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Impact of the Coronavirus Disease (COVID-19) Pandemic on Neonatal Nutrition: Focus on Low- and Middle-Income Countries

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Abstract

Purpose of Review This review serves to account for the published literature regarding the changing impact of the COVID-19 pandemic with a focus on neonatal nutrition in low- and middle-income countries.

Recent Findings Initial national and international guidelines regarding breastfeeding were often contradictory. Lack of clear guidelines resulted in separation of mother-neonate dyads and the reliance on non-human sources of milk at institutional levels. Mothers and families were less likely to initiate and/or continue breastfeed during the pandemic due to confusion regarding guidelines, lack of support for lactation, and concern for infection transmission to their neonates. Continued research in neonatal nutrition, however, continues to support the use of breastmilk as the optimal nutritional source for neonates.

Summary Despite concerns for increased risk of COVID-19 transmission with breastfeeding, the use of breastmilk with preserved and combined mother-baby care is associated with improved neonatal nutrition.

Keywords Neonatal nutrition · Breastmilk · Lactation · COVID-19 · Breastfeeding · LMIC

Introduction

Nutrition is crucial to all human growth and development. During the neonatal period, it is particularly important, as nutrition is vital to organ, immune, microbiome, and mother–child bond development and maturation. In low- and middle-income countries (LMIC), this nutrition most often comes in the form of exclusive breastfeeding. Alternatively, expressed breast milk (EBM) alone or breast milk in combination with formula can be employed. Despite great strides in nutrition and nutritional education over the past several decades, malnutrition continues to be a leading cause of death of infants and children under five, particularly in limited-resource settings.

Since the onset of the SARS-CoV-2 (COVID-19) global pandemic crisis in early 2020, all aspects of life and medicine shifted into uncertainty, with some shifts more detrimental than others. Global economies plummeted with LMICs disproportionately affected. Households on the brink of gaining food security were catapulted into or more deeply cemented into food insecurity, resulting in decreased capacity to ensure proper nutrition for all members of the family. Infants are particularly susceptible to fluctuations in available nutrition, as the mother often sacrifices her own nutrition for those in her family. In addition to economic factors, neonatal malnutrition was likely exacerbated by early, well-intentioned guidelines that endorsed postnatal separation of mother-and-child pairs to protect the newborn from exposure to SARS-CoV-2.

While the effects of the pandemic on resources, particularly those focused on nutrition, have been documented in the literature, to date no focused review on the impact of the COVID-19 pandemic on neonatal nutrition exists. This review serves to account for the published literature on neonatal nutrition and the changing impact of the COVID-19 pandemic, with a specific focus on care and management in Low- and Middle-Income Countries (LMICs) across the globe.

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Current State

Importance of Breastmilk

Globally, most neonates rely on maternal breastmilk as their sole source of nutrition. Human breast milk donation is available in some parts of the world for replacement or supplementation. Formula is more widely available than breast milk donation, but often exorbitantly expensive for families, especially in LMICs. Additionally, considerable stigma is attached to not breastfeeding one's child in LMICs, a long-lasting legacy of the HIV epidemic due to and recommendations against breastfeeding given the high risk of vertical HIV transmission.

Breastfeeding and breastmilk have a multitude of positive effects on mothers and infants throughout the world. Breastmilk provides essential nutritional components, promotes immunologic and gut maturity, facilitates bonding, and is associated with decreased neonatal and infant mortality rates. Long-term benefits of breastfeeding include improved cognitive development, reduced risk of allergies and inflammatory disease, and improved cholesterol, sugar, and blood pressure control [1].

SARS-CoV-2 Pandemic

Changes in Family Neonatal Nutritional Practices

The COVID-19 pandemic affected many aspects of essential health care and human health services in high-, middle-, and low-income countries [2]. Already-strained and limited-resource systems, particularly in low-income countries (LIC), became even more strained by COVID-19 specific morbidities, and struggled with a need for resource reallocation to COVID-19 management efforts [3, 4]. There is concern that resource limitations during the COVID pandemic will impact health care outcomes for years to come. Women unable to reach family planning services and who were already experiencing food insecurity could and did become pregnant, resulting in their offspring at increased risk of low birth weight and preterm birth, which both have significant long-term consequences [5–7].

Lack of coherent guidelines and decreased opportunities to communicate existing guidelines or the equipoise regarding breastfeeding often placed the burden of deciphering the safety of breastfeeding on mothers and their families [8].

Breastfeeding reduced for several reasons. Early guidance to not breastfeed, particularly in COVID-19 positive mothers inadvertently permeated over to non-positive mothers. Even in women intending to initiate or continue breastfeeding, a lack of support in hospital settings often thwarted these attempts [9••]. Lack of lactation support is also noted to be a major factor in many LMICs, including India and the Pacific [10••, 11, 16]. Women who were breastfeeding prior to the pandemic in Malaysia were also more likely to stop exclusively breastfeeding early due to self-reported lack of support, as well as mental and emotional disturbances [16].

Despite continued guidance that breastfeeding is the optimal source of nutrition for infants, breastfeeding overall reduced during the pandemic in both high- and low-income countries [9••, 10••]. COVID-19–positive women were more likely to not breastfeed their infants compared to non-positive women as seen in studies from Turkey and Java [11]. In Banyumas, Java, early initiation of breastfeeding decreased from 74.5 to 43.4%; while breastfeeding rates in this population increased as additional data on the safety of breastfeeding became available, the recovery was slow [12]. The effect of unclear guidelines may also have a differential effect on mothers and their neonates, as mothers in LMIC settings are more significantly affected by lower health literacy and reduced access to reliable information on appropriate safety measures [13].

Evidence

Change in Acute Care of Neonates

We will now review three areas of hospital-level impacts in neonatal nutrition during the SARS-CoV-2 pandemic: (1) change in acute care of neonates, (2) separation of the mother-baby dyad, (3) country-level and facility-level changes in neonatal nutritional practices.

Particularly in LICs, COVID-19 has exacerbated neonatal morbidity and mortality and aligns with the three-delays model often used to describe maternal mortality and morbidity [17]. Unfortunately, incidence of low-birth weight infants was noted to increase in LMICs, as did neonatal morbidity and mortality [7, 20]. Neonatal unit admission patterns changed, with decreased admission from deliveries in the healthcare-facility setting and also delayed admissions due to delayed recognition of the need for escalation of care(Type I delay). Finally, once the decision to seek care was in fact made, there were additionally delays in reaching healthcare facilities (Type II delay) due to travel restrictions. Regardless of how and when the neonate reached the healthcare facility, delays in high-quality care (Type III delay) were exacerbated by the COVID-19 virus itself [18]. In some studies, there were fewer reported infants who were SARS-CoV-2 in LICs, but those who were diagnosed with COVID-19 were at higher risk of morbidity and mortality [19]. LICs often do not have dedicated neonatal ICUs, with

critical neonates instead being cared for by the same staff and in the same space as less-critical newborns [5]. During the pandemic, staff that were previously allocated to neonatal units were diverted into COVID-focused units, resulting in less safe and higher staff-to-patient ratios. Critical supplies, such as oxygen and PPE, typically earmarked for the care of higher acuity and immunocompromised neonates, become more scarce due to their higher demand for treatment and prevention of COVID-19 infections [3, 4].

Some positive changes, however, were noted in the care of neonates during the pandemic. Telemedicine became more readily available globally, although networks, secure patient care systems, and technologic savvy may not be as robust in LMICs. Telemedicine avenues could be and were used to support families, improve counseling, and improve education opportunities [21].

Separation of Mother-baby Dyad

Recommendations regarding separation of COVID-position mothers from neonates were often confusing and varied [22]; for example, Indian Chinese and American guidelines initially recommend separation. A focus on separation may have detracted from opportunities for risk-reduction (via hygiene) practices for families choosing to avoid separation [8]. In early 2020, Brazilian hospitals prohibited immediate and uninterrupted skin-to-skin contact immediately after birth; expressed breastmilk was not accepted for use in neonates [23]. These recommendations often minimized bonding, interrupted breastfeeding practices, and interfered with the reliance on breastmilk. Within LMICs, adhering to guidelines was not always possible — UNICEF reported that in many cases skin-to-skin contact and room sharing continued despite the pandemic [8]. In LMICs, formula is relatively more expensive compared to high income countries (HICs) and out of the budget of most families. Separation of neonates from infants interrupted breastmilk supply available to the neonate, with the child becoming malnourished, having to be fed by other women, or precious income having to be spent on formula and diverted away from other nutritional resources for the family [3, 8].

Even prior to the pandemic, kangaroo mother care (KMC) has been noted to be beneficial to infants, particularly those who are born preterm and have low birth weight. Statistical models, utilizing recent data from LMICs, estimated that in a worst-case scenario where 100% of preterm, low-birth weight babies would become infected by COVID-19, this would result in 1950 neonatal deaths worldwide, while 125,680 lives would be saved by KMC coverage. In the more modest model of 10% transmission risk, incremental reduction of KMC was noted to result in at least 12,570 neonatal deaths (with a 50% reduction in KMC). Based on their calculations, the authors estimated that the benefit of KMC is 65–630 times greater than the risk of the preterm, low-birth weight infant dying from COVID-19 [25••]. The benefit of non-separation continues even in normal-weight and/or term infants. Using the Lives Saved Tool, Rollins et al. estimated that only 1800–2800 infants worldwide would die from COVID-19 infection, while mother-baby separation and cessation of breastfeeding would result in 188,000 to 273,000 infant deaths [26].

Although done with the best of intentions, separation of COVID-positive mothers from their neonates did not play a significant role in infection control. This may be due to lack of increased risk of transmission via the respiratory system (potentially balanced out by maternal SARS-CoV-2 antibodies transmitted in breast milk) or eventual subsequent exposure of the infant [3]. A study from a single institution in Italy showed no increased risk of infection from continued neonatal exposure with appropriate PPE; at 1 month of life, the infants were noted to have appropriate growth [24]. Additionally, separating mother from their babies could also contribute to increased risks of psychiatric disorders, which can also affect mother-baby bonding and a mother's ability to provide support to her child [8]. Recognition of the negative consequences of separation with little to no found benefit resulted in a global push for no separation [14].

Country-level, Facility-level, and Provider-level Changes in Neonatal Nutritional Practices

Over the course of the pandemic, guidance on breastfeeding varied by institution, region, and country, even though breastfeeding has well-evidenced maternal and neonatal benefits, whereas breastmilk substitutes have risks. Facile changes in guidance that "breast is best" towards the use of substitutes may reveal a covert assumption that abandoning breastfeeding does not have long-term consequences for mother or baby [8]. Unfortunately, early guidelines often underrated both the benefits of breastfeeding and long-term risks of not breastfeeding (which includes increased susceptibility to lower-respiratory tract viral infections) in lieu of theoretical concerns for vertical transmission [14].

The lack of uniformity and the uncertainty as to whether SARS-CoV-2 could be transmitted in breastmilk led to interruption of neonatal nutrition practices across all levels of countries [3, 27]. Guidelines from the People's Republic of China explicitly recommended against use of breastmilk (either through breastfeeding or expression) in known or suspected maternal COVID-19 cases [27]. American Guidelines eventually recommended shared decision-making with utilizing one of three options: pump and dump until two negative maternal tests, use of breast pump with breast hygiene, continued breastfeeding with maternal PPE precautions; the WHO guidelines favored the final option [28].

In sick mothers, concern for drug therapy and its effect on breastmilk and thus the neonate also resulted in discouraging the use of breast milk [29]. Regardless of separation of the mother-neonate pair, most country-level guidelines available for review either initially or eventually recommended continued use of breastmilk, either from breastfeeding or expression, in both well and sick neonates [22, 30].

Lack of coherent guidelines and decreased opportunities to communicate existing guidelines or the equipoise regarding breastfeeding often placed the burden of deciphering the safety of breastfeeding on women and their families. Many of the guidelines also centered on the actual act of breastfeeding and did not address how to provide expressed milk or milk substitutes safely while the providers were in close contact with the infants [8]. Even when policies did not actively argue against breastfeeding, lack of policies to encourage breastfeeding negatively impacted in-hospital breastfeeding rates [31, 31]. Preventing initial breastfeeding in COVID positive mothers also resulted in lack of future breastmilk supply when women were cleared to "resume" breastfeeding as breastmilk supplies diminish without adequate demand for them [32].

Breastmilk and the SARS-CoV-2 Pandemic

Pasteurization

Guidelines to avoid breastfeeding, as well as separation of COVID-19 positive lactating mothers from their neonates, resulted in decreased availability of the primary nutritional resource for neonates: their own mothers' breast milk. Formula is universally expensive throughout the world, often beyond the reach of families who may need to rely on this form of supplementation in LMICs. Human breast milk donation availability also suffered during the pandemic. Human milk donation is a resource generally available to more wealthy countries, although some middle-income countries also have these services available. Data is not available specifically for LMICs in regard to human milk banking systems, but there is no reason to believe that the experiences of the higher-income countries would have been any more positive than in less well-resourced locations. Human milk banking suffered from changes in supply, as well as demand [33]. Concerns for transmission of the virus through breastmilk, even without the act of breastfeeding, also lead to large drops in human milk donation. In addition, vertical transmission concerns, public safety measures, such as travel limitations and curfews, curtailed the ability of willing donors to actually donate [34]. Fewer babies being born in healthcare facilities and the fear of being exposed to COVID-19 while traveling to or being in a facility providing donated breastmilk resulted in decreased demand [15, 33, 35]. With decreased donation of breast milk and increased concern for viral transmission, rationing of donated breastmilk to extremely premature infants was proposed [28]. A few countries, however, were able to increase donations via social media campaigns, although this was more likely in higher-income countries [35].

Pasteurization of human milk, utilizing the Holder Pasteurization technique, does destroy SARS-CoV-2 [9••]. Equipment and technologic know-how to pasteurize maternal or donated milk, however, is often not readily available in LMICs. Fortunately, there is cause for hope that as the world recovers from the pandemic that even fledgling human milk banks can continue to operate and rebound from the public health impacts of COVID-19 [34] [35]. A virtual Collaborative Network of Human Milk Banks was also established during the pandemic – their work has resulted in additional guidelines for the use and care of human breastmilk in the current and subsequent recommendations from the WHO did not waver from recommending breastfeeding. Much research has shown that assessment of neonatal outcomes, particularly regarding transmission is also difficult to assess because the conduction of routine growth monitoring in populations also decreased [12].

Breastmilk and COVID-19 Transmission

Human breastmilk has also been noted to contain and provide the infant with antiviral compounds, both virus-specific and non-specific, while also promoting maturation of the immune system [1, 36]. Maternal antibodies to SARS-CoV-2 have been identified in breastmilk, which likely help protect neonates from infection [14]. Lacking initial data on viral transmission on breastmilk, an international group of scientists recommended looking at Koch's postulates as a way to assess if breastmilk of SARS-CoV-2 positive women might be safe. Based on Koch's postulates and applying these to known human viruses, including those that are and are not shed in human breastmilk, the authors felt that SARS-CoV-2 was unlikely to result in vertical transmission in breastmilk [37]. Although vertical transmission is a possibility, a direct correlation between COVID-19-positive infants and breastfeeding has not been established, and researchers have yet to identify severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in breastmilk [3]. Just the presence of the virus in breastmilk alone is not sufficient evidence that it can cause disease [37, 38].

Several studies in LMICs found that even among COVID-19 positive women, the incidence of a positive infant was either zero or low [20, 39]. Most studies of milk from postpartum women with COVID-19 have failed to show presence of the virus in breastmilk [40]. In a multinational study including countries from all income levels, no association was found between exclusive breastfeeding and neonatal positivity (RR 1.10, 95% CI 0.66–1.85) [41]. In another review of maternal

COVID-19 women and maternal and neonatal outcomes across multiple countries, only 5.2% of breast milk samples were noted to have SARS-CoV-2 present [30]. A study in Iran noted that none of the infants of COVID-19 positive women were positive — each of the infants had been fed the expressed milk of their COVID-positive mothers [42]. A multicenter longitudinal study from Wuhan, China, also demonstrated low rates of SARS-CoV-2 in breastmilk of COVID-positive women: no virus was detected in 44 samples, 8 samples tested positive for IgM, and none were positive for IgG [43].

As the pandemic continued, neonates have been found to be less susceptible to disease induced by SARS- CoV-2 due to lower risks of cytokine storm from the neonates' immune system [14]. Conversely, neonates in LMICs may have less robust immune systems and more exposure to the negative effects of environmental factors (such as air pollution) that may decrease their ability to overcome the disease should they develop a more severe form [6].

The context in which infant feeding is important to consider. Crowding of neonates and mothers may increase the risk of respiratory transmission due to inability to maintain hygiene practices, as noted in a report on nosocomial transmission in Botswana [32]. The majority of data and guidelines now suggests that breastfeeding can be done safely with appropriate infection-control measures, with supplementation with pasteurized human milk or formula if needed (also exercising similar control measures) [44–50].

Personal Experience from Malawi

Breastfeeding and breast milk have proved to be the best practice and best food for the growing neonate and continues to be. Malawi is a country of 19 million people with a fertility rate of 4.13; it is one of the poorest countries in Africa with just over 50% of the population living in poverty. Its maternal mortality ratio was estimated to be 349 per 100,000 live births and the neonatal mortality ratio has been estimated at 19.1 deaths per 1000 live births. According to national studies, exclusive breastfeeding rates vary between 61 and 71% in the decade prior to COVID.

During the COVID-19 pandemic in Malawi, the national guidelines continued to recommend breastfeeding and/or the use of expressed milk. Expressed milk has been particularly important for when mother-baby dyads had to be separated. In Malawi, positive women were not typically separated from the neonates, in alignment with national guidelines. These guidelines recognized the long-term benefits of breastmilk, as well as the historic and continued evidence that breastmilk is protective against infectious diseases. Appropriate infection control precautions were recommended in conjunction with continued breastfeeding.

Despite the consistency of the national guidelines, our personal experience at the central region's referral hospital, Kamuzu Central Hospital did see separation of neonates testing negative from mothers who were COVID-19 positive in the initial waves of the pandemic in Malawi. Expressed breast milk from their mothers was supplied to the separated infants or if she was critically ill and unable to supply breastmilk, her infant would receive standard formula. However, separated infants were not always spared from exposure to COVID-19 as guardians may have also been infected and could pass this on to the neonate. Standard infection control precautions (practicing hand washing, masks) were noted to help control the risk of infection.

Implications

Breastfeeding and breastmilk have a multitude of positive effects on mothers and infants, with both short- and long-term benefits. The data from the ongoing COVID-19 pandemic weighs strongly in favor of continued breast milk use and keeping mother-baby couplets together with appropriate infection control measures to decrease the risk of transmission between mother and child. In future pandemics, research should be conducted to quickly assess the safety of breastmilk while maintaining breastmilk as the preferred source of nutrition. Research should particularly focus on the effect of infection control guideline and neonatal nutrition changes in LMICs as donated human milk and formula are often not available or are too expensive. A shared decision-making process will help parents navigate complex feeding and care decisions as we face the different stages of the pandemic [8]. Health care systems should include a focus on effects of future pandemics on breastfeeding practices [51].

Practice Points

- Shared decision-making between mother/parents and clinical team is imperative for neonatal nutrition management.
- Breastfeeding can be performed safely with appropriate infection control measures.
- Statistical modeling suggests that continued Kangaroo Mother Care breastfeeding/breast milk use for neonates averts far more neonatal deaths than caused by SARS-CoV-2 infections.
- COVID-19 positive mothers should not be separated as this has not been found to decrease risk of COVID-19 infection in neonates.
- Establishment or bolstering of existing nutritional and lactation services is crucial to ensure universal access to

human milk to reduce neonatal morbidity and mortality now and in preparation for future global crises.

Declarations

Conflict of Interest The authors declare no competing interests.

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