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The Role of Maternal and Infant Diet in the Management of Infantile Colic: A Comprehensive Review

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Abstract

This systematic review aims to determine the effects of maternal and infant diet on the incidence and treatment of infant colic with emphasis on dietary modifications and its potential to reduce the symptoms. The role of maternal and infant diet on psychological health of the mother and breastfeeding practices as risk factors in reducing the frequency of colic episodes has been highlighted. The role of maternal gut microbiota composition especially the bacterial enterotypes has been discussed with relation to colic. Also, the efficacy of probiotics especially the Lactobacillus reuteri strains has been evaluated with variable results depending upon the strain and the dose used.

The review discusses how the definitions and criteria used, for instance Wessel and Rome IV, influence the perception of incidence and nature of colic. It also includes descriptive content analysis of various researches where cultural and socio-economic factors including maternal empowerment in different contexts are discussed in relation to the management plans. The analysis of meta-analysis and risk of bias studies enhances the conclusions and offers practical recommendations on dietary interventions.

The present study reveals that the personalized dietary approaches are effective and at the same time points out the need to fill the research gaps in order to provide better solutions for parents of colicky infants.

Keywords

Keywords: Maternal diet; infant diet; infantile colic; probiotics; gut microbiome; breastfeeding.

Introduction and Purpose

The treatment of infantile colic, which is defined by frequent crying and irritation in infants has garnered a lot of attention. There is one particular aspect that has gained much attention and that is the effect of maternal and infant diet on colic symptoms. This section is designed to try to determine the role of dietary modification in the prevention and management of infantile colic, to outline the most important findings of the research and to discuss the limitations of the existing evidence.

Infantile colic is one of the most common conditions that affect newborns and usually starts in the early months of the child's life, which can be extremely uncomfortable for both the child and the parents. Although the cause of colic has not been established, dietary issues are some of the factors that can be linked with the condition. Several studies have been conducted to assess the effectiveness of different dietary manipulations such as alteration of maternal diet for breastfeeding mothers and alteration of the infant formula for infants who are not breastfed.

There is evidence that suggests that maternal diet can alter the composition of breast milk and that this in turn can have an effect on infant colic. For example, some proteins and allergens in the maternal diet can be passed on to the infant via breast milk and may worsen the colic symptoms. Hence, the dietary changes in breastfeeding mothers, for instance avoiding certain foods that cause allergies like dairy products, soy and wheat have been suggested to alleviate the symptoms of colic [9, 2]

Besides the maternal diet, the kind of formula given to the infant also helps in the management of colic. The performance of the different kinds of formula such as protein hydrolysate formulas and those with probiotics has been compared with the incidence of colic. These studies are meant to establish whether certain formula compositions can help reduce colic through enhancing gut health and reducing inflammation [9, 1].

The efficacy of these dietary interventional measures is quite variable, and the findings are not always conclusive. Some research evidence has suggested that colic symptoms can be relieved with dietary alteration while other research evidence does not show much difference. This inconsistency calls for more research so that the roles of diet in colic and the best dietary modifications can be determined. [1, 10]. However, there are certain issues which have been identified in the present scenario with regards to the management of infantile colic: For instance, more randomized controlled trials are needed to establish the role of particular dietary manipulation [1, 10]

There are still certain issues regarding the knowledge on the dietary factors that affect infantile colic, although some improvements have been made in this field. In this regard, there is still a requirement for more large-scale, randomized controlled trials in order to establish the efficacy of certain dietary measures. Furthermore, there is a requirement for long term follow up studies in order to assess the effectiveness of dietary alterations on colic symptoms as well as the health of the infant in the long run [12, 10].

In conclusion, the possibility of using maternal and infant diets in the management of infantile colic is interesting. Further research is, however, required in order to set up guidelines and recommendations for dietary changes.

Overview of Infantile Colic

Infantile colic is an ailment that is associated with spasmodic crying and irritability of an otherwise strong and healthy newborn. These episodes of crying are common in the early months of the child's life and can be frustrating to both the child and the parents. Although the reason for infantile colic is still unknown, it is usually described by the 'rule of threes': crying for more than three hours in a day, crying for more than three days in a week and crying for more than three weeks [5, 13].

The main symptoms of infantile colic are the frequent and prolonged crying spells that are hard to calm. The crying spells are usually frequent at the end of the day or in the evening and can persist for long periods of time. The cry of the infant with colic is shrill and can be associated with other symptoms like fussing, flattening of the fists, arching of the back and

redness of the face. Other signs that may be present in infants with colic include gas, bloating and change in bowel habits [5; 14; 13].

There is a possibility that certain dietary factors may be involved in the aetiology and infantile treatment colic. of For example, proteins from the mother's diet that are not hydrolysed completely may appear in the breast milk and cause an allergic reaction in the infant thereby leading to colic. Thus, a low allergen maternal diet or hypoallergenic infant formula has been recommended as a possible solution. This hypothesis was first put forward by Shannon in 1921 and has been by backed subsequent researches as well [5]. Besides maternal diet, probiotics have been tried as a possible management of infantile colic. Probiotics are believed to have an impact on the gut micro flora and this may in turn affect colic. There are researches that have demonstrated that giving probiotics to colicky infants can help in decreasing the amount of time the infants spend crying but more research needs to be done in order to establish the efficacy and safety of this intervention [1, 15]

Other dietary changes that have been looked at include avoiding cow's milk protein. Research and systematic reviews have also pointed out that cow's milk allergy may be associated with colic in some infants and the elimination of cow's milk from the diet may reduce the symptoms [16].

The characteristics of mothers like age, socio-economic status and severity of colic pain in mothers have been examined to observe the possible effects on colic symptoms of the infants. Semi-structured interviews have helped in identifying patterns of colic and experiences across different groups of women [14].

In conclusion, it can be said that the current literature provides some support for the idea that dietary factors can affect the control of infantile colic, however, the existing knowledge is scarce and more research is required in order to make a connection between diet and colic symptoms. This includes large scale research on various dietary modifications and their impact in lessening the severity of colic [13, 1, 2]

Etiology

Infantile colic is a common condition affecting a significant proportion of infants worldwide. The prevalence of colic varies widely, with estimates suggesting that it affects between 5% and 25% of infants, depending on the population studied and the diagnostic criteria used [17, 11].

The etiology of infantile colic is currently thought to have more to do with a number of factors that include gastrointestinal, microbiological and psychosocial factors. One of the key elements is the part played by maternal psychological health. Research indicates that

maternal postpartum psychological state can affect the likelihood of infantile colic. More specifically, it has been established that exclusive breastfeeding can also help reduce the incidence of infantile colic as well as maternal depression [21]. This shows the need to address maternal depression in the management of colic.

Another crucial factor is the microbiome of the infant's gut. Research has revealed that certain bacterial enterotypes that are present in mothers can be associated with colic in their infants. For example, it was noted that mothers who had higher levels of enterotype 2 (Ruminococcus) belonged to the non-colic group, indicating that this bacterial profile might offer some protection against colic [7]. This implies that maternal gut microbiota may also play a significant role in shaping the health of the infant.

Similarly, probiotics have also been widely researched for their ability to cure colic. A lot of research has been conducted on various probiotic strains including Lactobacillus reuteri for colic. The study shows that probiotics are effective in shortening the colic time and the the infant intensity spends of with colic episodes [13; 6]. However, it was noted that the efficacy of probiotics is not constant and is based on the strain of probiotics used, the dosage, and the time of administration.

Additionally, the role of maternal diet in influencing colic symptoms has been investigated, with some evidence suggesting that a hypoallergenic diet in breastfeeding mothers may help reduce colic symptoms in their infants [17].

The diagnostic criteria for colic also belong to the understanding of etiology of the disease. The majority of the studies have used the Wessel diagnostic criteria where colic is defined as crying episodes that are prolonged and frequent. However, some research has employed the Rome IV criteria which provides a more detailed approach by also taking into account other GI symptoms [6]. This variation in the diagnostic criteria can affect the definition of colic prevalence and presentation and thus the comparison of the study findings

There are however some areas of research that have not been well explored thus giving a gap in the understanding of the etiology of infantile colic. For example, specific ways by which maternal diet and gut microbiome are linked to colic are still unclear. Also, the differences in the efficacy of probiotics emphasize the importance of further studies to determine the best type of probiotics and the optimal amount to take. In addition, the psychosocial dimension of colic, the effects of stress on parents and the role of social support mechanisms need to be explored in detail as well [14]

In conclusion, the cause of infantile colic is varied and it is known that many factors including the maternal psychological health, the gut microbiota, probiotics, diagnostic criteria

and parental support play a role. Although a lot of progress has been made in the understanding of these factors, more research is needed in order to gain a better insight into the causes of the condition and how to deal with it effectively [7, 5, 21, 6].

Maternal Diet and Infantile Colic

There has been a lot of research on the hypothesis and theories on the effects of maternal diet on the development of infantile colic. The most common hypothesis is that some compounds in mother's diet may be passed through breast milk to the infant and thus provoke or increase the severity of colic. This theory is also in line with previous findings which have shown that dietary changes in breastfeeding mothers including avoidance of dairy products can help in decreasing the incidence of colic in infants. It is proposed that cow's milk and other dairy products contain allergenic proteins that can induce gastrointestinal problems in sensitive babies.

Another hypothesis which deals with the use of probiotics in managing infantile colic. Some probiotics such as Lactobacillus reuteri has been found to have the potential of modifying the gut microbiota and thus enhance the gut function and reduce colic in infants. There have been research findings which suggest that the supplementation of probiotics can reduce the frequency and duration of crying spells in colicky infants [1; 20]. Interestingly, the use of probiotics seems to be more beneficial for the breastfed infants in contrast to the formula-fed infants. This may suggest that the probiotic-maternal diet may play a significant role [17].

Additionally there is also the theory that maternal stress and psychological wellbeing can cause infantile colic. Stress and anxiety in mothers have been associated with increased colic symptoms in their infants, which may be attributed to the effects of stress hormones on the composition of breast milk and the behavior of the infant [2]. This hypothesis supports the notion that mothers should also be offered psychological interventions when managing colic [14].

There are, however, several key limitations to these hypotheses. For been example, conducted while on some the research effects has of maternal elimination diets on colic, the existing literature is characterized by inconsistencies arising from variations in study design, sample sizes, and dietary interventions that have been implemented [3]. Also, the consequences of dietary changes and probiotic supplementation on infants' health in the long run are still unclear hence the need for more research in order to provide evidence based recommendations [13]

In conclusion, the present hypotheses and theories indicate that maternal diet, probiotics, and maternal psychological status are crucial in the prevention of infantile colic. [20].

Common Dietary Interventions

There have been several dietary measures that have been suggested to help in the management of infantile colic with the diet of the mother as well as the infant receiving a lot of attention in the studies. Another important aspect that has received consideration is the management of infant's gastrointestinal microbiome. The development of molecular technologies especially the 16S ribosomal RNA and ribosomal DNA has allowed the researchers to analyze the intestinal microbial composition. This has helped to establish the relationship between the gut microbiota and infant colic. A study has also been conducted to show that infants who have colic have been observed to have increased Proteobacteria and reduced bacterial diversity when compared to healthy infants [12].

Supplementation with probiotics has become a popular intervention. Out of all the probiotic strains, Lactobacillus reuteri DSM 17938 has been found to be very effective in treating colic. This strain seems to influence the gut bacteria profile and, therefore, may help to minimize the occurrence of colic. There is also research on the use of synbiotics, which are a combination of probiotics and prebiotics. These interventions are designed to improve the gut microbiota and foster a more favorable microbial profile [1].

The maternal diet is also an important factor in the management of infantile colic. It is not uncommon for breastfeeding mothers to be told to avoid certain foods in order to help minimize colic in their babies. Some of the dietary changes recommended are avoidance of dairy products, caffeine and other allergens. This is because when certain proteins and compounds are ingested by the mother they can be secreted into the breast milk and may cause colic in the infant.

The present evidence indicates that some infants have something to gain from these changes in diet while others may not have a lot to gain from it. This variability highlights the importance of individualised approaches to dietary management in colicky infants [5].

Furthermore, the role of maternal antibiotics during the perinatal period has been emphasized as a possible determinant of colic development. Antibiotic use can alter the composition of maternal gut microbiome and this in turn can have an impact on the infant's microbiome and thus the manifestation of colic [7].

In summary, common dietary interventions for managing infantile colic include the use of probiotics and synbiotics to modulate the infant's gut microbiota, as well as dietary adjustments for breastfeeding mothers to eliminate potential allergens. [7, 12, 1].

Specific Food Groups

Specific food groups have received much attention when it comes to managing infantile colic with the possibility of dietary changes from the mother. An area of interest is the elimination of certain food allergens from the mother's diet. It has been observed that feeding the mothers on a low allergen diet which is free from dairy products, soy, wheat, eggs, nuts and fish may help in lessening the colic symptoms in breastfed babies. Nevertheless, the evidence is not very compelling due to the fact that certain researches are questionable, for instance, they have small sample sizes and different criteria in defining colic [3].

There is also an emerging field of research on the use of probiotics in maternal and infant diets. Probiotics can be defined as live microorganisms which when administered in adequate amounts to the host will have beneficial health effects to the host. Probiotics have been given to infants to see if it will be of benefit in the management of colic. A meta-analysis of three studies with 1148 infants showed that there was no difference in the incidence of new cases of colic between the probiotic group and the control group although the incidence of colic was reduced by 40% in the probiotic group. This was established based on low-certainty evidence because of important inconsistency between the results of the trials. [1] Moreover, the composition of the microbiome in the gut, which is shaped by various factors including the microbiome of meconium, is also vital in the manifestation of colic. The formation of the gut microbiota can affect the synthesis of other useful organic compounds and the metabolism of carbohydrates which are very necessary for the health of the gut.

The study by Kozhakhmetov et al. highlighted the fact that the human gut microbiome of an infant is very complex and can change at any given moment and may have certain connection with colic. They pointed out that such factors as the microbiome of meconium may affect the course of development of the infant's microbiota and, thus, colic [7].

Another important aspect is the effect of maternal diet on the gut microbiome of infants. The differences in the microbiome of children with colic and those without colic highlight the possibility that dietary factors may contribute to the development of the microbiota and, therefore, to the manifestation of colic [7].

Furthermore, antimicrobials or probiotics used during pregnancy, and the duration of breastfeeding do not show significant differences between the children who developed colic

and those who did not. However, the level of maternal education seems to differ, suggesting that possibly socioeconomic factors are also important in the management of colic through dietary changes [22].

In summary, while certain food groups and dietary adjustments, such as low-allergen diets and probiotics, show promise in managing infantile colic, the evidence remains inconclusive.

Breastfeeding vs. Formula Feeding

Breastfeeding and formula feeding are the two mainly used methods of feeding an infant and both have different effects on the management of infant colic and the correlation between feeding method and colic symptoms has been well studied with the help of various researches

Breastfeeding is often encouraged because of the many health benefits that it has for both the mother and the child. Nevertheless, it is not without its problems, especially where infantile colic is concerned. A theory has been put forward that proteins from the mother's diet which are not hydrolysed could pass into the breast milk and may cause an allergic reaction in some infants thereby causing colic. This has resulted to suggestion of low allergen maternal diet as a possible way of managing colic. Several researches have suggested that dietary changes for mother including low FODMAP diet may help in decreasing colic in infants. This approach is based on the premise that certain fermentable carbohydrates in the maternal diet can influence the microbiome and gas production in the infant and thus lead to colic.

On the other hand, formula feeding has its own set of issues to take into account as well. There is a great deal of variation in the formulation of infant formula and some formulas are specially formulated to be low allergenic or to include probiotics to help with digestion. The efficacy of these specific formulas in managing colic has been studied and the findings are not consistent. For example, it has been suggested that probiotics in formula can reduce the incidence of colic by regulating the intestinal microflora. Due to variability in the research methods and findings, it is rather difficult to determine which of the two feeding approaches is better [1].

The same is true when comparing breastfeeding with formula feeding with regard to dealing with colic. The breast milk of the mother can be altered almost instantly depending on the diet of the mother and this can be helpful if certain foods have been identified to cause colic. On the other hand, formula feeding provides the benefit of a regulated and constant

nutritional content which might be helpful in treating colic if a particular formula is identified to provide relief.

There is however, potential for harm in using dietary modifications in both breastfeeding and formula feeding. This emphasises the fact that the natural process of infantile colic improves without treatment therefore there should be a balanced view when the well-being of the infant and the parents is concerned. This is because parents who have colicky children usually visit several places in search of solutions to the problem which is caused by the discomfort that the child presents to the parent. This underlines the need for offering evidence informed advice and assistance as well as the need to recognize that parents may turn to several sources for information and advice. [12]

Additionally, it was observed that psychological state of mothers also affects the incidence of colic in infants. The maternal mental health during the postpartum period and exclusive demand feeding breastfeeding may also help in preventing colic thus highlighting the fact that maternal factors should also be taken into account along with the infant's diet in the management of colic [21].

In conclusion, both breastfeeding and formula feeding have potential implications in the management of infantile colic. Although dietary changes in breastfeeding mothers and the use of formulated formulas may provide certain advantages, the findings of the studies demonstrate that personalized strategies are optimal.

Types of Formula

The different formulas that are used in infant diets are very important in the management of infantile colic. Several research works have been conducted to determine the effects of different formula compositions on colic symptoms in order to establish the best dietary modifications that can help in reducing these symptoms

There is also a lot of research regarding the elimination of cow's milk protein from the diet. A recent study has revealed that when mothers avoid milk protein, approximately one-third of the breast-fed infants get relief from colic [6]. This suggests that cow milk protein may play a role in the development of colic in some babies and eliminating it from the diet may be helpful

In addition to cow's milk protein elimination, the use of hydrolyzed formulas has been investigated. Hydrolyzed formulas contain proteins that are broken down into smaller peptides, making them easier to digest and less likely to cause allergic reactions. These formulas have been found to reduce colic symptoms in some infants, although the evidence is

not conclusive. The variability in study results indicates that while hydrolyzed formulas may help some infants, they are not universally effective.

Other strategies that have been considered include the use of synbiotics, which is the combination of probiotics and prebiotics. Prebiotics are defined as the non-digestible components of food that stimulate the growth and activity of beneficial microorganisms in the large intestine. The purpose of taking synbiotics is to improve the diversity of the gut microbiota and thus enhance the digestive health. Even though some research indicates that synbiotics can help with colic, more studies are required in order to establish the effectiveness of synbiotics [1].

Another aspect of interest is the use of formula for infants with colic and the formulas that are used for infants with colic include those with low lactose content, partial hydrolysis of proteins and or probiotics. The objective is to formulate a formula that would be digested easily and cause minimal gas and gastrointestinal discomfort. There have been some studies that have shown that these specific formulas have provided certain level of relief but the findings are not the same in all the research [12].

In summary, it can be stated that the types of formula used in the diets of infants can have a significant effect on the management of infantile colic. Although removing cow milk protein and the usage of hydrolyzed formulas has shown some positive outcomes, the evidence is not always consistent. There is still room for probiotics and synbiotics to provide positive outcomes, but more studies are needed to support their effectiveness. Some formulae that are used in the management of colic may be beneficial for some infants, but more consistent outcomes are needed to strictly suggest their usage. This is because establishing a standard definition of colic in research will help in the enhancement of the knowledge on the effects of diet in this condition [24, 19, 13, 6, 3].

Introduction of Solid Foods

The feeding of solids in an infant is an important and sensitive stage that can shape the strategy of managing infantile colic. This process usually starts at six months of age but this age may differ with the rate of infant development and cultural beliefs. The effect of solid foods on colic is still an interesting topic with many studies looking into the positive and negative aspects of introducing solids into the baby's diet

Among the factors that can be taken into account, there is the type of solid foods given to children. Some authors have suggested that hypoallergenic, hydrolyzed whey or hydrolyzed casein-based formulas may be helpful for some formula-fed infants who have colic. Such

formulas may be useful in decreasing the incidence of colic by decreasing the chances of allergic reactions that may cause gastrointestinal distress [16]

The maternal diet also has its contribution in the handling of solids by the infant. Research has revealed that the dietary practices of the breastfeeding mothers affect the likelihood of the infants having colic. For example, it was observed that the mothers of non-colicky infants had consumed significantly more grapes and lemons than the mothers of colicky infants [24]. This implies that there might be certain dietary factors in the maternal diet that could protect against colic by being transferred to the infant via breast milk

The timing and manner of feeding the child solids are also very important. Staging the process of feeding the child on solids, feeding the child on single ingredient foods and then progressing to more complex foods will allow for the identification of specific foods that may aggravate colic symptoms in the infant. New foods should be watched for the infant's reaction and changes made to the diet to help avoid distress and aid in digestion.

Thus, the introduction of solids is a very important and sometimes a challenging process that can management affect of the infantile colic. It is therefore important for parents and pediatricians to have knowledge of the relationship between maternal and infant diet as well as the timing and type of feeding on the onset of colic and other allergic diseases [24, 21, 16, 2].

Gut Microbiome and Infantile Colic

There is a growing interest in the part of microbiota in the treatment of infantile colic. The gut microbiome refers to the microbial population that lines the intestinal tract and it has been established that it has a vital effect on the well-being and growth of infants. There is a growing awareness that imbalances in the microbiota may be associated with the development and intensity of infant colic

There have been several research works that have looked into the possibility of using breastfeeding to prevent colic with the hypothesis that the breastfed infants may have better gut microbiota profile than the formula fed infants. However, the evidence is still ambiguous since some research did not show that breastfeeding can reduce the risk of colic development [5, 12]. This may be due to the differences in the study approaches for instance, whether the infants were exclusively breastfed or formula fed from the time of birth.

Probiotics which are live microorganisms which are believed to have beneficial effects on the host when consumed can also be used in the management of infantile colic. Probioitics are given with the view of altering the bacteria flora in the gut of the child and therefore

reducing the crying spells. Several recent systematic reviews and meta-analyses have indicated the efficacy of probiotics in the management of colicky infants by shortening the duration of crying. These findings indicate that probiotics can be used to maintain the normal flora of gut which in turns reduce the colic.

Dietary measures such as elimination of dietary milk protein antigens has also been tried with colic to prevent the condition. According to some studies, dietary milk protein antigens might be involved in the development of colic symptoms [9]. However, the effects of dietary modifications for colic are still quite inconclusive

Besides probiotics and dietary changes, the role of gut microbiome in modulating the immune system and possibility of its involvement in colic has also been explored. The use of probiotics has been seen to affect the microbial profile of the gut as well as the immune response and this may help in the management of colic [15]. This highlights the need to appreciate the relationships between the microbiota in the gut and the immune system with regard to colic in infants.

In conclusion, it can be said that there is still a lot of research to be done regarding the potential of gut microbiota in the treatment of infantile colic. Further investigations should be carried out in order to determine how microbiota affects colic, the consequences of probiotic use and in order to determine the most effective dietary modifications that can be made in order to prevent colic.

Impact of Maternal Diet on Gut Microbiome

The diet of the mother can have a great impact on the microbial environment of the infant especially when the mother is breastfeeding. Breast milk is the primary food given to infants and it has been identified to contain bioactive components that determine the development of the infant's gut of microbiome

The antimicrobial substances in breast milk include lactoferrin, lysozyme, and immunoglobulins which have antimicrobial and immunomodulatory properties. These substances provide protection against pathogens and help to establish a balanced microbiome in the infant.

There is evidence that suggests that maternal diet can influence the breast milk composition, and microbiome of the the newborn baby. For instance, the consumption of certain probiotics by the mother such as Lactobacillus reuteri has been found to influence the microbiome of the infant. However, the efficacy of these probiotics in managing colic symptoms has not been established particularly in formula feeding infants[19].

The mode of delivery also plays a role in the initial colonization of the infant's gut microbiome. Cesarean birth has been associated with differences in the microbiome of newborns as compared to the vaginal birth which has been linked with increased diversity of the microbiome and reduced chances of colic [7]. This shows that the role of maternal diet and delivery method also needs to be taken into consideration when analyzing the association between the microbiome and infantile colic

There are, however, several limitations that prevent a definitive conclusion on the efficacy of dietary modifications in the management of infant colic. The research is characterised by significant clinical and methodological heterogeneity, which hampers the ability to make firm statements regarding the efficacy of dietary interventions in reducing the symptoms of colic. It can be inferred from the current evidence that dietary interventions might be effective in the prevention of colic, however, their utility in the management of established symptoms remains debatable [5, 10].

Furthermore, the role of breast-feeding modality in the positive effects of lactobacilli on infant colic is also not well known. Some research has revealed that there are no significant variations in colic symptoms during probiotic or control feedings and this may be because other factors such as sleep and other infant activities take precedence [27].

A moderate negative correlation was observed between protein rich maternal diet and crying time in colicky infants. This suggests that there may be specific compounds in the maternal diet that have an effect on colic, however the overall differences in basic food groups between colicky and non-colicky infants were not statistically significant [24]. This suggests that certain dietary factors may be important but that overall dietary patterns may not be very important.

In summary, it was found that maternal diet plays a very important role in shaping the microbiome of an infant and how it relates to the development and maintenance of infantile colic. However, due to the current state of knowledge, it is not possible to determine which specific dietary factors may be useful in preventing or treating infantile colic, therefore the existing evidence base is considered to be inconclusive.

Impact of Infant Diet on Gut Microbiome

The gut microbiome refers to the multitude of microorganisms that are present in the gastrointestinal tract specifically in the infant and has been shown to have an important implication in the health and development of infants. It has been suggested that dietary

interventions in both breastfed and formula fed infants can shape the microbiome in the gut thus affecting the frequency and intensity of colic

Breastfeeding has been linked with the decreased probability of colic. A research shows that the breastfed babies have more complex and well-balanced microbiae in their gut than the formula-fed babies. This diversity is important as it is necessary for the maturation of the immune system and the avoidance of gastrointestinal diseases. For example, in, 70% of the babies who did not have colic were breastfed on demand, which points to the protective role of breastfeeding on colic. Other factors that have an impact on the establishment of the gut microbiome in the newborn include the route of delivery, that is whether the baby was delivered through vaginal birth or cesarean section, even though the link between the two and colic is yet to be established [21].

Probiotics and prebiotics have been the focus of much research as to their effectiveness in treating infantile colic. Probiotics can be defined as live microorganisms which when given in certain quantities will enhance the health of the individual. On the other hand, prebiotics are defined as the components of food that cannot be digested by the host but helps in the proliferation of the useful microorganisms in the large intestine. Giving probiotics to infants has produced encouraging outcomes in the management of colic as it alters the gut microbiota. For example, Karaahmet et al. [25] found that probiotics can modify the microbial profile of the gastrointestinal tract and thus improve the signs of colic. The results of the analysis of 16S rRNA and stool samples of infants before and after the probiotic treatment indicated the differential shifts in the bacterial species composition indicating the possibility of probiotic therapy.

Dietary interventions, such as the use of infant formulas with prebiotics and probiotics has also been tried. These formulas are designed to provide the benefits of breastfeeding by supporting the development of a healthy gut microbiome. The Happy Tummy Consortium et al. [28] found that infant formulas that included pre- and/or probiotics helped with digestion and lessened the symptoms of colic. This is in line with other randomized controlled trials that have shown that these formulas are effective in treating colic.

However, the efficacy of dietary changes as a way of dealing with colic has been a subject of debate. Research done by some authors indicates that the nonspecific factors such as time, attention and touch, or even placebo effect, can be important in the management of colic [20].

In summary, it is therefore evident that the diet during infancy plays a crucial role in shaping the gut microbiome, which further impacts the occurrence and intensity of colic.

Breast milk has been identified to have protective effects while probiotics and prebiotics have emerged as potential interventions to manage colic by regulating the composition of the gut microbiome.

Probiotics and Prebiotics

There is increasing interest in the use of probiotics and prebiotics in the management of infantile colic, especially because of the effects they may have on the gut microbiome. The gut microbiome has been postulated to be involved in the aetiology of colic and therefore any intervention that aims at modifying this microbial profile is of interest

Probiotics such as Lactobacillus reuteri has been known to be effective in the management of colic and improving the symptoms. Based on the evidence from randomized controlled trials (RCTs) L. reuteri can be used to reduce crying time in breastfed infants with colic. For example, the probiotic strain L. reuteri DSM 17938 has been found to be effective in the management of colicky infants particularly those who are breastfed [19, 3]. There have been many clinical trials conducted on this probiotic strain and the use of it has been linked with the reduction of colic symptoms thus making it a potential treatment

However, it is still not entirely understood whether probiotics are as effective in formula-fed infants as they are in breastfed infants. Some research suggests that there could be certain advantages but the evidence is not as compelling as in case of the latter. At this point, probiotics the in evidence formula-fed regarding infants the is use of of low quality, and more research has to be conducted to confirm the effectiveness of the supplements in this population as well. Also, the addition of probiotics in infant formulas makes it difficult to determine the effects of probiotics alone hence there is need to have more controlled trials to determine the effects [20].

On the other hand, prebiotics are the non-digestible food components that stimulate the growth of the helpful microorganisms in the large intestine. Although the studies on prebiotics in relation to infantile colic are not as numerous as the studies on probiotics, the interest in the possible effects of prebiotics is increasing. Prebiotics can assist in the development of normal gut microflora which in its turn can reduce the symptoms of colic.

The many factors that influence colic are all believed to play a role in the development of colic and are seen to have both biological and behavioural aspects, therefore it is suspected that a combination of dietary interventions, including the use of probiotics and prebiotics may be needed for treatment (10, 2).

In summary, although probiotics, including L. reuteri, have emerged as a viable option for managing colic in breastfed babies, the effectiveness of probiotics in formula-fed infants is still questionable. Prebiotics have also been identified as a possible solution but need more investigation to confirm their effectiveness in preventing and treating colic.

Healthcare Provider Recommendations

The role of healthcare providers in advising parents on how to deal with infantile colic and feeding changes is very significant. They may combine clinical practice with the current research and recommendations of various health-related agencies to advise parents. A rather popular piece of advice is the avoidance of certain foods by the mother, especially if she is breastfeeding. This approach is based on the premise that allergic proteins from the maternal diet may be secreted into the breast milk and cause colic in the infant. Research indicates that removing cow's milk protein from the maternal diet helps in lessening the severity of colic in some infants. [1, 20].

Along with maternal dietary modifications, the healthcare providers may also suggest certain infant formulas for bottle fed babies. Hypoallergenic formulas, which contain extensively hydrolyzed proteins or amino acids are suggested for infants who are thought to have cow's milk protein allergy. These formulas are made to be easier to break down and less likely to cause an allergic reaction thus may help with colic [5, 11].

Probiotics have also been studied in connection with infantile colic as a possible dietary remedy. Some health care givers advise the use of probiotic supplements such as Lactobacillus reuter which is alleged to have the capacity of restoring normal flora in the gut and hence reduce the colic symptoms [11].

Healthcare providers also stress that a comprehensive assessment must be conducted in order to exclude other possible causes of discomfort in infants. This may involve assessing feeding strategies, assessing for correct breastfeeding latch, and considering symptoms of gastroesophageal reflux disease or other gastrointestinal complaints. Thus, by identifying these factors, the providers can suggest better and more appropriate measures to help with the management of colic [5, 1].

Conclusions

The analysis of the current literature on the effects of maternal and infant diets on the management of infantile colic identifies several important findings and points that need further consideration. Several research works have been conducted to establish the link between dietary changes and colic with mixed results.

One of the major discoveries is the possible use of probiotics in treating infant colic. Research shows that probiotics such as Lactobacillus reuteri can help in decreasing the crying time in colicky infants. For example, the findings demonstrate that the effects of killed bacteria might be effective in reducing the symptoms of colic, however, the exact mechanisms are still ambiguous [18]. This is where more conclusive research is needed to support these outcomes and to determine how these processes work.

Another aspect that has gained interest is the effect of maternal diet during lactation. Research indicates that avoidance of specific foods by the mother or following certain diets might help in reducing colic in breastfed babies. Nevertheless, the evidence is not conclusive of all the studies and the confidence in these results is usually low owing to issues such as selection bias, imprecision and inconsistency [1].

The use of formula feeding and the use of hypoallergenic formulas and the introduction of such formulas has also been studied. Some research has also suggested that changing to a hypoallergenic formula can help with colic in infants who are fed formula. However, the evidence is again inconclusive with some studies revealing that there are positive changes while the others do not [19, 10]. This suggests that although hypoallergenic formulas may provide advantages to some infants, it is not effective for all and there can be differences in outcomes.

In addition, the review also emphasizes on the need of taking into account the gut microbiome as a factor in the development of infantile colic. The microbe profile of the gut in colicky infants is not the same as in non-colicky infants, which points to the possibility of an association between intestinal health and colic [7, 22]. This area of research is currently emerging and so far, there have been calls for more research to determine the possibility of modulating the gut microbiome through diet or probiotic supplementation for the management of colic.

In conclusion, it can be stated that the current research on the impact of dietary changes on the treatment of infantile colic is constrained by the presence of contradictory outcomes and the issues with the research methodology. Further studies should be carried out in the form of large scale clinical trials in order to get clearer results and establish guidelines for diet modifications in infants with colic. This will in the end assist in providing better management strategies and enhance the outcome of affected infants and their parents.

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