Infant Formula

- **Dr. Yekta Geran**

❖ PharmD/MPH in Health Policy

(May_2026)

Infant Formulas

اهداف :

پس از اتمام این دوره، انتظار می‌رود شرکت‌کنندگان قادر باشند:

- ✓ **محتوای درشت‌مغذی‌ها (ماکرونوترینت‌ها)** در فرمول‌های مورد استفاده به‌عنوان جایگزین شیر مادر برای نوزادان ترم و نارس را توصیف نمایند.
- ✓ **کاربردهای بالینی مناسب** فرمول‌های شیرخواران با ترکیب تغذیه‌ای تعدیل‌شده را، بر اساس اهمیت فیزیولوژیک تغییرات اختصاصی در ترکیب فرمول، شناسایی و تبیین کنند.

HUMAN MILK

- World Health Organization (WHO)
- The American Academy of Pediatrics (AAP)
- American Academy of Family Physicians
- Academy of Nutrition and Dietetics

who **1st -7th August**

- recommends that: **breastfeeding** for the first 6 month of life or at least 12 months.

Breastfeeding and Health Outcomes for Infants and Children: A Systematic Review

Carrie D Patnode [1], Nora B Henrikson [2], Elizabeth M Webber [1], Paula R Blasi [2], Caitlyn A Senger [1], Janelle M Guirguis-Blake [3]

Affiliations + expand

PMID: 40240318 DOI: 10.1542/peds.2025-071516

Abstract

Context: Our understanding of the benefits of breastfeeding and the consumption of human milk for specific infant outcomes and the magnitude of those benefits continues to evolve.

Objective: Review the evidence on the association between breastfeeding and child health outcomes.

Data sources: Systematic literature searches in MEDLINE, Embase, and CINAHL for English-language articles published from 2006 to August 14, 2024.

Study selection: Existing systematic reviews (ESRs) and primary studies comparing various breastfeeding exposures and child health outcomes among term infants in developed countries.

Data extraction: Abstracted data on study design, demographics, breastfeeding exposures and referents, and outcomes. Results of ESRs were synthesized alongside those of newer primary studies.

Results: Twenty-nine ESRs and 145 primary studies were included. An association indicating a reduced risk from more vs less breastfeeding was apparent for moderate-to-severe respiratory and gastrointestinal infections, otitis media, allergic rhinitis, asthma, malocclusion, inflammatory bowel disease, type 1 diabetes, rapid weight gain and growth, obesity, high systolic blood pressure, childhood leukemia, and infant mortality. There was no clear threshold of breastfeeding duration that appeared to be most beneficial for any outcome. There were few data on whether associations varied by mode of breastfeeding or source of breast milk.

Limitations: Observational studies with risks of bias related to confounding, missing data, and a lack of consistency in measurement and reporting of breastfeeding exposures.

Conclusions: Breastfeeding is associated with beneficial effects for several infant and child outcomes. Further research that addresses the limitations of existing studies is needed to continue to inform national initiatives.

This systematic review analyzed **29 systematic reviews and 145 primary studies** on breastfeeding and child health outcomes.

Results showed that breastfeeding is associated with **better health outcomes** in infants and children.

➢ Breastfeeding reduces the risk of:

- ✓ Respiratory and gastrointestinal infections
- ✓ Asthma and allergies
- ✓ Obesity
- ✓ Type 1 diabetes
- ✓ Childhood leukemia
- ✓ Infant mortality
- ✓ Overall, **greater breastfeeding was associated with better health outcomes**,

MCN Am J Matern Child Nurs. 2025 Jan-Feb;50(1):9-17. doi: 10.1097/NMC.0000000000001059. Epub 2024 Dec 3.

Maternal Nutrition and Human Milk Nutrients: A Scoping Review

Sukanya Kankaew, Carrie-Ellen Briere

PMID: 39623537 DOI: 10.1097/NMC.0000000000001059

Abstract

Purpose: To explore the influence of maternal nutrition factors, including body mass index, nutritional supplementation, and dietary intake during the breastfeeding period, on macro and micronutrient composition in human milk.

Study design and methods: We conducted a scoping review using the PRISMA-ScR checklist, initially identifying 5,984 original studies published in the English language from PubMed, Scopus, and Web of Science that presented findings on the association of maternal nutritional factors on human milk nutrient composition. After screening the title and abstract, we selected 69 studies for full review, including 3 studies found through checking reference lists. After full review, we included 23 studies in this scoping review.

Results: Most studies found maternal body mass index and supplement consumption affected human milk macro and micronutrient composition, whereas inconsistent results were found on the relationship between maternal diet and human milk nutrients. Methodologies varied substantially across studies, especially for milk sample collection methods and maternal nutrition assessments.

Clinical implications: Maternal nutrition factors may affect levels of human milk nutrients, requiring maternal nutrition monitoring during breastfeeding. However, given the considerable variability in the results between studies and methodological approaches, further studies should use standardized and validated procedures to strengthen the findings on this topic.

شیر مادر بهترین تغذیه برای نوزاد است.

- ✓ سلامت بهتر نوزاد
- ✓ سلامت بهتر مادر
- ✓ کاهش بیماری‌ها

frontiers | Frontiers in Pediatrics

Original Research
16 April 2025
10.3389/fped.2025.1508840

OPEN ACCESS

EDITED BY
Xinran Liu,
Peking University People's Hospital, China

REVIEWED BY
Marcel Henrique Marcondes Sari,
Federal University of Parana, Brazil
Katherine M. Ottolini,
Children's National Hospital, United States

*CORRESPONDENCE
Fang Wang
fangw@zju.edu.cn
Xinfen Xu
xuxinf@zju.edu.cn

†These authors have contributed equally to this work

RECEIVED 10 October 2024
ACCEPTED 31 March 2025
PUBLISHED 16 April 2025

CITATION
Yang R, Wang H, Cai Q, Chen D, Zhu J, Yuan S, Wang F and Xu X (2025) Higher in-hospital proportion of breast milk intake improves brain functional connectivity and neurological assessment in preterm infants.
Front. Pediatr. 13:1508840.
doi: 10.3389/fped.2025.1508840

Higher in-hospital proportion of breast milk intake improves brain functional connectivity and neurological assessment in preterm infants

Rui Yang[†], Hua Wang[†], Qian Cai, Danqi Chen, Jiajun Zhu, Shuiqin Yuan, Fang Wang* and Xinfen Xu*

School of Nursing, Capital Medical University, Beijing, China, Women's Hospital, School of Medicine, Zhejiang University, Hangzhou, China

Objective: Preterm infants may face neurodevelopmental challenges linked to altered brain maturation processes. This study aimed to investigate the impact of in-hospital breast milk intake on brain resting-state functional connectivity (rs-FC) and neurological assessment at discharge in preterm infants.

Methods: We collected data on breast milk intake from 97 preterm infants, evaluated neurological outcomes using the Amiel-Tison Neurological Assessment (ATNAT), and assessed rs-FC via functional near-infrared spectroscopy (fNIRS). Groups were stratified by breast milk intake proportion (cutoffs of >70% vs. ≤70%; cutoffs of >90% vs. ≤90%), and conducted logistic regression analysis to explore the relationship between rs-FC and neurological assessment.

Results: Preterm infants with >70% breast milk intake exhibited significantly higher ATNAT levels ($\chi^2 = 8.306$, $p = 0.004$) and stronger rs-FC ($p = 0.001$) between the right precentral gyrus (PCG) and inferior parietal lobe (IPL). The >90% intake group also showed higher ATNAT levels ($\chi^2 = 7.090$, $p = 0.008$) and further rs-FC enhancements (PCG-PFL: $p = 0.016$; PCG-IPL: $p = 0.008$). Logistic regression confirmed rs-FC as a predictor of optimal neurological assessment [$p = 0.011$; Exp (B) = 0.206, 95% CI: 0.062– 0.682].

Conclusion: Higher in-hospital breast milk intake (>70% of total enteral nutrition) improves rs-FC and neurological outcomes in preterm infants, with dose-dependent effects.

KEYWORDS

preterm infants, NICU, breast milk, neurological assessment, breastfeeding

نوزادان نارسی که **بیش از ٪۷۰ تغذیه با شیر مادر داشتند:**

- ✓ عملکرد مغزی بهتر
- ✓ رشد عصبی بهتر داشتند.

Indications for Using Infant Formula

- ✓ Insufficient breast milk supply
- ✓ Breast-related problems
- ✓ Multiple births (twins or more)
- ✓ Maternal death
- ✓ Separation from the mother (e.g., divorce or long-term absence)
- ✓ Maternal diseases such as **cardiac, renal, or hepatic disorders**
- ✓ Unsatisfactory infant growth pattern
- ✓ Maternal use of medications such as **amiodarone, bromocriptine, cyclosporine, methotrexate, hydroxyurea, lithium, and ergotamine, …**
- ✓ Infants with metabolic disorders such as **phenylketonuria or galactosemia**, or severe gastrointestinal allergie 

Ingredients

Classification of Infant Formula

Conclusions

فرمول‌های استاندارد بر اساس سه درشت‌مغذی اصلی طبقه‌بندی می‌شوند:

- Caloric density (Fat)
- Carbohydrate source
- Protein composition

اکثر آن‌ها: بر پایه شیر گاو

Lipid Components in Infant Formula

- **Cholesterol**
  - Major component of breast milk fat
  - Not included in infant formula
  - Unstable during commercial production

- **DHA and ARA**

  Long-chain polyunsaturated fatty acids (LCPUFAs)
  Naturally present in breast milk
  Added to formulas after 2001
  Associated with improved:
  - ✓ Brain development
  - ✓ Visual function

MCT Oil in Infant Nutrition

- **MCT oil (Medium-Chain Triglycerides)**
  - Occasionally discussed in infant nutrition
  - Used in children with impaired fat absorption

- **Clinical Consideration**
  - Beneficial in specific malabsorption conditions
  - Generally unnecessary for most infants
  - Most children can adequately digest and metabolize standard fats

Slide Heading

Herbal:

Soya

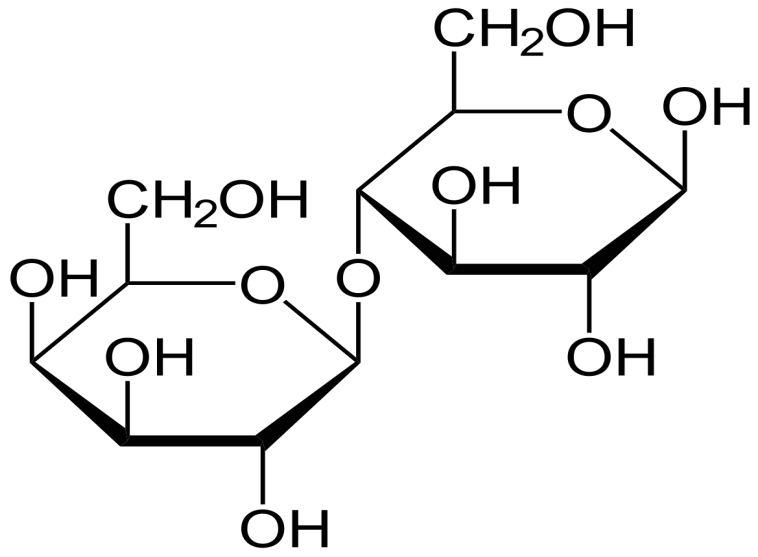
Canola

- Better GI absorption
- Less GI Reaction

Carbohydrate source

The carbohydrates found in milk-based formulas are **lactose** and **maltodextrin**.

Lactose



Protein composition

Proteins → Peptides → Amino acids

- **Human:**

Whey > Casein

Whey/Casein =70/30

- **Cow milk:**

Casein/Whey = 80/20

Whey and Casein in Infant Formula

- **Protein Composition**
  - Whey and casein in cow's milk differ structurally from those in human milk
- **Casein**
  - Forms curds in the stomach
  - Remains longer in the stomach
  - May promote prolonged satiety
- **Whey**
  - More easily digested
  - Empties from the stomach more rapidly
  - May reduce risk of reflux
  - Associated with softer, more frequent stools
- **Formula Design**
  - Most infant formulas are adjusted to approximate the whey-to-casein ratio of breast milk
  - Some formulas contain a higher proportion of whey

Vitamins, Minerals, and Electrolytes in Infant Formula

- **Iron**
  - Essential for red blood cell formation
  - Commonly indicated as “with iron” on product labels
- **Vitamin D**
  - Included in all infant formulas
  - May not always meet the full recommended daily intake
- **Electrolytes**
  - Maintain fluid balance
  - Prevent dehydration
  - Help avoid serious imbalances that may lead to seizures or life-threatening complications
- **Important Clinical Note**
  - Infant formula must always be prepared exactly as directed on the package
  - Dilution or concentration errors can disrupt electrolyte balance
  - Deviations should occur only under pediatric supervision

Nucleosides and Nucleotides in Infant Formula

- **Definition**
  Fundamental molecules required for the synthesis of DNA and RNA

- **Physiological Role**
  Can be synthesized through metabolic recycling pathways
  Present in free form in human breast milk

- **Potential Benefits**
  Associated with improved early growth
  May enhance immune function in infants

- **Use in Formula**
  Incorporated into infant formulas since the 1990s

Prebiotics and Probiotics in Infant Nutrition

Overview

Substances that promote the growth and maintenance of healthy gut microbiota

A balanced gut microbiome is associated with protection against:

- ✓ Autoimmune diseases
- ✓ Diarrheal illnesses
- ✓ Obesity
- ✓ Other pathological conditions

Prebiotics

Non-digestible compounds

Stimulate the growth and activity of beneficial bacteria

Probiotics

Live microorganisms

Represent the beneficial bacteria themselves

Forms of Infant Formula

- Infant formula is available in three primary forms:
- **Ready-to-Use**
  - Pre-mixed and sterile
  - Requires no dilution
  - Most convenient, but typically more expensive
- **Concentrated Liquid**
  - Requires dilution with water before use
  - Less expensive than ready-to-use
  - Must be mixed precisely as directed
- **Powder**
  - Most commonly used form
  - Requires reconstitution with water
  - Most cost-effective option
  - Accurate preparation is essential to ensure proper nutrient and electrolyte balance

Infant Situation

❖ Full-Term and Healthy Infants

Born ≥ 37 weeks, normal birth weight
Routine care: vaccination, growth, and development
Low risk; common issues: jaundice, mild infections

❖ Preterm or Low-Birth Weight Infants

Preterm: < 37 weeks
Low birth weight: < 2.5 kg
May require NICU care and monitoring
Risks: respiratory problems, hypoglycemia, infections, developmental delays

❖ Metabolic Disorder Infants

Congenital metabolic disorders (e.g., PKU, galactosemia)
Early screening and diagnosis essential
Special dietary management and metabolic monitoring
High risk if untreated

Classification of Infant Formula