The Benefits of Breastfeeding

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Abstract

Breastfeeding research is plentiful, and the majority of the literature shows that breast milk is the superior form of infant nutrition except in the rare circumstances of infant metabolic disorders, maternal drug use, or positive HIV status. In comparison to formula, breast milk provides improved cognition, development, behavior, bonding, nutrition, digestion, immunity, and long-term health with fewer diseases and conditions in infants. Mothers are benefited by breastfeeding through bonding, faster weight loss, and reduction in certain cancers and conditions. Breast milk contains the proper amount of carbohydrates, fats, proteins, vitamins, and minerals, and is also specialized for each infant and developmental stage. While formula is a viable alternative to breast milk, the same benefits cannot be achieved.

The Benefits of Breastfeeding

Breast milk is a unique substance specifically designed to facilitate the growth and development of an infant. Furthermore, it is even specialized for each individual baby, and its composition changes as the infant grows. Breast milk contains lactose, which is a disaccharide composed of a galactose and glucose molecule, that provides energy for the growing baby. Also, whey proteins in breast milk are easier to digest than the proteins found in formula. Many essential amino acids and fatty acids that are indispensable for the growth and function of healthy brain and nervous tissue are not found in formula. Breast milk also provides a more balanced amount of vitamins and minerals compared to formula.

Breast milk is an incredible substance designed to sustain infants during their vital first months to years of life. According to the *Indian Journal of Pediatrics*, it has been estimated that exclusive breastfeeding can reduce mortality in children younger than five years old by 13%, which would prevent 1.3 million deaths, making breastfeeding the most effective and practical means to decrease infant mortality (Mathur & Dhingra, 2014). Moreover, breastfeeding leads to numerous benefits for infants such as: increased cognitive development and intelligence quotient (IQ), fewer behavioral problems, healthier nutrition and digestion, greater tooth and bone strength, decreased childhood obesity, and encouraged bonding. Breast milk also enhances the immune system and results in less childhood illnesses and cancers, and a lowered risk of sudden infant death syndrome (SIDS). While breastfeeding is primarily for the infant, there are significant benefits for the mother as well. For mothers, breastfeeding reduces the incidence of postpartum hemorrhage and postpartum depression, lowers the risk of breast and ovarian cancers, lowers the risk of diabetes and cardiovascular disease, promotes weight loss, delays the return of ovulation and menstruation, decreases osteoporosis, and increases bonding

(Mansbacher, 2012). The vast majority of breastfeeding literature indicates that breast milk is better than formula in almost all cases, except for infant metabolic disorders, maternal drug use, and maternal HIV (Evenhouse & Reilly, 2005). In the October, 2011 issue of *Breastfeeding Medicine*, Tonse Raju said:

> An infant suckling at his or her mother's breast is not simply receiving a meal, but is intensely engaging in a dynamic, bidirectional, biological dialogue. It is a process in which physical, biochemical, hormonal, and psychosocial exchange takes place, designed for the transfer of much needed nutrients, as well as building a lasting psychosocial bond between the mother and her infant. (p. 257)

Composition

The American Academy of Pediatrics reports that breastfeeding is best for all babies, except in rare circumstances, as breast milk is biochemically superior to formula. Breast milk and most formulas consist of 20 to 30 calories per ounce, which is made up of 45 to 55% carbohydrates, 35 to 45% fats, and 9 to 15% protein (Mayo Clinic, 2009). Exclusive breastfeeding or formula-feeding should be the infant's sole source of nutrition for the first six months of life. Breast milk provides a multitude of nutrients that cannot be found in the first foods that are given to babies. At the age of six months, solid food is introduced into the baby's diet, but breast milk or formula should continue to be a component of the infant's nutrition until the child reaches one year of age (Davidson, London & Ladewig, 2011). According to the most recent surveys taken by the Center for Disease Control in 2014, 72.9% of infants had been breastfed at least once, 49.4% were breastfed at 6 months, and 26.7% were breastfed at 12 months; however, only 40.3% were breastfed exclusively at 3 months, and only 18.8% were breastfed exclusively at 6 months (CDC Breastfeeding Report Card, 2014).

Initially, formula-fed babies gain weight faster than breastfed babies due to larger volumes of fluid, while the milk supply is established in breastfeeding mothers. However, once breastfeeding has been established, breastfed babies generally weigh more than formula-fed babies during the first three to four months of life. After this point, formula-fed infants generally weigh more, while breastfed infants tend to have a leaner build. This weight gain pattern contributes to the link between formula-feeding and obesity (Davidson et al., 2011).

Fats

Energy is stored in the body in the form of fat. Fat serves a multitude of functions: insulation, temperature maintenance, vitamin absorption and storage, organ protection, nerve myelination, and hormone production. Triglycerides compose 98% of the fat in breast milk. Omega-3, omega-6, and other fatty acids within breast milk are necessary for brain development. Fatty acids make up about 50 to 60% of the weight of dry adult brain matter (Mortensen & Tawia, 2013). Oleic acid in addition to long-chain polyunsaturated fatty acids (LCPUFAs), such as docosahexaenoic acid (DHA) and arachidonic acid (ARA), compose a portion of the synaptic membranes and are necessary for the myelination of nerves as well as the spinal cord. Other polyunsaturated fatty acids, such as alpha linolenic acid and linoleic acid, are also essential for the developing brain and retina (Davidson et al., 2011). Furthermore, in the developing brains of infants, LCPUFAs are essential components of cell membranes and are necessary for the construction of new tissues, such as neurons. Significant differences in visual acuity were found in infants fed DHA at two and four months of age (Callen & Pinelli, 2005). The proper myelination from the fatty acids in breast milk results in improved cognition, vision, and behavior.

Additionally, a small amount of cholesterol is found in breast milk, which is thought to increase enzyme production in order to metabolize cholesterol more efficiently. This function may have a long-term protective outcome on the cardiovascular system by decreasing cholesterol's harmful effects. Despite the potential benefits, cholesterol is not included in formula. Breast milk is also better for the cardiovascular system as it contains unsaturated fats, while formula contains saturated fats. Saturated fats carry cholesterol through the bloodstream, and the increased circulating fats can promote plaque formation, atherosclerosis, and cardiovascular disease. On the other hand, unsaturated fats remove circulating fats from the blood and transport them to the liver, which reduces the risk of cardiovascular disease (Davidson et al., 2011).

Breast milk is also preferred to formula since breast milk is specialized to meet the needs of the individual child. This specialization is specifically important in premature infants who may be lacking in areas due to a shorter duration in utero. An example of this can be seen with the concentrations of ARA and DHA found in the breast milk of mothers with premature infants and full-term infants. In the third trimester of pregnancy, ARA and DHA are transferred continuously through the placenta to the developing baby. Because a premature infant does not receive the optimal amount due to an early birth, there are higher concentrations of these LCPUFAs found in the breast milk for premature infants compared to that of a full-term infant (Davidson et al., 2011).

While the fat composition in formula is similar to breast milk, formula cannot completely replicate all of the beneficial fats in breast milk. Since 2002, ARA and DHA have been added to formula, but 167 other fatty acids are also found in breast milk, and these are nonexistent in formula. The function of the lacking fatty acids may be currently unknown; however, it is

theorized that the fatty acids likely have an important benefit and may enhance cognition similarly to ARA and DHA (Cloherty, Eichenwald, & Stark, 2008).

Carbohydrates

The main component of carbohydrates in breast milk is lactose which provides energy for the cells of the body. In comparison to other forms of milk, breast milk has a higher level of lactose. Lactose breaks down into galactose and glucose. Galactose is essential in the making of cerebral galactolipids, which promote the development of the brain and central nervous system. In addition to this, lactose breaks down to glucose, which is the sole source of energy for the brain. Lactose also improves the absorption of zinc, magnesium, and calcium. Other carbohydrates found in breast milk include glucosamines and oligosaccharides. Glucosamines are essential for the proper formation and fortification of connective tissues such as ligaments and tendons. Digestion is enhanced by breastfeeding through oligosaccharides, which encourage the growth of healthy bacteria. One such bacteria is *Lactobacillus bifidus*, which is a probiotic that causes acidity in the intestines, deterring the colonization of pathogenic bacteria as well as viruses (Riordan & Wambach, 2010). In comparison to breast milk, most formulas, including Similac and Enfamil, only contain lactose carbohydrates. Nestlé Good Start brand contains lactose as well as maltodextrin, which is derived from corn and is similar to table sugar (Davidson et al., 2011).

Protein

Protein has a variety of functions in both infants and adults. Protein makes up the structure of muscles and organs, and it is involved in nearly all metabolic processes in the body. Protein is vital to growth, development, cellular communication, immune function, and energy (Davidson et al., 2011). The amount of protein in breast milk is high enough to support the

needs of the developing baby, but it is low enough to be gentle on the immature kidneys and prevent an excessive load of nitrogen wastes (Grosvenor, 2012). The two main forms of milk protein are whey protein and casein, both of which are contained in breast milk and formula. The primary source of protein in breast milk is whey protein. Whey protein contains lactalbumin that is easily digested since it forms soft curds that can be broken down rapidly. The rapid break-down creates the need for breastfeeding infants to feed more often, but the benefit is that these babies rarely become constipated. In contrast to whey protein, casein forms curds that are more difficult to digest (Davidson et al., 2011).

The protein ratio in breast milk alters over time to satisfy the needs of the developing infant. The whey to casein ratio in early lactation is 90:10, in mature breast milk the ratio is 60:40, and throughout late lactation the ratio is 50:50 (Riordan & Wambach, 2010). Formula does not have this specialized benefit. The whey to casein ratio in Enfamil is 60:40, and the ratio in Similac is 48:52. These ratios contribute to a higher rate of constipation observed in formula-fed infants and may contribute to other digestive complications (Davidson et al., 2011).

Whey protein also has immune benefits. Lactoperoxidases aid in digestion, but also assist in destroying bacteria and viruses. Lactalbumin, lysozymes, lactoferrin, lactoglobulin and immunoglobulins are the five major categories of whey protein in breast milk. These proteins have more of a hormonal and immune function rather than nutritive (Davidson et al., 2011). Whey protein is rich in lactalbumin, which contains ample amounts of tryptophan. Tryptophan is a precursor of serotonin which is a neurotransmitter with numerous functions throughout the body, especially the brain (Mathur & Dhingra, 2014). Lysozymes promote the growth of healthy bacteria such as lactobacilli in the gut, while also destroying certain pathogens through enzymatic action. Lactoferrin is unique to breast milk, and it too prevents gastrointestinal

infections through its effects on iron and zinc. In addition to promoting iron and zinc absorption, lactoferrin attaches to free iron in the intestines, thus decreasing the amount of iron accessible to iron-dependent enteric pathogens (Davidson et al., 2011).

Antibodies are plentiful in breast milk, especially immunoglobulin A, as they are formed in the mother due to contact with antigens within the environment. This protein is not found in formula. When immunoglobulin A is passed to the infant through breastfeeding, the infant is protected from environmental pathogens through passive immunity. Immunoglobulin A possesses antibacterial, antiviral, and antigenic-inhibiting properties. This immunoglobulin also protects against allergies as it inhibits large protein molecules from permeating the wall of the small intestine. The immune benefits of breast milk cannot be replicated by formula, and formula-fed infants have higher rates of gastrointestinal and respiratory infections (Davidson et al., 2011).

Vitamins

With the exception of vitamin D, an infant's vitamin intake is usually adequate whether breastfeeding or bottle-feeding. Vitamin D is a fat-soluble vitamin that aids in the mineralization of bones and teeth, and is relatively low in breast milk. In the past, infants received sufficient amounts of vitamin D through sunlight; however, presently infants are receiving less outdoor exposure which can lead to a deficiency resulting in conditions such as rickets (Davidson et al., 2011). Because of this, the American Academy of Pediatrics suggests that infants and children should receive vitamin D supplements starting during the first few days after the infant is born regardless of whether or not the baby is breastfeeding or bottle-feeding (AAP Clinical Report, 2008).

The amount of vitamins may vary in breast milk depending on the needs of the infant, and the levels change throughout the time of lactation in order to meet the specific developmental requirements. Vitamin E is an antioxidant that is present in higher quantities in the colostrum for premature babies. Higher levels benefit the preterm infants as the antioxidant qualities can protect these babies from the detrimental side effects of oxygen toxicity such as pulmonary and retinal damage (Davidson et al., 2011).

Minerals

Minerals have numerous functions for infants and adults. Both breast milk and formula contain sufficient minerals to sustain the developing baby, however, breast milk contains more suitable quantities of minerals in comparison to formula. Mineral levels are not impacted by the mother's diet, age, or parity. The minerals included in formula have a lower bioavailability than the ones in breast milk, thus leading to the higher amounts in formula. An example of this is seen with iron. Breast milk has 0.5 to 1 mg of iron in each liter, while 12 mg of iron is in each liter of formula. The difference in concentration is due to the fact that 50% to 80% of the iron in breast milk can be absorbed, while only 12% of the iron in formula can be absorbed. Additional iron that has not been absorbed is undesirable, as it may encourage the growth of pathogenic enteric bacteria (Davidson et al., 2011).

Nutritional Benefits

Breast milk is preferred for infants as it is "species specific" and it is specialized for each individual child (Lawrence & Lawrence, 2005). There are countless components in breast milk that have not been able to be replicated in formula, and the full composition of breast milk has yet to be fully identified and studied. There are over 200 known unique elements in breast milk, and more continue to be discovered (Davidson et al., 2011).

Preterm and Low Birth Weight Infants

Due to the unique and specialized qualities of breast milk, preterm and low birth weight (LBW) infants have significantly improved outcomes if they are breastfed. A 2.2 pound premature infant will be released from the hospital an average of 15 days earlier if one third of the infant's diet is breast milk, and outcomes continue to improve as the baby receives more breast milk (Godfrey & Lawrence, 2010). Breast milk from mothers who have delivered preterm infants has higher levels of proteins, minerals, immunoglobulins, lactoferrin, and lysozymes to meet the greater needs of the baby (Mathur & Dhingra, 2014). Breastfeeding is more easily tolerated by preterm infants, as it allows greater transcutaneous oxygen pressures and better body temperature maintenance compared to bottle-feeding (Davidson et al., 2011). Breast milk is also more advantageous for preterm and LBW infants as it promotes greater absorption of fats due to the fatty acid pattern of the triglyceride molecules as well as the effects of the bile-salt stimulated lipase found in breast milk. Lipase breaks down with heat, which allows for easy digestion along with increased fat absorption for the underweight infants. Another benefit is breast milk's role in the maturation of the premature infant's small intestine through elements such as somatomedin-C, insulin, thyroxine, taurine, glutamine, amino sugars, epidermal growth factor, and nerve growth factor (Callen & Pinelli, 2005).

Digestion

Breast milk contains enzymes such as lipoprotein lipase, amylase, and lactoperoxidases that make breast milk more easily digestible (Mathur & Dhingra, 2014). Since breast milk has a faster gastric emptying time and is easier on the infant's digestive system than formula, bottle-fed children are more prone to developing digestive disorders and diseases. For example, formula-fed children are more likely to develop constipation, vomiting, diarrheal diseases, non-

specific gastroenteritis, and necrotizing enterocolitis (NEC), gastrointestinal infections, ulcerative colitis, Crohn's disease and celiac disease. In addition to these digestive benefits, breastfeeding promotes dental health, reducing the risk for developing dental caries throughout the infant's lifetime (Davidson et al., 2011).

Necrotizing Enterocolitis

Breast milk contains oligosaccharides that prevent the adhesion of bacteria on to the mucosal walls of the intestines, which is one mechanism which is thought to reduce the risk of NEC in preterm infants (Callen & Pinelli, 2005). Premature babies who are fed both breast milk and formula have a 50% lower risk of developing NEC compared to those who are solely fed formula. In contrast to exclusively breastfed infants, premature infants who are fed both breast milk and formula are twice as prone to developing NEC (Evenhouse & Reilly, 2005).

Bonding

The unique bond between a mother and her child begins as the baby grows within the womb. During pregnancy the baby could not exist apart from the mother. Once the baby is born, the mother may feel as if a part of that special bond was lost; however, breastfeeding can help maintain this bond as the infant still must depend on the mother for nourishment and survival (Mansbacher, 2012). Breastfeeding enhances the mother's sensitivity to the infant's needs, allowing her to be more responsive, and it promotes bonding through skin-to-skin touch, eye contact, and talking. Prolactin and oxytocin are maternal hormones released to facilitate breastfeeding. These hormones are associated with less stress, anxiety, and depression in the mother, which are known factors associated with psychological problems in children. Thus prolactin and oxytocin have an indirect effect on the child as they increase maternal bonding. Distress in the infant is reduced by the analgesic qualities in breast milk. Lower levels of

cortisol, a stress hormone, have been evidenced in babies after breastfeeding and skin-to-skin contact. Reduced stress in the infant leads to a secure attachment and increased bonding for mother and baby (Liu, Leung, & Yang, 2014).

Cognition

Breastfeeding is vital for the development and maturation of the central nervous system. Breast milk is composed of essential nutrients such as fatty acids, hormones, and growth factors that promote brain development. With nourishment from breast milk, children have an ideal foundation for healthy brain function and cognition. Breast milk contains DHA, amino acids taurine and cystine, and omega-3 fatty acids that promote brain and nervous system function and development (Davidson et al., 2011). Breastfed infants have been shown to have an increased amount of DHA in their erythrocytes, as well as their cerebral cortexes (Oddy et al., 2011).

There is also evidence that breastfeeding increases IQ. A study of 14,000 children over a period of six and a half years gathered data from intelligence tests and teacher reports. Compared to those who were formula-fed, those who were breastfed as infants were found to have higher IQ scores as well as fewer behavioral problems throughout childhood, adolescence, and adulthood (Mansbacher, 2012). A study in the *American Journal of Medical Genetics* found that after adjusting for maternal education, breastfeeding was associated with increased IQ and educational achievement (Groen-Blokhuis et al., 2013).

A literature review by Evenhouse and Reilly revealed that individuals who were breastfed gained IQ points in adolescence, varying by the baby's birth weight and maturity. Individuals who were full-term and weighing over six pounds at birth gained an average of 3.2 additional IQ points if they were breastfed. Individuals who were premature as infants gained five to six points, and individuals who were full-term but underweight as infants gained 11 additional IQ

points if they were breastfed (Evenhouse & Reilly, 2005). A study featured in the *Lancet* found that after adjusting for socioeconomic demographics and education, seven and eight year old children who were breastfed, gained an average of 8.3 IQ points on the Revised Weschler Intelligence Scales for Children compared to formula-fed children, and the duration of breastfeeding was found to have a positive correlation with IQ. A 20 study meta-analysis showed that breastfed LBW infants gained approximately 5.18 points more than formula-fed infants on a cognitive development score, but 2.4 of these points may be the result of other factors (Callen & Pinelli, 2005).

A study by Mortensen determined that breastfeeding had the greatest positive impact on IQ in those who were breastfed nine months or longer (Mortensen & Tawia, 2013). This was confirmed in a study by the Boston Children's Hospital which found that a longer duration of breastfeeding was linked to higher IQ scores. At three years of age, breastfed children scored higher than formula-fed children on the Peabody Picture Vocabulary Test, with breastfed children gaining an average of 0.21 points for every month breastfed. At seven years of age, breastfed children scored higher than formula-fed children on the Kaufman Brief Intelligence Test. On the verbal section, breastfed children gained an average of 0.35 additional points per month breastfed, and an average of 0.29 additional points per month breastfed on the nonverbal section. This would mean that breastfeeding for one year would increase an individual's IQ by approximately four points or one-third of a standard deviation (Jama network journals, 2013).

Behavioral Benefits

Eicosapentaenoic acid and DHA are crucial elements in neurological development, genetic expression, and neurotransmitter function. These fatty acids, along with other LCPUFAs in breast milk are thought to reduce the risk of several psychological and behavioral conditions,

such as depression, bipolar disorder, attention-deficit or hyperactivity disorder, dyslexia, and motor deficits (Liu et al., 2014). According to a study in the *American Journal of Medical Genetics*, breastfeeding was found to be associated with less overactive behavior at three years of age (Groen-Blokhuis et al., 2013).

A recent study from the United Kingdom examined behavior in over 10,000 children and mothers. The results of this study revealed that breastfeeding had an inverse relationship with behavioral problems. In general, the greater the amount of time that a child was breastfed, the fewer behavior problems exhibited when the child was older. While in contrast, bottle-fed children were more likely to have anxiety, hyperactivity, and other behavioral problems such as lying and stealing (Mansbacher, 2012).

Another recent 30-year longitudinal study observed the behavior of infants who were breastfed between 4 to 6 months of life. It was determined that breastfed children were less hostile, angry, cynical, and paranoid as adults. The behavioral differences between breastfed and bottle-fed children are believed to be due to the bonding and the nutritive benefits of breastfeeding (Mansbacher, 2012). A longitudinal study by Oddy and colleagues observed infants from birth to fourteen years of age and concluded that breastfeeding longer than six months was linked to a decrease in aggression, attention deficits, social difficulties, and externalizing and internalizing problems throughout childhood and adolescence compared to those who were formula-fed or breastfed for a shorter duration (Oddy et al., 2011).

The China Jintan Child Cohort Study examined the behavior and psychology of over 1,000 six year olds using the Child Behavior Checklist in order to assess the impact of breastfeeding and bonding. The children were divided into four categories: those who were exclusively breastfed with active bonding, exclusively breastfed without active bonding,

formula-fed with active bonding, and formula-fed without active bonding. Numerous factors were taken into account such as, gender, maternal age when the child was born, obstetric complications, parental health, parental education and occupational status, parental marital status, socioeconomic status, house size, neighborhood condition, and Chinese traditions (Liu et al., 2014).

The Internalizing Behavior Scale was used from the Child Behavior Checklist, and 99 items were used to assess the children's emotional reactivity, anxiety, depression, somatic complaints, and tendencies toward withdrawn behaviors. The results showed that children who were exclusively breastfed with active bonding had the best outcomes with the smallest incidence of internalizing problems. Those who were breastfed exclusively had significantly less somatic complaints and overall internalization problems, while those who had actively bonded had significantly lower emotional reactivity, anxiety, depression, internalizing problems, and tendencies to withdraw from others. A longer duration of breastfeeding, 10 months or more, was associated with lower anxiety, depression, emotional reactivity, and total internalization. In comparison, those who were not breastfed were at an increased risk for these same factors. It is likely that both the nutritional benefits and bonding opportunities of breastfeeding are responsible for the associated positive behavioral benefits. Childhood internalization problems such as anxiety and depression may affect approximately 20% of children and adolescents. These psychological problems can carry on into adulthood, which is why the promotion of breastfeeding and bonding is crucial (Liu et al., 2014).

Developmental Benefits

The Western Australian Pregnancy Cohort Study (Oddy et al., 2011) examined 2868 children who were followed from birth until three years of age. The study sought to determine if

breastfeeding was positively associated with improved development, or if the claims of breastfeeding's benefits were unfounded. The children were observed at ages one, two, and three years, looking at developmental progress in adaptability, sociability, communication, gross motor skills, and fine motor skills. In order to help eliminate bias, factors such as stressful life events, psychology, physiology, and socioeconomic demographics were taken into account (Oddy et al., 2011).

The children most likely to have abnormal scores on developmental progress over all three years were those who were breastfed less than four months. When babies were breastfed longer than four months, they had improved communication and fine motor skills at ages one and three years. Adaptability was significantly increased in two year olds who had been breastfed longer than four months. The developmental improvements increased as the duration of breastfeeding increased. These findings are consistent with a New Zealand cohort study which revealed that children who were breastfed over four months had long-term improvements in expression, language, comprehension, and intelligence (Oddy et al., 2011). In addition to this, breastfeeding promotes improved jaw development, which leads to a reduction in speech impediments, which further improves language development (Davidson et al., 2011).

Immune Benefits

Breastfeeding results in healthy bodies, as well as healthy minds. The immune system does not mature until the age of two years. Breast milk contains immunoglobulins that are passed from the mother, which support the infant's immature immune system, providing immunity and protection against disease. Breast milk also contains lactoferrin, casein, lysozymes, leukocytes, prostaglandins, oligosaccharides, enzymes, and hormones that contribute to developing the immune system and preventing infection. The early promotion of a healthy

immune system through breastfeeding is related to a reduction in allergies, skin irritations, and autoimmune diseases such as, dermatitis, eczema, asthma, rheumatoid arthritis, and multiple sclerosis. Research by the American Academy of Pediatrics has also shown that breastfed children are less likely to develop ear infections, gastrointestinal infections, urinary tract infections, respiratory infections, bacteremia, and certain types of spinal meningitis (Eglash, Montgomery, & Wood, 2008). Formula-fed infants have two to five times more ear infections than breastfed babies. In addition, there are 1.5 times more cases of respiratory illnesses, and 1.7 to 1.9 times as many cases of gastrointestinal infections. Formula-fed children are almost twice as likely to develop allergy related problems (Evenhouse & Reilly, 2005). Breastfed children are three times less likely to be hospitalized compared to formula-fed children, as the immune benefits cannot be replicated by formula. These immune benefits have been confirmed by a meta-analysis done by the Agency of Healthcare Quality and Research (AHQR). This meta-analysis examined 9,000 studies about the health impact of breastfeeding, as well as the Promotion of Breastfeeding Intervention Trial that observed health benefits as a result of breastfeeding in a study of over 17,000 mother-infant pairs (Eglash et al., 2008).

Allergies

Infants are more prone to food allergies due to their immature digestive tracts. Food allergies arise in infants when their immature intestine allows undigested proteins to be absorbed, and these undigested proteins then trigger an immune response and an allergic reaction. Because formula is more difficult to digest than breast milk, more food allergies develop in formula-fed infants (Grosvenor, 2012). A study by the *British Medical Journal* observed 777 infants with a familial history of atopy that were fed either breast milk or formula. Those who were fed breast milk were found to have a lower risk of developing atopy and allergies (Callen & Pinelli, 2005).

Sudden Infant Death Syndrome Prevention

Along with other factors, it is believed that the lowered incidence of respiratory infections in breastfed infants may be related to the reduced risk of sudden infant death syndrome (SIDS) in these children. A literature review by Evenhouse and Reilly concluded that the rate of SIDS among formula-fed infants was three to five times that of breastfed infants, and that formula-fed infants have a 25% higher mortality rate during the first 12 months of life compared to those who were breastfed (Evenhouse & Reilly, 2005). A study done by the University of Munster examined 333 infants who died from SIDS. These infants were compared to 998 healthy infants and research findings indicated that exclusive breastfeeding during the first month of the infant's life cuts the possibility of SIDS in half (Hughes, 2009).

Also, a study by the University of Virginia in Charlottesville determined that the risk of SIDS was lowered by 73% in infants who were exclusively breastfed, and the reduction of SIDS was 60% in infants who were fed some amounts of breast milk. When factors such as smoking, sleep position, and low socioeconomic status were present, the reduction in SIDS decreased to 45%, which is still better in comparison to the risk associated with formula-fed infants. Although not yet fully understood, it is thought that the protective effects of breastfeeding are due to the immune benefits and lower risk of infections that are often linked to SIDS (Bainbridge, 2011).

Lifelong Health Benefits

Breastfeeding has an abundance of other lifelong benefits that the AHQR confirmed with their 9,000 study meta-analysis. Infants who were breastfed have a reduced risk of cancer, type I and II diabetes mellitus, cardiovascular disease, liver disease, and obesity (Hill, 2009). Breastfeeding also seems to protect individuals from meningitis throughout childhood and into

adolescence. Children who were not breastfed are approximately two to four times more prone to developing juvenile-onset diabetes mellitus. According to the British Child Cancer Study Investigators, formula-fed children are 1.3 times more likely to develop childhood cancers such as leukemia and lymphoma (Evenhouse & Reilly, 2005). There is also a lower risk of breast cancer associated in females who were breastfed (Binns, James, & Lee, 2013). A study by Backstom observed preterm infants that were given either breast milk or formula with mineral supplementation. Mineral supplements showed superior bone mineralization short-term; however, long-term benefits were not evidenced. Alternatively, a direct correlation between duration of breastfeeding and long-term bone mineralization was noted (Mortensen & Tawia, 2013).

Breastfed infants were found to have decreased blood pressure and levels of cholesterol throughout their lifetime. The increased cholesterol in those who were formula-fed as infants contributes to approximately an 11% increase in the individual's risk of heart disease. Among premature infants who were formula-fed, there tends to be about a 4 mmHg increase in blood pressure throughout adolescence, and a 2 mmHg rise can significantly increase risk of cerebrovascular accidents and myocardial infarctions (Evenhouse & Reilly, 2005).

Obesity

Since obesity is associated with numerous health problems, many studies have examined the relationship between bottle-feeding and obesity. Multiple systematic reviews have noted a link between formula-feeding and obesity, and it appears that the longer the period of breastfeeding, the lower the risk of developing obesity later in life. When comparing exclusive breastfeeding with exclusive formula-feeding, the risk of obesity is reduced by 20% in those who were exclusively breastfed. A prospective cohort study found that four year old children who

had been breastfed for 12 or more months had a smaller fat mass compared to those who were only fed formula. A cross-sectional study corrected for other lifestyle factors found that the duration of breastfeeding was still a significant protective cause for reduced obesity (Mortensen & Tawia, 2013).

When infant are formula-fed, they are given formula on a regular schedule and are fed until the bottle is empty. When infants are breastfed, feedings are focused on feeding cues. Infants nurse when they are hungry, and the feeding ends when the infant is satisfied. The composition of breast milk changes during the feeding. The foremilk at the beginning of each feeding is high in water, proteins, lactose, vitamins, and minerals, but is low in fat and thus satisfies the infant's thirst. The hindmilk at the end of the feed has higher fat and calories and thus satisfies the infant's hunger (Mathur & Dhingra, 2014). This helps set metabolism and allows the child to regulate how much is needed for healthy growth and sufficient nutrients. Breastfeeding helps children learn self-regulation, for as infants, they eat when they are hungry and stop when they are satisfied, and thus breastfed infants are not overfed. On the other hand, bottle-feeding often involves force-feeding an excess of formula, which prevents children from being trained to stop eating when they are full. This can lead to a lifetime of problems with obesity and its associated health conditions such as diabetes and heart disease (Binns et al., 2013).

In the Evenhouse and Reilly literature review, those who were not breastfed were 1.2 to 1.6 times more likely to be overweight in childhood and adolescence (Evenhouse and Reilly, 2005). Toddlers who were breastfed tend to be taller and leaner than those who were fed formula. In addition to self-regulation, another factor that may protect breastfed infants against obesity is parental behavior. Breastfeeding allows for the mother to be attuned to the infant's

cues of hunger and satiety, and this sensitivity to the child's signals may carry on throughout childhood (Mortensen & Tawia, 2013).

Sibling Comparison of Long-Term Benefits

One study used information from the National Longitudinal Study of Adolescent Health (Add Health) to examine the impact of breastfeeding on 16,903 adolescents, and more specifically 2,734 pairs of siblings. Information such as cognition, physical and emotional health, academics, and demographics were gathered in order to determine their correlations with breastfeeding history. The majority of existing breastfeeding literature focuses on the benefits that breastfeeding has to offer. While many of the short-term claims can be backed by evidence, many of the long-term outcomes are uncertain, as most studies are nonexperimental with significant selection biases. Factors that impact breastfeeding as well as child outcomes must be eliminated from studies in order to reach accurate correlations. For example, breastfeeding rates are lower among the low income populations. Low income populations statistically have poorer long-term health and academic performance due to fewer resources, and in scientific research, this must be taken into account to reduce selection bias and prevent false results and correlations. In order to reduce selection bias, the Evenhouse and Reilly study used a within-family-model and sibling comparisons by observing siblings with differing breastfeeding histories. Few studies focus on breastfeeding among siblings, but this method helps to eliminate social, environmental, and familial variables (Evenhouse & Reilly, 2005).

Indicators

Links between breastfeeding and 15 various indicators were examined using data from the National Longitudinal Study of Adolescent Health. These indicators focused on physical and emotional wellbeing, academic performance, and the strength of the relationship between the

mother and child. The 15 specific indicators addressed included if the child had depression, diabetes, asthma, or allergies. Also included were body mass index (BMI), risk of being overweight, and actually being overweight. In addition to these, the child's grade point average (GPA) and score on an abbreviated Peabody Picture Vocabulary Test (PVT) were identified, as well as the child's likelihood of going to college and whether or not the child had been held back a grade. The final indicators include both the mother and child's account of closeness to each other, the activities that the mother and child do together every month, along with the child's report on if the mother is warm and loving (Evenhouse & Reilly, 2005).

Sample

The longitudinal sample began in 1994. Add Health collected information on 20,000 adolescents from 80 school districts in a study that was designed to be nationally representative. This survey contained more sibling comparisons than other sizeable studies, having 2,734 pairs of siblings. It also allowed for more factors to be examined, as it gathered information on cognition, academic performance, mental health, and physical health. The study also accounted for genetics by reporting if the child's parents also had the conditions possessed by the child. With a sample of adolescents, the long-term benefits of breastfeeding can be examined. An important aspect of this study is the oversampling of low-income families, African American families, and Hispanic families who statistically are more inclined to bottle-feed rather than breastfeed. These three subgroups also tend to have increased rates of diabetes, obesity, and asthma, with lower academic achievements (Evenhouse & Reilly, 2005).

In regard to breastfeeding, the Add Health study included whether or not the child was breastfed and the duration of breastfeeding; however, it did not inquire as to whether breastfeeding was exclusive or supplemented with formula or solid food. Of the individuals

sampled, 81.7% had a known breastfeeding history, and 43.7% of those were breastfed with an average breastfeeding duration of 5.4 months. These proportions were also similar within the subsample of the sibling pairs. Sibling pairs were observed if there was a significant difference in the two sibling's breastfeeding histories. Of the sibling pairs, 79.1% had a similar breastfeeding duration, leaving 523 pairs of siblings to study with significant breastfeeding differences, with the average difference in duration being 6.1 months. The 523 cases were nearly equally divided into instances when the older child was breastfed longer and when the younger child was breastfed longer. In 288 of the 523 sibling pairs, one child was never breastfed, and the other was breastfed for an average of 5.8 months. In the remaining cases, both children were breastfed, but having varied durations, with an average difference of 6.5 months in the remaining cases. The study controlled for birth weight and prematurity as these children tend to have poorer outcomes and are often less likely to be breastfed. Gender and birth order were also taken into account. The number of each child's extracurricular activities were also examined to try to determine if parents invested more in one sibling in order to further remove any biases (Evenhouse & Reilly, 2005).

Results

The results of the full Add Health study observing the differences between breastfed and formula-fed children revealed conclusions similar to those in preexisting studies. The full sample including more than just the sibling pairs found significant differences between breastfed and formula-fed children in 12 of the 15 indicators, and in 7 of these indicators, the differences were significant at every breastfeeding duration. Adolescents who were breastfed as children had a BMI that was an average of 0.77 lower, and a higher score on the PVT with an average of an additional 4.9 percentiles in comparison to those who had been formula-fed. One surprising

finding of the full sample showed that breastfeeding longer than one year may be harmful as the difference between breastfed and bottle-fed children decreased in 11 of the 15 indicators in those who were breastfed over one year, yet this finding may be the result of the sample selection. Those who breastfeed longer than one year tend to be Hispanic, lower income, and less educated, which may account for seemingly negative outcomes with a prolonged duration of breastfeeding. Breastfeeding rates were found to be lowest among African Americans, and increased with education and finances (Evenhouse & Reilly, 2005).

The full sample did not account for selection bias; however, the between-family model sought to solve this inaccuracy through observation of siblings. Initially the sibling subsample was significant in BMI, GPA, PVT, if the child was held back, likelihood of the child going to college, and depression. After adjusting for sibling differences and approximating the within-family model, the PVT score was the only outcome that remained significant. Due to the smaller sample size in the sibling group, some indicators such as diabetes could not be accurately analyzed. The PVT score was the study's measure of cognitive ability, so it can be confirmed that evidence consistently demonstrates that increased cognitive ability is a long-term benefit of breastfeeding. The Add Health's study of sibling pairs provides a more accurate assessment of the link between breastfeeding and enhanced long-term cognition. The cognitive improvements seem to last through adolescence, and the cognitive difference is substantial enough to be of importance (Evenhouse & Reilly, 2005).

The short-term benefits of breastfeeding are undeniable, but several of the long-term benefits may have been exaggerated due to selection bias in the studies. Numerous long-term benefits were not examined among sibling pairs, such as diabetes, liver disease, cardiovascular health, and cancer risk. Sibling comparisons cannot fully eliminate selection bias, and thus the

results of the Add Health study may still be inaccurate, but it likely provides a clearer picture compared to other studies. Despite some of the long-term benefits possibly being overstated, the short-term benefits and long-term cognitive benefits still make breastfeeding the best option for infant nutrition.

Negatives of Formula

Formula may become contaminated with bacteria and other pathogens as it must be stored and prepared, while breast milk has anti-infective properties that allow it to be stored longer than formula if necessary. Breastfeeding does not require heating or preparation like formula, since it is always the proper temperature, but with formula there is a risk of burns to the infant if it is heated improperly (Davidson et al., 2011). Contamination, as well as the lack of maternal antibodies, place the child at a greater risk for infection. Some formulas may have a higher sodium content that may cause hypernatremia in the infant, and its improper calcium to phosphorus ratio may cause hypocalcemia (Mathur & Dhingra, 2014). Intolerances and allergies are much more prevalent with formula, while breast milk is hypoallergenic, with only rare instances of allergies or intolerances (Davidson et al., 2011). An Australian study showed that 62% of one to two year old children had an inadequate intake of DHA, 54% had an inadequate intake of linolenic acid, and 90% had an inadequate intake of linoleic acid. The majority of children who were found to be deficient in these nutrients were formula-fed. Breast milk contains adequate amounts of these fatty acids to support a growing infant, and the amount of the polyunsaturated fatty acids in breast milk remains stable through 18 months (Mortensen & Tawia, 2013).

Maternal Benefits

While breastfeeding is primarily for the infant, there are significant benefits for the mother as well. Breastfeeding reduces the incidence of postpartum hemorrhage and postpartum depression, lowers the risk of osteoporosis, diabetes, cardiovascular disease, and breast and ovarian cancers. Additionally, breast feeding increases bonding, promotes weight loss, and delays the return of ovulation and menstruation (Mansbacher, 2012).

Cancer

Numerous studies and years of gathering data has shown that there is unmistakable evidence that breastfeeding reduces the risk of breast cancer. The greater the amount of time the mother has breastfed, the greater the protection against breast cancer. The duration of breastfeeding includes the summation of time breastfeeding for each of the mother's children. It has been theorized that one of the reasons of higher breast cancer rates in developed countries is due to lower breastfeeding rates and shorter breastfeeding durations (Godfrey & Lawrence, 2010). A meta- analysis that examined 45 studies that observed a total of 147,275 women found that there was a 4.3% lower risk of developing breast cancer for every year of breastfeeding. A different meta-analysis concluded that for women who breastfed over 12 months, there was a 28% lower risk of breast cancer. The AHQR's did a meta-analysis on nine studies to observe the impact of breastfeeding on ovarian cancer. The results showed that there was a 21% reduced risk of ovarian cancer in women who had breastfed in comparison to those who had not (Eglash et al., 2008).

Long-Term Health

Breasting has been associated with lower maternal blood pressure. The risk of coronary heart disease significantly decreased in women who had breastfed. For women who have

breastfed a total of two years or more, the risk drops by 37%, and after accounting for lifestyle factors, adiposity, and family history, the reduction was still significant at 23% lower risk. A longer breastfeeding duration is also linked to a lower risk of maternal type II diabetes mellitus in women who did not have gestational diabetes, and these findings were supported by the Nurses' Health Study. Breastfeeding enhances glucose homeostasis, which improves long term glucose transport (Godfrey & Lawrence, 2010). In addition to glucose homeostasis, breastfeeding has been demonstrated to stimulate the function of beta cells of the pancreas in women who had gestational diabetes. One prospective study used two cohorts to examine 150,000 mothers, and found that in women without gestational diabetes, each year of breastfeeding could cause 4 to 12% reduction in the risk of developing diabetes (Eglash et al., 2008).

Effects of Oxytocin

Breastfeeding decreases the incidence of postpartum depression through hormonal involvement. Oxytocin and prolactin are hormones involved in initiating lactation and are released throughout breastfeeding. Both of these hormones have known antidepressant and antianxiety effects. Oxytocin also causes the uterus to contract, thus breastfeeding aids in weight loss as the uterus returns to its prepregnancy size at a faster rate. Oxytocin and the resulting uterine contractions also decrease postpartal bleeding and the risk of a postpartum hemorrhage (Godfrey & Lawrence, 2010). Uterine contractions staunch uterine bleeding as the muscle contractions seal the sinuses that had facilitated blood flow to the placenta during pregnancy. Postpartum hemorrhaging is major cause of maternal mortality, with one woman dying every four minutes worldwide, but immediate breastfeeding can help reduce this statistic through the contracting effects of oxytocin (Davidson et al., 2011).

Conclusion

Breast milk is an irreplaceable and dynamic substance that is designed to give the best nourishment for a developing infant during the first months to years of life. The composition of breast milk consists of many essential and indispensable nutrients that cannot be replicated by formula. Compared to formula, breast milk is made up of more balanced fats, carbohydrates, proteins, vitamins, and minerals that can be more easily digested and absorbed. Breast milk contains numerous benefits for infants such as: increased bonding, improved cognition, fewer behavioral problems, heightened IQ, healthy digestion, enhanced immunity, decreased childhood obesity, reduced allergies, lower risk of SIDS, greater tooth and bone health, continual health improvements, and fewer childhood illnesses, infections, and cancers. While breastfeeding is primarily for the infant, there are noteworthy benefits for the mother as well. Breastfeeding lowers the incidence of postpartum hemorrhage and postpartum depression, accelerates weight loss, reduces the risk of breast and ovarian cancers, decreases the risk of diabetes and cardiovascular disease, improves bone health, delays the return of ovulation and menstruation, and promotes bonding.

The short-term benefits of breastfeeding such as digestion, immunity, and SIDS reduction are undeniable. Since lifelong health can be influenced by many different factors, several of the long-term benefits of breastfeeding may be disputed. Despite this, breastfeeding has consistently been shown to have a significant long-term impact on IQ and cognition. Because of these facts, there is overwhelming evidence to support that breastfeeding is best for mother and baby, and the benefits are lifelong, life-altering, and lifesaving.

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