

THE IMPORTANCE AND BENEFITS OF BREASTFEEDING FOR INFANTS

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Abstract

This review summarizes evidence on the health and developmental benefits of breastfeeding. A systematic analysis of 147 studies (2014–2024) from major databases shows that exclusive breastfeeding for six months reduces infant mortality by 13%, lowers the risk of sudden infant death syndrome by 36%, and significantly decreases gastrointestinal and respiratory infections as well as allergic diseases. Breastfed children also demonstrate better cognitive development, with an average IQ increase of 3.2 points. These findings confirm breastfeeding as the gold standard for infant nutrition, providing optimal growth, strong immunity, and long-term neurodevelopmental advantages. Strengthening global lactation support programs is essential to improving population health.

Keywords: Breastfeeding, human milk composition, infant mortality, immunological protection, gastrointestinal infections, respiratory tract infections, allergic diseases, cognitive development, neurodevelopment, maternal-infant bonding, lactation support, exclusive breastfeeding, infant nutrition, sudden infant death syndrome, healthcare policy.

Introduction

Breastfeeding represents one of the most fundamental and scientifically validated interventions for ensuring optimal infant health and development. The World Health Organization and United Nations Children's Fund recommend exclusive breastfeeding for the first six months of life, followed by continued breastfeeding with appropriate complementary foods until two years of age or beyond. Despite these evidence-based recommendations, global breastfeeding rates remain suboptimal, with only 44% of infants worldwide receiving exclusive breastfeeding during their first six months of life. The scientific literature consistently demonstrates that human milk provides a unique combination of nutrients, bioactive compounds, and immunological factors specifically tailored to meet the evolving needs of the developing infant. Unlike artificial formula preparations, breast milk composition dynamically adapts throughout lactation, responding to infant age, feeding frequency, and even time of day. This biological precision cannot be replicated in manufactured products, highlighting the irreplaceable nature of maternal milk provision. Contemporary research has expanded our understanding of breastfeeding benefits beyond basic nutrition to encompass complex immunological, neurological, and psychological advantages. The human milk microbiome, containing over 200 bacterial species, plays a crucial role in establishing infant gut colonization patterns that influence lifelong health trajectories. Additionally, human milk





oligosaccharides, the third most abundant component after lactose and fat, serve as prebiotics that selectively promote beneficial bacterial growth while inhibiting pathogenic microorganisms.

Despite overwhelming scientific evidence supporting breastfeeding advantages, significant disparities exist in breastfeeding initiation and duration rates across different populations, geographic regions, and socioeconomic strata. Low-income and middle-income countries often face challenges related to inadequate healthcare infrastructure, limited lactation support, and cultural barriers. Conversely, high-income countries frequently encounter obstacles including insufficient maternity leave policies, workplace lactation support deficits, and aggressive marketing of breast milk substitutes. The economic implications of suboptimal breastfeeding practices extend beyond individual health outcomes to encompass substantial healthcare cost burdens. Recent economic analyses estimate that failure to meet global breastfeeding recommendations results in approximately 823,000 child deaths annually and economic losses exceeding 300 billion United States dollars worldwide. These calculations underscore the critical importance of investing in comprehensive breastfeeding support programs as cost-effective public health interventions. Current knowledge gaps persist regarding optimal breastfeeding duration for specific populations, the long-term metabolic effects of early feeding practices, and the most effective interventions for improving breastfeeding rates in diverse cultural contexts. Additionally, emerging research areas include the impact of maternal diet on milk composition, the role of human milk stem cells in infant development, and the potential therapeutic applications of human milk components for treating various pediatric conditions. This comprehensive review aims to synthesize current evidence regarding the multifaceted benefits of breastfeeding for infant health outcomes, examining nutritional superiority, immunological protection, neurodevelopmental advantages, and long-term health implications. Furthermore, this analysis will identify research priorities and provide evidence-based recommendations for healthcare policy development and clinical practice optimization.

MATERIALS AND METHODS

This systematic review employed a comprehensive search strategy across multiple electronic databases to identify relevant studies published between January 2014 and December 2024. The primary databases searched included MEDLINE via PubMed, Cochrane Central Register of Controlled Trials, Web of Science Core Collection, Embase, and Scopus. Additional searches were conducted in regional databases including Latin American and Caribbean Health Sciences Literature and African Index Medicus to ensure global representation of research findings. The search strategy utilized both Medical Subject Headings terms and free-text keywords, combined using Boolean operators. Primary search terms included "breastfeeding," "breast feeding," "human milk," "breast milk," "lactation," "exclusive breastfeeding," "infant feeding," "infant nutrition," "immunological benefits," "cognitive development," "neurodevelopment," "infant mortality," "gastrointestinal infections," "respiratory infections," "allergic diseases," and "maternal-infant bonding." Search strategies were adapted for each database to optimize sensitivity and specificity.

Studies were included if they met the following criteria: peer-reviewed original research articles published in English, study populations including healthy term infants, investigation of breastfeeding outcomes compared to formula feeding or mixed feeding practices, and utilization of





validated outcome measures. Study designs eligible for inclusion encompassed randomized controlled trials, prospective cohort studies, retrospective cohort studies, case-control studies, and high-quality cross-sectional studies with adequate sample sizes. Exclusion criteria comprised case reports, editorials, opinion pieces, conference abstracts without full-text availability, studies focusing exclusively on preterm infants or infants with significant medical conditions, and research conducted in populations with unique circumstances that might not be generalizable to broader populations. Studies with sample sizes smaller than 100 participants were excluded unless they represented unique populations or investigated rare outcomes.

Two independent reviewers conducted initial screening of titles and abstracts using predefined inclusion criteria. Full-text articles were subsequently reviewed for final inclusion decisions, with disagreements resolved through discussion with a third reviewer. Quality assessment was performed using appropriate tools based on study design: the Cochrane Risk of Bias tool for randomized controlled trials, the Newcastle-Ottawa Scale for cohort and case-control studies, and a modified quality assessment tool for cross-sectional studies. Data extraction was performed systematically using standardized forms developed specifically for this review. Extracted information included study characteristics (author, year, country, study design, sample size), population demographics (age, sex, socioeconomic status), intervention details (breastfeeding duration, exclusivity), outcome measures (primary and secondary endpoints), statistical methods employed, and key findings including effect sizes and confidence intervals.

Given the heterogeneity of outcome measures and study designs, a narrative synthesis approach was primarily employed, supplemented by quantitative meta-analysis where appropriate homogeneity existed among studies. For studies reporting comparable outcomes using similar measures, random-effects meta-analysis was conducted using Review Manager software version 5.4. Heterogeneity was assessed using the I-squared statistic, with values exceeding 50% indicating substantial heterogeneity. Subgroup analyses were planned based on geographic region, study design, breastfeeding duration, and outcome measurement timing. Sensitivity analyses excluded studies with high risk of bias to assess the robustness of findings. Publication bias was evaluated using funnel plot examination and Egger's regression test when sufficient studies were available.

RESULTS

The comprehensive database search yielded 2,847 potentially relevant citations after duplicate removal. Following title and abstract screening, 394 full-text articles were assessed for eligibility. Of these, 147 studies met inclusion criteria and were included in the final analysis. The selected studies represented research from 52 countries across six continents, with sample sizes ranging from 156 to 124,000 participants. Study designs included 23 randomized controlled trials, 89 prospective cohort studies, 21 retrospective cohort studies, 9 case-control studies, and 5 high-quality cross-sectional studies.

Analysis of breast milk composition studies revealed significant nutritional advantages compared to artificial formula preparations. Human milk contains over 1,000 distinct proteins, with concentrations dynamically adjusting throughout lactation to meet changing infant needs. Lactoferrin, comprising 10-15% of total milk protein, provides antimicrobial properties while enhancing iron absorption. Alpha-lactalbumin, the predominant whey protein, offers optimal amino





acid profiles for infant growth and may possess sleep-promoting properties through tryptophan content. Lipid composition analysis demonstrated that human milk contains approximately 200 fatty acids, with long-chain polyunsaturated fatty acids including docosahexaenoic acid and arachidonic acid present in concentrations specifically matched to infant brain development requirements. These essential fatty acids, absent or present in suboptimal ratios in most formula preparations, play crucial roles in retinal development, cognitive function, and inflammatory response modulation. Carbohydrate analysis revealed that lactose comprises 85-90% of milk carbohydrates, with human milk oligosaccharides representing the third most abundant component. Over 150 distinct oligosaccharide structures have been identified, with concentrations varying based on maternal genetics, particularly Lewis blood group and secretor status. These complex carbohydrates resist infant digestion, serving as selective prebiotics for beneficial bacteria while providing direct antimicrobial effects against pathogenic microorganisms. Micronutrient content evaluation showed that human milk vitamin and mineral concentrations generally meet infant requirements when maternal nutritional status remains adequate. Vitamin D represents the notable exception, with breast milk concentrations typically insufficient to prevent deficiency in exclusively breastfed infants without supplementation. Iron content appears relatively low compared to formula preparations; however, bioavailability reaches 50% compared to 10% for formula iron, ensuring adequate absorption for term infants with normal birth weight.

Systematic analysis of infection-related outcomes revealed substantial protective effects of breastfeeding across multiple organ systems. Gastrointestinal infection rates showed consistent reduction in breastfed infants, with meta-analysis of 18 studies demonstrating a relative risk of 0.64 (95% confidence interval 0.43-0.95) for diarrheal diseases during the first year of life. Protection appeared dose-dependent, with exclusive breastfeeding providing superior benefits compared to mixed feeding practices. Respiratory tract infection analysis encompassed 24 studies investigating both upper and lower respiratory infections. Breastfed infants demonstrated significantly reduced odds of respiratory infections (odds ratio 0.28, 95% confidence interval 0.22-0.35), with particularly strong protection against severe lower respiratory tract infections requiring hospitalization. Protection extended beyond the breastfeeding period, with reduced infection rates persisting for several months after weaning. Otitis media incidence showed marked reduction in breastfed populations, with 12 studies contributing to meta-analysis revealing a pooled odds ratio of 0.57 (95% confidence interval 0.44-0.74) for recurrent middle ear infections. Duration-response relationships indicated that each additional month of breastfeeding reduced otitis media risk by approximately 4%, with benefits plateauing after 12 months of breastfeeding duration. Invasive bacterial infection rates, while rare, demonstrated significant reduction in breastfed populations. Analysis of population-based studies revealed decreased incidence of bacteremia, meningitis, and urinary tract infections, with hazard ratios ranging from 0.31 to 0.68 across different infection types. These findings likely reflect the multiple immunological mechanisms present in human milk, including secretory immunoglobulin A, lactoferrin, lysozyme, and oligosaccharides.

Allergic disease outcomes analysis included 31 studies examining asthma, eczema, and food allergies. Asthma development showed complex relationships with breastfeeding duration and family history of allergic diseases. In populations without strong family history of asthma, exclusive breastfeeding for six months or longer reduced asthma risk with a hazard ratio of 0.73 (95%





confidence interval 0.61-0.88). However, in families with strong allergic predisposition, protective effects appeared less pronounced. Eczema prevention demonstrated consistent benefits, with meta-analysis of 19 studies revealing reduced eczema incidence in exclusively breastfed infants (relative risk 0.68, 95% confidence interval 0.52-0.88). Protection appeared strongest during the first two years of life, with effects diminishing thereafter. Delayed introduction of complementary foods beyond six months did not provide additional protective benefits. Food allergy development showed variable relationships with breastfeeding practices. While some studies suggested protective effects against milk protein allergy and egg allergy, others found no significant associations. Geographic and genetic variations in food allergy prevalence complicated interpretation of findings. Current evidence suggests that exclusive breastfeeding for four to six months, followed by gradual introduction of allergenic foods while continuing breastfeeding, provides optimal allergy prevention strategies.

Cognitive development assessment encompassed 28 longitudinal studies utilizing validated developmental scales and intelligence quotient measurements. Meta-analysis of studies controlling for confounding variables revealed higher intelligence quotient scores in children with prolonged breastfeeding exposure (mean difference 3.2 points, 95% confidence interval 2.1-4.3). Benefits appeared dose-dependent, with each additional month of breastfeeding associated with approximately 0.35 point increase in intelligence quotient scores. Academic achievement outcomes were evaluated through 15 studies examining standardized test scores, reading comprehension, and mathematical abilities. Breastfed children demonstrated superior performance across multiple academic domains, with effect sizes ranging from 0.2 to 0.4 standard deviations. Benefits persisted through adolescence in several longitudinal studies, suggesting long-term developmental advantages. Behavioral assessment included attention deficit hyperactivity disorder diagnosis rates, emotional regulation measures, and social competency evaluations. Breastfeeding duration showed inverse relationships with attention deficit hyperactivity disorder diagnosis (odds ratio 0.82 per additional month, 95% confidence interval 0.76-0.89). Emotional regulation and social skills demonstrated modest improvements in breastfed populations, though effect sizes remained relatively small. Neuroanatomical studies utilizing magnetic resonance imaging revealed structural brain differences associated with breastfeeding exposure. White matter development appeared enhanced in breastfed infants, particularly in regions associated with language development and executive function. These structural differences correlated with functional improvements in cognitive assessments.

Growth trajectory analysis included 42 studies examining weight gain patterns, linear growth, and long-term obesity risk. Breastfed infants demonstrated distinct growth patterns compared to formula-fed infants, with more rapid weight gain during the first four months followed by slower weight gain thereafter. These patterns align with World Health Organization growth standards derived from predominantly breastfed populations. Childhood obesity prevention showed significant associations with breastfeeding duration. Meta-analysis of 25 studies revealed reduced obesity risk in children with prolonged breastfeeding exposure (odds ratio 0.78 per additional month, 95% confidence interval 0.71-0.86). Protection appeared strongest for exclusive breastfeeding duration, with mixed feeding providing intermediate benefits. Metabolic programming effects were examined through studies measuring insulin sensitivity, glucose





metabolism, and lipid profiles in older children and adolescents. Breastfed individuals demonstrated improved metabolic profiles, including enhanced insulin sensitivity and more favorable lipid concentrations. These findings suggest that early feeding practices influence long-term metabolic health through epigenetic mechanisms and metabolic programming.

Sudden infant death syndrome analysis included 12 case-control studies and 8 cohort studies examining the relationship between breastfeeding practices and sudden infant death syndrome risk. Meta-analysis revealed substantial protective effects, with any breastfeeding reducing sudden infant death syndrome risk by 36% (odds ratio 0.64, 95% confidence interval 0.51-0.81). Exclusive breastfeeding provided superior protection compared to mixed feeding practices. Duration-response relationships indicated that each additional month of breastfeeding reduced sudden infant death syndrome risk by approximately 4%, with protection persisting for several months after weaning. Mechanisms underlying this protection likely involve multiple factors including reduced infection rates, improved arousal responses, and optimal sleep positioning practices among breastfeeding mothers.

DISCUSSION

The multifaceted benefits of breastfeeding demonstrated in this comprehensive review reflect complex biological mechanisms that extend far beyond simple nutritional provision. Human milk represents a dynamic biological system that adapts continuously to meet the evolving needs of the developing infant, providing not only essential nutrients but also bioactive compounds that actively promote health and development. The immunological superiority of human milk stems from its rich content of antibodies, particularly secretory immunoglobulin A, which provides passive immunity against pathogens in the infant's mucosal surfaces. Unlike systemic antibodies, secretory immunoglobulin A resists gastric acid degradation and maintains antimicrobial activity throughout the gastrointestinal tract. The antibody repertoire in maternal milk reflects the mother's lifetime exposure to pathogens, providing targeted protection against environmental threats specific to the infant's location and circumstances. Beyond antibodies, human milk contains numerous antimicrobial factors including lactoferrin, lysozyme, and human milk oligosaccharides that work synergistically to prevent infection. Lactoferrin sequesters iron from potential pathogens while directly binding to bacterial and viral surfaces. Lysozyme disrupts bacterial cell walls, particularly targeting gram-positive bacteria. Human milk oligosaccharides act as decoy receptors, preventing pathogen adherence to infant epithelial surfaces while simultaneously promoting beneficial bacterial growth. The neurodevelopmental advantages of breastfeeding likely result from optimal provision of long-chain polyunsaturated fatty acids, particularly docosahexaenoic acid, which comprises up to 60% of brain fat content. These fatty acids are incorporated into neuronal membranes, influencing membrane fluidity, neurotransmitter function, and signal transduction pathways. Additionally, human milk contains numerous growth factors and hormones that may directly influence brain development and maturation. The protective effect against sudden infant death syndrome probably involves multiple mechanisms including reduced infection rates, enhanced maternal-infant bonding leading to improved sleep monitoring, and physiological benefits of breastfeeding on infant arousal patterns and respiratory control. The act of breastfeeding itself requires active infant participation,





potentially strengthening respiratory muscles and improving coordination of sucking, swallowing, and breathing patterns.

The findings of this comprehensive review align closely with previous systematic reviews and meta-analyses, while providing updated evidence incorporating recent high-quality studies. The magnitude of protective effects observed for infectious diseases corresponds closely to earlier meta-analyses, with slight improvements in precision due to inclusion of additional studies and larger sample sizes. Cognitive development benefits demonstrated in this review confirm previous findings while extending the evidence base through inclusion of longer-term follow-up studies. The observed intelligence quotient difference of 3.2 points falls within the range reported in previous meta-analyses (2.6-5.9 points), suggesting consistent benefits across different populations and study designs. The dose-response relationships observed for multiple outcomes strengthen causal inferences by demonstrating biological gradients consistent with Bradford Hill criteria for causation. These relationships were particularly evident for infection prevention, sudden infant death syndrome risk reduction, and obesity prevention, where longer breastfeeding duration correlated with greater protective effects. Geographic variations in breastfeeding benefits noted in this review reflect differences in baseline disease rates, healthcare access, and environmental factors. Protective effects for infectious diseases appeared most pronounced in low-income and middle-income countries where baseline infection rates remain high and access to clean water and sanitation may be limited. Conversely, neurodevelopmental benefits showed more consistent effects across different economic settings.

The evidence presented in this review provides strong support for current recommendations promoting exclusive breastfeeding for the first six months of life, followed by continued breastfeeding with appropriate complementary foods. Healthcare providers should prioritize breastfeeding promotion and support as fundamental components of preventive pediatric care, recognizing the substantial health benefits and cost savings associated with optimal breastfeeding practices. Clinical practice should emphasize early initiation of breastfeeding within the first hour after birth, as supported by evidence demonstrating improved breastfeeding duration and success rates. Skin-to-skin contact immediately after delivery should be promoted as standard care for healthy term infants, facilitating early breastfeeding initiation and maternal-infant bonding. Healthcare systems must invest in comprehensive lactation support programs, including trained lactation consultants, peer support programs, and follow-up services extending beyond hospital discharge. Evidence demonstrates that professional lactation support significantly improves breastfeeding duration and exclusivity rates, ultimately reducing healthcare costs through decreased infant morbidity. Workplace policies should support breastfeeding continuation through adequate maternity leave provisions, lactation accommodation requirements, and flexible work arrangements. The economic benefits of breastfeeding extend beyond healthcare cost savings to include reduced absenteeism, improved employee retention, and enhanced productivity among working mothers. Several limitations must be acknowledged in interpreting the findings of this review. Observational studies dominate the evidence base due to ethical constraints preventing randomized controlled trials of breastfeeding versus formula feeding. Consequently, residual confounding by socioeconomic status, maternal education, and health-conscious behaviors may influence observed associations. The definition and measurement of breastfeeding practices varied considerably across





studies, with some investigating any breastfeeding, others focusing on exclusive breastfeeding, and many utilizing different duration thresholds. This heterogeneity complicates direct comparison of findings and limits the precision of pooled estimates in meta-analyses. Geographic representation remains skewed toward high-income countries, particularly for neurodevelopmental outcomes and long-term health effects. Additional research from diverse populations is needed to establish generalizability of findings across different cultural, economic, and environmental contexts. Research gaps persist regarding optimal breastfeeding duration for specific outcomes, particularly for allergy prevention where current evidence remains conflicted. The interaction between genetic factors and breastfeeding benefits requires further investigation, as personalized recommendations may ultimately improve outcomes for individual infants. Long-term follow-up studies extending into adulthood remain limited, particularly for emerging outcomes such as cardiovascular health, cancer risk, and reproductive outcomes. Additionally, the impact of maternal factors including diet, medication use, and health status on milk composition and infant outcomes requires continued investigation.

In conclusion, breastfeeding is the best feeding method for infants, providing superior nutrition, protection from infections, lower risk of sudden infant death, and better cognitive development. Exclusive breastfeeding for the first six months, followed by continued breastfeeding up to two years with complementary foods, should be a global priority. Strong healthcare support, workplace policies, and public programs are essential to overcome barriers and promote breastfeeding as the physiological norm. Future research and professional education must focus on improving support systems and ensuring better long-term health outcomes for mothers and infants.

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