International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

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ARTICLE TITLE	INTEGRATING HEALTH, EDUCATION, AND SPORT: THE IMPACT OF SARS-COV-2 INFECTION AND COVID-19 VACCINATION ON BREASTFEEDING, NEONATAL IMMUNITY, AND EARLY PHYSICAL DEVELOPMENT
DOI	https://doi.org/10.31435/ijitss.3(47).2025.3955
RECEIVED	29 July 2025
ACCEPTED	09 September 2025
PUBLISHED	30 September 2025
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INTEGRATING HEALTH, EDUCATION, AND SPORT: THE IMPACT OF SARS-COV-2 INFECTION AND COVID-19 VACCINATION ON BREASTFEEDING, NEONATAL IMMUNITY, AND EARLY PHYSICAL DEVELOPMENT

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ABSTRACT

The COVID-19 pandemic has underscored the critical role of public health education in promoting maternal and neonatal well-being. This systematic review examines the impact of SARS-CoV-2 infection and COVID-19 vaccination on breastfeeding practices, with a focus on viral transmission, the transfer of antibodies, and the broader implications for health education and early physical development. A comprehensive literature search covering studies from 2020 to 2024 was conducted. The review analyzed research on the presence of
SARS-CoV-2 in breast milk, antibody responses following natural infection and vaccination, and the subsequent effects on newborn health.
The results indicate that active transmission of SARS-CoV-2 via breast milk is extremely rare, with detected viral RNA not corresponding to infectious virus particles. Importantly, breast milk from both infected and vaccinated mothers contains significant levels of IgA and IgG antibodies, which confer passive immunity to newborns. Beyond immediate nutritional and immunological benefits, breastfeeding plays a pivotal role in fostering early physical development—a foundation that may influence later engagement in sports and active lifestyles. Moreover, the excellent safety profile of COVID-19 vaccines for breastfeeding women reinforces the integration of vaccination into public health education strategies aimed at promoting comprehensive maternal and child health.
These findings support the continued promotion of breastfeeding during the COVID-19 pandemic, not only for its direct health benefits but also for its broader educational and developmental impacts. The study advocates for interdisciplinary public health initiatives that integrate health education, vaccination campaigns, and the encouragement of early physical activity as essential elements in optimizing long-term health outcomes.
Objective: The aim of this study is to provide an in-depth analysis of the impact of SARS-CoV-2 infection and COVID-19 vaccination on breastfeeding, with a focus on the potential transmission of the virus and the transfer of antibodies through breast milk to newborns.
Materials and Methods: A systematic review of current scientific literature from 2020 to 2024 was conducted, focusing on studies examining the presence of SARS-CoV-2 in breast milk, levels of anti SARS-CoV-2 antibodies after infection and vaccination, and the clinical implications for newborn health. The search utilized a combination of keywords and logical operators such as "SARS-CoV-2, "“COVID-19, "“coronavirus, "“breastfeeding, "“lactation, "“human milk, " “transmission, "“antibodies, "“vaccination, " and”immunization." Electronic databases searched included PubMed, Scopus, Web of Science, and Embase. The review encompassed publications released from January 2020 to September 2024.
Conclusions: The analysis of available data indicates that the transmission of active virus through breast milk is extremely rare and does not pose a significant risk to the newborn. Detection of viral RNA in breast milk does not equate to the presence of replication-competent virus. Additionally, studies have shown that breast milk from both SARS-CoV-2-infected and COVID-19-vaccinated mothers contains specific antibodies, predominantly IgA and IgG. These antibodies may provide passive immunity to the newborn, potentially protecting against infection or mitigating disease severity. COVID-19 vaccination in breastfeeding women has been proven safe, with no significant adverse effects observed in mothers or their infants. The findings suggest that the benefits of breastfeeding outweigh the potential risks of SARS-CoV-2 transmission. Breastfeeding is recommended both during maternal infection and after COVID-19 vaccination. The available scientific evidence supports policies promoting breastfeeding as a safe and beneficial practice in the context of the COVID-19 pandemic.

KEYWORDS

SARS-Cov-2, COVID-19, Breastfeeding, Maternal Health, Neonatal Immunity, Public Health Education, Early Physical Development, Sports, Vaccination, Passive Immunization

CITATION

Patrycja Kinga Marta, Natalia Morawiecka, Agata Ossolińska, Magdalena Rosa-Bończak, Gabriela Monika Ferfecka, Klaudia Anna Pawełek, Filip Maciej Huzarski, Mikołaj Asztabski, Patrycja Misiaszek, Szymon Rydzewski. (2025) Integrating Health, Education, and Sport: The Impact of SARS-CoV-2 Infection and COVID-19 Vaccination on Breastfeeding, Neonatal Immunity, and Early Physical Development. *International Journal of Innovative Technologies in Social Science*, 3(47). doi: 10.31435/ijitss.3(47).2025.3955

1. Introduction and aim of the study

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has had a profound impact on public health, the economy, and social life worldwide since the end of 2019. Within just a few months of the first reported cases in Wuhan, China, the virus had spread to all continents, prompting the World Health Organization (WHO) to declare a pandemic on March 11, 2020. [1, 2]

The global response to the outbreak included the implementation of social restrictions —such as social distancing, quarantine measures, and the closure of many public sectors— aimed at limiting the transmission of the virus. [3] The effects of these measures were multifaceted: they led to a decline in economic activity, a rise in unemployment, and a noticeable deterioration in quality of life, particularly in developing countries where many people lost their income and faced hunger. [4] At the same time, the pandemic acted as a catalyst for scientific progress: it accelerated research into vaccines, therapies, and diagnostics, and intensified efforts in epidemic surveillance and preparedness for future public health crises. [5]

During the pandemic, particular attention has been focused on vulnerable groups, such as the elderly, chronically ill individuals, pregnant women, breastfeeding mothers, and newborns. [6] Breastfeeding is widely recognized as the optimal method of infant nutrition, providing essential nutrients, supporting immune system development, and fostering an emotional bond between mother and child. [7] Breast milk contains a range of bioactive components, including immunoglobulins, cytokines, enzymes, and immune cells, which protect the infant from infections and diseases. [8] Partial or non-breastfeeding increases the risk of diarrhea or respiratory infections in newborns and decreases infant survival rates. Preterm or non-breastfed newborns are at greater risk of sudden infant death syndrome (SIDS), necrotizing enterocolitis (NEC), and sepsis, and they have higher mortality rates compared to breastfed infants. [9] For mothers, long-term benefits of breastfeeding include a reduced risk of breast and ovarian cancer, osteoporosis, and type 2 diabetes, as well as protection against postpartum depression and quicker postpartum weight recovery. [10]

Most studies have shown that active SARS-CoV-2 virus transmission through breast milk is extremely rare. Additionally, antibodies such as IgA and IgG have been detected in the milk of mothers infected with the virus or vaccinated against COVID-19, potentially

providing passive immunological protection for newbornsv. [11, 12] The transfer of immunity through breast milk is especially critical in infectious diseases, as newborns have immature immune systems. [13] Furthermore, COVID-19 vaccination during pregnancy has been shown to result in the transfer of antibodies through the placenta, providing protection to newborns from birth. Studies involving women vaccinated in the third trimester have demonstrated this protective effect. [14, 15] Research by Hochmayr revealed that mothers infected with SARS-CoV-2 or vaccinated against COVID-19 transmit anti-S1RBD-IgG antibodies to their newborns, offering some protection against infection. The concentration of these antibodies is highest in colostrum and decreases in transitional and mature milk. Mothers with symptomatic infections or those who delivered prematurely had higher antibody levels in their milk. Vaccination further increased antibody levels, particularly IgG. The findings suggest that both natural infection and maternal vaccination have a positive impact on protecting the newborn during the first months of life. [16]

Despite promising data, initial COVID-19 vaccination campaigns raised concerns for pregnant and breastfeeding women, as these groups were excluded from early clinical trials. [17] As new scientific evidence emerged, organizations such as WHO, CDC, and the Polish Neonatal Society began recommending vaccination for these groups, emphasizing its safety and the importance of protecting both mothers and their children. [17, 18, 19] Additionally, data analysis indicates that adverse effects of vaccination in pregnant and breastfeeding women are mild and comparable to those observed in the general population. [18]

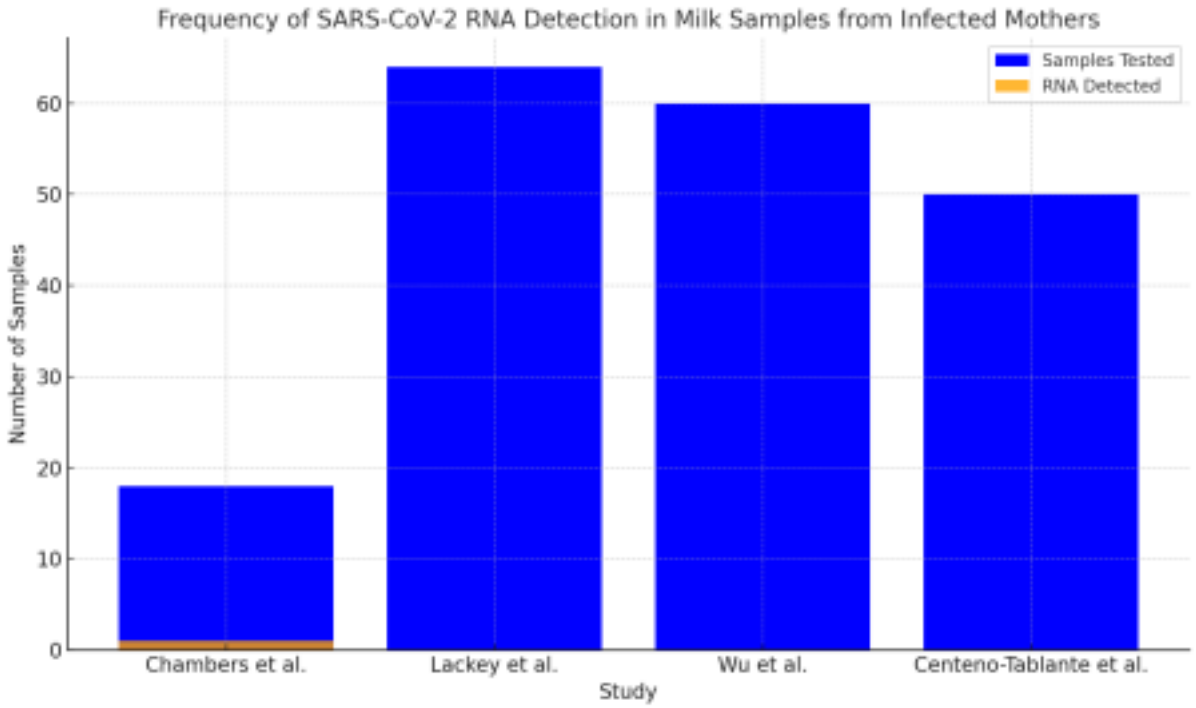
The aim of this study is to thoroughly analyze the impact of SARS-CoV-2 infection and COVID-19 vaccination on breastfeeding, with a focus on virus transmission and the transfer of antibodies from breast milk to the newborn. The study also evaluates the safety of COVID-19 vaccines for pregnant and breastfeeding women, their impact on maternal and newborn health, and the presence and effectiveness of antibodies transmitted through breast milk and the placenta during pregnancy.

2. Current knowledge

2.1 Transmission of SARS-CoV-2 Through Breast Milk

Most studies analyzed have focused on evaluating the presence of SARS-CoV-2 RNA in breast milk and the potential for virus transmission to the newborn during breastfeeding. Chambers et al. [11] analyzed milk samples from 18 mothers infected with SARS-CoV-2 and did not detect any active, replicable virus in any of the samples. Only trace amounts of viral RNA were identified in one sample, but no infectious virus was present. Similarly, Lackey et al., in a study of 64 milk samples from 18 infected mothers, did not detect SARS-CoV-2 RNA in any sample. [12]

Wu et al. analyzed 60 milk samples from 31 mothers with confirmed SARS-CoV-2 infection. The results confirmed the absence of viral RNA in the milk samples, as well as the absence of virus transmission to the newborns during breastfeeding. [19] A systematic review and meta-analysis conducted by Centeno-Tablante et al., encompassing 50 studies on the presence of SARS-CoV-2 in breast milk, concluded that the risk of virus transmission through milk is extremely low. [20]



The mechanism of SARS-CoV-2 infection requires the presence of the ACE2 receptor and proteases such as TMPRSS2, CTSB, or CTSL, which enable the virus to enter cells. Goad et al. investigated whether epithelial cells of the mammary gland, responsible for milk production, express these receptors and proteases. They found that only 5% of mammary gland cells expressed ACE2, and none of them simultaneously expressed ACE2 along with TMPRSS2, CTSB, or CTSL. These findings suggest that the absence of appropriate receptors and proteases prevents the virus from entering mammary gland cells, eliminating the risk of vertical transmission of SARS-CoV-2 through breast milk. [21]

A systematic review and meta-analysis by Boukoura further indicate that the risk of SARS-CoV-2 transmission through breast milk is extremely low. While viral RNA was detected in some milk samples, no evidence of infectious viral particles was found. [22]

Recent studies, such as those by Hochmayr et al., confirm that breast milk contains antiviral components like lactoferrin and immunoglobulins, which may reduce the potential risk of virus transmission. None of the studied infants were infected with SARS-CoV-2 through breast milk, underscoring the safety of breastfeeding in mothers with SARS-CoV-2 infection. [16] Furthermore, analyses conducted in various regions worldwide, including Shanghai, have similarly found no evidence of active virus in the milk of mothers infected with the Omicron variant of SARS-CoV-2. [23]

2.2 Biological Mechanisms Preventing SARS-CoV-2 Transmission Through Breast Milk

An analysis of current scientific evidence highlights several biological mechanisms that prevent SARS-CoV-2 transmission through breast milk:

- **Filtration processes in the mammary gland:** The mammary gland acts as a physical barrier, limiting viral penetration into the milk.
- **Antiviral properties of breast milk:** Breast milk contains components such as lactoferrin, lysozyme, immunoglobulins, and oligosaccharides, which can neutralize the virus or inhibit its replication.
- **Absence of viral receptors:** Low expression of ACE2 receptors and TMPRSS2, CTSB, and CTSL proteases in the mammary gland minimizes the risk of infectious virus presence in breast milk.

These findings align with earlier observations on other coronaviruses, such as SARS-CoV and MERS-CoV, which also showed no evidence of transmission through breast milk.

The available scientific evidence clearly indicates that breast milk is not a likely source of SARS-CoV-2 transmission. Even in cases where viral RNA is detected in milk, the lack of infectious viral particles confirms the safety of breastfeeding. Moreover, breast milk plays a crucial role in protecting newborns by providing immunological components, further emphasizing its importance during the COVID-19 pandemic. Breastfeeding should be encouraged, particularly during the pandemic, with appropriate precautions in place.

2.3 Antibodies in Breast Milk: Protective Mechanisms and Significance in the Context of SARS-CoV-2

Studies have unequivocally demonstrated the presence of specific anti-SARS-CoV-2 antibodies in the breast milk of mothers following natural infection and COVID-19 vaccination. These antibodies play a key role in the passive immunization of newborns, protecting them from viral infections during the period when their own immune system is still immature.

2.4 Presence of Antibodies in the Milk of Mothers Infected with SARS-CoV-2

Fox et al. analyzed milk samples from 15 mothers who had experienced SARS-CoV-2 infection and detected high levels of virus-specific IgA antibodies. Importantly, these antibodies demonstrated the ability to neutralize SARS-CoV-2 in vitro, suggesting their

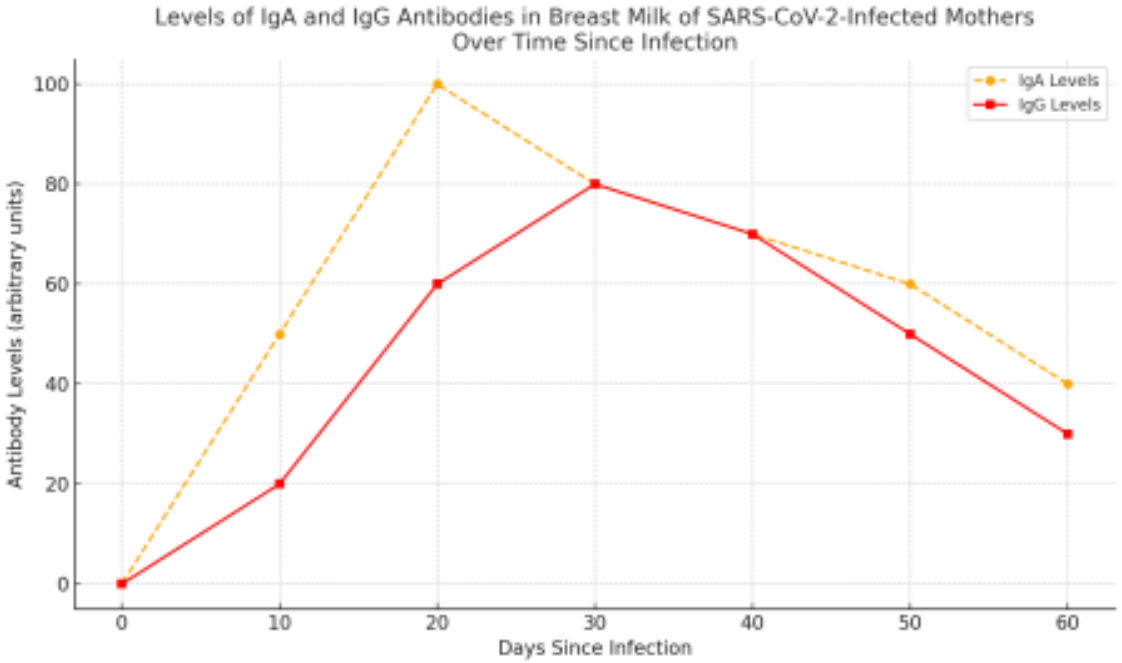
potential effectiveness in protecting the newborn from infection. [24] Similarly, Pace et al., examining milk samples from 37 mothers infected with SARS-CoV-2, found the presence of both IgA and IgG antibodies, which also exhibited virus-neutralizing activity. [25]

A Polish study by Jakuszko et al. evaluated antibody levels in the milk of mothers who recovered from COVID-19. The majority of the samples showed the presence of IgA and IgG antibodies, confirming the possibility of passive immunity being transferred to newborns. [13] Comparable results were obtained in the study by Hochmayr et al., which revealed that IgA and IgG antibody levels were higher in the milk of mothers who had a natural infection compared to vaccinated mothers. Nonetheless, both groups provided protective antibodies to their newborns. [16]

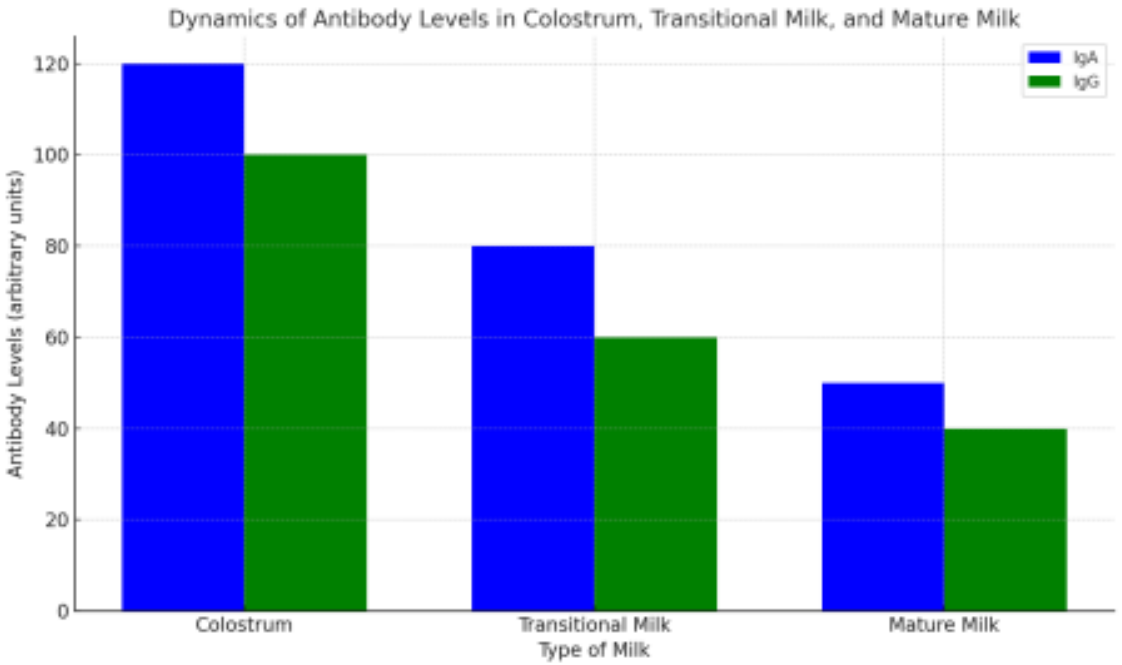
Here is a chart illustrating IgA and IgG antibody levels in the milk of mothers infected with SARS-CoV-2 over time since infection.

2.5. Antibodies in the Milk of Mothers Vaccinated Against SARS-CoV-2

COVID-19 vaccination also induces the production of antibodies, which are present in breast milk. Perl et al. demonstrated that IgG antibody levels increased following the administration of the second dose of an mRNA vaccine, further enhancing the potential protection for the child. [15] A study by Gray et al. confirmed that mRNA vaccines generate higher levels of IgG antibodies in breast milk, which may be crucial for protecting newborns against SARS-CoV-2. [14] Hochmayr et al. found that mothers vaccinated against COVID-19 during the third trimester of pregnancy transferred anti-S1RBD-IgG antibodies to their newborns both through the placenta and breast milk, providing protection during the first months of life. Particularly high concentrations of IgG antibodies were observed in colostrum, followed by transitional and mature milk. Mothers with symptomatic infections or those who delivered prematurely had higher antibody concentrations in their milk. Vaccination further elevated antibody levels, particularly IgG. [16]



Below is a chart illustrating the dynamics of IgA and IgG antibody levels in colostrum, transitional milk, and mature milk.



2.6. Mechanisms of Antibody Action in Breast Milk

The antibodies present in breast milk operate on multiple levels, providing immunological protection for the newborn:

- **Virus Neutralization:** IgA antibodies, which dominate in breast milk, neutralize viruses on the mucosal surfaces of the infant's digestive tract, preventing adherence and invasion. [24]
- **Systemic Transfer:** IgG antibodies, particularly prevalent in the milk of vaccinated mothers, can be absorbed through the newborn's digestive tract and enter circulation, offering systemic protection against SARS-CoV-2. [15]
- **Long-Term Immune Support:** Breastfed children exhibit a slower decline in serum antibody levels compared to formula-fed infants. [26]

2.7. Benefits of Antibodies Transferred Through Breast Milk for Newborns

● **Reduced Risk of SARS-CoV-2 Infection in Newborns:** Passive immunization can protect the child during a period when their immune system is immature. ● **Milder Course of Potential Infection:** The presence of antibodies may reduce the severity of symptoms and the risk of complications. [27]

● **Support for the Development of the Child's Immune System:** Antibodies and other breast milk components, such as lactoferrin and cytokines, modulate the infant's immune response, positively influencing their long-term immunological health. [26]

2.8. Summary

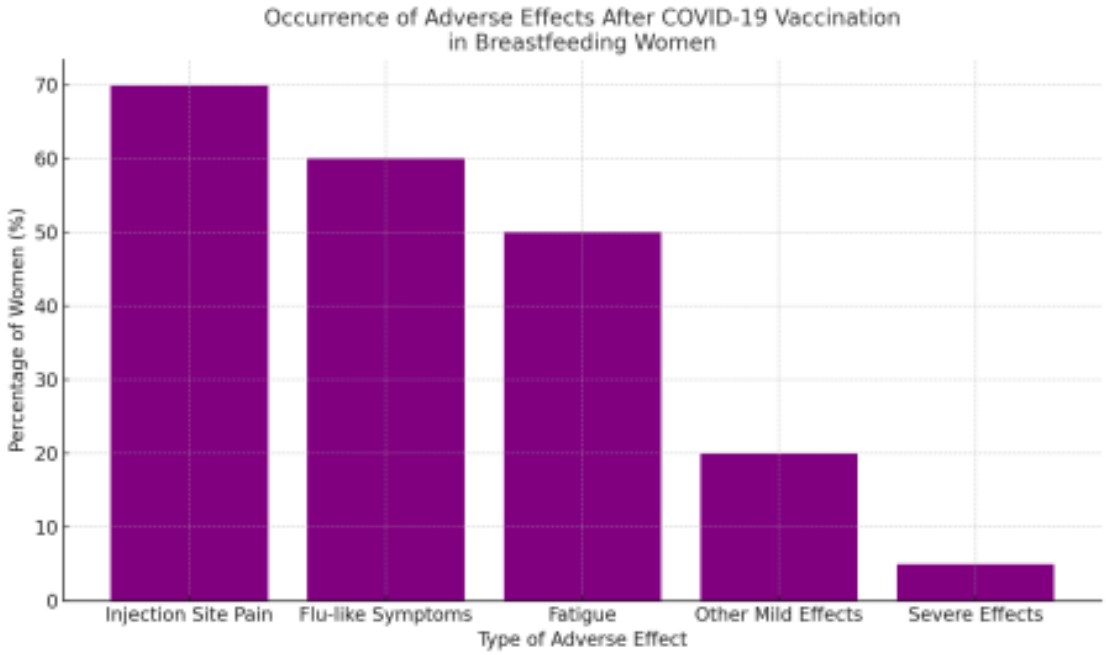
The antibodies present in breast milk, whether from natural SARS-CoV-2 infection or COVID-19 vaccination, play a crucial role in protecting newborns from infections. These mechanisms highlight the importance of breastfeeding as an effective strategy to support the child's immunological health, particularly in the context of the COVID-19 pandemic. Research indicates that both natural infection and maternal vaccination are effective methods of enhancing newborn immunity, providing a strong foundation for further studies in this field.

3. Impact of COVID-19 Vaccination on Breastfeeding and Child Health

Initially, COVID-19 vaccinations for breastfeeding women raised concerns due to the lack of data from early clinical trials. However, numerous scientific studies now confirm that these vaccinations are safe, effective, and bring significant benefits for both mothers and their children. mRNA vaccines, in particular, have demonstrated high efficacy in inducing an immune response.

3.1. Safety of Vaccination for Breastfeeding Women

Available studies indicate that COVID-19 vaccines are well-tolerated by breastfeeding women. Most mothers reported only mild symptoms, such as injection site pain, transient flu-like symptoms, or fatigue. Severe adverse effects were extremely rare and were no different from those observed in the general population. An analysis conducted by Amer et al. found that for most women, vaccination had no negative impact on their health, with side effects primarily limited to localized and temporary symptoms. [28]



Studies indicate that COVID-19 vaccination does not alter milk production or composition, and its quality continues to support the child's health. [14] These findings unequivocally confirm that COVID-19 vaccinations for breastfeeding women are safe and do not negatively impact the breastfeeding process.

3.2. Transfer of Antibodies Through Breast Milk

One of the key protective mechanisms resulting from vaccinating breastfeeding women is the transfer of anti-SARS-CoV-2 antibodies into breast milk. COVID-19 vaccinations lead to the production of IgG and IgA antibodies, which are then present in the mother's milk. Studies by Perl et al. demonstrated that IgG antibodies appear in breast milk after the first vaccine dose, with levels increasing following the second dose. No significant adverse effects were observed in either mothers or their children. [15]

Gray et al. highlighted the presence of both IgG and IgA antibodies in breast milk after vaccination, emphasizing their role in protecting newborns from SARS-CoV-2. IgA antibodies act on the mucosal surfaces of the infant's gastrointestinal tract, neutralizing

pathogens, while IgG antibodies can be absorbed through the intestinal epithelium, entering systemic circulation to provide additional immunological protection. [14, 26]

Data suggest that mRNA vaccines, such as Pfizer-BioNTech and Moderna, generate higher antibody levels in breast milk compared to vector-based vaccines, such as AstraZeneca. Narayanaswamy et al. found that IgG antibody levels in the milk of mothers vaccinated with vector-based vaccines were lower but still demonstrated protective potential.

[29] Hochmayr et al. confirmed that both mRNA and vector-based vaccines result in the presence of antibodies in breast milk, although mRNA vaccines generate higher IgG levels. [16]

3.3. The Importance of Antibodies for Child Health

Antibodies transferred through breast milk play a crucial role in protecting newborns from SARS-CoV-2. Studies by Proto et al. and Esteve-Palau et al. indicate that these antibodies can be absorbed through the infant's gastrointestinal tract and may even enter systemic circulation, providing protection against infection. [17, 26] Additionally, breastfed infants show a slower decline in serum antibody levels compared to formula-fed infants, further emphasizing the role of breast milk in immunological protection. [16]

The presence of IgA and IgG antibodies in the milk of vaccinated mothers enhances the child’s immunity, reducing the risk of SARS-CoV-2 infection and mitigating the severity of a potential infection. Studies on animal models have also shown that antibodies present in breast milk neutralize the virus in the infant's gastrointestinal tract, protecting them from infection. [27]

In Shah’s study, COVID-19 vaccinations were deemed safe and effective, improving health outcomes for both mothers and newborns while reducing the risk of severe disease. The study highlighted the protective role of antibodies transferred through the placenta and breast milk, as well as emerging risks such as Multisystem Inflammatory Syndrome in Newborns (MIS-N). It also underscored the need for further research into the long-term impacts of the pandemic and challenges in medical education. [30]

REFERENCES

1. World Health Organization. (2020). Coronavirus disease (COVID-19) pandemic. https://www.who.int/emergencies/diseases/novel-coronavirus-2019
2. World Health Organization. (2020, March 11). 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---11-march-2020
3. Hosseinzadeh, P., Zareipour, M., Baljani, E., & Moradali, M. R. (2022). Social consequences of the COVID-19 pandemic: A systematic review. Investigación y Educación en Enfermería, 40(1), e10. https://doi.org/10.17533/udea.iee.v40n1e10
4. Nicola, M., Alsafi, Z., Sohrabi, C., et al. (2020). The socio-economic implications of the coronavirus pandemic (COVID-19): A review. International Journal of Surgery, 78, 185–193. https://doi.org/10.1016/j.ijsu.2020.04.018
5. Chavda, V. P., Vuppu, S., Mishra, T., et al. (2022). Recent review of COVID-19 management: Diagnosis, treatment and vaccination. Pharmacological Reports, 74(6), 1120–1148. https://doi.org/10.1007/s43440-022-00425-5
6. Centers for Disease Control and Prevention. (2023). People at increased risk. https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/index.htm
7. American Academy of Pediatrics. (2012). Breastfeeding and the use of human milk. Pediatrics, 129(3), e827–e841. https://pediatrics.aappublications.org/content/129/3/e827
8. Ballard, O., & Morrow, A. L. (2013). Human milk composition: Nutrients and bioactive factors. Pediatric Clinics of North America, 60(1), 49–74.
9. Pang, Z., Hu, R., Tian, L., Lou, F., Chen, Y., Wang, S., He, S., Zhu, S., An, X., Song, L., et al. (2022). A review of breastfeeding during the COVID-19 pandemic. Frontiers in Immunology, 13, 896068. https://doi.org/10.3389/fimmu.2022.896068

10. Chowdhury, R., Sinha, B., Sankar, M. J., Taneja, S., Bhandari, N., Rollins, N., Bahl, R., & Martines, J. (2015). Breastfeeding and maternal health outcomes: A systematic review and meta-analysis. Acta Paediatrica, 104(S467), 96–113. https://doi.org/10.1111/apa.13102
11. Chambers, C., Krogstad, P., Bertrand, K., et al. (2025). Evaluation for SARS-CoV-2 in breast milk from 18 infected women. JAMA.
12. Lackey, K. A., Pace, R. M., Williams, J. E., et al. (2020). SARS-CoV-2 and human milk: What is the evidence? Maternal & Child Nutrition, 16(4), e13032. https://doi.org/10.1111/mcn.13032
13. Jakuszko, K., Kościelska-Kasprzak, K., Żabińska, M., et al. (2021). Immune response to vaccination against COVID-19 in breastfeeding health workers. Vaccines (Basel), 9(6), 663. https://doi.org/10.3390/vaccines9060663
14. Gray, K. J., Bordt, E. A., Atyeo, C., et al. (2021). COVID-19 vaccine response in pregnant and lactating women: A cohort study. American Journal of Obstetrics and Gynecology, 225(3), 303.e1–303.e17. https://doi.org/10.1016/j.ajog.2021.03.023
15. Perl, S. H., Uzan-Yulzari, A., Klainer, H., et al. (2021). SARS-CoV-2–specific antibodies in breast milk after COVID-19 vaccination of breastfeeding women. JAMA, 325(19), 2013–2014. https://doi.org/10.1001/jama.2021.5782
16. Hochmayr, C., Winkler, I., Hammerl, M., Höller, A., Huber, E., Urbanek, M., Kiechl Kohlendorfer, U., Griesmaier, E., & Posod, A. (2024). Factors influencing antibody levels in human milk during the COVID-19 pandemic: An observational study. Nutrients, 16(14), 2320. https://doi.org/10.3390/nu16142320
17. Esteve-Palau, M., et al. (2025). Transfer of SARS-CoV-2 antibodies to neonates via breastfeeding post-vaccination. Pediatrics.
18. Amer, A. A., Amer, S. A., Badokhon, A., Hammad, S. M., Wasfy, M. A., Khan, M., Al-Harbi, T. A., Alobaid, S. Q., Eskander, G., Abdel-Azeem, A., Alshowair, A., & Ramadan, M. S. (2022). Investigation of adverse events associated with COVID-19 vaccination among pregnant women: A cross-sectional study. Journal of Maternal and Neonatal Health Research.
19. Wu, J., Zeng, W., Guo, Z., Jiang, X., & Li, H. (2020). Absence of SARS-CoV-2 RNA in breast milk from mothers with COVID-19: A multicenter study. Journal of Human Lactation, 36(3), 534–536. https://doi.org/10.1177/0890334420937678
20. Centeno-Tablante, E., Medina-Rivera, M., Finkelstein, J. L., et al. (2021). SARS-CoV-2 transmission through breastfeeding: A systematic review and meta-analysis. Pediatric Research, 89(5), 889–897. https://doi.org/10.1038/s41390-020-01171-0
21. Goad, J., Rudolph, J., & Rajkovic, A. (2020). Female reproductive tract has low concentration of SARS-CoV-2 receptors. Frontiers in Immunology, 11, 7735593. https://doi.org/10.3389/fimmu.2020.7735593
22. Boukoura, M. E., Dagla, M., Gourounti, K., Nieri, A. S., Taskou, C., Tsoukala, E., & Sarantaki, A. (2024). Breastfeeding practices for COVID-19-infected mothers: A systematic review and meta-analysis. Nursing Reports, 14(1), 516–531. https://doi.org/10.3390/nursrep14010040
23. Deng, H., Jin, Y., Sheng, M., Liu, M., Shen, J., Qian, W., Zou, G., Liao, Y., Liu, T., Ling, Y., & Xiaohonga, W. (2023). Safety and efficacy of COVID-19 vaccination during pregnancy among 1,024 pregnant women infected with the SARS-CoV-2 Omicron variant in Shanghai, China. Frontiers in Immunology, 14, 1303058. https://doi.org/10.3389/fimmu.2023.1303058
24. Fox, A., Marino, J., & Sano, K. (2021). Protective effects of breast milk antibodies against SARS-CoV-2 infection in neonates. Science Immunology, 6(60), eabn3129. https://doi.org/10.1126/sciimmunol.abn3129
25. Pace, R. M., Williams, J. E., Jarvinen, K. M., et al. (2021). Characterization of SARS-CoV-2-specific antibodies in human milk. Nature Communications, 12(1), 1236. https://doi.org/10.1038/s41467-021-21438-2
26. Proto, A., Agliardi, S., Pani, A., Renica, S., Gazzaniga, G., Giossi, R., Senatore, M., Di Ruscio, F., Campisi, D., Vismara, C., Panetta, V., Scaglione, F., & Martinelli, S. (2022). COVID-vaccines in pregnancy: Maternal and neonatal response over the first 9 months after delivery. Vaccine. https://doi.org/10.1016/j.vaccine.2022.09.021
27. Kelly, J. C., Carter, E. B., Raghuraman, N., et al. (2021). Anti-SARS-CoV-2 antibodies induced by COVID-19 mRNA vaccine in breast milk. Obstetrics & Gynecology, 137(5), 824–828. https://doi.org/10.1097/AOG.0000000000004333
28. Ahmed, A., Amer, S. A., Badokhon, A., Hammad, S. M., Wasfy, M. A., Khan, M., Al-Harbi, T. A., Alobaid, S. Q., Eskander, G., Abdel-Azeem, A., Alshowair, A., & Ramadan, M. S. (2024). Exploring COVID-19 vaccine adverse events among pregnant women: A cross-sectional study. Therapeutic Advances in Vaccines and Immunotherapy, 12, 25151355241285594. https://doi.org/10.1177/25151355241285594
29. Narayanaswamy, V., et al. (2021). Antibody responses in lactating women following COVID-19 vaccination: A comparative analysis of vaccine platforms. Clinical Infectious Diseases, 73(11), e4287–e4295. https://doi.org/10.1093/cid/ciab762
30. Shah, M. D., Miller, N., & Saugstad, O. D. (2024). Newborns at risk of COVID-19, the story continues. Journal of Perinatal Medicine. https://doi.org/10.1515/jpm-2024-0125