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Review

Global evolution of research on breast milk composition: a bibliometric analysis

Bunga A. Paramashanti[1], Dea Anita Ariani Kurniasih[1], Lintang Purwara Dewanti[2], Meralda Nindyasti Eka Budiastutie[3], Yanuarti Petrika[4], Yessi Marlina[5], Yunita Amraeni[6], Nadhea Alriessyanne Hindarta[7]

[1]Research Center for Public Health and Nutrition, National Research and Innovation Agency (BRIN), Bogor, West Java, Indonesia
[2]Department of Nutrition Science, Faculty of Health Science, Universitas Esa Unggul, Jakarta, Indonesia
[3]Lactashare Foundation, Lowokwaru, Malang, East Java, Indonesia
[4]Department of Nutrition, Poltekkes Kemenkes Pontianak, Pontianak, West Kalimantan, Indonesia
[5]Department of Nutrition, Poltekkes Kemenkes Riau, Riau, Indonesia
[6]Department of Public Health, Universitas Pembangunan Nasional Veteran Jakarta, Jakarta, Indonesia
[7]Department of Nutrition Science, Faculty of Medicine, Diponegoro University, Semarang, Central Java, Indonesia

Abstract

Breast milk is the optimal source of infant nutrition, with its composition influencing growth, development, and immune function. As interest in its bioactive components has increased, mapping research trends in this field is essential. This study provides a comprehensive bibliometric analysis of global research on breast milk composition. Publications indexed in the Scopus database from 1983 to 2024 were analyzed. Descriptive statistics were computed in Microsoft® Excel®, and VOSviewer (version 1.6.20) was used for bibliometric mapping. A total of 4,289 documents were retrieved, comprising 3,658 original articles (85.3%) and 631 reviews (14.7%). Output increased steadily, with a sharp rise between 2019 and 2023, peaking in 2022. Research originated from 133 countries, led by the United States (28.0%), China (7.9%), and the United Kingdom (7.5%). The University of California, Davis, and the University of Western Australia were the most productive institutions, while the U.S. National Institutes of Health and the National Natural Science Foundation of China were the top funders. Keyword co-occurrence analysis identified 7 major thematic clusters, including the gut microbiome, fatty acids, micronutrients, maternal obesity, and human milk oligosaccharides. Over time, research has shifted from a primary focus on fatty acids to emerging themes such as microbiome interactions and the influence of maternal health and diet. To our knowledge, this is the first bibliometric study offering a global perspective on breast milk composition research. These findings highlight evolving research priorities and provide evidence to guide future investigations, funding strategies, and policies that support breastfeeding and improve maternal-infant health outcomes worldwide.

Keywords

Bibliometric, review, breast milk, breastfeeding, composition, nutrition.

Corresponding author

Dr Bunga A. Paramahsanti. Research Center for Public Health and Nutrition, National Research and Innovation Agency (BRIN), Bogor, West Java, 16911, Indonesia; e-mail: pshanti.bunga@gmail.com.

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Introduction

Breastfeeding plays a pivotal role in ensuring the health and well-being of mothers and children [1]. For mothers, breastfeeding is not only good for physical and emotional health, but also for their future life, e.g. reducing the risk of postpartum depression, the risk of type 2 diabetes mellitus, breast cancer, ovarian cancer, cancer of the endometrium, and Alzheimer's disease [2]. For babies, breastfeeding not only reduces the risk of death and disease in early life but has lasting health benefits through adult life, such as reduced risk of chronic diseases, allergies, asthma, diabetes, obesity, irritable bowel syndrome, and Crohn's disease [3]. Additionally, breastfeeding is beneficial for the healthy growth and development of infants and children [4]. From an economic perspective, low breastfeeding rates result in global economic losses of about $341.3 billion, or 0.70% of gross national income, likely underestimating true costs by not including caregiving time and healthcare expenses. Meanwhile, investing in breastfeeding promotion could provide significant economic benefits [5].

The World Health Organization (WHO) recommends exclusive breastfeeding for the first 6 months of life and continued breastfeeding for up to 2 years or beyond [6]. Despite progress, global breastfeeding rates are still inadequate. In 2023, the rate of exclusive breastfeeding at 6 months of life was 48%, falling short of the World Health Assembly's target of 50% in 2025. The proportion of breastfeeding at 2 years old stands at 45%, which is below the 60% target. Furthermore, the initiation of breastfeeding is at 46%, less than the desired target of 70% [7]. Challenges remain in implementing the priority policy actions needed to promote optimal feeding practices. Misunderstandings of typical infant behavior often cause parents to perceive milk insufficiency, resulting in the use of commercial milk formulas that are heavily marketed despite WHO guidelines [8].

Breastfeeding is widely acknowledged in public health, but research is hindered by significant variability in human milk composition, which can fluctuate with the time of day, stage of lactation, and differences among women and populations [9]. The composition is influenced by maternal, infant, and environmental factors. Maternal factors include dietary intake, which affects macronutrient levels and varies with the lactation period [10, 11]. Nutritional status and certain medications can also modify breast milk composition [12]. Moreover, maternal stress can alter fatty acid (FA) profiles, reducing key FA concentrations [13], while tobacco use can introduce nicotine into breast milk, potentially impacting production [14]. Infant factors, such as gestational age and health, influence the nutrient profile to meet developmental needs [15]. Environmental factors, including geographic location and mode of delivery, further affect milk composition, notably through variations in vitamin D levels from sunlight exposure and the presence of bioactive factors [16, 17]. Nonetheless, breast milk remains the gold standard for infant nutrition, providing essential nutrients and bioactive components crucial for growth, development, and immune protection [18].

Maternal factors include dietary intake, which influences the quality of breast milk, particularly the FA profile and micronutrient levels (e.g., vitamins A, D, E, B12, iodine), while total macronutrient levels (protein, carbohydrate, total fat) remain largely stable under normal dietary conditions due to physiological homeostasis [19-21]. The consumption of vitamin and mineral supplements, particularly fat-soluble vitamins such as vitamins A and D, as well as vitamins B1, B2, and C, is a current intervention aimed at enhancing breast milk composition [22]. An appropriate dietary pattern that includes balanced fat and protein intake supports breast milk composition and aligns with the estimated energy requirements for infants, especially during the exclusive breastfeeding phase (infants aged 0-6 months); therefore, high-fat and high-protein diets, as well as irrational dietary patterns, should be avoided [23]. Additionally, weight loss interventions have shown a positive correlation with leptin levels in breast milk [24]. Maternal body composition management is also positively associated with leptin and adiponectin levels in breast milk, both of which play roles in early-life metabolic programming for infants [25]. It is essential to note that, even under conditions of maternal undernutrition, breast milk exhibits remarkable physiological homeostasis, maintaining its overall macronutrient balance and its protective bioactive properties. Minor variations in certain micronutrients or hormones reflect adaptive biological responses rather than deficiencies. These natural adaptations further illustrate the resilience and adequacy of breast milk as the universal standard for infant feeding across all settings [26, 27].

Research on breast milk composition has been extensive for many years and continues to evolve. These studies are widespread, and their findings are rapidly disseminated. There is an urgent need for a comprehensive bibliometric analysis to evaluate the expanding body of evidence. Unlike scoping reviews, which assess the breadth and scope of research evidence, and systematic reviews, which focus on specific research questions based on a limited number of publications, the bibliometric analysis provides a detailed overview of the literature on a given topic [28, 29]. Therefore, this study aims to assess the current state and research trends related to breast milk composition through bibliometric analysis. Mapping global research output helps identify not only scientific advances but also regions where engagement should be strengthened to ensure that evidence reflects the diversity of mothers and infants worldwide.

Methods

This study used bibliometric analysis to examine the trends, emerging topics, and future research directions in breast milk composition research. Bibliometric analysis is a widely used and systematic approach for reviewing and interpreting extensive scientific data, enabling the exploration of developmental trends within a specific field while highlighting emerging subfields and topics. While it may not provide strong evidence found in systematic reviews and meta-analyses, this method is a high-quality, reliable, and informative tool in medical research [28].

Database

We utilized the Scopus database to gather a comprehensive set of publications focused on breast milk composition. Scopus is a prominent and well-established publication database, renowned for its extensive coverage and robust set of features. It provides a wide range of scholarly content, along with individual profiles for authors, institutions, and sources, as well as various impact indicators that are comparable to, or in some cases exceed, those found in the Web of Science. Additionally, Scopus offers the advantage of a single subscription for access to a vast array of resources, and it provides open access to valuable author and source metrics, further enhancing its usability and transparency [30, 31]. To ensure the accuracy and consistency of our analysis, we extracted all relevant data on July 18, 2024, thereby minimizing the risk of bias arising from any subsequent updates or changes made to the Scopus database.

Search strategy

We conducted a comprehensive literature search targeting records published between 1983 and 2024. The search was applied to the Title, Abstract, and Keywords fields using the following Boolean query: ("breast milk" OR "human milk" OR "breastfeeding" OR "lactation") AND "composition". This strategy was designed to capture studies focusing on human milk composition and related terms. Filters were applied to restrict results to English-language publications, document types of original articles and reviews, and human-related studies. To ensure subject relevance, we included the following categories: Medicine, Nursing, Agricultural and Biological Sciences, Biochemistry, Genetics and Molecular Biology, Immunology and Microbiology, Multidisciplinary, Pharmacology, Toxicology and Pharmaceutics, Social Sciences, Health Professions, and Psychology. For bibliometric analysis, we used VOSviewer (version 1.6.20) (Leiden University, Leiden, The Netherlands) to conduct keyword co-occurrence mapping. We set a minimum keyword occurrence threshold of 15, applied association strength as the normalization method, and employed the LinLog/modularity algorithm for clustering to identify thematic groups within the field.

Data management and analysis

Following the search strategy, we exported the retrieved data from Scopus to Microsoft® Excel® in CSV format. The exported dataset encompassed a broad range of bibliometric information, including author names, document titles, journal titles, publication years, institutional affiliations, document types, and keywords. To analyze publication trends over time, we utilized descriptive statistics in Microsoft® Excel®, enabling us to assess yearly publication patterns and calculate the frequency and percentage of the most influential publications within the dataset. For the science mapping process, we employed VOSviewer (version 1.6.20) to conduct co-authorship analysis, which helped identify collaborative networks across countries [32]. Additionally, we performed co-occurrence analysis to visualize keyword relationships and uncover emerging research trends within the field.

Results

We found a total of 4,289 published documents on breast milk composition between 1983 and 2024, consisting of 3,658 (85.3%) original articles and 631 (14.7%) reviews.

Publication trends

Fig. 1 depicts the annual number of publications globally. The total number of publications has steadily increased. Between 1983 and 2011, the number of publications increased relatively steadily and modestly. From 2012 to 2018, the trend exhibited fluctuations. However, a significant increase in publications occurred from 2019 to 2023, with 2022 recording the peak in research output on breast milk composition. The number of publications in 2024 was lower than the previous year due to the data extracted from the database in mid-2024.

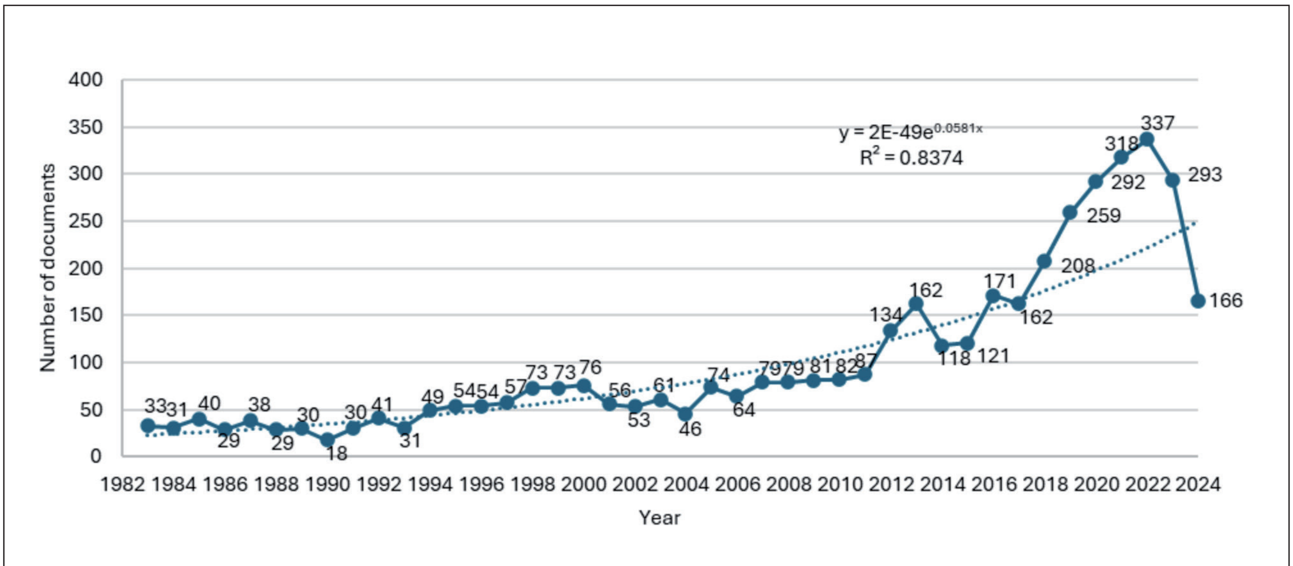

Figure 1. Trends in annual publications on breast milk composition research.

Countries with the highest publications

Research on breast milk composition included contributions from 133 countries. Out of 4,289 documents, the United States was the most prolific, with 1,201 publications (28.0%), followed by China with 337 publications (7.9%) and the United Kingdom with 320 publications (7.5%). **Tab. 1** lists the top 10 countries with the highest number of publications on breast milk composition.

Fig. 2 presents a network visualization map that highlights research collaboration among countries, where each country has contributed a minimum of 10 documents. The United States

Table 1. Top 10 countries with the highest publications on breast milk composition.

Rank	Country	Number of documents	%
1st	United States	1,201	28.0
2nd	China	337	7.9
3rd	United Kingdom	320	7.5
4th	Canada	278	6.5
5th	Australia	271	6.3
6th	Spain	254	5.9
7th	Germany	252	5.9
8th	Italy	249	5.8
9th	Netherlands	233	5.4
10th	Brazil	164	3.8

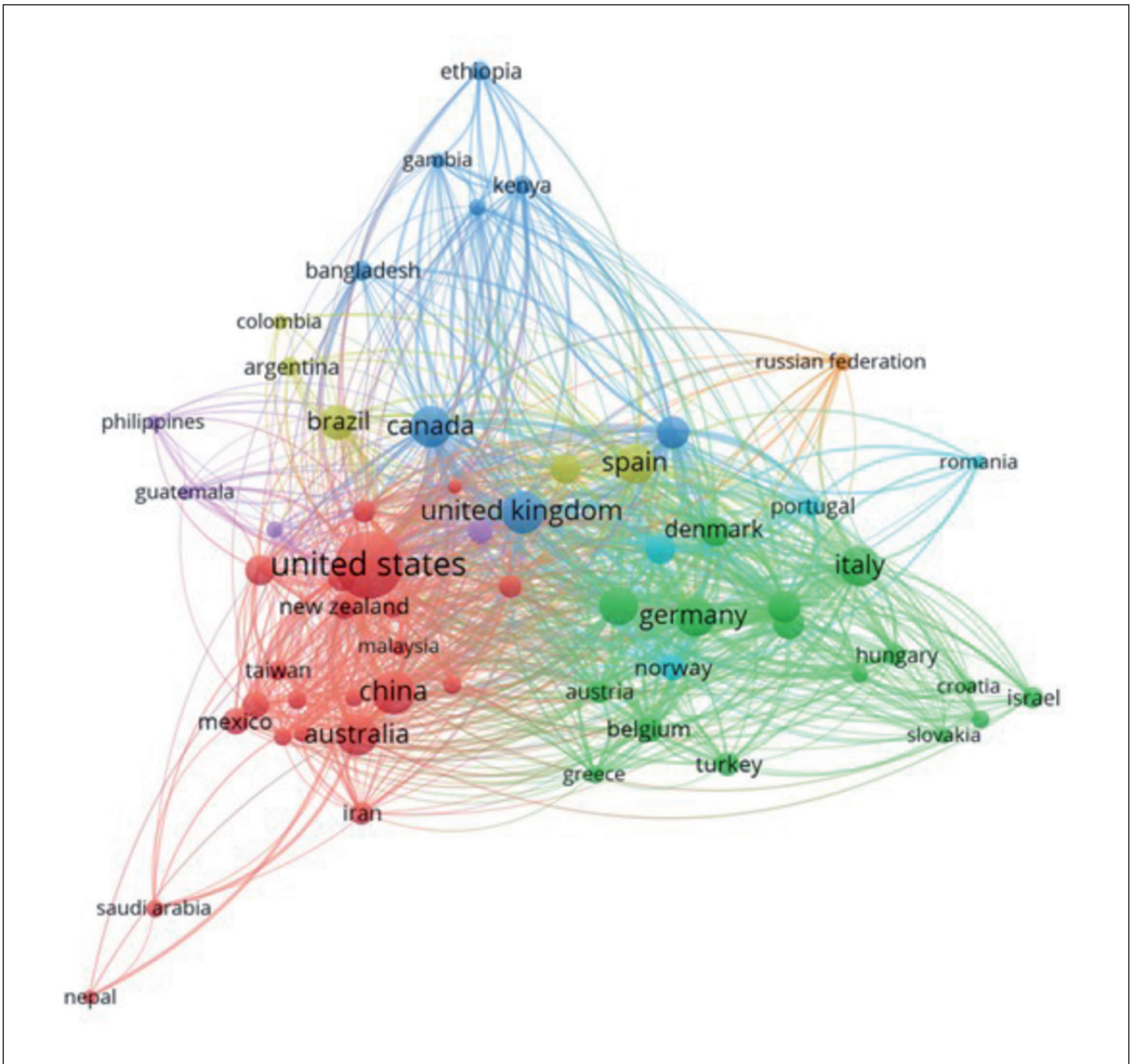

Figure 2. Country collaboration map related to breast milk composition research.
For the science mapping process, VOSviewer version 1.6.20 (Leiden University, Leiden, The Netherlands) was employed.

exhibited the most substantial international collaboration, evident from the thickness of the connecting lines and the size of its nodes, followed by China, the United Kingdom, and Canada.

Institutions with the highest publications

A total of 160 institutions have worked in this area. Of a total of 4,289 documents, the University of California, Davis, contributed the largest share of documents, accounting for 2.4% (n = 104), followed by the University of Western Australia at 2.1% (n = 92), the Nestlé S.A. and the Università degli Studi di Milano, each at 1.6% (n = 70). **Tab. 2** presents the leading 10 institutions publishing on the topics of breast milk composition research.

Table 2. Top 10 institutions with the highest publications on breast milk composition.

Rank	Institution	Number of documents	%
1st	University of California, Davis	104	2.4
2nd	The University of Western Australia	92	2.1
3rd	Nestlé S.A.	70	1.6
4th	Università degli Studi di Milano	70	1.6
5th	University of Toronto	63	1.5
6th	Turun Yliopisto	61	1.4
7th	Ludwig-Maximilians-Universität München	57	1.3
8th	University of California, San Diego	53	1.2
9th	Københavns Universitet	53	1.2
10th	Baylor College of Medicine	52	1.2

Funding sponsors with the highest publications

As many as 159 sponsors funded research in the area of breast milk composition. Of a total of 4,289 documents, the U.S. National Institutes of Health funded most of the publications with 233 (5.4%) documents, followed by the National Natural Science Foundation of China with 118 (2.8%) documents, and the U.S. Eunice Kennedy Shriver National Institute of Child Health and Human Development with 98 (2.3%) documents. **Tab. 3** presents the 10 primary funding organizations with the greatest number of publications related to breast milk composition.

Table 3. Top 10 funding sponsors with the highest publications on breast milk composition.

Rank	Funding sponsor	Number of documents	%
1st	National Institutes of Health	233	5.4
2nd	National Natural Science Foundation of China	118	2.8
3rd	Eunice Kennedy Shriver National Institute of Child Health and Human Development	98	2.3
4th	U.S. Department of Health and Human Services	93	2.2
5th	National Institute of Diabetes and Digestive and Kidney Diseases	84	2.0
6th	European Commission	74	1.7
7th	National Institute of Child Health and Human Development	54	1.3
8th	Canadian Institutes of Health Research	53	1.2
9th	Medical Research Council	52	1.2
10th	Conselho Nacional de Desenvolvimento Científico e Tecnológico	50	1.2

Journals with the highest publications

Tab. 4 ranks the top journals in terms of publishing research on breast milk composition. *Nutrients* was the most productive journal, with 240 articles (5.6%). The *American Journal of Clinical Nutrition* followed with 165 publications (3.8%), and the *Journal of Pediatric Gastroenterology and Nutrition* with 99 publications (2.3%).

Table 4. Top 10 journals with the highest publications on breast milk composition.

Rank	Journal	Number of documents	%
1st	*Nutrients*	240	5.6
2nd	*American Journal of Clinical Nutrition*	165	3.8
3rd	*Journal of Pediatric Gastroenterology and Nutrition*	99	2.3
4th	*British Journal of Nutrition*	68	1.6
5th	*Frontiers in Nutrition*	68	1.6
6th	*Pediatric Research*	67	1.6
7th	*European Journal of Clinical Nutrition*	65	1.5
8th	*Journal of Human Lactation*	62	1.4
9th	*Breastfeeding Medicine*	56	1.3
10th	*Maternal and Child Nutrition*	54	1.3

Co-occurrence analysis

Co-occurrence analysis is performed by examining the frequency with which terms appear together in the titles or abstracts of articles. This analysis aims to reveal current research trends and identify key issues that are essential for monitoring scientific progress. **Fig. 3** illustrates the identified terms that appeared at least 15 times in titles and abstracts. The circle size indicates the frequency of term occurrence, while different colors represent distinct clusters. The identified terms on the map include: 1) breast milk and its link to the gut microbiome, bifidobacteria, immunity, allergy, inflammation, cytokines, and pre-and probiotics (red cluster); 2) impacts of maternal overweight, obesity, and excessive gestational weight gain on breast milk composition and infant growth (green cluster); 3) FA composition in breast milk (blue cluster); 4) effects of maternal diet and nutrition supplementation on micronutrient composition in breast milk (yellow cluster); 5) other breast milk composition, such as protein, hormones, and amino acids (purple cluster); 6) donor human milk (DHM) (cyan cluster); and 7) human milk oligosaccharides (HMOs) (orange cluster).

The evolution of research themes

Fig. 4 displays each term in a distinct color to reflect its average frequency across all retrieved publications. Terms in yellow are those that have emerged more recently, whereas blue represents terms that appeared earlier. Before 2012, research on breast milk composition primarily focused on FA content. After 2012, there was a significant

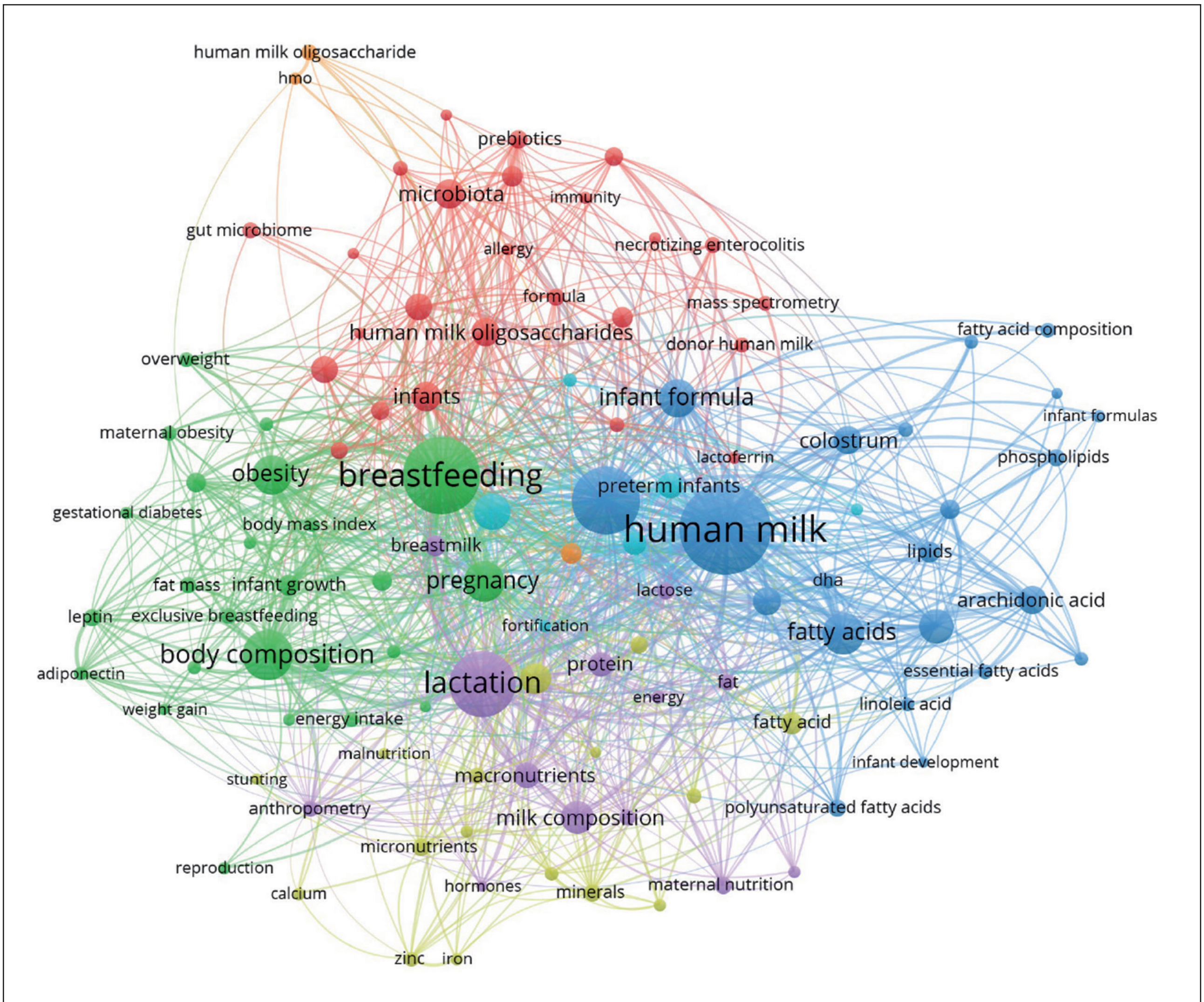

Figure 3. Network visualization of terms appearing in titles and abstracts of publications on breast milk composition research, based on clusters.
For the science mapping process, VOSviewer version 1.6.20 (Leiden University, Leiden, The Netherlands) was employed.

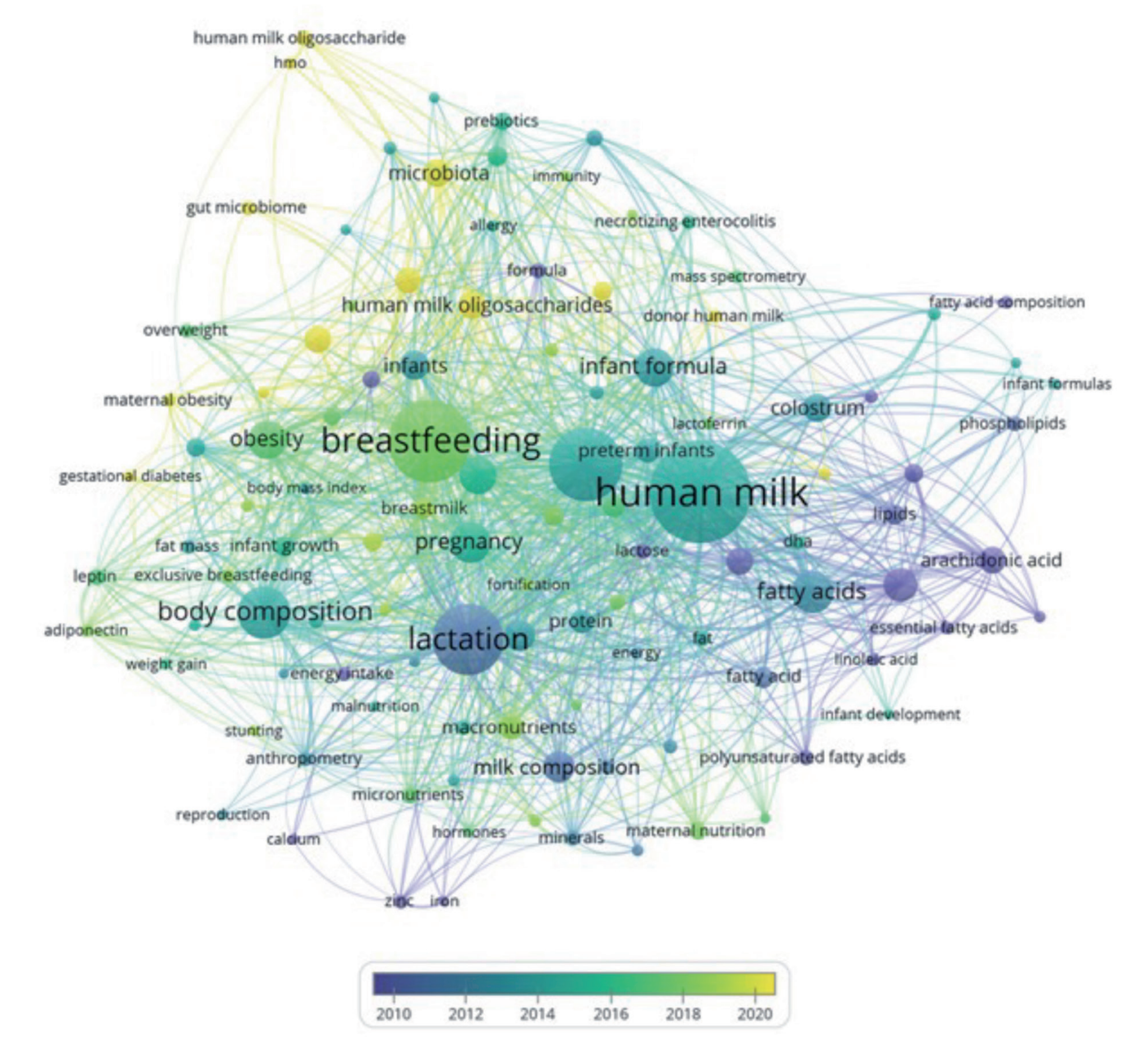

Figure 4. Overlay visualization of terms appearing in titles and abstracts of publications on breast milk composition research, based on publication years.
For the science mapping process, VOSviewer version 1.6.20 (Leiden University, Leiden, The Netherlands) was employed.

shift towards studying micronutrients, proteins, and hormones in breast milk. From 2018 to 2024, the focus of research has further shifted to the gut microbiome, HMOs, and the impact of maternal obesity on breast milk composition.

Discussion

Based on bibliometric analysis, there has been a notable increase in publications focusing on breast milk nutrition research, particularly from 2019 to 2023. The United States emerged as the major contributor to this research area, leading both in publication output and collaborative actions with other countries, followed by China and the United Kingdom. The University of California, Davis, demonstrated the highest productivity among academic institutions, followed by The University of Western Australia. *Nutrients* ranked highest among journals publishing on these topics. Keyword co-occurrence analysis revealed a major shift in research focus from FAs, proteins, micronutrients, and hormones to themes like the gut microbiome, HMOs, and the impact of maternal obesity.

In **Fig. 3**, cluster 1 (red) reflects the growing body of research on the gut microbiome, highlighting links with immunity, allergy prevention, and inflammatory pathways [33]; cluster 2 (green) focuses on maternal obesity and metabolic hormones in milk, which have been increasingly studied in the context of early-life metabolic programming [9]; cluster 3 (blue) represents FA composition, a historically dominant theme that continues to evolve with population-specific studies [34]; cluster 4 (yellow) centers on the influence of maternal diet and supplementation on micronutrient levels, underscoring the role of vitamin D, iodine, and other key nutrients [35]; cluster 5 (purple) captures research on proteins, hormones, and amino acids, including bioactive peptides [36]; cluster 6 (cyan) highlights human milk donation and preterm feeding [37]; cluster 7 (orange) focuses on HMOs, reflecting recent interest in their prebiotic and immunomodulatory functions [38]. This thematic mapping allows differentiation between established research areas (e.g., FAs) and emerging fields (e.g., HMOs, microbiome), offering guidance for targeted future investigations.

Publications on breast milk composition have increased gradually for over four decades, but there has been a considerable surge in this field since the beginning of the 2010s, which can be linked to a greater understanding of its importance to newborn and child health. For example, the *2012 World Health Assembly Resolution* sought to reduce childhood stunting, prevent obesity, and promote breastfeeding during the first 6 months of life. This is consistent with *Sustainable Development Goal 2*, which aims to eliminate all kinds of malnutrition by 2030, including meeting the nutritional needs of breastfeeding women [39]. Furthermore, advances in research and innovation led to an increase in breast milk composition studies, particularly post-2018. Advanced analytical techniques, such as chromatographic separation strategies, high-performance liquid chromatography, reverse-phase chromatography, and electromigration methods, have improved our ability to assess HMOs. Moreover, multiomic approaches provide significant insights into the gut microbiome, enabling researchers to explore its complex functions and connections to health and disease [40, 41].

Breast milk composition research is essential and has garnered considerable global attention. Evidence indicates that even under prolonged maternal undernutrition, the macronutrient composition of breast milk remains largely stable, with some variation in certain micronutrients and bioactive components [26, 27]. Furthermore, investigations of environmental contaminants in breast milk serve primarily as tools for epidemiological surveillance of toxic exposures within populations, rather than as assessments for infant feeding safety. Even in heavily polluted settings, breastfeeding continues to confer protective effects due to the presence of bioactive and reparative components, such as growth factors, antioxidants, and maternal stem cells, that may mitigate prenatal or transplacental toxic effects. These findings further underscore that breast milk remains the optimal and irreplaceable source of infant nutrition [42, 43].

The increase in publications can be attributed to several factors, including urgent issues, policy support, advancements in technology, and enhanced research funding. Notably, the National Institutes of Health and other significant funding sources play a crucial role in supporting research efforts in the United States [44]. Institutions such as the University of California, Davis, and the University of Western Australia are significant contributors to breast milk composition research due to their resources and specialized focus. However, there is an urgent need to enhance research capacity and participation from low- and middle-income countries (LMICs), given their large share of the world's population and the diversity of their breastfeeding practices. Expanding research in these settings is crucial to generate context-specific evidence that supports global understanding and policy relevance [45]. This call does not imply any inadequacy or inferior quality of breast milk in these populations. Human milk composition naturally varies according to maternal, environmental, and cultural factors, yet it remains the biologically optimal and most protective source of infant nutrition everywhere. Framing LMICs as vital contributors to this research field helps ensure scientific equity while guarding against misinterpretations that could be exploited to promote commercial breast milk substitutes contrary to WHO's *International Code of Marketing of Breast-Milk Substitutes*. Additionally, research on breast milk composition is predominantly featured in nutrition-related journals, such as *Nutrients*, the *American Journal of Clinical Nutrition*, and the *Journal of Pediatric Gastroenterology and Nutrition*, underscoring the importance of aligning research with the specific scope of the journals [46].

Breast milk is the ideal nutrition for infants up to 6 months, providing essential nutrients, antibacterial properties, and immunomodulatory factors vital for growth [47]. It helps combat infections and reduces the risk of allergic diseases by exposing infants to the mother's immune system, influencing oral tolerance and allergy development [48, 49]. The varied composition of breast milk among mothers may enhance its protective effects and support gut development, facilitating the transition from a sterile environment to one populated with beneficial bacteria [50, 51]. This gut microbiome is crucial for immune function and may impact future susceptibility to immune diseases [52]. Additionally, breast milk contains pre- and probiotics, HMOs, and cytokines that regulate gut bacteria and contribute to metabolic balance [48, 53]. Further research should explore the microbial and other components of breast milk (e.g., bacteria, fungi, archaea, and viruses) and their effects on infant health and allergic diseases. Longitudinal studies are needed to understand how these components shape the gut microbiome and immune development, leading to tailored health interventions [33, 54].

Recent studies have explored how maternal overweight, obesity, and excessive gestational weight gain may influence certain hormonal and metabolic profiles in breast milk [12, 55-57]. Elevated concentrations of leptin, for instance, are observed in milk from mothers with higher body mass index [56]. Rather than indicating any detrimental quality, such variations are understood as part of nature's adaptive mechanisms that may help protect infants from adverse metabolic programming initiated during intrauterine life and from suboptimal dietary environments. Leptin in breast milk acts as a key regulator of appetite and energy balance and may contribute to healthy metabolic development rather than promote obesity [58]. Therefore, any interpretation proposing a causal role of breast milk in childhood obesity should be approached with great caution. Breast milk remains the biological norm and continues to be the most protective and optimal source of infant nutrition [59].

Breast milk contains a complex mixture of FAs. Various factors shape the FA composition of breast milk, including maternal metabolic changes during pregnancy and lactation, as well as the duration of breastfeeding [34, 60]. Several studies highlighted population-specific variation in FA components of breast milk and formula across populations. In Poland, breast milk contained palmitic (28%), oleic (30%), and linoleic (8.6%) acids, while formulas had higher levels of polyunsaturated FAs (PUFAs) [61]. In Spain, although the total profiles of saturated FAs (SFAs), monounsaturated FAs (MUFAs), and PUFAs were similar, significant differences were found in essential FAs like ALA, DHA, and AA, crucial for fetal growth and development [62]. These findings underscore the need for further exploration of FA profiles in diverse populations to better understand their nutritional implications. Additionally, there remain areas for further investigation, including large-scale prospective studies to investigate the long-term effects and mechanisms of breast milk short-chain FAs (SCFAs) on infant growth and health [63] as well as clinical and population-based studies to better understand the pathophysiology of various FA groups in human milk during lactation [60].

Numerous studies have explored the effects of maternal diet and nutrition supplementation on the micronutrient composition of breast milk, revealing significant variability in study designs that hamper comparability. Breast milk generally provides adequate vitamins for infant growth, although vitamin D levels are particularly responsive to maternal status, and supplementation can help ensure sufficiency [64, 65]. Mixed results have been observed regarding the association between maternal diet and minerals such as calcium, zinc, and iron [65]. Despite increasing research on human milk nutrients, standardization in sampling and analytical methods is essential. Additionally, while most studies have focused on the exclusive breastfeeding period, evidence shows that breast milk composition evolves over 24 months and that longer breastfeeding provides added benefits for infant growth and development [66]. Furthermore, to evaluate maternal dietary intake, metabolomics provides a promising complementary approach to traditional dietary assessment methods, improving the accuracy of dietary measurements [67].

Some studies have examined other breast milk compositions, focusing on DHM, breast milk for preterm infants, and HMOs, highlighting areas needing further research. A study reveals significant variability in the protein, fat, and calorie content of DHM, while data on its vitamin and mineral content is scarce. This variability supports the need for point-of-care analysis and targeted fortification. On the other hand, although mother's milk is ideal for very low birth weight infants, DHM is a vital alternative when maternal milk is unavailable. Regarding HMOs, despite not providing direct nutrition, HMOs play crucial roles in gut health and immune response. Overall, this research emphasizes both the irreplaceable role of mother's own milk and the importance of understanding DHM's composition and the functional benefits of HMOs for infant health.

Our study presents a comprehensive overview of research concerning breast milk composition, yet it is crucial to acknowledge its limitations. Firstly, we utilized only one database, Scopus, which may not capture all relevant literature. Nonetheless, Scopus is among the most widely utilized and accessible databases, making it adequate for bibliometric analysis. Secondly, our focus was restricted to articles published in English, which may result in some loss of data. However, we maintain that the majority of high-quality publications on breast milk composition were incorporated. Lastly, while bibliometric analysis offers a broad perspective on advancements within this research domain, its methodological limitations should be recognized, particularly its inability to examine the specific content of each article. Despite these challenges, a key strength of bibliometric analysis is its capacity to reveal trends and identify gaps in the literature, thereby informing future research directions.

Conclusion

Research on breast milk composition reflects its biological importance and complexity. Studies have expanded from describing its components to examining how maternal, environmental, and lifestyle factors contribute to natural variation. Despite these influences, breast milk remains the gold standard for infant nutrition and central to child health. This bibliometric analysis demonstrates a marked increase in publications, driven largely by institutions in high-income countries, with the United States showing leadership in both output and collaboration. Co-occurrence analysis and cluster mapping highlight emerging research frontiers, including the gut microbiome, HMOs, and maternal overnutrition, alongside established areas such as FAs and micronutrients. By distinguishing established from emerging themes, this mapping can guide strategic research funding, foster cross-disciplinary collaboration, and support policies that prioritize breastfeeding. Greater participation from researchers and institutions in LMICs is essential to generate context-specific evidence and strengthen the global knowledge base. Such inclusion enriches the scientific landscape without implying any inadequacy of breast milk in these settings. It also reinforces the universal value of human milk and helps contextualize findings within diverse maternal and environmental conditions.

Data availability

Data will be made available upon request from the corresponding author.

Ethics statement

No animal or human experimentation is conducted in this review manuscript.

Declaration of interest

The Authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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