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Health Benefits Of Breastfeeding For Infants, Leading To Developmental Differences Between Breast-fed And Formula-fed Infants

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**HEALTH BENEFITS OF BREASTFEEDING FOR INFANTS,
LEADING TO DEVELOPMENTAL DIFFERENCES BETWEEN
BREAST-FED AND FORMULA-FED INFANTS**

Honors Thesis

**Presented in Partial Fulfillment of the Requirements
For the Degree of Bachelor of Science**

In the School of Nursing
at Salem State University

By

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Abstract

This systematic literature review of health benefits of breastfeeding for infants serves to educate mothers about any potential developmental differences between breast-fed and formula-fed infants. Many factors go into a mother's decision regarding feeding methods, but there may be gaps in knowledge that are important and significant between feeding methods. Breastfeeding vs. formula feeding has become a controversial social issue in our society. Other literature reviews as well as qualitative and quantitative studies were reviewed in order to clarify which method is better, specifically in terms of infant development and why. Analysis and review of data from these studies may clarify the answer to this question and may support the hypothesis that breastfeeding is more beneficial developmentally for infants than formula feeding. From this review, it can be concluded that the differences in development between breastfed and formula-fed infants are not significant, but there appear to be more benefits and advancements in infants who were breastfed, even for short periods. In yielding these results, it is possible that more mothers will choose breastfeeding and more healthcare providers, particularly nurses, will better educate about the differences and benefits of both methods. This may lead to healthier infant development in the future.

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Introduction

One decision may impact the entire developmental process and future health of an infant. Food and nutrition are key determinants of the health of human beings. Infant feeding has become a very important, controversial topic of discussion, since there may be influence on infant development, especially in the first year of life (Smith, 2012). There is debate and question about whether breastfeeding and formula feeding are of equal value to infants, and if not, what the major differences are between the two. Along with debate, there is some gap in knowledge about feeding methods, potentially affecting some women's decision to breast or bottle feed their babies. Although breastfeeding has become more common and rates continue to rise (Street & Lewallen, 2013), the question remains of why breastfeeding is becoming more prevalent. Another important question asked regards developmental differences between breastfed and formula fed infants. Many studies are unclear whether there are major differences in development between breast-fed and formula-fed infants because of uncertainties and inconclusive associations (Gale et al., 2012).

Background/Significance

Since the choice to breastfeed or formula feed may affect an infant's development, it is important to explore each category of infant development. Infant development not only consists of physical development, but cognitive and socio-emotional development as well. Breastfeeding is modifiable as a health behavior (McCrary & Murray, 2012), so knowing whether there are significant advantages or disadvantages may be a major reason for education, especially in the medical and nursing field. Researching the subject of developmental differences between breast-fed and formula-fed infants may provide more material for physicians and nurses to improve teaching for this population. With the results and conclusions of this literature review, there is

potential for further research regarding breastfeeding benefits and differences between breast-fed infants and formula-fed infants.

Aim of Study

Although breastfeeding seems to be the more popular choice among mothers who have the choice of feeding method, there is still a population that chooses to formula-feed their infants. If there really are developmental benefits of breastfeeding in comparison to formula feeding, there is potential for further education and information that could influence the pro-formula population to choose breastfeeding. The goal of this systematic literature review is to take research from these reviewed sources and determine if there are significant differences between infants in both groups developmentally, and what those differences are.

Methods

A systematic review of the literature was conducted in order to determine the benefits of breastfeeding and if there are developmental differences between breast-fed and formula-fed infants. The database CINAHL was used to search from January 2016 to January 2017. Both qualitative and quantitative studies were used, as well as some other literature reviews. The years of publication of the included studies are 2007 through 2016, since recent literature in this topic was limited. Literature was included from over the last ten years. Keyword search terms included: breastfeeding benefits, breast-fed and formula-fed infants, infant development and feeding methods, breast milk and formula differences, breast-fed infant development compared to formula-fed infant development, and feeding methods effect on infant development. The population in this literature review included infants, pregnant mothers, and mothers of infants. Figure 1 depicts the search strategy of the included studies in this literature review (N=10).

Limitations of the literature review include limitations within each study. Not every study used in the review examined the same age group of infants. Different measurements of development were used in the studies reviewed. Not every study looked at the same physical developmental achievements or the same cognitive developmental achievements. There was some lack of specificity among the literature, which limited the outcomes. Many pieces of the literature used mother's report or subjective data, which may potentially alter results in those studies.

Figure 1: Research flow map

Results

Table 1 describes the included studies in this review. While reviewing the literature, certain categories of development were prevalent, such as physical development, neuro/cognitive development, physical development, and socio-emotional development. The majority of the literature consisted of neurocognitive development, including motor skills, problem solving, communication/language and memory, and intelligence. Physical development included infant growth rates and patterns, and body composition. Physical development also included one research article about allergy development related to feeding method. Socio-emotional development was not as prevalent in the research, but consisted of behavior and social skills.

According to the literature, physical developmental differences between breastfed and formula fed infants varied. Infants who have ever been breastfed for any amount of time had significantly higher chances of meeting appropriate milestones for their age in gross and fine motor skills compared to infants who were never breastfed. Duration of breastfeeding did not have significant effect on differences in motor skills among infants who were breastfed for a short amount of time compared to infants breastfed for a longer amount of time (McCrary & Murray, 2012). Breastfed infants gained weight more slowly, while formula fed infants gained weight at a faster rate in the first year of life (Sidnell & Greenstreet, 2009). In terms of body composition, there were variances depending on age of the infant. Breastfed and formula fed infants from one to two months of age did not show significant differences in composition. From three to four months of age, formula fed infants had lower fat mass, higher fat-free mass, and lower fat mass percentage than breastfed infants. At six months, formula fed infants still showed lower fat mass and lower fat mass percentage, but fat-free mass differences were not significant. In both eight to nine months and twelve months of age, formula fed infants showed higher fat-

free mass than breastfed infants, but differences between fat mass percentage and composition of fat mass were insignificant (Gale et al. 2012). Another study showed no significant differences in weight, length, and head circumference between breastfed and formula fed infants in the first four months of life (Gianni et al. 2014). Antibodies IgA and IgM were measured among breastfed and formula fed infants in the first week of life in a study in Taipei. Formula fed infants had higher concentrations of serum IgA on days three, four, five, and six of the study, compared to breastfed and mixed fed infants. No significant differences were found in serum IgM levels amongst the three groups of infants (Cheng et al. 2012). There were some differences between the two groups in brain structure development. One study showed that there were differences in head circumference; formula fed infants displayed deficits in head circumference compared to breastfed infants as well as smaller gangliothalamic ovoid diameters, less white matter, and lower visual acuity than exclusively breastfed infants (Tawia, 2013). A study looking at cow's milk allergy showed that infants who were fed cow's milk formula were at greater risk for developing an allergy to cow's milk than infants who were breastfed and not exposed to cow's milk formula (Smith, 2012).

Results of cognitive developmental differences among breastfed and formula fed infants also vary in the literature. There is a 3.45-point difference between formula fed and breastfed infant IQ, with formula fed infants IQ being lower. Although this is not a highly significant difference in IQ, it may later have influence on IQ in childhood according to this study (Tawia, 2013). Breastfed infants had a larger memory capacity than infants who were artificially fed or infants who were not breastfed as much as those exclusively breastfed. Higher breastfeeding exposure was associated with better memory at six months of age, but no significant differences were seen at eighteen months. Positive language domain scores were seen in breastfed infants

compared to formula fed infants in the first two years of life. Infants who were more exposed to breast milk scored significantly higher in receptive and expressive language domains (Cai et al. 2015). Any amount of breastfeeding was associated with higher chances of meeting problem solving developmental milestones. Although breastfed infants appeared to be at an advantage in problem solving, there were no significant differences between infants breastfed for a short amount of time and infants breastfed for a longer amount of time (McCrory & Murray, 2013). Socio-emotional development in infants was only found in two of the ten sources of literature, but observed differences were found. Infants who were formula fed had two and a half times the risk for below average socio-emotional development than breastfed infants. Exclusively breastfed and mixed-fed infants both scored higher in socio-emotional development than formula fed infants, but there were not significant differences between exclusive and mixed breastfed infants (Metwally et al. 2016).

Discussion

A review of the literature focusing on infant feeding methods identified several developmental differences between breastfed and formula fed infants. Although some of the differences were not significant, breastfed infants experienced more developmental benefits than formula fed infants. The common theme throughout the literature was breastfed infants having advantage over formula fed infants in most areas of development. Any amount or duration of breastfeeding put infants at higher advantage developmentally than infants who have never been breastfed at all, according to these results.

Physically, breastfed infants were at an advantage as far as gross and fine motor skills, body composition, brain development, and were also at lesser risk for future problems, such as obesity and cow's milk allergy. Since breastfed infants developed gross and fine motor skills at

appropriate levels more often than formula fed infants (McCrorry & Murray, 2013), they were more likely to perform these skills at earlier ages. Performing gross and fine motor skills at higher levels and at earlier cut-offs may be evidence of advanced brain development in breastfed infants (McCrorry & Murray, 2012). Weight gain in the first year of life was slower in breastfed infants compared to formula fed infants, but was not a disadvantage (Sidnell & Greenstreet, 2009). Although formula fed infants gained weight faster than breast fed infants, this put them at higher risk for being overweight or developing metabolic problems later on in childhood or adulthood (Gale et al. 2012). The faster growth rate of formula-fed infants relates to the composition of formula itself, which contains more protein than breast-milk (Sidnell & Greenstreet, 2009). The excessive amount of protein in some formula may be due to overcompensating for the lack of natural nutrients that are found in breast-milk. Breast-milk contains a naturally high content of amino acids, which could be the reason large amounts of extra protein are added to many formulas. Fat-free mass was the only significant difference in body composition between the two groups of infants, so fat mass is excluded from significant results of the study. Formula fed infants had higher fat-free mass than breastfed infants, which is another indicator that these infants consumed larger amount of nutrients at one time. Fat-free mass consists of protein, which attributes to the higher amount of protein in formula, possibly leading to faster weight gain in formula fed infants. This shows clear differences in the content of breast-milk and formula in terms of macronutrients and other bioactive factors (Gianni et al. 2014). Immunity differences in serum IgA were significant, with formula fed infants having higher amounts of serum IgA. Although having more IgA may seem beneficial, these levels were only measured in the first seven days of life. At six months, breast-fed infants showed significantly higher amounts of serum IgA, indicating that it may depend on how long the infant

was exposed to the mother's milk and diet (Cheng et al. 2012). These findings showed that serum IgM was not significantly different between breastfed and formula fed infants. If breastfed infants had higher levels of IgA, it may lead to less risk and occurrence of illnesses compared to formula fed infants. Breastfed infants may be less likely to catch disease and illness with higher levels of immunity.

Brain development in infants was not looked at extensively, but some differences were found. Breastfed infants had more white matter, higher visual acuity, larger head circumference, and larger gangliothalamic ovoid diameters compared to formula fed infants. The gangliothalamic ovoid covers the thalamus and basal ganglia in the brain. When small in diameter, it may cause disordered attachment and higher staving behavioral problems. The smaller diameter of the gangliothalamic ovoid in formula fed infants may possibly lead to higher chance of behavioral problems. No differences were found between infants who were exclusively breastfed and infants who were breast and bottle-fed, which could indicate that breast-milk may specifically influence how the gangliothalamic ovoid develops (Tawia, 2013). The higher amount of white matter in breastfed infants suggests that these infants' impulses may be transmitted more efficiently than formula fed infants. This suggests that breast-feeding may have more benefits in terms of brain development, which is crucial in the early stages of life. The development of brain structure is a physical difference between the two groups of infants, and may cause further cognitive and functional differences. Lower visual acuity in artificially fed infants may also appear later on in life and continue throughout life. It is suggested that formula feeding may have negative effects on depth perception and visual development in childhood (Tawia, 2013). If formula fed infants have this risk, they may be more likely to need glasses or other visual aids later in life. Although only one piece of literature discussed cow's milk allergy

comparison between breastfed and formula fed infants, the results seemed significant enough to include. Formula fed infants had a higher chance of developing cow's milk allergy than breastfed infants (Smith, 2012). While not all formula fed infants develop an allergy to cow's milk, they are at higher risk. This risk for formula fed infants means that breastfed infants have an advantage in terms of milk allergies. Infants who develop allergies early on have higher chances of developing other food allergies later in life (Smith, 2012). Breastfeeding does not pose this risk, making it more beneficial than formula/supplemental feeding methods.

Cognitive developmental differences were also found between breastfed and formula fed infants, favoring breast-milk benefits. Although IQ is an odd form of measurement among infants, breastfed infants appear to have higher IQ than formula-fed infants. IQ measurement in infants may follow into childhood and further academic success. Both verbal and nonverbal IQ is affected by feeding method; each month of formula feeding decreases these IQ values (Tawia, 2013). This suggests that lack of breast-milk may lower IQ in infants, potentially affecting IQ later on in life. This IQ difference may also reflect the difference in brain development between breastfed and artificially fed infants. It is suggested that breastfed infants have higher cognitive function and brain development than formula-fed infants. This study was important in this literature review because it suggested that effects of being artificially fed might continue throughout life in childhood, adolescence, and adulthood (Tawia, 2013). Breastfeeding may have beneficial effects on neurocognitive development in infancy. Memory skills are a component of cognitive development, and are suggested to be better among breastfed infants. If infants have higher memory capacity, then they may be more likely to have good memory capacity later on in life. Language differences between breastfed and formula fed infants also seemed significant enough to suggest that breastfed infants are at an advantage with language development.

Breastfed infants may begin to speak sooner than formula fed infants and may have larger vocabularies at a younger age. This finding also proposes that there are extensive differences in brain development between infants who are breastfed or artificially fed. Problem solving was another aspect of cognitive development that appeared to be different between breastfed and formula fed infants. The composition of breast-milk may be the reason that breastfed infants score higher in cognitive developmental tasks. Breast-milk contains fatty acids and DHA, which is much different than the composition of formula. Formula fed infants have significantly lower levels of these components that are in breast-milk since formula does not contain them (McCrorry & Murray, 2013).

Socio-emotional differences were found in the literature, suggesting that breastfed infants had higher levels of socio-emotional development compared to formula fed infants. Infant nutrition has an effect on socio-emotional development. Aside from the components of breast-milk, the process of breastfeeding may enhance an infant's socio-emotional development. Breastfeeding involves skin-to-skin contact between mother and infant and enhances interaction, possibly leading to closer attachment. Breastfeeding may lead to more positive relationships between mother and child, which is an important aspect of socio-emotional development (Metwally et al. 2016).

The review of the literature suggests that there may be numerous benefits of breastfeeding and those benefits do lead to developmental differences between breastfed and formula fed infants. The common theme within the literature is that breastfeeding is beneficial for infants and may result in developmental advancements. Awareness of the benefits of breastfeeding was the second most common influence on infant feeding decision in a qualitative

study. A majority of women choose to breastfeed based on the benefits that breast milk has compared to formula (Lewallen & Street, 2013).

Conclusion/Recommendation

The information found in this review of the literature is important for new or future mothers and health educators. It is crucial for mothers to receive proper education regarding feeding methods, in order to ensure that the right method for that person is chosen. Knowledge of feeding methods and their benefits has significant influence on one's decision to breastfeed or formula-feed. Although breastfeeding benefits were a significant influence on a mother's feeding method choice, it was not the only influence. Other factors that influenced mothers to choose breastfeeding or formula feeding were family background, career, bonding, and friends opinion. Some mothers choose to formula feed because of return to work or school, frustration or difficulty breastfeeding, and busy schedules (Lewallen & Street, 2013). It is important for people, mothers specifically, to understand the differences between breastfeeding and formula feeding. In this systematic review, evidence has shown that breastfeeding has major benefits and leads to developmental differences between breastfed and formula fed infants. Breastfeeding may lead to advantages in physical, cognitive, and socio-emotional development in infancy. The results found in reviewing the literature may lead to more education and knowledge about feeding methods. Nutrition is a major factor in the health of human beings and begins from birth. Providing an infant with adequate and proper nutrition leads to positive development throughout infancy and into toddlerhood and childhood. The information found in the literature may lead to better feeding method choices and healthier nutrition for infants. Feeding methodology is a modifiable health behavior, meaning a woman can change whether she breastfeeds or formula feeds her baby. Healthcare workers can use evidence and research from the literature review to

teach mothers about feeding methods, which may then influence or modify this health behavior.

Further research would be beneficial to determine more extensive and specific differences between breastfed and formula fed infants. It should be recommended to include older age groups in future studies on the subject of infant feeding method effects on development. Future studies may specify one type of development to research, in order to better focus the developmental differences into one category. It may also be important to follow some of the infants in past studies into childhood or adolescence to determine whether the effects continued throughout their lives.

Appendix A

Citation Author(s)/ Year	Design	Theoretical Foundations	Target Population, Sample Size, Location	Type Intervention	Outcomes/Aims	Results	Limitations	Developmental Differences and BF vs. Formula Fed Infants	Nursing Implications/Gaps
Cai et al. (2015)	Prospective cohort study – Neurocognitive testing on memory, attention tasks, and Bayley Scales of Infant and Toddler Development	N/A	408 healthy children 6 months, 18 months, 24 months in Singapore of Chinese, Malay, and Indian background	Interview with feeding practice questionnaires, neurocognitive assessments (cognitive tasks, behavioral observation, eye tracking, electrophysiology)	Assess/determine the relationship between infant feeding and neurocognitive development in Asian infants 6 months, 18 months, and 24 months	Significant differences were found in 4/15 of the tests – infants with higher breastfeeding exposure had better memory at 6 months of age, effects were not seen at 18 months, at 24 months infants who were breastfed were more likely to show sequential memory, and toddlers who were breastfed contact had higher scores in receptive and expressive language. There are small, significant benefits of breastfeeding in memory and language.	There is lack of specificity, so the degree that the associations found have an affect on development is unknown. Outcomes were limited to language and memory domains.	There is an uncertain, but significant benefit in the effects of breastfeeding on infant memory and language development. Breastfeeding was associated with higher performance in 4/15 cognitive measurements. Infants in the high-breastfeeding group at age 6 months scored higher in relational and retrieval memory tasks. There was no difference in habituation. There were associations between duration of breastfeeding and higher cognitive scores on the BSID-III. 3 and 6 month old infants showed improvement in motor skills if breastfed.	This source shows that breastfeeding can be more beneficial than not, which indicated the need for the nurse to educate patients about feeding options and breastfeeding benefits.
Cheng et al. (2012)	Quantitative study	N/A	220 infants with normal birth weight, born after uncomplicated pregnancies, who delivered at Taipei Veterans General Hospital, 131 boys and 89 girls, 96 of	Capillary blood samples taken by heel sticks within the first week of life and used to measure serum IgM and IgA	To determine if there is an effect of breast milk versus formula on the development of humoral immunity of infants in the first week of life	There were significantly higher amounts of serum IgA in the formula fed group than the mixed fed group and breast-fed group at days five and six. IgA	It was not recorded how many times each infant had been breastfed or fed in general, in their first week of life, infants were only studied from one hospital, the study only	Formula fed infants have significantly higher levels of serum IgA in the first week of life than breast-fed infants, potentially leading to stronger humoral immunity	Nurses are responsible for teaching patients about feeding options for their infants, so this could be an important point to teach to parents who are having difficulty breastfeeding or are choosing to formula feed. The nurse educates the patient about what is in formula and why it is okay for infants to be fed

			which were exclusively breastfed, 27 formula fed, and 97 mixed-fed with both			decreased significantly in the breast-fed group but not in the other groups. Serum IgM increased significantly in all of the groups	measured the serum levels in the first week of life, there was not an equal ratio of girls to boys studied		with formula. The nurse could also teach about formula supplementation.
Gale et al. (2012)	Systematic review and meta-analysis	N/A	15 studies with over 1,000 infants reporting outcomes of healthy, term infants looking at fat mass, fat-free mass, and percentage of fat mass. 11 studies were included in the meta-analysis	Literature search, analysis, and review of longitudinal and cross-sectional studies	Determine if there is an identified effect of infant feeding on body composition in the preweaning and postweaning period in relation to breastfeeding and formula feeding	Fat free mass was higher at 3-4 mo., 8-9 mo., and 12 months in formula fed infants than in breastfed infants. At 12 mo. fat mass was higher in formula fed infants than breast fed infants. Formula feeding is associated with change in body composition during infancy. No significant mean differences	The analysis was based on studies that used different methods to assess body composition of infants, so they may not be comparable to each other. Only 2 studies had sex-specific results, sufficient studies were only available for a minimal time; there is rapid tissue maturation in childhood, which affects the body composition. Some studies were bias about breastfeeding and contamination bias occurred. The definition of the two groups varied extensively and there were no criteria for who was involved in the studies for exclusive breastfeeding (contamination bias).	Formula fed infants weigh about 400-600 g more than breastfed infants, formula fed infants have higher fat-free mass in the first year of life, formula fed infants had lower fat mass than breastfed infants at 3-4 and 6 months. There are key differences in macronutrient content and bioactive factors in breast milk and formula, formula has more protein than breast milk. Breast milk has higher number of bioactive hormones, proteins, cytokines, and growth factors than formula. Infant formula is not fully supporting the normal development of adipose tissue.	Teaching about the components of both breast milk and formula is important in order to educate patients about the feeding options. It is also important to recognize feeding method as a possible cause for differences in development, especially if infants appear to be overweight or underweight, or lacking certain nutrients.
Gianni et al. (2014)	Longitudinal observational study		158 healthy term, Caucasian infants weighing more than 2500 g and at least 3 weeks in age (72 exclusively breastfed, 86 exclusively formula-fed)	Statistical analysis	Determine if exclusively formula-fed infants have a higher fat-free mass compared to infants who are exclusively breast-fed	No significant difference in anthropometrics parameters between groups. Mean fat mass and fat-free mass were not different between the two groups. There was higher fat-free	Only looked at fat mass and fat-free mass values.	Formula-fed infants have higher intake of protein than breast-fed infants. Breast-fed infants may have higher adiposity in the first months of life because of leptin levels in breast milk. Infants who are formula fed	This study shows the importance of monitoring and assessing weight gain in infants, especially in infants who are exclusively formula fed. It is important for the nurse to monitor these values in order to recognize the effect on metabolic system later in life.

						mass change in infants who were exclusively formula fed at 4 months. Exclusively formula-fed female infants were the only group to have higher fat-free mass content at 4 months.		exclusively have higher risk of obesity later in life and have different body composition development.	
Lewallen et al. (2013)	Qualitative descriptive study	Theory of Culture Care Diversity and Universality	3 locations in North Carolina at prenatal classes, 119 white women and 67 African American women (186 total)	Survey response to this question: The word culture means beliefs and traditions passed down by your family and friends. How has culture affected how you plan to feed your baby?	To examine how culture influences the decision to breastfeed in African American and white women	Family was the most prevalent factor in the decision to breastfeed, with known benefits of breastfeeding being the next biggest influence, followed by friends, then personal choice	The participants completed the survey independently without guidance, women were attending prenatal classes so they could have already been educated about the benefits of breastfeeding, many of the women were with their family members while answering the questions, the sample contained twice as many whites as African Americans, all women were from the same state	Breastfeeding has more benefits than formula feeding, which is a reason women choose to breastfeed	Education is crucial in order to influence one's decision to breastfeed, especially since it was the second most influential factor in the decision process. It is the nurse's job to educate the patient on her choices regarding infant feeding. This source is important to nursing because it shows how women come to their decision and how nurse's can teach more to increase the rate of breastfeeding decisions.
Metwally et al. (2016)	Cross-sectional comparative study	N/A	322 breast fed, 240 bottle fed and 93 mixed fed infants, from 6–24 months enrolled at Well–Baby Clinic of the National Research Centre and from pediatric outpatient facilities in urban Cairo	Bayley scale of Infant and Toddler Development was used to assess socio-emotional development we well as detailed mother and baby history and CBC results of 193 infants. Questionnaires were used as well.	To determine predictors, specifically in this case infant feeding practices, of socio-emotional development in Egyptian infants	Feeding practices are the most important nutritional factors in the first 6 months of life. Risk for below average socio-emotional development was about 2.5 times in formula-fed infants than breast-fed infants. Both breast-fed exclusive and	This study was done in Egypt, so results could be different than if it were done in the US. This study used infants up to age 24 months, which is outside the inclusion in my study, which could affect the results. Causality cannot be inferred since this is a cross-sectional study. Questionnaires were used, which can	Formula-fed infants had 2.5 times higher risk of below the average socio-emotional composite score on the Bayley Scale than did breast-fed infants. The physical act of breastfeeding can enhance interaction between mother and infant, which may lead to higher cognitive and socio-emotional development	With the results of this study, the nurse and other health professionals can teach women benefits of breastfeeding on socio-emotional development. Feeding method does not just affect cognitive development, but emotional and social development as well. This may be more important to some mothers, especially when it comes to bonding with their infant. If breastfeeding has more developmental benefits in this category, mothers should be informed if that might have an effect on their feeding method decision.

						mixed fed infants scored higher in socio-emotional development than bottle/formula-fed infants. There were no statistical significant differences between the exclusively breast-fed group and the mixed fed group.	indicate bias in the research.	compared to formula-fed infants. Any amount of breastfeeding during infancy is associated with infant development.	
McCroy et al. (2012)	Quantitative large cohort study	N/A	9 month old Irish infants	Household interview, binary logistic regression	To determine if infants who were never breastfed have reached fewer developmental milestones than those who were partially or exclusively breastfed	Breastfeeding held a positive effect on gross motor; fine motor, problem-solving, and personal-social skills, but not communication. There was very little evidence showing that exclusive breastfeeding had more of an effect than partial breastfeeding	Only nine month old infants were studied, but there may be a specific/critical time where breast-milk has an effect on brain development, other factors may have contaminated the effect of breastfeeding on cognitive development, used a 10-month age interval score for infants even though they were 9 months, breastfeeding duration was used as a proxy for dose, the assessment of developmental relied on parent's report	Breastfeeding is associated with neuro-development, especially in motor outcomes, little evidence of dose-related advantages	Patient education about why breastfeeding is beneficial and a better choice than formula feeding. This source is important because it serves as evidence that breastfeeding is more beneficial than not breastfeeding. It is also important to teach patients that any amount of breastfeeding can be beneficial, which this article shows. Even partial breastfeeding is better than not at all when it comes to infant development.
Sidnell et al. (2009)	Literature review/bulletin	N/A	Breast-fed and formula-fed infants in the UK	Survey/literature review	Compare infant nutrition amongst breast-fed and formula-fed infants regarding protein and growth rate	Formula-fed infants gain weight faster than breastfed infants in the first year of life possibly due to protein quantity, breastfed infants gain weight slower than formula-fed infants, it is not certain why formula fed	This review was not very specific or thorough, but did have some good information. It was more of a bulletin with information than a study itself.	Breastfeeding is the best source of nutrition for infants and formula should try to mimic breast milk as much as possible as well as growth outcomes	Educating patients about the composition of both breast milk and formula is essential to help them make their decision regarding infant feeding.

						infants gain more weight, reducing protein concentration in formula is a major objective in order to mimic the composition of breast milk. Breast milk provides 9-12g/l of protein and formula provides 13-16 g/l protein. Breast milk has high tryptophan levels, high alpha-lactalbumin which increases cysteine which serves to function the antioxidant system			
Smith (2012)	Literature review/meta-analysis	N/A	Infants in the first few weeks of life/studies that investigate the effects of supplementing breastfed infants with cow's milk formula/breast-fed infants	Review of the literature and meta-analysis	To explore the risks of supplementation in infants who are breastfed with cow's milk formula during the first few weeks of life, making them at risk for cow's milk allergy. The aim is to show the benefits of breastfeeding	Three of the studies provided enough information to create a risk ratio with breastfed infants supplemented with cow's milk formula having risk ratio of 1.71 of developing allergy to cow's milk. Giving cow's milk formula to infants increases likelihood of reduction in milk supply and reduces the duration of breastfeeding	There were no limitations on year of publication of the articles used for this review, which means information could be dated. The studied relied on the mother's recollection of infant feeding, mother's who had infants who developed cow's milk allergy are more likely to remember the feeding history	Infants who are supplemented with cow's milk formula have higher chance of developing cow's milk allergy than infants who are not supplemented with formula	This article is important because it gives nurses' information to teach patients about infant feeding. The nurse should teach women about formula supplementation and the different options for supplements as well as breastfeeding. It is important for the nurse to teach that cow's milk formula may reduce their milk supply and breastfeeding duration, increasing their child's chance of developing an allergy to cow's milk. It is important to assess family history of allergies to teach mothers to be even more cautious with their choice of supplementation. It shows that supplementing in general poses a risk for infants, which supports the idea that breastfeeding, is more beneficial than artificial feeding.

Tawia (2013)	Systematic literature review/meta-analysis	N/A	Breastfed infants and artificially fed infants, children, and adolescents who were breast-fed or artificially fed	Review of the literature and meta-analysis	To explore evidence that breastfeeding has an effect on cognitive development, looking at the type of brain development, educational, and social development between breast-fed and artificially fed infants. The aim is to determine if there are IQ differences between the two groups.	There were consequences when the duration and exclusivity of breastfeeding were shortened. These consequences or negative effects were persistent throughout childhood and into adulthood. No or lack of breastfeeding leads to reduced brain development, alteration in brain structure development, reduction in white matter, poor visual acuity, reduced IQ, or cognitive function, weakened performance academically, and decreased social mobility	This source was not a study in itself, but a review of other literature, it does not have an abstract, a wide variation of ages were looked at in the literature despite the inclusion criteria of my review, the studies used were not all from the same country	Infants who were breast-fed have higher chances of reduced development of white matter and brain structure development, lessened visual acuity, lower IQ, and lower social mobility	The nurse is responsible for providing education about feeding options to mothers. The nurse should explain the benefits of breastfeeding that are in this review. Teaching these benefits could lead to more prevalence of exclusively breast-fed infants.
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Appendix B

Cai, S., Pang, W., Low, Y., Sim, L., Sam, S., Bruntraeger, M., . . . Rifkin-Graboi, A.

(2015). Infant feeding effects on early neurocognitive development in Asian children. *The American journal of Clinical Nutrition*, 326-336.

<http://dx.doi.org/10.3945/ajcn.114.095414>

This is a prospective cohort study that used neuro-cognitive testing on memory, attention, and Bayley Scales of Infant and Toddler Development. The study was conducted in Singapore and consisted of 408 Asian children ages six, eighteen, and twenty-four months old. Neuro-cognitive assessments were made, but interview and questionnaire was also used to assess development. It was found that infants with higher breastfeeding exposure had better-developed memory at six months and higher scores in receptive language. This study is important for this literature review to show the relationship between feeding method and language and memory development in infants. It also indicates the need for nurses to educate patients about feeding options and these benefits.

Cheng, M., Huang, C., Yang, L., Lin, Y., Peng, H., Chang, C., . . . Wu, T. (2012).

Development of serum IgA and IgM levels in breast-fed and formula-fed infants during the first week of life. *Early Human Development*, 88(9), 743-745.

[doi:10.1016/j.earlhumdev.2012.03.005](https://doi.org/10.1016/j.earlhumdev.2012.03.005)

This is a quantitative study that explores the effects of breast-feeding and formula feeding on serum IgA and IgM in the first week of life in infants. 220 infants were used in the study and underwent heel-sticks to obtain serum IgA and IgM levels. Breast-fed, formula fed, and mixed fed infants were compared to each other to determine whether either antibody was more prevalent in one group over another. Formula fed infants had higher serum IgA levels than the mixed group and breast-fed infants had higher IgM levels than both groups. This study is relevant because it discusses the physical serum antibody differences between these two groups of infants. With higher levels of antibodies, breast-fed infants may be at an advantage developmentally as well.

Gale, C., Logan, K., Santhakumaran, S., Parkinson, J., Hyde, M., & Modi, N. (2012).

Effect of breastfeeding compared with formula feeding on infant body

composition: a systematic review and meta-analysis. *The American Journal of Clinical Nutrition* , 656-669. doi:10.4016/39335.01

This is a systematic review and meta-analysis that looks at body compositional differences between breastfed and formula fed infants. It included fifteen studies with eleven included in the analysis. One thousand healthy term infants were involved in these studies. This review specifically analyzed weight, fat free mass, and fat mass. Formula fed infants showed higher fat free mass at three to four months, six to eight months, and twelve months than breastfed infants. Macronutrient content and composition of breast milk and formula were compared to evaluate the amount of factors infants in both groups were getting from feeding method. This review is important in this literature review because it discusses both the content of methods in terms of nutrients and those effects on infant body composition.

Gianni, M. L., Roggero, P., Morlacchi, L., Garavaglia, E., Piemontese, P., & Mosca, F.

(2014). Formula-fed infants have significantly higher fat-free mass content in their bodies than breastfed babies. *Acta Paediatrica*, 277-281.

doi:10.1111/apa.12643

This is a longitudinal observational study of 158 healthy term Caucasian infants. 72 of the infants included were breastfed exclusively and 86 were exclusively formula fed. This study used statistical analysis to determine if exclusively formula fed infants have higher fat-free mass compared to exclusively breastfed infants. Formula fed infants were found to have significantly higher fat-free mass only at four months of age. This study explored the background of these findings in terms of content of the two feeding methods. It determined that formula fed infants take in higher amounts of protein from formula, causing the increased fat-free mass and faster weight gain. This study shows the importance of monitoring and assessing weight gain among infants and why the weight differs between the two groups. It is important to this review because it determined clear differences between formula fed and breastfed infants with explanation as to why that is.

McCrary, C., & Murray, A. (2013). The Effect of Breastfeeding on Neuro-Development

in Infancy. *Maternity Child Health Journal*, 17, 1680-1688. doi:10.1007/s10995-012-1182-9

This is a quantitative study that looks at if breastfeeding is associated with advances in neuro-development in 9-month-old Irish infants. The study made the hypothesis that if there is a significant benefit to breast-milk, infants who were not breast-fed will not have reached as many milestones developmentally than infants who are breastfed. Household interviews were used to gather information about practices and development progress. It was found that infants who were breastfed had 1.2 times the chance of reaching the appropriate milestones developmentally for their age in problem solving. Motor skills and gross motor skill were more advanced in infants who were breastfed. The study also examined duration of breast-feeding, but did not find as much evidence relating to that. It was concluded that breastfeeding for any duration will lead to more developmental advances. It suggested that even some breastfeeding is better than none. This is a useful source, especially because it relates directly to my topic about the developmental differences between breast-fed and formula fed infants. There are significant differences in development between the two, which support my research question. It comes from the *Maternity Child Health Journal*, so it is a reliable source as well. It was helpful because it gave specific examples and evidence of how breast-fed infants achieve milestones more efficiently and faster than those who are not breast-fed.

Metwally, A. M., Din, E. M., Shehata, M. A., Shaalan, A., Etreby, L. A., Kandeel, W. A., . . . Rabah, T. M. (2016). Early Life Predictors of Socio-Emotional Development in a Sample of Egyptian Infants. *Plos One*, 11(7).

doi:10.1371/journal.pone.0158086

This was a cross-sectional comparative study consisting of 322 breastfed infants, 240 bottle-fed infants, and 93 mixed-fed infants between the ages of six and twenty-four months. The study took place in Cairo, Egypt. The Bayley Scale of Infant and Toddler Development was used to assess infant's socio-emotional development. Detailed history from the mother and questionnaires were also used to assess. The aim of this study was to determine what effects feeding methods have on infant socio-emotional development. It was found that formula fed infants had 2.5 times below the average socio-emotional development when compared to breastfed infants. This study was important in this research because it explained and used evidence to support how this could be true. It discussed the attachment and bonding that breastfeeding brings between mothers and infants, which ultimately increases their socio-emotional development to higher levels than infants who are bottle-fed. This study was important to include in order to include the emotional and social levels of development in this research among infants.

Sidnell, A., & Greenstreet, E. (2009). Infant nutrition - protein and its influence on

growth rate. *Nutrition Bulletin*, 34(4), 395-400. doi:10.1111/j.1467-3010.2009.01785.x

This literature review or bulletin studied breastfed and formula fed infants in the UK by survey and reviewing literature. This review discussed the difference between infant nutrition regarding protein and growth rate. It was found that formula fed infants gain weight at a faster rate than breastfed infants in the first year of life. This was thought to be due to protein quantity in formula. This review also discussed the possibility of getting rid of the extra protein content in formula, to decrease the later risk of obesity in formula fed infants. Although this review was not as specific as others, it provided great recommendations as far as formula content. Educating people about feeding methods is crucial to infant nutrition, so this review was important to include in this research.

Smith, H. A. (2012). Formula supplementation and the risk of cow's milk allergy. *Br J Midwifery British Journal of Midwifery*, 20(5), 345-350.

doi:10.12968/bjom.2012.20.5.345

This source is a systematic review of literature regarding research on cow's milk allergy and how formula supplementation may increase risk of cow's milk allergy. It explains the risks that supplementing with cow's milk has on breastfeeding, such as decrease milk supply and reduced duration of breastfeeding. It also increases chance of cow's milk allergy, which can lead to further allergies. The article also discusses benefits of breastfeeding in itself. The study compared breastfed infants that were given cow's milk formula as supplements with infants who were exclusively breastfed without supplementation. This is important and relevant to my research to show how not breastfeeding or using breast milk can have a negative impact on child development, as an allergy in this case.

Street, D. J., & Lewallen, L. P. (2013). The Influence of Culture on Breast-Feeding Decisions by African American and White Women. *The Journal of Perinatal & Neonatal Nursing*, 27(1), 43-51. doi:10.1097/jpn.0b013e31827e57e7

This is a qualitative research study that examines how culture affects African American and white women's decision to breast-feed. Women were given a questionnaire and asked how they came to the decision to either breast or bottle-feed and why. Factors that affected decisions included family and friend influence, knowledge of the benefits of breastfeeding, and personal choice. It was found that race might not necessarily be the determining factor relating to culture that influences the decision, but it goes along with family influence. Many women listed more than one factor that influenced her decision,

so there were more responses than the amount of participants. The most common factor of influence was family, second was known benefits of breastfeeding. The majority of responses indicated that culture was not an influence in their decision. This was a useful source, coming from the Journal of Perinatal and Neonatal Nursing. It is a reliable source with the goal to determine whether the choice to breast-feed is influenced by culture of African American and white women. This source was helpful and may help shape my argument/review. It touches on the benefits of breast-feeding and other reasons why women choose breast-feeding over formula feeding.

Tawia, S. (2013). Breastfeeding, brain structure and function, cognitive development and educational attainment. *Breastfeeding Review*, 21(3), 15-20. Retrieved March 20, 2016.

This source is a review of literature on cognitive development between breast-fed and artificially fed infants. It also directly looks at IQ. From a literature review on different studies, the author came to the conclusion that not being breastfed results in immature EEG activity, slower visual acuity, reduced social mobility, reduced brain development, lower amounts of white matter development in the brain, lower academic performance and educational attainment. This source is not a study in itself, so it may not be as reliable as the others. Although, it is a review of literature, which is what I am going to be doing with my research. For that reason, I think that this source will be helpful to guide me through a literature review, and I can pull some of her findings from her review.