



### Short Review Paper

# A systematic review of the effects of breastfeeding and formula feeding on cognitive development among infants and children

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Available online at: [www.isca.in](http://www.isca.in), [www.isca.me](http://www.isca.me)

Received 8<sup>th</sup> February 2019, revised 11<sup>th</sup> March 2019, accepted 26<sup>th</sup> March 2019

## Abstract

*Breast milk and formula feed are both available for babies; however, breast milk is more nutritious than formula. The properties of various types of feeding on the intellectual development of toddlers, infants and older children have been assessed, but the results indicate the two might not be different. Thus, this systematic review assessed the relationship between cognitive development and breastfeeding or formula feeding among children/infants. Were viewed nine studies obtained from electronic databases, including Google Scholar, EBSCOHOST, Pub Med, and Medline, to determine which method of feeding was best for children. One review found that most studies used retrospective, longitudinal, and prospective cohorts, and the prospective cohort experiment results lacked precise conclusions. Most studies divided children into groups based on their breastfeeding regimes and examined cognitive skills at various ages. Nearly all studies showed either a positive or no correlation between cognitive development and breastfeeding. Although most studies drew no clear conclusions, the findings suggested that breast milk is better than formula for cognitive development. Moreover, longer duration of breastfeeding, particularly >2 months, promote cognitive development. Healthcare practitioners can use these findings to educate mothers about the importance and minimum duration of breastfeeding to enhance cognitive development in children.*

**Keywords:** Systematic review, breastfeeding, formula feeding, cognitive development, intelligence quotient.

## Introduction

There are several ways of raising a child properly, and parents and researchers have explored optimal ways of raising a child successfully. One of the many debates in childcare and psychology is based on whether breast milk or formula is more beneficial for infants<sup>1</sup>. The decision to either breastfeed or formula feed is considered crucial because one of the two is more likely to be the infant's main source of nutrition in early life. Many studies suggest that breast milk provides nutritional and immunological benefits to infants; nevertheless, there is limited research regarding its effects on cognitive development<sup>2</sup>. Identifying which of the two feeding types is healthier is important because the effects on cognitive development persist after infancy and into adulthood<sup>3</sup>. Knowledge regarding the feeding types can help researchers differentiate and analyze the effects on cognitive development in infants, toddlers, and older children. Furthermore, if researchers find that breastfeeding benefits cognitive development, breast milk can be promoted as an inexpensive source of nutrition. However, if researchers find that breastfeeding is not helpful, then parents, especially mothers, can be reassured that not breastfeeding will not be detrimental to infants. Therefore, this systematic review aimed to evaluate the repercussion of breast milk and formula on the intellectual development of infants/children.

## Methods

This systematic review was conducted using electronic databases, comprising PubMed, Medline, EBSCOHOST, as well as Google Scholar, to ascertain studies that were related to the topic under study. The search terms used to search relevant studies were breastfeeding, cognitive developments, breastfeeding and cognitive development, breastfeeding and formula feeding, and formula feeding in infants and children. The initial search generated 30 studies that were further assessed for relevance based on the abstract, content, and significance of the findings. One author assessed the abstract for the overview of studies with respect to the topic of the study. Furthermore, the contents of the studies were screened for similarities in relation to breastfeeding and formula feeding for the cognitive growth of children and infant. Finally, the significance of the findings was assessed with respect to their applicability to the topic and how they could help reach a more conclusive result. Studies published >20 years ago were excluded. Finally, only nine studies were included, and these were systematically reviewed.

## Results and discussion

A summary of the nine studies that were reviewed is included in Table-1.

**Table-1:** Summary of the nine studies that were reviewed.

Title of the Study	Findings	References
Breast milk and cognitive development—the role of confounders: a systematic review	Nearly all studies showed either a positive or no correlation between cognitive development and breastfeeding	2
A critical appraisal of the role of dietary long-chain polyunsaturated fatty acids on neural indices of term infants: a randomized, controlled trial	There were no differences among the three formula groups on the visual evoked potential acuity test.	3
Infant feeding practice and childhood cognitive performance in South India	Low-income communities do not tend to show a relationship between longer breastfeeding duration and greater cognitive development.	4
Breast-feeding and cognitive development in the first seven years of life	The results showed a relationship between cognitive tests scores and the duration of breastfeeding.	5
Breastfeeding and mental and motor development at 5 1/2 years	The results, after adjusting for confounding factors, showed that only breastfeeding for <2 months or >8 months correlated with poor cognitive and language development.	6
Breastfeeding and intelligence: a systematic review and meta-analysis	Breastfeeding was seen to be related to improved performance in intelligence tests. A positive effect of breastfeeding on cognition was also observed in a randomized trial.	7
Breast Milk versus Formula Milk and Neuropsychological Development and Sleep	Exclusive breast-feeding for 6 months was linked to better developmental milestone acquisition than it did with introducing solid food.	8
Human Milk Fortification and Formula Feeding and Cognitive Development in The Premature Infant	A mother who is more accepting of her child’s intelligence or mistakes would be more beneficial to the child’s overall cognitive growth.	9
Effect of supplementation with long-chain ω-3 polyunsaturated fatty acids on behavior and cognition in children with attention deficit/hyperactivity disorder (ADHD): A randomized placebo-controlled intervention trial	There is a relationship between cognitive tests scores and the duration of breastfeeding	10

**Role of Confounders in Breast Milk and Cognitive Development:** A systematic reviews of 84 studies<sup>2</sup> assessed the role of confounders on breastfeeding and cognitive development of infants, toddlers, and adults. Most participants were from high-income countries, and most studies used retrospective, longitudinal, and prospective cohorts with preferred reporting items for systematic review and meta-analyses strategies<sup>4</sup>. Moreover, in most studies, the infants had a specific breastfeeding regime, and their cognitive skills were examined at later ages<sup>5</sup>. For each study, the researchers described the design of the study, target population, exposure of breast milk, intellectual development evaluation tool, participants’ ages, results, and confounding variables that were adjusted.

Nearly all studies showed either a positive or no correlation between cognitive development and breastfeeding. Nevertheless, the number of studies with any type of correlation decreased once the researchers discovered numerous confounding variables, especially maternal socioeconomic status and intelligence quotient (IQ)<sup>3</sup>. Furthermore, higher quality studies showed a “reduced consequence after analysis of

multivariate”<sup>2</sup>. Although >84 studies were analyzed at the beginning of the review, the researchers found that most did not provide a clear answer<sup>6</sup>.

**Effects of Dietary Long-chain Polyunsaturated Fatty Acids on Neural Indices of Term Infants:** A controlled randomized trial<sup>7</sup> compared three formulas. The researchers aimed to observe the neurological effects of polyunsaturated long-chain fatty acids. Placebo formula, docosahexaenoic acid (DHA)-supplemented formula, or DHA+arachidonic acid-supplemented formula were given to 21, 23, and 24 infants, respectively. All the infants were fed starting from the first week to the first year. The infants’ visual evoked potential acuities were tested from 16 to 34 weeks. Psychomotor Progressive Index and Mental Developmental Index were used to assess neurological effects when the infants were aged 1 and 2 years<sup>4</sup>.

The researchers attempted “to obtain whether nutritive long-chain polyunsaturated fatty acids” affected formula-fed infants in the same manner as it did for breastfed infants<sup>7</sup>. The optical induced possible acuity test outcomes showed that there were no

dissimilarities in the 3 groups of formula. The breast milk group performed better on the visually evoked potential (VEP) acuity test than did the three formula groups; however, this result was only observed in infants aged 34 weeks. The breast milk group also showed a higher mental developmental index than did the formula groups on the tests conducted when the infants were aged 2 years. These results proposed that adding polyunsaturated long-chain fatty acids to formulas had no effect on the development of intellectual.

**Breastfeeding and Cognitive Development at the Early Stages of Life:** One study aimed to identify the correlation between intellectual development and breastfeeding in the first seven years, especially with respect to language development, speech, and intelligence.<sup>8</sup> For the feeding part of the test, the infants were divided into three groups: bottle-fed for about four months, breast-fed for about four months, and breast-fed more than four months. The infants were then tested at ages 3, 5, and 7 years. The Test of the Vocabulary of Peabody Picture was administered at 3 years of age ( $n=1,037$ ), the Stanford-Binet Intelligence Scale was administered at 5 years ( $n=991$ ), and the Weschler's Intelligence Scale for Children (WISC) was administered at 7 years ( $n=954$ ). To specifically assess language development, the experimenters used the Reynell Developmental Language Scales for the 3- and 5-year-olds and the Illinois Test of Psycholinguistic Capabilities for the 7-year-olds. Only the 5- and 7-year-olds' articulation was measured using the Dunedin Articulation Screening Scale. Maternal intelligence, maternal education, socioeconomic status, birth weight, and gestational age were some of the controlled confounding variables<sup>9</sup>.

The prospective cohort experiment results lacked a precise conclusion. The infants who were breast-fed tended to have higher test scores, but this could be due to other confounding factors that were not considered. The results showed a relationship between cognitive test scores and the duration of breastfeeding<sup>10</sup>. The group that was fed for a period of more than four months had higher test scores than did the 4-month bottle-fed group. However, once the data were adjusted for confounding variables and gender, the mean test scores showed a smaller difference.

**The relationship between Breastfeeding and Cognitive Performance:** Veena et al.<sup>11</sup> studied the correlation between the duration of intellectual development and breastfeeding in South India, with a focus on the "middle class or lower middle class". All 514 children were breastfed for the initial part of the experiment. The Mysore Parthenon birth cohort had varying durations, from less than 3 months to more than 18 months. Furthermore, the age of introducing foods along with breastfeeding varied from less than 4 months to more than 6 months<sup>6</sup>. The data from all 514 children were collected at annual follow-up visits at ages 1 to 3 years. The data were obtained for 94% of the children when they were aged 1 year, and the remaining were obtained at the next two annual visits. The children's cognitive functioning was assessed using the

Kaufman Assessment Battery when they were aged 9-10 years. Between ages of 9 and 10 years, the children's cognitive functioning was tested using several tests: Kaufman Assessment Battery, Atlantis, pattern reasoning, word order, verbal eloquence, Kohs block scheme, and coding-WISC-III. Confounding factors, like gestation, age, gender, birth weight, socioeconomic status as well as habitation in rural/urban, were adjusted for<sup>11</sup>.

The results showed that low-income communities tended not to show a relationship amid more period of breastfeeding and greater intellectual growth. Even before adjusting for the confounding variables, there was no sign with a lengthier period of breastfeeding would improve intellectual growth. The sum of complementary foodstuffs did not affect the scores of the tests either<sup>12</sup>.

**Breastfeeding and Motor and Mental Development:** Clark et al.<sup>13</sup> focused on controlling the confounding effects of the socioeconomic status. In this longitudinal experiment, infants were initially screened and approved at the age of 4 months based on several criteria: gestational age, birth weight (cutoff = 3.0kg), cesarean section, and iron therapy. Infants aged 5-6 months ( $n=1657$ ) were randomly assigned to two groups<sup>14</sup>. Infants who consumed more than 250ml of cow's milk or formula per day, i.e., cow's milk which is not modified and multivitamins having no iron<sup>13</sup> either had a high or low iron formula. The infants consuming breast milk were given a liquid vitamin fortified with iron while those who consumed less than 250ml of cow's milk per day were given a liquid vitamin without iron. In Chile, the formula is uncommon, so most participants used cow's milk. Initially, of the 784 children, only four were not breastfed since birth. At the five-and-a-half-year mark, the children's cognitive development was tested using the following tests<sup>13</sup>.

Once the experiment started, fieldworkers collected data directly from homes every week until the children turned 1-year-old. Some of the data they collected included the type of feeding and the amount of milk. After adjusting for confounding factors, the authors found that only breastfeeding for <2 months or >8 months caused poor cognitive and language development. The WPPSI-R showed that after adjusting for confounding factors, the other tests showed non-linear results. Children who were fed only through breast for about 2 to 8 months had the highest notches on the cognitive tests based on the WPPSI-R.

**Discussion:** Many studies have implied that breastfeeding particularly influences IQ<sup>3</sup>. Nevertheless, the association has yet to be proven because in most cases, breastfeeding and formula have similar effects on cognitive development. Confounding variables were the main issue in identifying the better feeding method. In the aforementioned research on the age groups 3, 5, and 7 years, the relationship and interaction between the mother and child were considered, possibly affecting the study results significantly<sup>14</sup>. A mother who is more

accepting of a child's intelligence or mistakes would be more beneficial to the child's overall cognitive growth. In Veena et al.<sup>11</sup> study, the quality of breast milk and complementary foods could have affected the results. Furthermore, since the duration of breastfeeding was self-reported, inconsistent feeding durations could have contributed to the negative result to the effect that breast-milk did not improve cognitive development. If the cognitive influence of breastfeeding, as noted previously<sup>13</sup>, depends on age, then Veena et al.<sup>11</sup> study would have failed to obtain this result because nearly all the participants were breastfed for the first 6 months. Furthermore, breastfeeding would be more common in wealthier communities. Thus, the main confounding variables were maternal, cognitive, and socioeconomic. Despite these inconsistencies, breast milk tends to be more beneficial than formula in most cases<sup>10</sup>.

Breastfeeding should last for more than 2 months because this period is considered critical for the child to receive benefits. This implies that breastfeeding for a longer period, until the age of 8 months, could lead to improved cognitive development. The results of this study agreed with those of other studies<sup>8, 13</sup> because all three experiments showed that a longer breastfeeding duration promotes intellectual development. In Clark et al.'s<sup>13</sup> study in Chile, the group that was breastfed for less than 2 months did not have enough time to provide children with the nutritional, polyunsaturated long-chain fatty acids and its interactional benefits<sup>4</sup>. The proof on the effect of intellectual development and breastfeeding is inconclusive; nevertheless, there is enough evidence to suggest that breastfeeding is better than only formula feeding. The implication of this finding is that breast milk is more important for aiding cognitive development in children that are formula diets. Significantly, a child who is breastfed for at least 8 months demonstrates excellent cognitive capabilities<sup>11</sup>.

Therefore, healthcare practitioners could use the findings of this review to educate mothers on the importance of breast milk and the minimum duration to breastfeed their children to enhance their cognitive development. Nevertheless, more rigorous research should be executed to find clearer results. Including twins or siblings in the studies would be very beneficial because more confounding variables would be controlled for, especially the environmental effects<sup>10</sup>.

## Conclusion

The studies conducted varied in their findings, some showing a positive correlation between cognitive development and feeding method while others showed no association. Correlation decreased with the discovery of confounding variables such as IQ and mother's social and economic status<sup>15</sup>. Multivariate analysis further reduced the correlation. Looking at parameters related to vision, there was no effect on adding polyunsaturated long-chain fatty acids on intellectual children growth who used formula milk. On testing language development, speech and intellect in the first 7 years of their life, it was noted that breastfed infants led to higher test scores than for kids who were

formula fed<sup>16</sup>. However, when the data was adjusted to accommodate variables that could not be controlled, the influences of breastfeeding on cognition were reduced. It could be concluded that breast milk contributed to a small percentage of cognitive development<sup>17</sup>. There was no relationship between breastfeeding and cognitive performance in low-income communities. Additionally, more extended periods of breastfeeding did not improve cognitive performance<sup>18</sup>. Introduction of complementary foods also did not promote the test scores. It was therefore concluded that breastfeeding does not influence the cognitive performance of children from low-income areas. Breastfeeding children from 2–8 months leads to higher scores<sup>19</sup>. This implies feeding for less than 2 months or more than 8 months leads to poor cognitive development; therefore, it is essential for parents to note the timings. Confounding variables can best identify a better method as both breast milk, and formula of feeding have similar persecution on intellectual development. The relations between a child and mother had an impact on the results of the study<sup>20</sup>. Mothers who are more accepting of a child's intelligence or mistakes would be more beneficial to the child's overall cognitive growth.

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