) in March 2020 [2]. To date, COVID-19 is still epidemic in most areas of the world, such as Europe, the Americas, and Southeast Asia [3]. The pandemic is more serious in the Americas (contributing to 38.2% of cases and 46.1% of deaths) than in other areas. The North American region accounted for the highest proportions of cases (76%) and deaths (72%). The number of confirmed infected cases was 243,327,429 globally as of 23 October 2021, including 4,943,742 (2.03%) deaths [4].

Pregnant women and young children are susceptible to COVID-19 [5, 6]. During pregnancy, some adaptive immune responses in pregnant women are downregulated (e.g., the decrease in the number of T cells and B cells) [7]. Additionally, the upper respiratory tract tends to be swollen due to high levels of estrogen and progesterone, and restricted lung expansion makes pregnant women susceptible to respiratory pathogens [5]. As newborns do not have antibodies against coronaviruses, they are theoretically more vulnerable to SARS-CoV-2 infection [6]. Therefore, lactation among infected mothers deserves special attention during this pandemic. Although the benefits of breastfeeding for mothers and children have been well acknowledged [8], SARS-CoV-2-positive women are still concerned about the risks of virus transmission from mother to infant during breastfeeding [9]. There were two reviews on breastfeeding and COVID-19 published in 2020. Both recommended breastfeeding among infected mothers [10, 11]. However, much new evidence emerged in the following year. A comprehensive summary of the current evidence verifying the safety of breastfeeding among SARS-CoV-2-positive women is still needed. Moreover, recommendations put forwards by different national authorities and health organizations have been updated [8, 10, 12–16].

Evidence on the safety of breast milk from SARS-CoV-2-infected mothers and recommendations of breastfeeding practices that have not yet reached a consensus may lead to anxiety and affect the health and survival of young children.

To determine the plausibility of viral transmission by breast milk, van de Perre et al. [17] established an analytical framework using the underlying principles of Koch’s postulate. The framework was proposed to help clarify the relationship between breastfeeding exposure and viral infections and was based on five criteria: viral infection in children breastfed by infected mothers; the presence of virus/antigen/genome in the breast milk of infected mothers; the infectivity of virus in breast milk; attempts to rule out other transmission modalities; and the reproduction of transmission by breast milk in an animal model. If five criteria were met, there was 100% possibility of virus transmission. If four criteria were met, virus transmission was very likely to occur. If three criteria were met, virus transmission was possible. If two criteria and even fewer were met, virus transmission was unlikely [17].

The present review was conducted to summarize 1) the latest evidence about the safety of breastfeeding among SARS-CoV-2-infected mothers and 2) the recommendations on breastfeeding from different organizations during the COVID-19 pandemic. The analytical framework by van de Perre et al. [17] was adopted in the present review to summarize the existing evidence. In the current literature, animal studies about breastfeeding and SARS-CoV-2 transmission were not available. However, there have been studies reporting SARS-CoV-2-specific antibodies in the breast milk of infected mothers. As a result, modification of van de Perre’s framework [17] was made in the present review. This review might be useful to ensure optimal infant feeding practices, as well as maternal and child health over the critical period of the COVID-19 pandemic.

**Methods**

**Search strategy and selection criteria**

A comprehensive literature review of the publications on breastfeeding during COVID-19 to date was conducted. The scope of the literature search included databases of journal articles and official websites of the health organizations. Due to the authors’ language literacy, articles and recommendations written in English and Chinese were included.

Databases including PubMed, Scopus, Embase, Web of Science, Cochrane Library, China National Knowledge Infrastructure (CNKI), and WANFANG DATA were searched up to 26 May 2021 regarding the evidence about the safety of breastfeeding among SARS-CoV-2-infected mothers. The key words for searching included “COVID-19”, “SARS-CoV-2”, “breastfeeding”, “formula feeding”, “breast milk”, “human milk”, “antibodies”, “antiviral”, “pregnant”, “infant”, “neonate”, and “newborn”. The reference lists of retrieved reviews were also manually searched. Journal articles, including those published online ahead of print, were included. The inclusion criteria were as follows: (1) the subjects were lactating mothers diagnosed with COVID-19 or SARS-CoV-2 infection; and (2) the study outcome was the safety of breast milk and/or the wellbeing of infants. The exclusion criteria were (1) conference abstracts, preprints, comments, and letters; (2) studies not published in Chinese or English; (3) studies for which the full text was not retrievable; (4) irrelevant studies; and (5) incomplete studies or studies without outcome information. Two researchers (XL and HC) independently searched, screened, and reviewed the literature. Disagreements were resolved by consulting a
third researcher (MA). The evidence included in the present review was then summarized into five perspectives according to van de Perre’s framework [17] with certain modifications.

For recommendations, official websites of medical institutions and governmental and nongovernmental organizations were searched, including the American Academy of Pediatrics (AAP), Academy of Breastfeeding Medicine (ABM), U.S. Centers for Disease Control and Prevention (CDC), Italian National Institute of Health (ISS), International Society of Ultrasound in Obstetrics and Gynecology (ISUOG), National Health Commission of the People’s Republic of China, Royal College of Obstetricians and Gynecologists (RCOG), United Nations International Children’s Emergency Fund (UNICEF), and WHO. The recommendations were then summarized into a table.

**Results**

**Evidence about the safety of breastfeeding**

A total of 2677 articles were identified by the comprehensive literature search. After excluding duplicates, the titles, abstracts and full texts were screened. A total of 53 articles were included in this review (Fig. 1. Flowchart of the study selection). Of the included studies, 16 reported the infection status of infants who had been breastfed by infected mothers; 33 reported the results of SARS-CoV-2 detection in breast milk from infected mothers; five

**Fig. 1 Flowchart of the study selection**
were associated with the infectivity of breast milk from infected mothers; four assessed other relevant transmission modalities associated with breastfeeding; and nine were associated with the protective effect of breast milk. The included studies were summarized into the following five perspectives according to the framework mentioned above [17].

**Infection status of infants breastfed by infected mothers**
Breastfed infants of SARS-CoV-2-positive mothers were followed-up with health assessments (Table 1). Among 16 studies included in this perspective, six found that breastfed children were positive for SARS-CoV-2. Notably, some breastfed infants who were positive for SARS-CoV-2 did not show clinical symptoms and turned negative several days later. In Italy [24], a preterm newborn was inadvertently fed with SARS-CoV-2-positive expressed breast milk. However, this newborn was not infected. Another study in Italy [6] showed that two breastfed infants tested SARS-CoV-2 positive 3 days and 7 days postpartum, respectively. However, both infants turned negative on the 14th day after delivery.

**The likelihood of SARS-CoV-2 contained in breast milk**
Thirty-three studies included in this review examined whether SARS-CoV-2 existed in breast milk samples collected from mothers with COVID-19 during pregnancy or lactation (Table 2). The RT-PCR method was conducted in all included studies to detect SARS-CoV-2 nucleic acid in breast milk samples.

There were 14 studies examining breast milk at a single time point and 14 studies examining breast milk at multiple time points. The majority of evidence demonstrated SARS-CoV-2 negative results in breast milk. For example, a study in Spain examined hand-expressed colostrum samples from seven infected women within the first hour of delivery; all seven breast milk samples tested SARS-CoV-2 negative [47]. Similarly, in China, two separate studies (n = 6 [36] and n = 10 [46]) reported that breast milk samples collected from infected mothers during their first lactation were found to be negative for SARS-CoV-2. Another two studies in China also reported negative results of breast milk samples collected from infected mothers at 36h [55] and the sixth day [38] postdelivery. There were also examples of studies that conducted assessments at multiple time points demonstrating negative results. A study from China [58] reported that a mother’s nasopharyngeal swab specimens collected on her second day of hospital stay were positive for SARS-CoV-2 nucleic acid, while her breast milk samples collected on days two, nine, 16, and 19 after delivery were negative. In addition to the majority of evidence that demonstrated negative results, a small proportion of studies showed SARS-CoV-2 positive results in breast milk samples, including studies in Turkey [23, 33], Italy [19, 24, 34, 40], the USA [35], Mexico [42], Australia [53], India [54] and China [56].

**The infectivity of breast milk from infected mothers**
A study in the USA [35] reported that one breast milk sample from an infected mother tested positive for SARS-CoV-2 RNA. However, no replication-competent virus was detectable in this positive breast milk sample, which indicated that SARS-CoV-2 in breast milk may not be infectious. No additional studies that directly tested viral infectivity in breast milk were retrieved.

Four studies included in this review focused on the activity of the added SARS-CoV-2 in breast milk after pasteurization. Chambers et al. [35] added SARS-CoV-2 virus into breast milk and then used Holder pasteurization to pasteurize some of the samples. The authors failed to detect SARS-CoV-2 viral RNA or culturable virus in breast milk samples that underwent Holder pasteurization. In contrast, the nonpasteurization samples were found to be positive for viral RNA. A study in Canada [60] added SARS-CoV-2 to breast milk samples from a milk bank and then pasteurized these samples. The study showed that Holder pasteurization of human milk could inactivate SARS-CoV-2 [60]. Similarly, an experiment in Australia [61] demonstrated that Holder pasteurization could inactivate replicative SARS-CoV-2, which was added to breast milk samples from healthy donors. Moreover, Conzelmann et al. [62] added SARS-CoV-2 into five breast milk samples. After pasteurization, no RNA particles were detected in these samples.

**Other transmission modalities associated with breastfeeding**
According to the mechanisms of SARS-CoV-2 transmission, the ways of mother-to-child transmission associated with breastfeeding may include close contact transmission and droplet transmission [63]. Tam et al. [53] believed that the risk of environmental and patient’s own oropharynx contamination of breast milk was possible. Recent studies found that the external surfaces of breast milk containers could be contaminated by SARS-CoV-2. Kampf et al. [64] and van Doremalen et al. [65] reported that SARS-CoV-2 was more stable on plastic surfaces (i.e., contamination lasting 2–9 days) and glass surfaces (i.e., contamination lasting 4–5 days). These bottles could be potential sources of contamination and transmission.

**The possible protective effect of breast milk from infected mothers**
Nine studies included in this review showed that breast milk from infected mothers contained SARS-CoV-2-specific
antibodies, which may be protective for children (Table 3). A study in Brazil detected IgA in a SARS-CoV-2-infected mother’s breast milk [68]. In the USA, all breast milk samples from 18 infected women were reported to contain anti-SARS-CoV-2 IgA and IgG [49]. Another study in the USA [67] detected breast milk samples from eight COVID-19-recovered and seven COVID-19-suspected women 3–4 weeks after symptoms had abated and found that 80%

Table 1  Summary of evidence on breastfeeding and infant outcomes

| Authors            | Study site | Design                      | Follow-up time                      | Breastfeeding                                      | Outcome * | No breastfeeding                                       | Outcome * |
|--------------------|------------|-----------------------------|--------------------------------------|----------------------------------------------------|-----------|-------------------------------------------------------|-----------|
| Ajith et al. [18]  | India      | Single-center observational study | Within 24h of delivery              | 165 No breastfeeding                               | 31 positive | 56 1 positive                                         |           |
| Bertino et al. [19]| Italy      | Prospective observational study | 48h and 6 weeks postpartum           | 13 Yes                                             | 4 positive in the first 48h of life; becoming negative by 6 weeks of life | 1 Negative |           |
| Biasucci et al. [6]| Italy      | Prospective study            | 3, 7 and 14 days postpartum          | 13 NA                                              | 1 positive on 3 days postpartum 1 positive on 7 days postpartum All negative on 14 days postpartum | 2 All negative |           |
| Chu et al. [20]    | China      | Case report                 | 1 month postpartum                  | 1 NA                                               | Negative   | 0 –                                                   |           |
| Cojocaru et al. [21]| USA       | Retrospective study          | 24h, 48h and a week postpartum       | 16 NA                                              | All negative | 15 All negative                                       |           |
| Gao et al. [22]    | China      | Ambispective observational clinical analysis | During admission | 4 NA                                               | All negative | 10 All negative                                       |           |
| Kilic et al. [23]  | Turkey     | Prospective observational study | During the 14-day isolation          | 12 NA                                              | 6 positive   | 3 2 positive                                         |           |
| Lugli et al. [24]  | Italy      | Case report                 | 8, 10 and 18 days postpartum         | 1 NA                                               | Negative    | 0 –                                                   |           |
| Oncel et al. [25]  | Turkey     | Multicenter cohort study     | 1, 2, 5 days postpartum              | 54 NA                                              | All negative | 71 4 positive                                        |           |
| Pereira et al. [26]| Spain      | Retrospective case series study | 1.8 months                          | 17 15 exclusive breastfeeding and 2 supplementing with formula | All negative | 3 All negative                                        |           |
| Piersigilli et al. [27]| Belgium  | Case report                 | 7 and 14 days postpartum             | 1 NA                                               | 7-day postpartum positive and 14-day negative         | 0 –       |           |
| Salvatore et al. [28]| USA       | Cohort study                | 5–7 days and 14 days postpartum      | 64 With or without addition of formula             | All negative | 18 All negative                                       |           |
| Savasi et al. [29] | Italy      | Prospective multicenter cohort study | Early postpartum period              | 57 NA                                              | 4 positive   | 0 –                                                   |           |
| Shlomai et al. [30]| Israel     | Multicenter study            | 14 to 21 days post-discharge         | 47 Yes                                             | All negative | 8 All negative                                        |           |
| Tran et al. [31]   | Vietnam    | Case report                 | 34 days postpartum                   | 1 Yes                                              | Negative    | 0 –                                                   |           |
| Vila-Candel et al. [32]| Spain   | Retrospective and multicenter study | During admission                      | 10 Yes                                             | All negative | 3 All negative                                        |           |

*: There was no infant who was not breastfed included in the study

* Some studies failed to obtain follow-up SARS-CoV-2 detection results of all infants
| Authors                  | Study country | Study design                      | Sample size | Time of mothers’ SARS-CoV-2 positive test | Time points of breast milk collection | RT-PCR test results |
|-------------------------|---------------|-----------------------------------|-------------|------------------------------------------|----------------------------------------|---------------------|
| Bastug et al. [33]      | Turkey        | Case report                       | 1           | On the day of delivery                   | On the day of delivery and the 3rd, 4th day after delivery | 3 positive          |
| Bertino et al. [19]     | Italy         | Prospective collaborative observational study | 14          | Several days before or after delivery, 0–12 days before breast milk collection | Several times after delivery | 1 positive          |
| Buonsenso et al. [34]   | Italy         | Observational study               | 2           | 5, 7 days before delivery, respectively | Mother 1: on the 11th and 14th day after delivery; Mother 2: during the first 5 days after delivery | 3 out of 5 samples from Mother 2 were positive |
| Chambers et al. [35]    | USA           | Case series                       | 18          | After delivery                           | A total of 64 milk samples were collected at different time points before and after the positive SARS-CoV-2 test result | 1 positive collected on the day of symptom onset |
| Chen et al. [36]        | China         | Case series                       | 6           | Third trimester of pregnancy             | After first lactation                  | All negative        |
| Chu et al. [20]         | China         | Case report                       | 1           | 22 days after delivery                   | 9 and 10 days after mother’s SARS-CoV-2 positive test | All negative        |
| Cui et al. [37]         | China         | Case report                       | 1           | More than one month after delivery      | 2–4 days after mother’s SARS-CoV-2 positive test | All negative        |
| Dong et al. [38]        | China         | Case report                       | 1           | 22 days before delivery                  | 6 days after delivery                  | Negative            |
| Fan et al. [39]         | China         | Case report                       | 2           | 4, 5 days before delivery, respectively | After delivery                         | All negative        |
| Fenizia et al. [40]     | Italy         | Prospective multicenter study     | 11          | Before delivery                         | 5 days after delivery                  | 1 positive          |
| Gao et al. [22]         | China         | Ambispective observational clinical analysis | 12          | Before delivery                         | Within 7 days after delivery          | All negative        |
| Han et al. [41]         | Korea         | Case report                       | 1           | After delivery                          | After mother’s SARS-CoV-2 positive test | Negative            |
| Hinojosa-Velasco et al. [42] | Mexico   | Case report                       | 1           | On the day of delivery                  | Collected on the fourth day after delivery | Positive            |
| Kalafat et al. [43]     | Turkey        | Case report                       | 1           | On the day of delivery                  | After mother’s SARS-CoV-2 positive test | Negative            |
| Kam et al. [44]         | Singapore     | Case report                       | 1           | 6 month after delivery                  | 10 days after mother’s SARS-CoV-2 positive test | Negative            |
| Kilic et al. [23]       | Turkey        | Prospective observational study   | 15          | Lactation period                        | A total of 26 milk samples were collected within 2 days after the mothers’ symptoms began | 4 positive          |
| Lei et al. [45]         | China         | Case series                       | 4           | Several days before or after delivery   | After mothers’ SARS-CoV-2 positive test | All negative        |
| Liu et al. [46]         | China         | Case series                       | 10          | During late pregnancy                   | After first lactation                  | All negative        |
| Lugli et al. [24]       | Italy         | Case report                       | 1           | 9 days after delivery                   | Before or after mothers’ SARS-CoV-2 positive test | All positive        |
| Authors                        | Study country | Study design                  | Sample size | Time of mothers’ SARS-CoV-2 positive test | Time points of breast milk collection                                                                 | RT-PCR test results |
|-------------------------------|---------------|-------------------------------|-------------|------------------------------------------|--------------------------------------------------------------------------------------------------------|---------------------|
| Marin Gabriel et al. [47]     | Spain         | Observational prospective study | 7           | 6 on the day of delivery; 1 two months before delivery | Within the first hour after delivery                                                                   | All negative        |
| Mattar et al. [48]            | Singapore     | Prospective observational study | 2           | 50, 81 days before delivery, respectively | Colostrum samples                                                                                       | All negative        |
| Pace et al. [49]              | USA           | Prospective study             | 18          | 6.8±7.8 months after delivery            | A total of 37 milk samples were collected after mothers’ SARS-CoV-2 positive test                      | All negative        |
| Peng et al. [50]              | China         | Longitudinal study            | 16          | Before delivery                         | A total of 44 milk samples were collected on the day of delivery, the 3rd, 7th, 14th, 21st, 28th, 35th, 42nd, 56th and 70th day after delivery | All negative        |
| Peng et al. [51]              | China         | Case report                   | 1           | One day before delivery                 | At day 2, 3, 4, 5, 6, 7, 10 and 14 of delivery                                                       | All negative        |
| Piersigilli et al. [27]       | Belgium       | Case report                   | 1           | 7 days after delivery                   | Before mothers’ SARS-CoV-2 positive test                                                             | Negative            |
| Sharma et al. [52]            | India         | Ambispective observational study | 23          | Second or third trimester of delivery  | After mothers’ SARS-CoV-2 positive test                                                              | All negative        |
| Tam et al. [53]               | Australia     | Case report                   | 1           | 8 months after delivery                 | A total of 7 milk samples were collected between 6 to 16 days after mothers’ SARS-CoV-2 positive test | 2 positive          |
| Thanigainathan et al. [54]    | India         | Descriptive study             | 30          | Before delivery                        | Between 48 to 72h after delivery                                                                    | 1 positive          |
| Wang et al. [55]              | China         | Case report                   | 1           | On the day of delivery                 | 36h after delivery                                                                                   | Negative            |
| Wu et al. [56]                | China         | Case series                   | 3           | The last month of pregnancy           | On the 1st, 6th and 27th day after delivery                                                           | 1 positive (collected 1st day after delivery) |
| Xiong et al. [57]             | China         | Case report                   | 1           | 37 days before delivery                | At the day of delivery                                                                               | Negative            |
| Yu et al. [58]                | China         | Case report                   | 1           | More than one year after delivery      | On the 2nd, 9th, 16th and 19th day after mothers’ SARS-CoV-2 positive test                            | All negative        |
| Zhuang et al. [59]            | China         | Case report                   | 1           | 1 day after delivery                   | On the 5th day after delivery                                                                       | Negative            |
| Authors                  | Study country | Sample size | Milk samples | Time of breast milk collection | Detection results                                                                 | Titers                      | Detection methods | Infection status                      |
|-------------------------|---------------|-------------|--------------|--------------------------------|----------------------------------------------------------------------------------|----------------------------|------------------|-------------------------------|
| Demers-Mathieu et al. [66] | USA           | 27          | 27           | Collected during lactation time between 4 and 10 months | S2 SARS-CoV-2-specific IgG level was higher in the COVID-19 group than in the control group | NA                          | ELISA            | 7 confirmed, 20 suspected       |
| Fenizia et al. [40]     | Italy         | 10          | 10           | Collected 5 days after delivery; tested SARS-CoV-2 positive during the third trimester | One sample positive for IgM                                                       | NA                          | CLIA             | Confirmed, symptomatic          |
| Fox et al. [67]         | USA           | 15          | 15           | 3–4 weeks after symptoms abated | 80% positive for IgA and 67% positive for IgG and/or IgM | All endpoint titers significantly higher than control samples, 10–10⁸ | ELISA            | 8 confirmed, recovered and 7 suspected |
| Gao et al. [22]         | China         | 14          | 14           | Collected within 7 days after delivery | 3 positive for IgG or IgM | IgG: 103.15–145.31 AU/ml; IgM: 1986–92.01 AU/ml | CLIA             | Confirmed, symptomatic          |
| Lebrao et al. [68]      | Brazil        | 1           | 2            | On the 3rd day after delivery and the 6th day since the onset of symptoms | Both positive for IgA | 2.5 (3rd day after delivery) and 1.9 (the 6th day since the onset of symptoms) | ELISA            | Confirmed, symptomatic          |
| Pace et al. [49]        | USA           | 18          | 37           | 12.0 ± 8.9 days after the onset of symptoms | 76% positive for IgA and 80% positive for IgG | Antibody concentration of samples from infected mothers higher than antibody concentration of milk samples collected before the pandemic | ELISA            | Confirmed, 15 symptomatic and 3 asymptomatic |
| Peng et al. [50]        | China         | 15          | 38           | Collected at 10 time points: the day of delivery; the 3rd, 7th, 14th, 21st, 28th, 35th, 42nd, 56th and 70th day after delivery | 21 positive for IgM | 0.1–3.03 | ELISA            | Confirmed, symptomatic          |
| van Keulen et al. [69]  | Netherlands   | 38          | 38           | Approximately 6 days after the onset of symptoms | 83% confirmed cases and 67% suspected cases positive for IgA | NA                          | ELISA            | 29 confirmed and 9 suspected   |
| Yu et al. [58]          | China         | 1           | 2            | Collected on the 11th and 27th after the onset of symptoms | Both positive for IgG | NA                          | ELISA            | Confirmed, symptomatic          |

CLIA Chemiluminescence immunoassay
ELISA Enzyme-linked immunosorbent assay
of samples contained IgA and 67% of samples contained IgG and/or IgM binding to the receptor-binding domain [67]. A study in the Netherlands reported that 83% of the confirmed cases and 67% of the suspected cases had SARS-CoV-2 antibodies in their breast milk samples [69]. A study in China [22] also detected anti-SARS-CoV-2 IgG and IgM in breast milk samples of 14 infected mothers [22]. Another study in China detected IgM in 21 out of 38 breast milk samples of infected mothers [50]. In addition, in the study of Fenizia et al. [40], anti-SARS-CoV-2 IgM was detected in breast milk from one confirmed mother. According to a case report [58] in China, anti-SARS-CoV-2 IgG was found in breast milk samples. Finally, COVID-19-positive mothers had breast milk antibodies against the S2 subunit SARS-CoV-2 [66]. The majority of studies did not specify the value of antibody titers. Instead, some studies used graphs to show that antibody titers of milk samples from infected mothers were higher than those from control cases, while others studies stated this phenomenon in brief.

Current recommendations about breastfeeding

National and international organizations have provided different recommendations about breastfeeding during the COVID-19 pandemic [8, 10, 12–16, 70–75], which are described in detail in Table 4. In February 2020, the National Health Commission of the People’s Republic of China recommended stopping breastfeeding for mothers who were suspected/confirmed to have COVID-19 or had not recovered after diagnosis [14]. If the nucleic acid test of the suspected infected mother was negative twice in a row, the newborn could be transferred out of the isolation and observation area and breastfed [14, 73]. In March 2020, ABM [13] suggested breastfeeding among infected mothers with recommendations in home and hospital settings. At home, confirmed mothers should remain separate from other family members, including the infant, except for the occasions of breastfeeding. In the hospital, if the mother was suspected or confirmed to have COVID-19, it was still reasonable to breastfeed or to provide expressed milk for her infant. In April 2020, ISS [10] recommended breastfeeding in a conservative manner. They suggested that asymptomatic or mildly affected mothers consider breastfeeding and rooming-in in coordination with healthcare providers. Separation with attempts to express breast milk to maintain milk production was recommended for severely or critically ill patients.

With much new evidence emerging in 2021, ISUOG [12, 76], WHO [8, 77, 78], AAP [75], CDC [70–72], UNICEF [16, 74], and RCOG [15] continued updating their breastfeeding recommendations. According to the current evidence, breast milk was unlikely to be the source of transmission of SARS-CoV-2 [11, 67, 80, 81]; these organizations consistently recommended that mothers continue to breastfeed their infants with precautions if suspected or known to have COVID-19. The AAP [75] strongly supported breastfeeding as the best choice for infant feeding. The RCOG [15], UNICEF [16, 74], and WHO [8, 77, 78] suggested that suspected or infected mothers stay together with their infants after delivery, keep skin-to-skin contacts and breastfeed directly with careful precautions if mothers feel well. When a woman was not well enough to care for her infant or when direct breastfeeding was not possible, expressing breast milk could be considered. Pasteurized donor human milk was also recommended when mothers’ breast milk was not available by the WHO [8, 77, 78], CDC [70–72], UNICEF [16, 74], and RCOG [15]. In contrast, the ISUOG [76] recommended breastfeeding in a conservative manner: whether to start breastfeeding should be decided by shared decision with the parents with consideration of healthcare providers’ advice.

Precautions for direct breastfeeding put forwards by the above organizations included washing hands before touching the infant, wearing a medical mask during any contacts with the infant, and routinely cleaning and disinfecting surfaces that mothers had touched. Precautions for expressing breast milk included wearing a mask during expression, washing hands before touching any pumps/bottle parts and expressing breast milk, following recommendations for proper pump cleaning after each use, and feeding expressed milk to the infant by a healthy caregiver who was not at risk for COVID-19, if possible.

Discussion

The present review article summarizes the latest evidence about the safety of breastfeeding and the current recommendations on breastfeeding during the COVID-19 pandemic. The evidence summarization was generally based on van de Perre’s framework, which has been specifically used to assess the likelihood of viral infections during breastfeeding [17]. Consistent with van de Perre et al. [17], we did not find any animal models related to SARS-CoV-2 transmission by breastfeeding. However, we found some evidence related to antibodies in breast milk samples and categorized them into the perspective of “the possible protective effect of breast milk from infected mothers”.

From the perspective of infants’ health status, current evidence suggests that infants breastfed by infected mothers might test positive for SARS-CoV-2; however, the population of infected infants was small. Our findings were consistent with a systematic review [11] that summarized evidence from 17 countries. The systematic review demonstrated that among 148 infants who were breastfed by infected mothers, only seven (4.9%) were
| Timeline       | International organizations                                           | Recommendations                                                                                                                                                                                                                                                                                                                                 | Specific precautions                                                                                      |
|----------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Feb 8, 2020    | National Health Commission of the People's Republic of China\[14, 73]\  | • For mothers who are suspected or confirmed with COVID-19 or have not recovered after diagnosis, breastfeeding should be stopped. If the nucleic acid test of the suspected infected mother is negative twice in a row, the newborn can be transferred out of the isolation and observation area and be breastfed. | • Not available                                                                                                                                                                                                                                                             |
| March 10, 2020 | Academy of Breastfeeding Medicine, ABM\[13]\                           | • At home, mothers with confirmed COVID-19 infection should remain separate (home isolation precautions) from other family members and friends or neighbors including the infant, except for breastfeeding.  
• In hospital, if the mother is well and has only been exposed or is a person-under-investigation with mild symptoms, breastfeeding with careful precautions is a very reasonable choice. If the mother has COVID-19, it is still reasonable to choose to breastfeed and provide expressed milk for her infant. | • Precautions for breastfeeding directly at the breast.  
✓ Washing her hands before touching the infant.  
✓ Wearing a face mask.  
• Precautions for expressing breast milk.  
✓ Washing hands before touching any pump or bottle parts.  
✓ Following recommendations for proper pump cleaning after each use.  
• If possible, considering having someone who is well care for and feed the expressed breast milk to the infant.  
• In the hospital, rooming-in (mother and infant stay in the same room without any other patients in that room) with the infant should keep in a bassinet 6 ft from the mother’s bed. Ideally, there should be another well adult who cares for the infant in the room. |
| Apr 26, 2020   | Italian National Institute of Health, ISS\[10]\                       | • If the mother is severely or critically ill, separation appears to be the best option, with attempts to express breast milk in order to maintain milk production.  
• If the mother is asymptomatic or mildly affected, breastfeeding and rooming-in can be considered by the mother in coordination with healthcare providers. | • Precautions for breastfeeding directly at the breast.  
✓ Cleaning hands.  
✓ Using a face mask. |
| Jun 1, 2020    | International Society of Ultrasound in Obstetrics and Gynecology, ISUOG\[76]\ | • If the mother is severely or critically ill, separation appears to be the best option, with attempts to express breast milk in order to maintain milk production.  
• If the mother is asymptomatic or mildly affected, breastfeeding and colocation (also called rooming-in) can be considered by the mother in coordination with healthcare providers, or may be necessary if facility limitations prevent mother-infant separation. | • Precautions for breastfeeding directly at the breast.  
✓ Washing hands.  
✓ Wearing a three-ply surgical mask before touching the infant.  
• Precautions for expressing breast milk.  
✓ A dedicated breast pump should be used.  
✓ The machine should be washed thoroughly, according to the manufacturer's recommendations, after each use.  
• In case of rooming-in, the infant’s cot should be kept at least 2 m from the mother’s bed, and a physical barrier such as a curtain may be used. |
| Timeline       | International organizations                                      | Recommendations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Specific precautions                                                                                                                                                                                                                                                                                                                                                     |
|---------------|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Jan 25, 2021  | World Health Organization, WHO [8, 77, 78]                       | • Mothers with suspected or confirmed COVID-19 should be encouraged to initiate or continue to breastfeed.  
• If suspected or confirmed infected mothers are well enough, they should keep skin-to-skin contact with their babies and breastfeed with appropriate precautions. Mothers with symptoms of COVID-19 are advised to wear a medical mask, but even if this is not possible, breastfeeding should be continued. For those who are too unwell to breastfeed, expressing milk and donor human milk could be considered.                                                                                       | • Precautions for breastfeeding directly at the breast.  
✓ Washing hands frequently with soap and water or using alcohol-based hand rub and especially before touching the infant.  
✓ Wearing a medical mask during any contact with the infant, including while feeding.  
✓ Sneezing or coughing into a tissue, then disposing of it immediately and washing hands again.  
✓ Routinely cleaning and disinfecting surfaces that mothers have touched.                                                                                                                                                                                                                   |
| March 29, 2021| American Academy of Pediatrics, AAP [75]                         | • The AAP strongly supports breastfeeding as the best choice for infant feeding.  
• Counsel families to consider delaying weaning and extending the duration of breastfeeding to maximize the protection conferred via human milk during the pandemic.  
• If mothers choose not to breastfeed during the first week postpartum, pediatricians should consider asking family whether they might reconsider this choice, and engage in a discussion about the importance of breastfeeding and expressed human milk in protecting against infections and other diseases during this most vulnerable time.                                                                 | • Precautions for breastfeeding directly at the breast.  
✓ Proper hand washing with soap and water before handling the infant.  
✓ Wearing a mask.  
✓ When not nursing, the infant can be cared for by a healthy caregiver, if available, and/or maintained in a separate room or at least 6ft away from the mother.  
• Precautions for expressing breast milk.  
✓ Wearing a mask.  
✓ Thoroughly cleaning her hands as well as any pump parts, bottles, and artificial nipples.  
✓ The expressed milk can be fed to the infant by a healthy caregiver.                                                                                                                                                                                                                       |
Table 4 (continued)

| Timeline   | International organizations                                                                 | Recommendations                                                                 | Specific precautions |
|------------|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------|
| June 17, 2021 | Centers for Disease Control and Prevention, CDC\[^{70–72}\] | • Breast milk is the best source of nutrition for most infants, and it provides protection against many illnesses. There are rare exceptions when breastfeeding or feeding expressed breast milk is not recommended.  
• People without suspected or confirmed COVID-19 and who have not been in close contact with someone who has COVID-19, or who have been fully vaccinated for COVID-19 do not need to take special precautions when feeding at the breast or expressing milk.  
• When a lactating caregiver's milk is not available, pasteurized donor human milk is important for preterm infants. If hospitals have difficulty acquiring donor human milk, available supplies should be prioritized for preterm infants who will benefit most from breast milk. | • Precautions for breastfeeding directly at the breast.  
✓ Wearing a mask when they are less than 6 ft from the child during feeding.  
✓ Washing hands with soap and water for 20 s before each feeding.  
✓ Precautions for expressing breast milk.  
✓ A dedicated breast pump should be used.  
✓ Wearing a mask when they are less than 6 ft from the child during expression and wash hands with soap and water for 20 s before touching any pump or bottle parts and before expressing breast milk.  
✓ Following recommendations for proper pump cleaning after each use. Clean all parts that come into contact with breast milk.  
✓ Consider having a healthy caregiver who does not have COVID-19, is not at increased risk for severe illness from COVID-19, and is living in the same home feed the expressed breast milk to the baby. If the caregiver is living in the same home or has been in close contact with you, they might have been exposed. Any caregiver feeding the baby should wear a mask when caring for the baby for the entire time you are in isolation and during their own quarantine period after you complete isolation.  
• In the hospital, engineering controls like physical barriers are used (e.g., placing the neonate in a temperature-controlled isolator), and the neonate is kept ≥6 ft away from the mother as much as possible.  
• In a workplace with a multiuser lactation room, efforts should be made to implement engineering and administrative controls to enable physical distancing (e.g., spacing lactation stations at least 6 ft apart, installing physical shields between lactation stations, staggering lactation schedules, encouraging telework). | |
| Jul 29, 2021 | United Nations International Children's Emergency Fund, UNICEF\[^{16, 74}\] | • For suspected or confirmed infected mothers who are well enough to breastfeed, breastfeeding should be continued with appropriate precautions.  
• For those who are too unwell to breastfeed, expressing milk and donor human milk could be considered. | • Precautions for breastfeeding directly at the breast.  
✓ Wearing a mask if available.  
✓ Washing hands before and after contact.  
✓ Cleaning/disinfecting surfaces.  
• Express milk should be given to infant via a clean cup and/ or spoon – all while following the same precautions. |
| Timeline       | International organizations                                      | Recommendations                                                                                                                                                                                                 | Specific precautions                                                                                     |
|---------------|----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| Nov 2 2021    | Royal College of Obstetricians and Gynecologists, RCOG\(^{a}\) [15] | - Breastfeeding should be recommended to all women in line with usual guidance.  
  - Women with suspected or confirmed COVID-19 should remain with their baby and be supported to practice skin-to-skin/kangaroo care, if the newborn does not require additional medical care at this time.  
  - Adopt a precautionary approach for a woman who has suspected or confirmed COVID-19 and whose baby needs to be cared for on the neonatal unit to minimize any risk of women-to-infant transmission; at the same time, involve parents in decisions, mitigating potential problems for the baby’s health and wellbeing and for breastfeeding, bonding and attachment.  
  - Women and their families should be informed that infection with COVID-19 is not a contraindication to breastfeeding. Women should be supported to make an informed decision about how they feed their baby. Women who choose to breastfeed should be supported to do so, even if they have probable or confirmed COVID-19.  
  - When a woman is not well enough to care for her own infant or where direct breastfeeding is not possible, support her to express her breast milk by hand or using a breast pump, and/or offer access to donor breast milk. | - Precautions for breastfeeding directly at the breast.  
  ✓ Washing hands before touching the infant.  
  ✓ Trying to avoid coughing or sneezing on the infant while feeding at the breast.  
  ✓ Considering wearing a face mask while breastfeeding, if available.  
  - Precautions for expressing breast milk.  
  ✓ Washing hands before touching breast pump or bottles.  
  ✓ Following recommendations for pump cleaning after each use.  
  ✓ Considering asking someone who is well to feed expressed breast milk to the infant.  
  - If mothers are expressing breast milk in hospital, a dedicated breast pump should be used. |
infected; in comparison, 5.3% of formula-fed infants were infected. Similarly, a meta-analysis of 176 published cases reported that breastfeeding might not be associated with SARS-CoV-2 infections, and SARS-CoV-2 viral transmission through breast milk might be rare [82]. However, there were studies [18] demonstrating positive results for SARS-CoV-2 among breastfed infants; therefore, vertical and respiratory transmission could not be ruled out. Moreover, the majority of the studies assessed infants at a single time point. Further studies to follow up the health status of breastfed infants are warranted to detect false positive results.

Of studies testing SARS-CoV-2 in breast milk, 66.7% (22/33) reported that milk samples from infected mothers were all negative, and 33.3% reported positive results. The reasons for positive results in some breast milk samples remain unclear. Bastug et al. [33] suggested that the viral load in breast milk, the testing method, the timing of sample collection, and the transport and storage of samples were potential contributors to the positive results. Therefore, the role of breast milk as a vehicle to transmit COVID-19 from mother to newborn could not be confirmed [83]. Further studies are needed to collect breast milk samples from more cases in different regions and at multiple time points.

Few studies have directly tested the viral activity and infectivity of breast milk from infected mothers. Therefore, we could not confirm that SARS-CoV-2 in breast milk was infectious. Studies have focused on the activity of the added SARS-CoV-2 in breast milk after pasteurization. Pasteurization is an important method to eliminate viral and bacterial agents and ensure the safety of donated breast milk in human milk banks [84]. Evidence included in our review suggested that pasteurized breast milk was an alternative and effective option for SARS-CoV-2-infected mothers who were not able to breastfeed directly [26]. However, considering that some of the bioactive components in breast milk could be lost after pasteurization [84], pasteurized breast milk may not be the best choice.

Blackshaw et al. [85] listed infant feeding pathways and possible transmission modalities in their review. Our results were consistent with Blackshaw et al. [85], who found that transmission routes other than breast milk could not be ruled out during feeding. The potential routes included mother and other family members’ skin, bottle surfaces, etc.

This review included evidence showing that breast milk from infected mothers contained SARS-CoV-2-specific antibodies, which may be protective for children. This evidence supported Davanzo et al’s hypothesis that specific antibodies of SARS-CoV-2 could be passed from the COVID-19-infected mother via breast milk to her infant within a few days after the onset of the disease and modulate the clinical expression of the infant’s infection [10]. In addition, a previous review on vaccination and breastfeeding showed that anti-SARS-CoV-2 immunoglobulins may be transferred from healthy vaccinated lactating mothers to newborns through breastfeeding [86]. In addition to SARS-CoV-2-specific antibodies, as confirmed in the literature, breast milk contains immunoglobulins that can protect infants from a variety of respiratory and digestive infections [87]. For example, whey protein in human milk could block SARS-CoV-2 and its related pangolin coronavirus (GX_P2V) attachment and replication at entry and even post entry to inhibit the virus [88]. Lactoferrin in breast milk can prevent viral infections and may protect infants and boost their innate immune system against COVID-19 [89, 90]. As a result, not breastfeeding could expose infants to a high risk of infections during the COVID-19 pandemic [10].

According to our results and the analytical framework, only two criteria (“viral infection in children breastfed by infected mothers” and “the presence of virus/antigen/genome in the breast milk of infected mothers”) were met with limited evidence demonstrating positive results. Therefore, we believe that the breast milk of infected mothers is unlikely to transmit SARS-CoV-2. Moreover, a large amount of evidence was from case reports; studies with more robust designs are still lacking. Publication bias might also exist. We thus consider that the safety of breastfeeding during COVID-19 was insufficiently documented. Further studies to follow up the health status of infants who were directly breastfed by their confirmed/suspected infected mothers, to collect breast milk samples at multiple time points for viral tests and to examine specific antibodies in breast milk samples are warranted.

We found that recommendations on breastfeeding during COVID-19 from different organizations were controversial. Similarly, a previous review found that the aspects in the guidance documents from 33 countries were poorly consistent with the WHO guidelines [91]. The other study found that in 73 articles, recommendations regarding breastfeeding, separation of mother and newborns after birth and decontamination practices were varied [92]. In our review, China seemed to have stricter measures about breastfeeding. Chinese experts thought that breastfeeding should be stopped among confirmed or suspected mothers, as the possibility of the vertical transmission of COVID-19 could not be completely ruled out [93, 94]. The ISS and ISUOG also recommended breastfeeding in a conservative manner. They thought decisions towards breastfeeding should be made by mothers and their family members, with the consideration of healthcare providers’ advice.
In comparison, other organizations (e.g., ABM, WHO, AAP, CDC, UNICEF, and RCOG) encouraged breastfeeding among suspected or confirmed infected mothers. Indeed, the currently available scientific evidence does not allow us to accurately inform the best practices of breastfeeding during the COVID-19 pandemic [80]. As new evidence accumulates, recommendations should be updated in a timely manner to ensure appropriate practices.

Conclusions
This article provides comprehensive evidence for the safety and recommendations of breastfeeding during the COVID-19 pandemic. Based on an analytical framework, the current evidence proved that transmission of SARS-CoV-2 from infected mothers via breast milk was unlikely to happen. However, owing to the low quality of the current evidence, the safety of breastfeeding during COVID-19 is still insufficiently reported. Further studies with robust designs are warranted to determine the safety of breastfeeding. Studies to follow up the health status of infants who were breastfed by confirmed/suspected infected mothers, to conduct viral tests on breast milk samples at multiple time points and to examine specific antibodies in breast milk samples are needed to fill the research gaps. This review contributed to the literature by providing scientific evidence and recommendations on breastfeeding and identifying the focus for further research during the COVID-19 pandemic.

Abbreviations
AAP: American Academy of Pediatrics; ABM: Academy of Breastfeeding Medicine; CDC: U.S. Centers for Disease Control and Prevention; CNKI: China National Knowledge Infrastructure; COVID-19: Coronavirus Disease 2019; ISS: Italian National Institute of Health; ISUOG: International Society of Ultrasound in Obstetrics and Gynecology; RCOG: Royal College of Obstetricians and Gynecologists; SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2; UNICEF: United Nations International Children’s Emergency Fund; WHO: World Health Organization.

Acknowledgements
Not applicable.

Authors’ contributions
Q.Z. and M.A. conceived the study. H.C., X.L., W.Y., and Z.C. searched the literatures. X.L., H.C., M.A., and Q.Z. drafted and revised the manuscript. Y.W. and L.W. revised the manuscript. All authors have read and approved the final manuscript.

Funding
This work was supported by Peking University Research Initiation Fund [grant number BMU2018YJ005]. The funding body had no role in the design of the study, the collection, analysis, and interpretation of the data or the writing of this article.

Availability of data and materials
Not applicable.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Received: 2 September 2021 Accepted: 12 March 2022
Published online: 11 April 2022

References
1. World Health Organization. Naming the coronavirus disease (COVID-19) and the virus that causes it. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it. Accessed 4 Jun 2021.

2. World Health Organization. WHO Director-General’s opening remarks at the media briefing on COVID-19 - 11 March 2020. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-20200311. Accessed 4 Jun 2021.

3. World Health Organization. WHO Coronavirus (COVID-19) dashboard. https://covid19.who.int. Accessed 4 Nov 2021.

4. Pan American Health Organization, World Health Organization. Epidemiological update: Coronavirus disease (COVID-19), 23 December 2020, Washington, D.C.: PAHO/WHO; 2021.

5. Liu H, Wang L, Zhao SJ, Kwak-Kim J, Mor G, Liao AH. Why are pregnant women susceptible to COVID-19? An immunological viewpoint. J Reprod Immunol. 2020;139:103122.

6. Biasucci G, Cannalire G, Raymond A, Capra ME, Benenati B, Vadacca G, et al. Safe perinatal management of neonates born to SARS-CoV-2 positive mothers at the epicenter of the Italian epidemic. Front Pediatr. 2020;8:65522.

7. Aghaeepour N, Ganio EA, Mcllwain D, Tsi AS, Tingle M, Van Gassen S, et al. An immune clock of human pregnancy. Sci Immunol. 2017;2(15):eaan2946.

8. World Health Organization. Q&A on COVID-19 and breastfeeding. https://www.who.int/news-room/q-a-detail/q-a-on-covid-19-and-breastfeeding. Accessed 4 Jun 2021.

9. Davanzo R. Breast feeding at the time of COVID-19: do not forget expressed mother’s milk, please. Arch Dis Child Fetal Neonatal Ed. 2020;105(4):455.

10. Davanzo R, Moro G, Sandri F, Agosti M, Moretti C, Mosca F. Breastfeeding and coronavirus disease-2019: ad interim indications of the Italian Society of Neonatology endorsed by the Union of European Neonatal & perinatal societies. Matern Child Nutr. 2020;16(3):e13016.

11. Walker KF, O’Donoghue K, Grace N, Dorling J, Comeau JL, Li W, et al. Maternal transmission of SARS-COV-2 to the neonate, and possible routes for such transmission: a systematic review and critical analysis. BJOG. 2020;127(11):1324–36.

12. Poon LC, Yang H, Lee JCS, Copel JA, Leung TY, Zhang Y, et al. ISUOG interim guidance on 2019 novel coronavirus infection during pregnancy and puerperium: information for healthcare professionals. Ultrasound Obstet Gynecol. 2020;55(5):700–8.

13. Academy of Breastfeeding Medicine. ABM statement on coronavirus 2019 (COVID-19). https://www.bfmed.org/abm-statement-coronavirus. Accessed 4 Jun 2021.

14. National Health Commission of the People’s Republic of China. [Notice on COVID-19 infection prevention and control work for children and pregnant women]. http://www.nhc.gov.cn/yns/s9002/202002/de2d62a5711c41e9b2c4b6f4df1f2136.shtml. Accessed 4 Jun 2021.

15. Royal College of Obstetricians & Gynecologists. Coronavirus (COVID-19) infection in pregnancy: Information for healthcare professionals. https://www.rcog.org.uk/en/guidelines-research-services/guidelines/coronavirus-pregnancy/. Accessed 4 Jun 2021.
16. United Nations International Children's Emergency Fund. Navigating pregnancy during the coronavirus disease (COVID-19) pandemic. https://www.unicef.org/coronavirus/navigating-pregnancy-during-coronavirus-disease-covid-19-pandemic. Accessed 4 Jun 2021.

17. Van de Perre P, Mobes P, Nagent N, Tuuillon E, Cecchi P, Poga A, et al. Revisiting Koch's postulate to determine the plausibility of viral transmission by human milk. Pediatr Allergy Immunol. 2021;32(5):835–42.

18. Ajith S, Reshmi VP, Nambiar S, Naser A, Athulya B. Prevalence and risk factors of neonatal Covid-19 infection: a single-Centre observational study. J Obstet Gynaecol India. 2021;71(1):1–4.

19. Berto E, Moro GE, De Renzi G, Viberni G, Cavallo R, Coscia A, et al. Detection of SARS-CoV-2 in milk from COVID-19 positive mothers and follow-up of their infants. Front Pediatr. 2020;8:597699.

20. Chu H, Li J, Yan B, Bai T, Schnabl B, Zou L, et al. Persistent SARS-CoV-2 RNA positive in feces but negative in breastmilk: a case report of COVID-19 in a breastfeeding patient. Front Med. 2020;7:562700.

21. Cojocaru L, Crimmins S, Sundaranjan S, Goetzinger K, Elamadcy E, Lankford A, et al. An initiative to evaluate the safety of maternal bonding in patients with SARS-CoV-2 infection. J Matern Fetal Neonatal Med, Online ahead of print. 2020. https://doi.org/10.1080/14767058.2020.1828335.

22. Gao X, Wang S, Zeng W, Chen S, Wu J, Lin X, et al. Clinical and immunologic features among COVID-19 affected mother-infant pairs: antibodies to SARS-CoV-2 detected in breast milk. New Microbes New Infect. 2020;37:100753.

23. Kilic T, Kilic S, Berber NK, Gunduz A, Ercsy Y. Investigation of SARS-CoV-2 RNA in milk produced by women with COVID-19 and follow-up of their infants: a preliminary study. Int J Clin Pract. 2021;75(7):14175.

24. Lugli L, Bedetti L, Luccacchini L, Cennani W, Leone C, Ancora G, et al. An uninfected preterm newborn inadvertently fed SARS-CoV-2-positive breast milk. Pediatrics. 2020;146(6):e202004960.

25. Oncel MY, Akin IM, Kanburoglu MK, Tayman C, Coskun S, Narter F, et al. A breastfeeding patient. Front Med. 2020;7:562700.

26. Tam PCK, Ly KM, Kernich ML, Spurrier N, Lawrence D, Gordon DL, et al. A study of breast milk from COVID-19 positive women. Breastfeed Med. 2020;15(8):492–4.

27. Peng Z, Wang J, Li W, Zhou Z, Liu S, Rong Z. Clinical characteristics of 19 neonates born to mothers with COVID-19. Front Med. 2020;14(2):193–8.

28. Berto E, Moro GE, De Renzi G, Viberni G, Cavallo R, Coscia A, et al. A multicenter study on epidemiological and clinical characteristics of 125 newborns born to women infected with COVID-19 by Turkish neonatal society. Eur J Pediatr. 2021;180(3):733–42.

29. Pereira A, Cruz-Melguizo S, Adhien M, Fuentes L, Marin E, Forti A, et al. Breastfeeding mothers with COVID-19 infection: a case series. Int Breastfeed J. 2020;15:69.

30. Piersigilli F, Carkeek H, Hoqc C, van Grambezen B, Hubencont C, Chatzis et al. COVID-19 in a 26-week preterm neonate. Lancet Child Adolesc Health. 2020;4:100045.

31. Tran HT, Huyhn LT, Le CMH, Nguyen VD, Nguyen PT, Hoang DT, et al. Early essential newborn care can still be used with mothers who have COVID-19 if effective infection control measures are applied. Acta Paediatr. 2021;110(7):1991–4.

32. Salvatore CM, Han JY, Acker KP, Tiwari P, Jin J, Brandler M, et al. Revisiting Koch's postulate to determine the plausibility of viral transmission by human milk. Pediatr Allergy Immunol. 2021;32(5):835–42.

33. Chambers C, Krosgstad P, Bertrand K, Contreras D, Tobin NH, Bode L, et al. Evaluation for SARS-CoV-2 in breast milk from 18 infected women. JAMA. 2020;324(13):1347–8.

34. Chuen H, Guo J, Wang C, Luo F, Yu X, Zhang W, et al. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. Lancet. 2020;395(10266):809–15.

35. Cui Y, Tian M, Huang D, Wang X, Huang Y, Fan L, et al. A 55-day-old female infant infected with 2019 novel coronavirus disease: presenting with pneumonia, liver injury, and heart damage. J Infect Dis. 2020;221(11):1775–81.

36. Dong L, Tian J, He S, Zhu C, Wang J, Liu C, et al. Possible vertical transmission of SARS-CoV-2 from an infected mother to her newborn. JAMA. 2020;323(18):1846–8.

37. Fan C, Lei D, Fang C, Li C, Wang M, Liu Y, et al. Perinatal transmission of 2019 coronavirus disease-associated severe acute respiratory syndrome coronavirus 2: should we worry? Clin Infect Dis. 2021;72(5):862–4.

38. Fenizia C, Biasin M, Cetin I, Vergani P, Mileto D, Spinillo A, et al. Analysis of SARS-CoV-2 vertical transmission during pregnancy Nat Commun. 2020;11:5128.

39. Han MS, Seong MW, Heo EY, Park JH, Kim N, Shin S, et al. Sequential analysis of viral load in a neonate and her mother infected with severe acute respiratory syndrome coronavirus 2. Clin Infect Dis. 2020;71(16):2236–9.

40. Hinojoia-Velasco A, Bobadilla-Montes de Oca PV, Garcia-Sosa LE, Gabriel Mendoza-Duran J, Perez-Mendez MJ, Davila-Gonzalez E, et al. A case report of newborn infant with severe COVID-19 in Mexico: detection of SARS-CoV-2 in human breast milk and stool. Int J Infect Dis. 2020;100:21–4.

41. Kalafat E, Yaprak E, Cinar G, Varli B, Oziski S, Uzun C, et al. Lung ultrasound and computed tomographic findings in pregnant woman with COVID-19. Ultrasound Obstet Gynecol. 2020;55:60353–7.

42. Kam KG, Yung CF, Cui L, Tzer Pin Lin R, Mak TM, Maivald M, et al. A well neonate with coronavirus disease 2019 with high viral load. Clin Infect Dis. 2020;71(15):847–9.

43. Lei D, Wang C, Li C, Fang C, Yang W, Chen B, et al. Clinical characteristics of COVID-19 in pregnancy analysis of nine cases. Chin J Perinat Med. 2020;23(3):159–65.

44. Peng S, Zhu H, Yang L, Cao L, Huang X, Dynes M, et al. A study of breastfeeding practices, SARS-CoV-2 and its antibodies in the breast milk of mothers confirmed with COVID-19. Lancet Resp Health. 2020;4:100045.

45. Peng S, Zhou H, Yang L, Cao L, Huang X, Dynes M, et al. A study of breastfeeding practices, SARS-CoV-2 and its antibodies in the breast milk of mothers confirmed with COVID-19. Lancet Resp Health. 2020;4:100045.

46. Sharma R, Seth S, Sharma R, Yadav S, Mishra P, Mukhopadhyay S. Perinatal outcome and possible vertical transmission of coronavirus disease 2019: experience from North India. Clin Exp Pediatr. 2021;64(5):239–46.

47. Tam PCK, Ly KM, Kemich ML, Spurrner N, Lawrence D, Gordon DL, et al. 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. 2021;72(1):128–30.

48. Thanigainathan S, Kallyaperumal S, Sivanandam S, Rengaraj S, Dhodapkar R, Bethou A. Is SARS-CoV-2 transmitted through breastfeeding? Indian J Pediatr. 2020;71(5):818–20.

49. Wang S, Guo L, Chen L, Liu W, Cao Y, Zhang J, et al. A case report of neonatal 2019 coronavirus disease in China. Clin Infect Dis. 2020;71(15):853–7.

50. Wu Y, Liu C, Dong L, Zhang C, Chen Y, Liu J, et al. Coronavirus disease 2019 among pregnant Chinese women: case series data on the safety of vaginal birth and breastfeeding. BJOG. 2020;127(9):1109–15.

51. Xiong X, Wei H, Zhang Z, Chang J, Ma X, Gao X, et al. Vaginal delivery report of a healthy neonate born to a convalescent mother with COVID-19. J Med Virol. 2020;92(9):1657–9.

52. Yu L, Li Y, Hu L, Li B, Xu J. Breastfed 13-month-old infant of a mother with COVID-19 pneumonia: a case report. Int Breastfeed J. 2020;15:68.
59. Zhuang S, Guan J, Cao Y, Chen H, Xu D, Li J, et al. Perinatal COVID-19: a case report. Chin J Perinat Med. 2020;23(2):85–90.

60. Unger S, Christie-Holmes N, Guvenc F, Budylovskii P, Mubareka S, Gray-Owen SD, et al. Holder pasteurization of donated human milk is effective in inactivating SARS-CoV-2. CMAJ. 2020;192(31):E871–E4.

61. Walker GJ, Clifford V, Bansal N, Stella AO, Turville S, Steber-Braid S, et al. SARS-CoV-2 in human milk is inactivated by holder pasteurisation but not cold storage. J Paediatr Child Health. 2020;56(12):1872–4.

62. Conzelmann C, Gross R, Meister TL, Todt D, Kravczyk A, Dittmer U, et al. Pasteurization inactivates SARS-CoV-2-spiked breast milk. Pediatrics. 2021;147(1):e2020031609.

63. Wang SQ, Zhou X, Lin YG, Liu YJ, Wu JL, Shafiu LM, et al. Experience of clinical management for pregnant women and newborns with novel coronavirus pneumonia in Tongji Hospital, China. Curr Med Sci. 2020;40(2):285–9.

64. Kampf G, Todt D, Pfänder S, Steinhäuser E. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. J Hosp Infect. 2020;104(3):246–51.

65. van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, et al. Aerosol and surface stability of SARS-CoV-2 as compared to SARS-CoV-1. Emerg Infect Dis. 2020;26(2):264–7.

66. Demers-Mathieu V, DaPra C, Mathijssen G, Sela DA, Jarvinen KM, Seppo A, et al. Human milk antibodies against S1 and S2 subunits from SARS-CoV-2, HCoV-OC43, and HCoV-229E in mothers with a confirmed COVID-19 PCR viral symptoms, and unexposed mothers. Int J Mol Sci. 2021;22(4):1749.

67. Fox A, Marino J, Amanat F, Krammer F, Hahn-Holbrook J, Zolla-Pazner S, et al. Robust and specific secretory IgA against SARS-CoV-2 detected in human milk. Science. 2020;368(6492):10733.

68. Lebrao CW, Cruz MN, da Silva MH, Dutra LV, Cristiani C, Affonso Fonseca FL, et al. Early identification of IgA anti-SARS-CoV-2 in milk of mother with COVID-19 infection. J Hum Lact. 2020;36(4):609–13.

69. van Keulen BJ, Vauloup-Fellous C, Liu B, Benachi A, De Luca D. Synthesis and systematic review of reported neutral SARS-CoV-2 infections. Nat Commun. 2020;11:5164.

70. Cheema R, Partridge E, Kair LR, Kuhn-Riedon KM, Silva AI, Bettinelli ME, et al. Protecting breastfeeding during the COVID-19 pandemic. Am J Perinatol. 2020. Online ahead of print. https://doi.org/10.1097/AJPD.000000000000174277.

71. Centers for Disease Control and Prevention. Evaluation and management of breastfeeding and neonatal issues in the context of COVID-19. https://www.cdc.gov/COVID-19/breastfeeding/safely-during-covid-19-pandemic. Accessed 4 Jun 2021.

72. Centers for Disease Control and Prevention. Interim guidance on breastfeeding and breast milk feeds in the context of COVID-19. https://www.cdc.gov/coronavirus/2019-ncov/hcp/care-for-breastfeeding-women.html. Accessed 4 Jun 2021.

73. Zhu LQM, Li L, Xu B, Lu J, Zhu L. Health care management of pregnancy and childbirth system during COVID-19 in Shanghai. Chin J Fam Plan Gynecol. 2020;12(3):94–6.

74. United Nations International Children’s Emergency Fund. Breastfeeding safely during the COVID-19 pandemic. https://www.unicef.org/coronavirus/breastfeeding-safely-during-covid-19-pandemic. Accessed 4 Jun 2021.

75. American Academy of Pediatrics. Breastfeeding guidancepost hospital discharge for mothers or infants with suspected or confirmed SARS-CoV-2 infection. https://services.aap.org/en/pages/2019-novel-coronavirus-covid-19-infections/covid-19-guidance-post-hospital-discharge. Accessed 4 Jun 2021.

76. International Society of Ultrasound in Obstetrics and Gynecology. New ISUOG interim guidance - 2019 novel coronavirus infection during pregnancy and puerperium: information for healthcare professionals - an update. https://www.isuog.org/clinical-resources/coronavirus-covid-19-resources/research-and-journal/interim-guidance-coronavirus-pregnancy-puerperium.html. Accessed 4 Jun 2021.

77. World Health Organization. Breastfeeding and COVID-19: scientific brief. https://www.who.int/publications/i/item/WHO-2019-nCoV-Sci-Brief-Breastfeeding-2020.1. Accessed 4 Jun 2021.

78. World Health Organization. COVID-19 clinical management: living guidance (27 May 2020). Geneva. World Health Organization, 2020.

79. Martins-Filho PR, Santos VS, Santos HP Jr. To breastfeeding or not to breastfeeding? Lack of evidence on the presence of SARS-CoV-2 in breastmilk of pregnant women with COVID-19. Rev Panam Salud Publica. 2020;44:e59.

80. Golan Y, Frahl M, Cassidy AG, Gay C, Wu AH, Jigmiedjevaga U, et al. COS-19 mRNA vaccination in lactation: assessment of adverse events and vaccine related antibodies in mother-infant dyads. Front Immunol. 2021;12:777103.

81. Golan Y, Frahl M, Cassidy AG, Gay C, Wu AH, Jigmiedjevaga U, et al. COS-19 mRNA vaccination in lactation: assessment of adverse events and vaccine related antibodies in mother-infant dyads. Front Immunol. 2021;12:777103.

82. Blackshaw K, Valtchev P, Kooijsi N, Berry N, Schindeler A, Dehghani F, et al. The risk of infectious pathogens in breast-feeding, donated human milk and breast milk substitutes. Public Health Nutr. 2021;24(7):1725–40.

83. Falsaperla R, Leone G, Familiari M, Ruggieri M. COVID-19 vaccination in pregnant and lactating women: a systematic review. Expert Rev Vaccines. 2021;20(12):1619–28.

84. van de Perre P. Transfer of antibody via mother’s milk. Vaccine. 2003;21(24):3774–7.

85. Fan H, Hong B, Luo Y, Peng Q, Wang L, Jin X, et al. The effect of whey protein on viral infection and replication of SARS-CoV-2 and pangolin coronavirus in vitro. Signal Transduct Target Ther. 2020;5:275.

86. Alkhazindar M, Elmagdy SM. Can lactoferrin boost human immunity against COVID-19? Pathog Glob Health. 2020;114(5):234–5.

87. Peroni DG, Fanox V. Lactoferrin is an important factor when breastfeeding and breast milk substitutes. Public Health Nutr. 2021;24(7):1725–40.

88. Van de Perre P. Transfer of antibody via mother’s milk. Vaccine. 2003;21(24):3774–7.

89. Golan Y, Frahl M, Cassidy AG, Gay C, Wu AH, Jigmiedjevaga U, et al. COS-19 mRNA vaccination in lactation: assessment of adverse events and vaccine related antibodies in mother-infant dyads. Front Immunol. 2021;12:777103.

90. Golan Y, Frahl M, Cassidy AG, Gay C, Wu AH, Jigmiedjevaga U, et al. COS-19 mRNA vaccination in lactation: assessment of adverse events and vaccine related antibodies in mother-infant dyads. Front Immunol. 2021;12:777103.