

## IS BREASTFEEDING SUPERIOR TO FORMULA FEEDING IN IMPACTING CHILD COGNITIVE DEVELOPMENT? A SYSTEMATIC REVIEW

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### ABSTRACT

*Background: Past research evidence has shown that breastfeeding has significant benefits with regard to cognitive development. However, emerging evidence has shown how breastfeeding may lead to equally beneficial outcomes with regard to cognitive development. Therefore, the present study was undertaken to assess the relevant evidence. Aims: The aim of this systematic review was to compare the impact of breastfeeding and formula feeding on cognitive development by analyzing prospective cohort studies. Methods: This research conducted a thorough search of several databases such as AMED, PUBMED in addition to British Nursing Index and CINAHL. The goal was to utilize all sources of information with regard to identification of prospective studies. The search was limited to articles published between 2000 and 2016, resulting in a total of 15 studies, including 10 quantitative and 5 qualitative studies, that were deemed relevant for review. To ensure that the studies selected for review were of high quality and free from biases, two critical appraisal tools were used. The first tool, the Critical Appraisal Skills Program (CASP), is a widely recognized tool for evaluating the quality and rigor of qualitative and quantitative research studies. The second tool, the Quality Assessment Tool for Quantitative Studies developed by the Effective Public Health Project (EPHPP), is specifically designed to assess the quality of quantitative studies. Results: The review findings revealed that breastfeeding may provide cognitive advantages to children when compared to formula feeding. However, it is pertinent to note how these results are often confounding by factors such as socioeconomic status, parental education etc. Consequently, when evaluating the effects of breastfeeding and formula feeding on cognitive development, it is necessary to consider the role of environmental, biological, social, and cultural factors. Conclusion: Overall, this review underscores the need for further research to better understand the complex relationships between breastfeeding, formula feeding, and cognitive development and to help inform public health policies and interventions aimed at promoting optimal cognitive development in children.*

**Keywords:** breast feeding, formula feeding, cognitive development, CASP, Medline, EMBASE

### INTRODUCTION

Both breastfeeding and formula feeding are popular methods for feeding infants, and their effects on cognitive development have been the subject of discussion for many years. Because to its nutritional and immune benefits as well as the experiences it builds between mother and child, breastfeeding is commonly thought to provide cognitive benefits (Xiong & Xiong, 2021). Nonetheless, there is a growing interest in figuring out the relative advantages of each approach given the popularity of formula feeding and the accessibility of high-quality formula products (Ishikawa et al., 2021). While some research indicates that nursing has a favourable impact on cognitive development, others contend that formula feeding can have cognitive advantages comparable to breastfeeding. The purpose of this study is to examine how breastfeeding and formula feeding affect cognitive development, taking into account any potential confounding effects of maternal education.

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A vast body of research has consistently shown that breastfeeding provides a higher range of cognitive benefits and developmental milestones for children when compared to other measures such as formula feeding. Therefore, it is imperative to raise awareness among the population about the advantages of breastfeeding. The cognitive development of children is determined by a wide range of environmental and genetic factors. Numerous healthcare professionals around the world have emphasized the significance of breastfeeding and its impact on a variety of individual outcomes, which has been consistently validated (Daniels et al., 2021). Various healthcare institutions in the UK, including the NHS, have proposed objectives for breastfeeding due to its many reported benefits, particularly in terms of cognitive development. Despite these benefits, formula feeding is becoming more prevalent in the UK, which is a public health concern given the established importance of breastfeeding in children's cognitive development. Furthermore, there is evidence to suggest that formula-fed children may not develop cognitively as well as those who are breastfed.

A recent meta-analysis found that breastfeeding is significantly linked to higher cognitive development scores than formula feeding, after controlling for confounding factors (Pundir et al., 2021). However, the meta-analysis mostly included breastfed children compared to formula-fed children in Scandinavian regions, where almost all children are breastfed and about 50% for more than 6 months (Lopez-Sanchez et al., 2020). This region has a homogenous population with high education, good public healthcare systems, and sufficient levels of awareness, which may confound the results (Zhao et al., 2021).

Some areas of cognitive development may lag behind in formula-fed children compared to breastfed children, as reported by studies that compared both feeding methods (Walfisch et al., 2013). However, few studies have directly linked formula feeding to cognitive development scores (Boucher et al., 2021). Nonetheless, the findings of both breastfed and formula-fed children can be questioned based on factors such as maternal educational level, home environment, genetics, learning opportunities for the child, and other related factors (Van Den Berg et al., 2020).

Another study in this regard had been conducted with the presumption that most studies exploring breastfeeding and cognitive development had been conducted using observational studies and measures (Horta et al., 2015). It is critical to note that the use of observational approaches for studying breastfeeding, formula feeding and cognitive development do not provide a great deal of support for the notion that such practices impact cognitive development. In order to overcome the biases and limitations of past studies, a prolonged and exclusive investigation had been conducted for assessing cognitive development at the age of 6.5 years. The study had used a cluster randomized trial with successive enrollments from 1996 till 1997. After that, follow up sessions had been called for in 2002 and 2005. The sample size for the study was 17046 breastfeeding infants. In the follow up, 13889 of the participants had been evaluated (Strobel et al., 2022). The degree of cognitive development in these children had been assessed using Wechsler Intelligence Scales for Children and the evaluations made by teachers in terms of reading, writing and mathematical skills of the children.

Researchers have also tried to assess the effects of breast milk on neuro-behavioral and cognitive development in a sample of pre-mature infants (Redsell et al., 2021). The sample for the study included 86 pre-mature infants who had been tested for examination of the effects of breastfeeding. The participants had been classified into three groups during the span of hospitalization. The first group included those who had been receiving less than 25 % optimal nutrition (Feldman and Eidelman, 2003). The second group were those who were receiving a level of 75 % nutrition through being subject to breastfeeding while the third group included those who were exclusively subjected to breast feeding. The participants in the three groups had been matched on the basis of their age, medical risk, family demographics etc. (Linde et al., 2020). During the span of the study, the mother child interaction had been videotaped and neuro-behavioral assessments had been carried out. The neuro-behavioral assessment had been done using Neo-Natal Behavioral Assessment Scale. The results had shown that children who had been breastfed with more than 75 % nutrition had shown higher cognitive development and neuro-behavioral tendencies. Also, higher maternal depression had been reported for mothers who engaged in lower level of breastfeeding. The results had clearly shown that cognitive development progresses faster in children who are subject to breastfeeding. Also, maternal depression for mothers who breastfeed their children is lower. Another important finding is that neurobehavioral development is better in children who are subject to breastfeeding than formula feeding.

The age range for assessing cognitive development and for giving breastfeeding is really important. Numerous studies have examined how breastfeeding during the age range of birth to five years is important. One study in this regard had examined whether the time duration for breastfeeding has an impact on cognitive and motor development under the span of favorable environmental conditions. The sample included 345 Scandinavian children (Hou et al., 2021). The data in terms of breastfeeding had been prospectively recorded during the 1<sup>st</sup> life year. Neurodevelopmental assessments had been carried out at the age of 1 year and then at the age of five years. The outcome measures used for the assessment included Bayley's Scale of Infant Development, Mental Index, Psychomotor Index, Wechsler Preschool and Primary Scales of Intelligence (Hou et al., 2021). The results had shown that children who had breastfed for less than 3 months had an increased risk of lower mental index than those children who had been breastfed for at least 6 months. Maternal intelligence, smoking status of mother and other related factors were also significant in terms of influencing the results of the study. The results clearly showed that there is a strong correlation between cognitive development and breastfeeding. However, no such relationship had been reported for breastfeeding and motor development (Zhang et al., 2021).

#### **Cohort Studies on Breastfeeding and Cognitive Development**

Cohort studies have also been carried out on this area of research. One study had used a prospective cohort based research design for exploring the link between breastfeeding and cognitive development. More specifically, the focus was on examining the relationship between the duration of breastfeeding and the degree of cognitive development (Wallenborn et al., 2021). A total of 2860 infants had been enrolled into the study prior to their birth. For the study, data had been collected from 2939 infants who had English speaking mothers. Complete feeding data had been recorded for the 1<sup>st</sup> year of life. Assessments pertaining to verbal cognitive IQ had also been performed on the sample (Guzzardi et al., 2020). The cognitive assessments on the sample had been done at the age of 1 year and had been continued till the age of 8 years. Peabody Picture Vocabulary Tests had also been carried out on the sample. The assessments had been done after adjusting for factors such as gender, maternal age, parental smoking, educational level of mother and the availability and presence of older siblings. The results had shown that an early cessation of breastfeeding was accompanied with lower IQ development and low performance on different subtests. The scores of children were also higher on the Peabody Picture Vocabulary Test. Interaction effects had also been estimated for this investigation. The results clearly showed that breastfeeding had an advantage over formula feeding in terms of cognitive development and scores on other areas.

The relevant literature has also shown how cognitive development continues well beyond the ages of 7 and 8, and most assessments on this topic have been conducted on small age ranges (Kim et al., 2020). To address this issue, a study was conducted to examine the relationship between duration of breastfeeding and cognitive ability at ages 7-8 in a selective birth cohort. The study involved evaluating 280 children who had been breastfed for varying durations, using the Wechsler Intelligence Scale for Children-Revised to assess verbal and performance IQ. The evidence analyzed also shows that children who had been breastfed for more than 8 months had higher verbal and performance IQ scores, even after controlling for confounding factors. However, the benefits of breastfeeding were found to be smaller in comparison to those reported in other studies.

#### **Critical Reviews on Breastfeeding, Formula Feeding and Cognitive Development**

Researchers have been interested in the positive impact of breastfeeding on cognitive development during childhood, but there are limited studies that assess the relationship between breastfeeding and adult intelligence (Keim et al., 2021). To explore this, a prospective longitudinal birth cohort study was conducted on 973 men and women born between 1959 and 1961 (Walfisch et al., 2013). The participants were divided into five categories based on the duration of breastfeeding, and their intelligence was assessed at mean age 27.2 using Wechsler Adult Intelligence Scale and at mean age 18.7 using Borge Priens Prove. Thirteen potential confounders were identified, and the results showed that longer duration of breastfeeding was associated with higher scores on verbal, performance, and full-scale intelligence quotients. This association remained significant even after controlling for confounding factors, and the researchers concluded that the results were reliable and generalizable due to the large sample size and controlling for a large number of confounding factors.

### **Confounding Factors in Breastfeeding and Cognitive Development**

One study had carried out exploring the relationship between breastfeeding, maternal and infant health outcomes. The main aim of the study was to determine how infant development, mothers' health and breastfeeding benefits were related to one another in developed regions (Chung et al., 2007). The main objective of the study was on examining the positive short and long term effects of breastfeeding on children and also on positive health outcomes for mothers. The data sources that had been consulted in this regard included: MEDLINE, CINAHL and the Cochrane Library. Supplemental researchers were also carried out in 2006. The review methods that had been used included: systematic reviews, meta-analyses, randomized as well as non-randomized trials (Chung et al., 2007). The focus was on looking for studies that helped in exploring and answering the research objectives. Only English language studies had been included for conducting the investigation.

Several studies have explored the relationship between smoking habits of mothers, breastfeeding, and cognitive development in children (Choi et al., 2018; Horta et al., 2015). It has been found that smoking during pregnancy and after birth can negatively affect the cognitive development of children, even if they are breastfed. Parental employment is another confounding factor that has been identified to influence cognitive development in children. Breastfeeding, especially when combined with formula-based supplements, has been shown to have a positive impact on cognitive development in children. However, low birth weight is also a confounding factor that can affect the benefits of breastfeeding. Studies have found that breastfeeding can compensate for the cognitive deficits associated with low birth weight.

Research findings have also shown how breastfeeding was associated with reduced risks of diseases and conditions such as acute otitis media, atopic dermatitis, type 2 diabetes, and ovarian cancer (Pedale et al., 2022). Breastfeeding also led to higher cognitive developmental gains for infants. However, the preference for breastfeeding has decreased due to various barriers such as milk supply, parental attitudes, and concerns about body image (Jafar et al., 2021). A prospective study found that breastfeeding resulted in higher cognitive skills in children compared to formula feeding, but confounding factors were not controlled for. Another study found that formula feeding was more effective in providing low birth weight infants with the required nutrients for optimal development.

Nuzzi et al. (2021) aimed to investigate the cognitive benefits of breastfeeding up to the age of 2 years, as well as estimate the global prevalence of breastfeeding in this age range. They searched Medline and LILACs databases for relevant studies, finding 3561 titles. After analyzing 453 abstracts and 49 full-text articles, they included 19 articles that met their criteria. The results showed increasing trends in breastfeeding, but contradictory findings regarding its benefits for child development. While some medium-term effects were identified, there was no association reported for child development (Dennis et al., 2019).

Pang et al. (2020) reported an increasing trend in formula feeding, a study was conducted to promote breastfeeding by engaging and supporting fathers to encourage mothers to breastfeed. While fathers have a significant impact on mother's decision to breastfeed or use formula, there is no consensus on the specific behaviors and actions that constitute father support for breastfeeding. The study used a concept analysis and evolutionary model of concept development and conducted repeated qualitative studies in two phases with 16 parents using focus groups and telephonic interviews. The results identified important attributes that influence fathers' perceptions of breastfeeding and their ability to support mothers, including knowledge of the benefits of breastfeeding, positive attitudes toward breastfeeding, involvement in decision-making, and practical and emotional support. The role of the home environment is also a critical confounding factor that cannot be overlooked.

In exploring the effects of breastfeeding on cognitive development, Lee et al. (2021) found that the home environment plays a significant role. Previous studies had often neglected this factor, raising questions about the credibility of their results. The study aimed to determine whether breastfeeding and cognitive development in one-year-old children are related, and if the home environment confounds the positive cognitive benefits of breastfeeding. To address this, socioeconomic and other home-related factors were controlled. The degree of stimulation in the home was assessed using the Home Inventory, while cognitive development was assessed using Bayley Scales of Infant Development. The results showed that breastfeeding for over one month resulted in positive and beneficial cognitive development effects, highlighting the need to promote breastfeeding as a beneficial option for cognitive development.

Couto et al. (2020) reported evidence that breastfeeding promotes language development, in addition to cognitive development, in children. Their study aimed to explore language, cognitive, and motor development in children subject to breastfeeding, and assess the impact of dose-response relationships on cognitive development. The study used a mother-child cohort of 540 pairs, and collected information on parent and child characteristics via qualitative interviews. Cognitive, language, and motor development assessments were conducted using Bayley Scales of Infant Toddler Development at 18 months of age. Duration of breastfeeding was positively correlated with scores on Bayley Scales, except for gross motor skills, with children breastfed for more than six months showing higher cognitive, language, and motor development. The characteristics of infants and mothers and other related factors were controlled, demonstrating a direct link between breastfeeding and cognitive, language, and motor development benefits.

### **Purpose of the Study**

This study aims to contribute to the existing knowledge on the impact of breastfeeding on cognitive development by conducting a thorough literature review. The review will incorporate both quantitative and qualitative assessments, utilizing relevant sources from the past few years. Secondary data will be collected to determine whether there is a consensus among researchers regarding the benefits of breastfeeding versus formula feeding. The review will focus on studies with large sample sizes from different regions. The mixed approach of including both qualitative and quantitative assessments in the literature review is considered effective. However, there is a gap in the literature regarding systematic reviews that use both types of assessments to evaluate the impact of breastfeeding on cognitive development.

### **Research Questions**

- What is the impact of breastfeeding on cognitive development in comparison to formula feeding?
- Does Breastfeeding have an advantage over formula feeding in regard to children's cognitive development as reported in cohort studies?
- What are the potential confounding factors that could affect the relationship between breastfeeding/formula feeding and cognitive development?

### **Research Objectives**

- To review the existing literature exploring the impact of breastfeeding and formula feeding on cognitive development
- To assess studies using primary data in this area of investigation
- To thoroughly explore quantitative and qualitative studies on the differential effects of breastfeeding and formula feeding on cognitive development

## **METHODOLOGY**

### **Research Design**

An exploratory systematic review was carried out in accordance with the purpose of the study and the research question. The emphasis was on conducting a critical literature review of the existing and past findings with an emphasis on prospective cohort studies.

### **Participants**

The eligibility criteria for inclusion of studies in this analysis were as follows: the participants had to be children or adolescents aged between 0 to 14 years belonging to any region. The studies fulfilling this age criteria were selected.

### **Data Sources and Search Strategy**

This research conducted a thorough search of several databases such as AMED, CINAHL, PUBMED, British Nursing Index, Cochrane database, and Archives of General Psychiatry to identify primary research articles that focused on the impact of breastfeeding and formula feeding on various aspects of child development. The search was limited to articles published between 2000 and 2016, resulting in a total of 15 studies, including 10 quantitative and 5 qualitative studies, that were deemed relevant for review.

To ensure that the studies selected for review were of high quality and free from biases, two critical appraisal tools were used. The first tool, the Critical Appraisal Skills Program (CASP), is a widely recognized tool for evaluating the quality and rigor of qualitative and quantitative research

studies. The second tool, the Quality Assessment Tool for Quantitative Studies developed by the Effective Public Health Project (EPHPP), is specifically designed to assess the quality of quantitative studies. Using these tools, the studies were carefully evaluated for their methodological strengths and limitations, potential sources of bias, and overall quality of evidence by two independent reviewers. This approach ensured that only studies that met a high standard of quality and rigor were included in the final review. Overall, the selection and evaluation of studies for this research were conducted with great care to ensure that the findings and conclusions drawn from the review were reliable and informative.

#### **Inclusion Criteria**

Only prospective studies had been included keeping in view the purpose of the study. Moreover, studies that had controlled for confounding variables such as maternal, education as well as SES were included.

#### **Exclusion Criteria**

The present investigation excluded studies conducted prior to the year 2000, as well as studies using secondary sources of information. Furthermore, any studies conducted using handicapped children were also excluded. This approach was adopted to investigate the impact of breastfeeding and formula feeding on cognitive development in normal children.

#### **Study Quality Grading and Data Extraction**

The assessment of the quality of the studies and possible biases was done using two tools: the Critical Appraisal Skills Program (CASP) as suggested by Long et al. (2020) and the Quality Assessment Tool for Quantitative Studies, which was developed by the Effective Public Health Project (EPHPP). The evaluation of qualitative studies was based on several criteria, such as the study's purpose, design, use of theoretical perspectives, form of reasoning, saturation-n sampling, constant comparison, inductive and collaborative findings, rules of analysis and transformation of themes. On the other hand, the evaluation of quantitative studies was based on several dimensions, such as selection bias, study design, confounding factors, blinding, methods used for data collection, withdrawals and amount of dropouts, integrity in terms of intervention, and analysis. In terms of the aforementioned tools, All study types, including cohort, case-control, and RCTs, can be graded using this system. Studies that fulfil the generally recognised high-quality standards fall under category A. There must be an accurate description of the population, setting, interventions, and comparison groups. In addition, there must be appropriate outcome measurements, statistical and analytical methods, and reporting. Less than 20% of participants must drop out, and potential confounders must be properly taken into account and adjusted for. Although category B research do not always fulfil category A standards, these shortcomings rarely result in major biases. These studies may not have made the best adjustments for potential confounders and missing data, which makes it challenging to determine any restrictions or potential issues. Studies in category C either failed to account for potential confounders or did so inadequately thus limiting the accuracy of the findings.

#### **Data Extraction**

The data used in this study consists of the material contained within the studies chosen for the literature review. Both qualitative and quantitative studies' data will be gathered. The primary focus will be on studies that employed primary data. A total of 15 studies, 5 of which were qualitative and 10 were quantitative cohort studies, were identified based on the inclusion criteria and research question. The stages involved in the selection process have been shown in figure 1 (Prisma Flow Diagram). Moreover, table 1 provides information about data extraction along with brief descriptions of the studies, information about the target population, method of categorization, cognitive development assessment tools in addition to summaries of confounding factors.

#### **Data Synthesis**

In a systematic review, data synthesis involves combining the results of multiple studies to arrive at an overall understanding of the topic. Thematic analysis is one way to do this. It involves identifying common themes or patterns that emerge from the studies being reviewed. The idea is to identify what the different studies have in common and group them accordingly. For example, in a review of studies on meditation's mental health benefits, the common themes may include better mood, reduced anxiety, and improved sleep quality (Clarke and Braun, 2014). Thematic analysis is an effective way to draw more conclusive results by summarizing the key findings of multiple studies. However, it's worth noting that other methods of data synthesis might be used depending on the research question or the type of studies being reviewed.

### Procedure and Ethics Approval

The approval for the research was obtained through the Ethics Review Board of University of Lahore. The present study did not warrant any ethical review. As there was no primary data involved in the study and as the studied selected for review and analysis were freely available, no ethical approval was warranted for the study.

### RESULTS AND DATA ANALYSIS

To evaluate both quantitative and qualitative studies, researchers used critical appraisal tools. They used a tool called the Quality Assessment Tool. It is an instrument that provides systematic criteria and guidelines for quality assessment of quantitative studies within the domain of public health. The ratings were done by an independent reviewer and the researcher, and the participants were also given a rating form to evaluate the studies. The studies were rated on a scale ranging from strong to weak. Evidence and quality assessment tables were used to analyze both the quantitative and qualitative studies, and the results of the analysis are presented in the tables below.

Figure 1 Prisma Flow Diagram

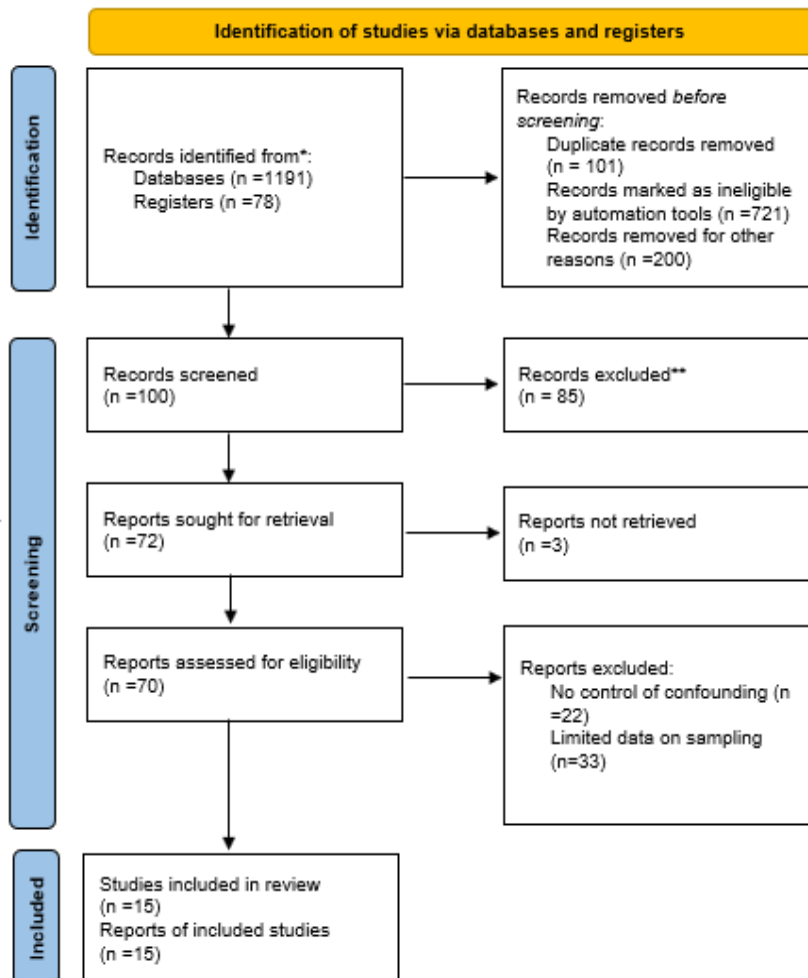


Table 1. Characteristics and Findings of Studies on Impact of Breastfeeding Vs. Formula Feeding on Cognitive Development							
Author and Reference	Selection Bias; Rating	Study Design	Confounders	Blinding	Data Collection Method	Withdrawals and Dropouts	Final Ratings by Both Reviewers
1. Walfisch et al., 2013	No attempt was made for controlling for confounding factors and the sample was selected in a biased manner; 3	Prospective cohort and the feeding method was collected in a retrospective manner	No confounders were adjusted for due to which the results cannot be termed reliable. The rating in this regard is 3	Blinding methods were used.	Cognitive assessment measures were used.	The initial sample was 84. However, the withdrawals and dropouts had taken the sample down to 60. The rating in this regard is moderate.	B
2. Andres et al., 2012	The researcher was able to eliminate selection biases by defining the population clearly, selecting an appropriate comparison group, and ensuring that the groups were similar except for the exposure. The rating given for this aspect is 1.	Prospective cohort study was used.	SES, maternal education, age, birth weight and other associated factors were controlled	The individuals who participated in the study as well as the experts who collected the data were not informed about the research questions or the study's outcome. This aspect has been given a rating of 1.	The methods used in the study were deemed to be valid and reliable. The assessment tools that were utilized included the Bayley Scales of Infant Development and the Psychomotor Development index. The rating received for these methods is 1.	The sample for this study was initially selected from Arkansas, but the number of participants was later reduced to 350 during subsequent stages. As a result, the rating for sample size is 2.	A
3. Wang et al. (2014)	The criteria was the same as above. The rating is 1.	Prospective and randomized longitudinal study was used	Factors such as home environment, education level of parents,	Blinding was used.	Bayley Scales in addition to developmental	The initial sample size was sufficient which was	A



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			birth weight, IQ, gender and age of the parents were controlled.		assessment inventories were used,	selected from Hong Kong. The fallout was about 10 % with the remaining sample about 265.	
4. Quigley et al., 2012	Approaches for minimization of selection biases were not used. Convenience sampling was used instead.	Prospective research design	Socioeconomic status, pesticide exposure as well as gender.	The researchers themselves collected the data and were aware of the study's purpose. Additionally, the participants were informed about the study's results through cues. This approach received a rating of 3.	The McCarthy Scales of Children's Abilities were used. The tool was valid and reliable.	The initial sample size was 50 participants, and approximately 5 participants dropped out, which corresponds to a dropout rate of around 10%.	A
5. Bernard et al., 2013	No effort for randomization and no efforts for eliminating of biases in in selection. The rating is 3.	A cohort design was used. No randomization. The rating is 3.	No effort for elimination of confounding. The rating is 3.	No evidence of blinding	PM-47 non-verbal test was used. The tool is not designed for assessing most of the varying dimensions of cognitive development . The rating is 3.	The initial sample size was 954 which was reduced to 500. The fallout and withdrawal was about 50 %. The rating is 3.	C
6. Dashti et al. 2014	Randomized was used. No selection biases were found	Prospective cohort design	Confounding factors such as birth, age, absence of father and maternal education were controlled	Blinding was done	Infant feeding assessments were used..	The study initially had 200 children as the sample size, but it was later reduced	A
7. Daniels and Adair, 2005	Selection biases were controlled	Prospective Cohort design had been used.	Confounding factors were controlled for including parental education, gender, level of household income, hygiene etc.	Double blinded interventions were used	Philippines Non-Verbal Intelligence Test	Initially, 1984 Filipino children were recruited for the study. However, approximately 400 participants dropped out during the course of the study.	A

8. Leventakou et al., 2015*	Some attempts were made for prevention of selection biases through blinding.	Prospective Cohort	SES, maternal intelligence, home environment, stressful events were controlled.	Single blind method was used	BSID, MDI and PDI.	A total of 788 infants aged between 4 to 6 months were initially recruited for the study. However, a significant number of participants dropped out during the course of the study. Moreover, the time period available for conducting the later assessments was limited.	B
9. Evenhouse and Reilly, 2005	Randomization was done which contributed towards limiting selection biases	Prospective study, sibling pair analysis	Control was exercised over birth weight, parental education and birth order	Blinding procedures were undertaken	Peabody Picture Vocabulary Test were used	2734 sibling pairs had been selected. The fallout was below 5 % during the later phases.	A
10. Belfort et al. 2016	Randomization was not done. However, selection biases were minimized through blinding.	Prospective Cohort was used.	No. of siblings, parental education, birth weight, gender and home environment were analyzed and controlled	Blinding was used.	Sentence completion reading in addition to different measures vocabulary, visual tests etc.	A total of children individuals were sampled. The fallout was about 20 %.	B

**Table 2. CASP (Critical Appraisal Skills Program) was used for the assessment of qualitative studies. The quality assessments in this regard are as follows.**

Author and Reference	Purpose of the Study	Study Design	Reasoning Involved	Use of Theoretical Perspectives	Saturation Sampling	Constant Comparison	Inductive and Collaborative Findings	Rules of Analysis	Rating
Bonia et al. 2013	The focus of the study was clearly defined. The factors behind the decision of mothers towards breast and formula feeding were in focus.	Qualitative research design was used and the data was collected using focus groups.	Inductive reasoning was used.	No theory was used in terms of supporting the findings.	Sufficient level of saturation sampling was achieved.	No comparison was done.	The findings were inductive in nature and has been subject to rigorous analysis.	Thematic analysis was used. Coding was done and emergent and master themes were identified.	B

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Avery and Magnus, 2011	Perceptions of mothers and fathers towards breast vs formula feeding	Focus groups were used for data collection.	Inductive and deductive reasoning was used.	Theoretical perspectives were used for analysis of findings.	Saturation sampling was done using focus groups that were conducted in 3 major US cities with a sample size of 121 participants.	The views were subject to constant comparative analysis. Also, the themes identified were critically compared.	The study scored high in terms of collaborative and inductive findings.	Thematic analysis was used. Coding was done and emergent and master themes were identified.	A
Leahy-Warren et al. 2017	The purpose was to assess the role of fathers in providing support for breastfeeding and influencing their wives to support it.	Semi-structured interviews were used on 20 fathers. The interview items were specific and focused on recording the role of fathers in providing support for breastfeeding in comparison to formula feeding.	Inductive reasoning was used.	Theoretical support was available for the findings.	No evidence of saturation.	A comparative analysis was not visible in terms of the findings.	The findings were inductive but not highly collaborative	Interpretative phenomenological analysis was used. The themes were identified and clustered in a standardized manner.	A
Ludlow et al. 2012	The purpose of the study was on identifying the benefits of breastfeeding and identifying the risks associated with formula feeding.	Focus groups were used and the design was qualitative in nature.	Inductive and deductive reasoning was used.	The findings were supported using theoretical perspectives.	Saturation sampling was done. The sample size was 80 participants. The sampling process was continued until an enough level of saturation was achieved.	Comparative analysis was performed. A constant comparative analysis was done.	Findings were inductive and collaborative in nature.	Thematic analysis was used. Coding was done, sub themes were identified, emergent themes were identified and then they were combined to form super-ordinate themes.	A
Zhang et al., 2015	The purpose of the study was on assessing why young infants engage in formula feeding in china.	In depth interviews were used.	Deductive reasoning was used.	Theoretical support was made available. The findings were analyzed and interpreted using the relevant theoretical models.	Saturation sampling was not done. The sample size was 50. The saturation was not done due to which the diversity in terms of findings and saturation of data was not possible.	Constant comparative analysis was done.	Findings can be termed inductive and collaborative	Thematic analysis was used for identifying themes of information or patterns of meaning from inside the data.	A

**DISCUSSION**

The age-old argument of whether breastfeeding gives a direct boost to a child's cognitive abilities or whether it's merely linked to a higher socioeconomic status and intelligence in the family is more than just a theoretical discussion. From a public health standpoint, if breastfeeding can actually have a biological impact on a child's IQ, then it would be an incredibly cost-effective way to significantly enhance their neurodevelopment. On the flip side, if there is no such effect, then mothers who are unable or choose not to breastfeed can take solace in knowing that their decision will not have any long-term developmental consequences for their child. During the systematic review, a total of 15 studies were examined, comprising of 10 cohort studies and 5 qualitative studies. This mixed-method approach was employed to obtain both quantitative and qualitative results and gain insight into the benefits of

breastfeeding regarding cognitive development and other associated factors. By conducting a comparative analysis using both types of data, the researchers could evaluate the effectiveness of breastfeeding and whether any confounding variables affected its effects on the independent variable (breastfeeding). The results indicated that the significance of the effect of breastfeeding on cognitive development is significantly reduced when controlling for confounding factors, which were not accounted for in previous studies. This highlights the importance of considering and controlling for these factors in future studies, as a considerable number of existing studies on this topic may have confounded results (Belfort et al., 2016). Though a number of the abovementioned problems can be resolved through conducting randomized control trials, it would not be ethically feasible to do so. A closer comparison to such a study design can be utilized through a research approach that would reduce selection biases or through using studies based on siblings-paired analysis, in terms of which children who are breastfed may be compared with their siblings who have been formula-fed to study whether breastfeeding leads to protective effects.

The systematic review evaluated 10 quantitative studies, of which 8 reported a positive correlation between breastfeeding and cognitive development. However, only 9 of the 15 studies were of high quality, with 4 being of moderate quality and 6 being of low quality. Confounding factors were controlled for in 8 of the 13 studies, and studies that did not control for confounding factors are questionable. Critics of the notion that breastfeeding provides cognitive benefits argue that most studies in this area are biased and influenced by confounding factors such as home environment, gender, socioeconomic status, and education of mothers (Avery & Magnus, 2013). Findings cannot be generalized to developing regions, where factors such as economic, social, cultural, and political contexts influence cognitive development. Two studies reported that formula feeding provides similar benefits to breastfeeding (Bonia et al., 2013; Quiglet et al., 2012). The systematic review highlights the importance of the environment in which children are raised, the nature-nurture debate, age-appropriate tools for cognitive assessments, and maternal cognitive and socioeconomic factors in explaining the effects of breastfeeding on cognitive development. Research evidence has also shown how test scores attained by children who had been subjected to breastfeeding for six months or more were higher in comparison to those who did not receive it (Zhang et al., 2015).

Breastfeeding is also linked with better cognitive outcomes in children as confirmed by Appleton et al. (2018), but the extent of this relationship is not entirely clear. A systematic review of 15 quantitative studies on this topic found that 13 studies reported a positive relationship between breastfeeding and cognitive development, with 5 studies rated as high quality, 4 studies as moderate quality, and 6 studies as low quality. However, confounding factors were not always controlled for, which raises questions about the reliability of the findings. Critics of the notion that breastfeeding provides cognitive benefits point out that many studies on this topic are biased, and confounding factors such as home environment, gender, socioeconomic status, education of mothers, and blinding procedures were not always taken into account (Leahy-Warren et al., 2017). Breastfeeding is very common in Scandinavian regions where almost all children are breastfed, and about 50% of them are breastfed for more than six months (Quiglet et al., 2012). The people living in these regions are similar to each other in terms of their income, education level, and access to healthcare, which is not the case in other parts of the world (Evenhouse and Reilly, 2005). They have a good public healthcare system and are generally well informed about the benefits of breastfeeding. This is probably why breastfeeding rates are high in these regions (Wang et al., 2014).

The studies reviewed in this systematic review used various tools to assess cognitive abilities and covered a wide age range. Most of the studies focused on intelligence during childhood (ages 1-18 years, 75%). However, studies that looked at infancy or adulthood were more likely to find no association between breastfeeding and cognitive abilities, even after making necessary adjustments. This could be due to the limitations in accurately assessing IQ during infancy, as well as the multiple factors that can affect IQ during adulthood. Additionally, our review highlights the potential bias against studies that do not find significant effects. Studies that report positive findings are more likely to be published in peer-reviewed literature, creating an unbalanced perspective that can skew the overall conclusions regarding the impact of interventions. Considering these factors is essential in interpreting the results of this review, particularly regarding the effects of breastfeeding on cognitive development.

The review also found that the effects of breastfeeding on IQ were reduced when controlled for confounding factors. Additionally, the effects of breastfeeding on cognitive development cannot be

generalized to developing regions, where a range of economic, social, cultural, and political factors may influence cognitive development in children. Two studies indicated that formula feeding provides similar benefits to breastfeeding, although most studies on the benefits of breastfeeding had methodological flaws (Daniels & Adair, 2005). The evidence suggests that the environment in which children are raised is an important factor in cognitive development. The nature vs. nurture debate has a great deal of significance in influencing the findings of comparative assessments of breastfeeding and formula feeding. The age range of participants is important for assessing cognitive development, but as the age of cohorts progresses, the role of confounding factors continues. It is therefore imperative to use age appropriate tools and measures for the purpose of achieving reliable findings (Bernard et al., 2013).

Previous reviews have mostly focused on studies from high-income countries (HICs) where mothers with higher education and income tend to breastfeed exclusively and for longer durations (Dashti et al., 2014). This could lead to confounding results, as higher socioeconomic status is associated with better cognitive development and educational achievements in HICs. While efforts have been made to minimize confounding variables and other associated factors. It is also imperative to note how the usage of reviews that are based on sampling low and middle income countries have reported inconclusive results. The main reason being that these studies did not account for maternal education as well as economic wellbeing and social status of the family. One review found that studies from LMICs were twice as likely to report no cognitive benefits of breastfeeding compared to studies from HICs. However, studies in LMICs using psychometric tools developed and validated in HICs to assess cognitive development may have led to misclassification and misleading results. To address this, future studies need to be structured with the aim of using culturally sensitive measures and assessment tools as they will provide more reliable and valid outcomes.

## **CONCLUSION**

It is thus concluded that breastfeeding offers numerous cognitive benefits, but several factors mediate the identification of these benefits. This systematic review indicates that the association between breastfeeding and child cognitive abilities may be mostly attributed to the cognitive and socioeconomic effects of the mother. Moreover, a recent systematic review did not support the idea that milk PUFA has a biological effect on brain development. Therefore, it is probable that breastfeeding alone does not have a direct impact on child IQ. Despite the fact that it is unlikely that new studies will alter the current conclusion, future research should aim to control for all significant confounders, including parental IQ, even if it is challenging to acquire. Alternatively, studies using sibling cohorts discordant for breastfeeding may produce more robust results to resolve this issue. Many previous studies did not consider these factors, leading to confusing results. While some studies have suggested that breastfeeding has cognitive benefits, there are numerous factors that can mediate and moderate these effects. Studies that controlled for these factors showed reduced effects on cognitive development. In fact, some studies even suggested that the cognitive effects of breastfeeding are similar to formula feeding when confounding factors are controlled. The review's quality assessment tools showed that many studies conducted after 2000 were of high quality, but some low-quality studies have also been published. Independent research is crucial because formula feed manufacturers have funded some studies. It is unclear whether breastfed children are cognitively superior to formula-fed children due to confounding factors and selection biases in some studies. The process of examining the cognitive benefits of breastfeeding is complex, and many researchers believe that these factors cannot be entirely controlled. Therefore, the debate on the cognitive benefits of breastfeeding versus formula feeding is ongoing. Future research should focus on conducting controlled studies that minimize the effects of selection biases and confounding factors. One recommendation is to study sibling pairs subjected to breastfeeding and formula feeding to obtain more reliable results, as this would control for factors such as home environment, parenting impact, parents' education, race, ethnicity, resources available, household income, and assets. Such research could accurately document and understand the cognitive and other related benefits of formula feeding compared to breastfeeding.

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