LUMEN ET VIRTUS
ISSN: 2177-2789

IMPACT OF VITAMIN B12 DEFICIENCY IN CHILDREN AND INFANTS: CAUSES, DIAGNOSIS, TREATMENT, AND PREVENTION

https://doi.org/10.56238/levv16n46-008

Submitted on: 03/02/2025 **Publication date:** 03/03/2025

Pedro Vinicius Figueiredo Pereira[1], Maria Teresa Scarano Carrijo[2], Thiago Honório Gouveia[3], Guilherme Souza Andrade[4], Luana Cardoso Coelho[5], Layana Patrícia de Paiva Marques[6], Roberta Ticiana Rocha Pontes de Castro[7], João Víctor Pinto de Paiva[8], Camilla de Senna Brayner[9], Gabriel Guimarães Rocha[10] and Maria Eugênia Alves Martins de Araújo Tristão[11]

ABSTRACT

Objective: This systematic review aims to gather and examine the scientific evidence on vitamin B12 deficiency in infants and children, investigating its causes, clinical symptoms, diagnostic methods, therapeutic approaches, and preventive strategies. The article seeks to provide a comprehensive and up-to-date view, identify gaps in research, and guide future investigations and clinical practices. Methodology: We used the PVO strategy (population, variable and objective) to formulate the guiding question of this systematic review. The search was conducted in the PubMed Central (PMC) database with the combination of five descriptors using the Boolean term "AND": Vitamin B12 Deficiency, Child Development, Infant Health, Nutritional Deficiency, Pediatrics. Of the 150 articles found, 15 were selected

[1] Graduating in Medicine at the University of Franca- UNIFRAN
E-mail: pedro.vfpereira@hotmail.com
[2] Graduating in Medicine at the University of Franca- UNIFRAN
E-mail: scaranomariateresa0@gmail.com
[3] Graduating in Medicine from the University of Franca
E-mail: justago2000@hormail.com
[4] Graduating in Medicine from the University of Franca - UNIFRAN
E-mail: gsouza.2609@gmail.com
Slats: http://lattes.cnpq.br/9096455507181163
[5] Graduating in Medicine at the University of Franca- UNIFRAN
E-mail: luana.coelho@ymail.com
Slats: http://lattes.cnpq.br/3108863325030884
[6] Medical Degree from the Facid Wyden University Center - UniFacid
E-mail: lpatriciamrqs@gmail.com
Slats: http://lattes.cnpq.br/9643279493424958
[7] Physician from the Faculty of Medicine of Juazeiro do Norte- CE
E-mail: robertaticianarocha@gmail.com
[8] Doctor from the Federal University of Juiz de Fora (UFJF)
E-mail: joaovppaiva@gmail.com
[9] Medical Doctor from the Faculty of Medical Sciences of Paraíba (AFYA)
E-mail: camillasennab@gmail.com
[10] Doctor from the Evangelical University of Goiás
E-mail: gabrielguimaraesrocha@hotmail.com
[11] Guidance counselor
Doctor from the University of Franca (UNIFRAN), Pediatrician and Post Graduate in Pediatric Palliative Care, Pediatric and Neonatal ICU and Pediatric Nutrition, acting as a professor of the Medicine course
University of France
E-mail: Maria Eugênia _059@hotmail.com

after applying the inclusion and exclusion criteria, resulting in 7 articles used to compose the final collection. Results: Vitamin B12 is critical for DNA synthesis, red blood cell formation, and neurological health. Vitamin B12 deficiency can cause megaloblastic anemia, neurological disorders, and delays in cognitive and motor development, especially in children and infants. Causes include inadequate intake during pregnancy and breastfeeding, especially on vegetarian or vegan diets, and absorption problems such as celiac disease. Laboratory evaluation should include the measurement of serum cobalamin, total homocysteine, and methylmalonic acid. Studies indicate that vitamin B12 supplementation significantly improves cobalamin and hemoglobin levels, reduces homocysteine levels, and reverses neurological and hematological symptoms. Conclusion: Early detection and prompt treatment of vitamin B12 deficiency are crucial to avoid serious complications. Adequate supplementation is essential for at-risk populations, such as pregnant women, breastfeeding women, infants and young children, as well as individuals who follow vegan or vegetarian diets. Preventive strategies, such as newborn screening and nutritional education, are essential to reduce the incidence of this deficiency. More research is needed to fully understand the relationship between maternal vitamin B12 levels and neonatal outcomes, as well as to improve diagnostic and therapeutic approaches.

Keywords: Supplementation. Diagnosis. Complications. Paediatrics. Vitamin B12.

INTRODUCTION

Cobalamin (B12) is a water-soluble vitamin found exclusively in foods of animal origin, such as meat, fish, eggs, and dairy products (WIRTHENSOHN et al., 2023). The absorption of B12 from food is a complex process that begins in the mouth with the production of haptocorrine by the salivary glands. In the stomach, gastric acid and pepsin release B12 from food, allowing it to bind to haptocorrin. Stomach cells also secrete intrinsic factor, which can only bind to B12 after haptocorrine is degraded by pancreatic enzymes in the duodenum (SOCHA et al., 2020).

The complex formed by B12 and intrinsic factor binds to receptors on ileum enterocytes, allowing B12 to enter the bloodstream where it rapidly binds to transcobalamin II. Thus, free B12 is available to be used in cellular metabolism (SOCHA et al., 2020).

Vitamin B12 is essential for red blood cell formation, DNA synthesis, fatty acid production, energy generation, and nervous system functionality. Its deficiency can cause megaloblastic anemia and neurological problems. In infants with B12 deficiency, initial symptoms may include irritability, delayed growth, and food refusal, which can lead to irreversible damage to the central nervous system in the most severe cases (PANZERI et al., 2024).

B12 levels in newborns depend on maternal levels, but after the sixth month, B12 intake comes from external sources. Because B12 is mainly in animal products, its deficiency is common in children in developing countries and those with diets low in animal products (TANDON et al., 2022). The recommended daily amount of B12 is 0.5 µg/d for infants up to three months, 1.4 µg/d for infants aged 4 to 12 months, 4 µg/d for adults, 4.5 µg/d during pregnancy, and 5.5 µg/d for breastfeeding mothers (WIRTHENSOHN et al., 2023).

In a study of Brazilian children under five years of age, 14.2% of the children had B12 deficiency, and it was more prevalent (25.3%) among those aged 6 to 23 months in unfavorable socioeconomic conditions. The North region had a disability rate of 28.5%, almost three times higher than the South region (9.7%). These data highlight regional disparities in micronutrient deficiency, indicating the need for public policies to address B12 deficiency in areas with greater social inequalities (SALVATTE et al., 2023).

This systematic review article aims to compile and analyze evidence on the diagnosis and management of Vitamin B12 Deficiency Anemia in pediatric patients. It aims to provide a comprehensive and up-to-date view, synthesizing existing knowledge and identifying gaps in research, guiding future investigations and clinical practices. The

analysis of evidence seeks to be a valuable resource for health professionals, researchers, and academics, contributing to improvements in diagnostic and therapeutic approaches.

The rationale for writing this article lies in the critical importance of raising awareness of vitamin B12 deficiency in children and infants, a condition that can have devastating consequences if not diagnosed and treated early. Vitamin B12 is essential for a number of biological processes, including DNA synthesis, the formation of red blood cells, and the functioning of the nervous system. The absence of this vitamin can lead to severe neurological disorders, megaloblastic anemia, and significant delays in cognitive and motor development.

In addition, the prevalence of vitamin B12 deficiency is particularly high in vulnerable populations, such as those in developing countries and in communities with low socioeconomic status. This is especially concerning in children, whose healthy development depends on proper nutrition. Regional inequalities in micronutrient deficiencies also highlight the urgent need for targeted public policies to address this issue.

Writing this article is justified by the need to provide a comprehensive and up-to-date analysis on the causes, symptoms, diagnosis, treatment, and prevention of vitamin B12 deficiency. By compiling and analyzing the available scientific evidence, we seek to identify gaps in existing research and guide future investigations and clinical practices. We hope that this article will serve as a valuable resource for healthcare professionals, researchers, and policymakers, contributing to the improvement of diagnostic and therapeutic approaches and, ultimately, to the health and well-being of children and infants affected by this condition.

This article is expected to achieve several important goals: to raise awareness by informing health professionals, educators, and parents about the risks and symptoms of vitamin B12 deficiency in children and infants; guide diagnosis and treatment by providing a detailed guide on diagnostic methods and treatment options for vitamin B12 deficiency, aiding in early identification and effective intervention; promote prevention, highlighting the importance of prevention strategies, such as vitamin B12 supplementation for pregnant and breastfeeding women, newborn screening and nutritional education, to reduce the incidence of deficiency; influence public health policies, contributing to the formulation of public health policies that include the fortification of foods with vitamin B12 and nutritional supplementation programs, especially in vulnerable populations; and improve child health by providing information that can lead to improved clinical practices and more positive health outcomes for children and infants, ensuring they receive the necessary amount of vitamin B12 for healthy development.

METHODOLOGY

This systematic review aims to understand the main aspects related to the clinical manifestations of vitamin B12 deficiency in pediatric patients, in addition to presenting the predominant methods of diagnosis and treatment of the condition, seeking to ensure a greater clinical understanding of this pathology. To develop this research, a guiding question was formulated using the PVO (population, variable and objective) strategy: "What are the main aspects that permeate vitamin B12 deficiency anemia in the pediatric population, as well as what are the diagnostic and therapeutic resources used in clinical practice?"

The searches were conducted in the PubMed Central (PMC) databases, using five descriptors combined with the Boolean operator "AND": Vitamin B12 Deficiency, Child Development, Infant Health, Nutritional Deficiency, Pediatrics. The search strategy applied was: Vitamin B12 Deficiency AND Child Development, Vitamin B12 Deficiency AND Infant Health, Vitamin B12 Deficiency AND Nutritional Deficiency AND Pediatrics. The searches resulted in 150 articles, which were then submitted to the selection criteria.

The inclusion criteria included articles in English, Portuguese, and Spanish, published between 2019 and 2024, that addressed the topics proposed by the research. Review, observational, and experimental studies were considered, as long as they were available in full. Exclusion criteria included duplicate articles, abstracts, those that did not directly address the topic of the study, and those that did not meet the other inclusion criteria.

After applying the descriptors in the searched databases, 150 articles were found. After applying the inclusion and exclusion criteria, 15 articles were selected from the PubMed database, and 7 studies were used to compose the final collection.

DISCUSSION

The main causes of vitamin B12 deficiency include inadequate intake during pregnancy and breastfeeding, especially by women following vegetarian or vegan diets, naturally low in vitamin B12 (WIRTHENSOHN et al., 2023). Additionally, conditions such as celiac disease or intrinsic factor deficiency can affect the absorption of the vitamin (Ljungblad et al., 2022). Absorption problems, such as celiac disease, can also contribute to deficiency (Ljungblad et al., 2022).

CLINICAL MANIFESTATIONS

Vitamin B12 deficiency in children and infants can lead to a wide range of clinical symptoms, affecting both the hematologic and neurological systems. In older children, this

deficiency can manifest itself through megaloblastic anemia, characterized by large, immature red blood cells in the blood, causing fatigue, pallor, and weakness. Neurological disorders are common, including tremors, seizures, and motor coordination difficulties, and children may experience irritability, lethargy, and attention deficit. Additionally, vitamin B12 deficiency can result in delays in cognitive development, leading to learning disabilities and memory problems (Sharawat et al., 2023; SAXENA et al., 2023).

In infants, symptoms include apneas, which are temporary stops in breathing during sleep or when awake, and seizures, which can be motor or absences, characterized by brief episodes of loss of consciousness. Babies with vitamin B12 deficiency may be excessively irritable and have hypotonia, which is decreased muscle tone, resulting in weakness and difficulty moving. Additionally, movement disorders such as tremors and abnormal movements can be observed in infants affected by vitamin B12 deficiency (Ljungblad et al., 2022).

In both age groups, the persistence of hyperhomocysteinemia is an indicator of functional vitamin B12 deficiency. Elevated levels of homocysteine in the blood are often found in patients with vitamin B12 deficiency (SAXENA et al., 2023).

Hyperhomocysteinemia is a condition characterized by elevated levels of homocysteine in the blood. Homocysteine is an amino acid that, at normal concentrations, plays an important role in cellular metabolism. However, elevated homocysteine levels are associated with a number of health complications, including cardiovascular disease and neurological problems. The persistence of hyperhomocysteinemia is a significant indicator of functional vitamin B12 deficiency (SAXENA et al., 2023).

Homocysteine is a byproduct of the metabolism of methionine, an essential amino acid obtained through the diet. Normally, homocysteine is converted to methionine or cysteine through enzymatic reactions that require vitamin B12, folate, and vitamin B6 as cofactors. When there is vitamin B12 deficiency, this conversion is impaired, resulting in accumulation of homocysteine in the blood (Ljungblad et al., 2022).

High levels of homocysteine can cause damage to blood vessels, increasing the risk of cardiovascular diseases such as atherosclerosis, myocardial infarction, and stroke. In children and infants, the persistence of hyperhomocysteinemia is associated with severe neurological consequences, such as delays in cognitive and motor development, seizures, and other neurological disorders (Sharawat et al., 2023).

Vitamin B12 deficiency can have devastating consequences on the neurological development of children and infants, affecting several areas of the central and peripheral nervous system:

1. **Delayed Cognitive Development:** Vitamin B12 deficiency is associated with significant delays in cognitive development. Children may have learning disabilities, memory problems, attention deficit and limited language skills. These delays are caused by a decrease in DNA synthesis and the formation of myelin, a substance that insulates nerve fibers and is crucial for the rapid and efficient transmission of nerve signals (SAXENA et al., 2023; Sharawat et al., 2023). Without adequate myelin, nerve conduction is compromised, resulting in impaired cognitive performance.
2. **Impaired Motor Development:** Inadequate levels of vitamin B12 can lead to motor difficulties, ranging from problems with fine and gross motor coordination to hypotonia (decreased muscle tone). Infants and children with B12 deficiency may have delayed development of motor skills, such as sitting, crawling, and walking. Hypotonia can result in muscle weakness and difficulties sustaining proper body posture (Ljungblad et al., 2022).
3. **Neurological Disorders:** Vitamin B12 deficiency can cause a number of serious neurological disorders, such as seizures, tremors, and movement disorders. Motor seizures or absences, tremors, and abnormal movements are often seen in infants with B12 deficiency. These disorders result from the interruption in the transmission of nerve signals due to a lack of myelin (Sharawat et al., 2023).
4. **Behavioral and Emotional Problems:** Children with vitamin B12 deficiency may exhibit irritability, lethargy, apathy, and regressive behaviors. Irritability and lethargy are often seen in affected infants and children, making it difficult for them to interact appropriately with their environments and caregivers. Apathy can lead to a decrease in interest in activities and social engagement, negatively impacting the child's emotional and social development (Ljungblad et al., 2022).
5. **Delayed Language Development:** Vitamin B12 deficiency can delay language development, impairing a child's ability to communicate effectively. Affected children may have difficulties acquiring basic language skills, such as forming words and sentences, understanding commands, and expressing themselves verbally. The impact on language development is related to interference in the formation of neural connections necessary for language acquisition and processing (Sharawat et al., 2023).
6. **Persistence of hyperhomocysteinemia:** The persistence of hyperhomocysteinemia, or elevated levels of homocysteine in the blood, is an indicator of functional vitamin B12 deficiency. Elevated homocysteine can cause

damage to blood vessels and increase the risk of cardiovascular disease. In cases of vitamin B12 deficiency, homocysteine is not converted to methionine efficiently, resulting in its accumulation (SAXENA et al., 2023).

7. **Long-Term Impact:** Vitamin B12 deficiency during the first few years of life can have long-term consequences on neurological and cognitive development. Even with adequate supplementation, some children may continue to have deficits in their cognitive and motor skills. This highlights the importance of prevention and early diagnosis to minimize permanent damage (Sharawat et al., 2023).

DIAGNOSIS

Vitamin B12 deficiency can cause severe neurological and hematological damage, making early diagnosis essential to prevent long-term complications. Identifying disability accurately and quickly allows for appropriate therapeutic interventions, significantly improving health outcomes (SAXENA et al., 2023).

Laboratory Methods:

1. Serum Vitamin B12 Dosage Serum vitamin B12 dosage is the most common method for diagnosing deficiency. However, this method may have limitations in sensitivity and specificity. In some cases, patients may experience deficiency symptoms even with serum vitamin B12 levels within the normal range, or they may have low vitamin B12 levels without symptoms (WIRTHENSOHN et al., 2023).
2. **Methylmalonic Acid (MMA):** Methylmalonic acid (MMA) is a biochemical marker that accumulates in the blood when there is a vitamin B12 deficiency. MMA measurement is considered a more sensitive and specific method to detect vitamin B12 deficiency, especially in subclinical cases. Elevated MMA levels indicate a functional vitamin B12 deficiency, even when serum B12 levels are normal (Ljungblad et al., 2022).
3. **Total Homocysteine (tHcy):** Homocysteine is an amino acid that accumulates in the blood when there is a deficiency of vitamin B12, folate, or vitamin B6. Total homocysteine (tHcy) measurement is another important marker for the diagnosis of vitamin B12 deficiency. Elevated homocysteine levels are indicative of vitamin B12 deficiency and are associated with an increased risk of cardiovascular and neurological diseases (SAXENA et al., 2023).
4. **Transcobalamin II (Tc II):** Transcobalamin II (Tc II) is the protein that transports active vitamin B12 to cells. The measurement of Tc II can be used to evaluate

the fraction of vitamin B12 available to the cells. This method is useful for identifying functional vitamin B12 deficiencies that are not detected by traditional serum measurement (WIRTHENSOHN et al., 2023).

The diagnosis can be given by clinical evaluation:

1. **Clinical History**: Evaluation of the patient's medical history is critical to identify risk factors and symptoms associated with vitamin B12 deficiency. Restrictive diets, such as vegetarian or vegan, gastrointestinal conditions that affect nutrient absorption, and long-term use of certain medications are important risk factors (Ljungblad et al., 2022).
2. **Physical and Neurological Examination:** The physical and neurological examination helps identify clinical signs of vitamin B12 deficiency, such as pallor, jaundice, glossitis (inflammation of the tongue), and neurological symptoms such as tingling, numbness in the extremities, difficulty walking, loss of balance, and mood swings. Neurological evaluation is crucial in determining the impact of deficiency on the nervous system (Sharawat et al., 2023).

It is important to differentiate vitamin B12 deficiency from other conditions that may present with similar symptoms, such as folate deficiency, iron deficiency anemia, and neurological diseases. The combination of laboratory methods and clinical evaluation allows for a more accurate diagnosis and the exclusion of other potential causes (WIRTHENSOHN et al., 2023).

Diagnosing vitamin B12 deficiency involves a multifaceted approach, combining laboratory methods and clinical evaluation to identify the deficiency accurately and early. Serum measurement of vitamin B12, methylmalonic acid (MMA), total homocysteine (tHcy), and transcobalamin II (Tc II) are essential laboratory tools. Assessment of clinical history and physical and neurological examination complement the diagnosis, allowing appropriate therapeutic interventions and preventing long-term complications (SAXENA et al., 2023; Ljungblad et al., 2022; WIRTHENSOHN et al., 2023).

On the same side we have the diagnosis of Hyperhomocysteinemia which also has its importance. Measuring total homocysteine levels in the blood is a crucial diagnostic tool for detecting vitamin B12 deficiency. In addition, the assessment of homocysteine levels is complemented by the measurement of serum levels of vitamin B12 and methylmalonic acid (MMA). High levels of homocysteine and MMA, along with low levels of vitamin B12, confirm vitamin B12 deficiency (WIRTHENSOHN et al., 2023). Treatment of persistent hyperhomocysteinemia involves vitamin B12 supplementation. Vitamin B12 administration can be done orally or parenterally, depending on the severity of the deficiency and the

underlying conditions. In severe cases, parenteral administration of hydroxocobalamin is often used to quickly correct vitamin B12 levels and reduce homocysteine levels (TANDON et al., 2022). Studies show that vitamin B12 supplementation results in significant improvements in cobalamin and hemoglobin levels, as well as normalizing homocysteine levels. Resolution of hyperhomocysteinemia is crucial to prevent cardiovascular and neurological complications associated with vitamin B12 deficiency (SAXENA et al., 2023). Prevention of hyperhomocysteinemia involves ensuring adequate intake of vitamin B12 through diet or supplementation, especially in at-risk populations such as pregnant women, breastfeeding women, and individuals following vegetarian or vegan diets. In addition, newborn screening and nutrition education for women of childbearing age are key strategies to prevent vitamin B12 deficiency and associated hyperhomocysteinemia (Ljungblad et al., 2022; WIRTHENSOHN et al., 2023).

TREATMENT OF VITAMIN B12 DEFICIENCY

Within the therapeutic approaches we have: Oral vitamin B12 supplementation is a common and effective approach to treat mild to moderate deficiencies. Oral forms of vitamin B12, such as cyanocobalamin and methylcobalamin, are given in varying doses depending on the severity of the deficiency. In general, daily doses of 1,000 to 2,000 micrograms are recommended initially, followed by lower maintenance doses after normalization of serum vitamin B12 levels (TANDON et al., 2022). The advantages of this method include being non-invasive, easy to administer, and cost-effective. However, oral supplementation may have lower absorption in cases of gastrointestinal problems and requires continuous adherence to treatment. On the other hand, parenteral supplementation, which includes intramuscular or subcutaneous injections of vitamin B12, is preferred in cases of severe deficiency, malabsorption, or significant neurological manifestations. Hydroxocobalamin is a commonly used form for injections, with an initial regimen of frequent injections (e.g., daily or weekly) followed by maintenance injections at longer intervals (Lipari Pinto et al., 2022). The advantages of parenteral supplementation include fast and effective absorption, being suitable for cases of malabsorption. However, this method is invasive, requires administration by a healthcare professional, and has a higher cost compared to oral supplementation.

RESPONSES TO TREATMENT

Vitamin B12 supplementation results in significant increases in serum cobalamin and hemoglobin levels. This is crucial for correcting megaloblastic anemia associated with

vitamin B12 deficiency, and normalizing hemoglobin levels improves symptoms such as fatigue, pallor, and weakness (SAXENA et al., 2023). Correcting vitamin B12 deficiency leads to decreased homocysteine levels in the blood, reducing the risk of cardiovascular and neurological complications. Normalization of homocysteine levels is indicative of functional resolution of deficiency (Sharawat et al., 2023). Proper treatment of vitamin B12 deficiency can reverse or improve neurological symptoms such as tingling, numbness in the extremities, tremors, and seizures. In infants with infantile epileptic spasms syndrome (EEIS), B12 supplementation resulted in complete cessation of spasms within six months (Sharawat et al., 2023). In addition, vitamin B12 supplementation is crucial for healthy neurological development, as correcting the deficiency can mitigate delays in cognitive, motor, and linguistic development. Children and infants who receive adequate supplementation show significant improvements in motor skills, coordination, and school performance (Sharawat et al., 2023).

After initiating treatment of vitamin B12 deficiency, it is critical to perform continuous monitoring of serum levels of vitamin B12, homocysteine, and methylmalonic acid. This monitoring allows the effectiveness of the treatment to be evaluated and doses adjusted as needed, ensuring that vitamin B12 levels remain within the normal range and preventing relapses of the deficiency (WIRTHENSOHN et al., 2023). In addition, educating patients and caregivers about the importance of treatment adherence is crucial for therapeutic success. Explaining the benefits of continuous supplementation and the risks of premature cessation of treatment can significantly increase adherence, resulting in improved long-term health outcomes (Ljungblad et al., 2022). To prevent the recurrence of vitamin B12 deficiency, it is essential to consider dietary adjustments, especially in individuals on restrictive diets. Recommending food sources rich in vitamin B12, such as meat, fish, eggs, and dairy products, or suggesting the use of dietary supplements may be necessary to ensure adequate intake of the vitamin (WIRTHENSOHN et al., 2023).

PREVENTION OF VITAMIN B12 DEFICIENCY

Preventing vitamin B12 deficiency is key to avoiding the serious neurological and hematological consequences associated with this condition. The following are detailed strategies and approaches to prevent vitamin B12 deficiency in various populations:

Pregnant and breastfeeding women have a higher need for vitamin B12 to ensure the healthy development of the fetus and baby. Strategies include:

1. Direct Supplementation Pregnant and breastfeeding women, especially those who follow vegetarian or vegan diets, should receive vitamin B12

supplementation. Specific supplements for these stages of life, containing vitamin B12, are recommended to ensure adequate intake of the vitamin (WIRTHENSOHN et al., 2023).

2. Monitoring Vitamin B12 Levels Regularly monitoring serum vitamin B12 levels during pregnancy and lactation helps to identify any deficiencies early and adjust supplementation as needed. Early maternal screening is crucial to ensure that mothers maintain adequate levels of vitamin B12, thereby preventing deficiency in the baby (Lipari Pinto et al., 2022).

NUTRITIONAL EDUCATION

1. Education for Women of Childbearing Age Educating women of childbearing age about the importance of vitamin B12 in the diet is essential to prevent future deficiencies. Educational programs should emphasize the need to include vitamin B12-rich food sources, such as meat, fish, eggs, and dairy products, in the daily diet. For vegetarians and vegans, dietary supplementation should be encouraged (Ljungblad et al., 2022).
2. Information on Food Sources and Supplementation Women following vegetarian or vegan diets need to be informed about alternative sources of vitamin B12 and the importance of supplementation to ensure adequate levels. Foods fortified with vitamin B12, such as cereals and nutritional yeast, may also be recommended (WIRTHENSOHN et al., 2023).

NEWBORN SCREENING AND EARLY DIAGNOSIS

1. Newborn Screening Implement newborn screening programs to detect vitamin B12 deficiencies in newborns early. Newborn screening may include measuring levels of vitamin B12, total homocysteine (tHcy), and methylmalonic acid (MMA) to identify infants at risk of deficiency (Lipari Pinto et al., 2022).
2. Early Diagnosis and Intervention Infants identified with vitamin B12 deficiency should receive immediate intervention, including vitamin B12 supplementation to quickly correct vitamin B12 levels and prevent complications. Early intervention is crucial to minimize neurological damage and ensure healthy development (Sharawat et al., 2023).

PUBLIC HEALTH STRATEGIES

1. Nutritional Supplementation Programs Develop and implement nutritional supplementation programs in vulnerable communities and those of low socioeconomic status, where vitamin B12 deficiency may be more prevalent. Supplementation programs may include distributing vitamin B12 supplements to pregnant women, breastfeeding women, and children at risk (Sharawat et al., 2023).
2. Public Health Policies Develop public health policies that promote vitamin B12 supplementation and nutritional education. Policies should include recommendations for newborn screening and monitoring of vitamin B12 levels in at-risk populations, as well as awareness campaigns on the importance of vitamin B12 for health (WIRTHENSOHN et al., 2023).
3. Fortification of Foods Consider fortification of staple foods with vitamin B12 as a public health measure to increase intake of the vitamin in the general population. Foods such as breakfast cereals, breads, and plant-based milks can be fortified with vitamin B12 to help prevent deficiencies, especially in populations with restrictive diets (Ljungblad et al., 2022).

Prevention of vitamin B12 deficiency requires a multifaceted approach, including adequate supplementation, nutrition education, newborn screening, and public health strategies. These measures are essential to ensure that pregnant women, breastfeeding women, infants, and children receive the necessary amount of vitamin B12, promoting healthy development and preventing complications associated with deficiency (WIRTHENSOHN et al., 2023; Ljungblad et al., 2022; Lipari Pinto et al., 2022; Sharawat et al., 2023).

4 RESULTS

Table 1: Main results of the systematic review.

Author	Main Collaborations
SAXENA et al. (2023)	- Highlighted the importance of vitamin B12 in DNA synthesis, red blood cell formation, and maintenance of neurological health. - Documented clinical symptoms in children, such as megaloblastic anemia, lethargy and neurological disorders. - Described the impact on neurological development and positive responses to treatment with vitamin B12.
Ljungblad et al. (2022)	- Identified the causes of vitamin B12 deficiency, including vegetarian or vegan diets and absorption problems. - They listed clinical manifestations, such as apneas, convulsions, irritability and hypotonia in babies. - They defined diagnostic methods, such as measuring serum levels of vitamin B12, total homocysteine and methylmalonic acid. - They recommended neonatal screening and prevention strategies through nutritional education.

WIRTHENSOHN et al. (2023)	- Highlighted the need for vitamin B12 supplementation for pregnant and breastfeeding women, especially in restrictive diets. - Diagnostic methods have been described, such as serum vitamin B12, total homocysteine, and methylmalonic acid. - They discussed prevention strategies, including nutritional education and newborn screening.
Sharawat et al. (2023)	- Documented the clinical manifestations of vitamin B12 deficiency, such as seizures and neurological disorders. - Cases of infantile epileptic spasms syndrome (EEI) associated with vitamin B12 deficiency and positive response to treatment with B12 supplementation have been reported. - They discussed the impact of B12 deficiency on neurological development and the benefit of supplementation.
TANDON et al. (2022)	- Described different therapeutic approaches for the treatment of vitamin B12 deficiency, including oral and parenteral supplementation. - They compared the benefits and challenges of each treatment method. - They highlighted the importance of early intervention to prevent neurological and hematological complications.
Lipari Pinto et al. (2022)	- Addressed the importance of newborn screening for the early identification of vitamin B12 deficiency. - They discussed the use of hydroxocobalamin injections to quickly correct metabolic imbalances in severe cases. - They suggested early maternal screening to identify and treat deficiencies during pregnancy.
Chandra et al. (2022)	- Focused on iron and vitamin B12 deficiency, including causes and impacts on neurological and physical development. - They discussed diagnostic and screening methods for nutritional deficiencies in newborns. - They addressed the treatment of nutritional deficiencies, including oral and parenteral supplementation.
SOURCE: PREPARED BY THE AUTHOR	

CONCLUSION

The article highlights the importance of vitamin B12 for the healthy development of children and infants, highlighting the serious impacts that its deficiency can cause, such as delays in neurological and cognitive development, megaloblastic anemia, and neurological disorders. Vitamin B12 deficiency can result from inadequate intake during pregnancy and breastfeeding, especially on vegetarian or vegan diets, as well as absorption problems such as celiac disease.

Clinical manifestations range from mild to severe, including symptoms such as irritability, lethargy, tremors, seizures, and hypotonia. The persistence of hyperhomocysteinemia is an important indicator of functional vitamin B12 deficiency. Early diagnosis is critical and involves measuring serum levels of vitamin B12, total homocysteine, and methylmalonic acid.

Treatment of vitamin B12 deficiency can be done orally or parenterally, with significant improvements in cobalamin and hemoglobin levels, as well as reduced homocysteine levels. Proper supplementation can reverse or mitigate delays in neurological and cognitive development.

The prevention of vitamin B12 deficiency involves supplementation for pregnant and breastfeeding women, neonatal screening, nutritional education, and public health policies aimed at nutritional supplementation and food fortification.

SUGGESTIONS FOR IMPROVING THE PROBLEMS IMPLIED IN THE ARTICLE

To improve the problems implicated in the article, it is essential to implement specific vitamin B12 supplementation programs for pregnant and breastfeeding women, especially those on restrictive diets, ensuring adequate intake of the vitamin during pregnancy and breastfeeding. Performing regular monitoring of serum vitamin B12 levels in pregnant women, breastfeeding women, and infants is crucial to identify any deficiency early and adjust supplementation as needed. In addition, developing educational programs that emphasize the importance of vitamin B12 in the diet, especially for women of childbearing age, including information on food sources and the need for supplementation in vegetarian or vegan diets, is critical. Implementing newborn screening programs that include measuring levels of vitamin B12, total homocysteine, and methylmalonic acid will help identify and treat deficiency in newborns early. Public health policies aimed at fortifying staple foods with vitamin B12, such as breakfast cereals, breads, and plant-based milks, will increase vitamin B12 intake in the general population and prevent deficiencies, especially in populations with restrictive diets. Promoting awareness campaigns to inform the population about the risks of vitamin B12 deficiency, the associated symptoms, and the importance of maintaining adequate levels of the vitamin for overall health is essential. Finally, ensuring that vitamin B12 supplements are available and affordable, especially for communities of low socioeconomic status, is necessary. Government programs can subsidize or distribute supplements to vulnerable populations, ensuring that everyone has access to the nutrients essential for healthy development.

REFERENCES

1. LJUNGBLAD, Ulf Wike et al. Breastfed infants with spells, tremor, or irritability: rule out vitamin B12 deficiency. Pediatric Neurology, v. 131, p. 4-12, 2022.

2. PANZERI, Carolà et al. Potential Micronutrient Deficiencies in the First 1000 Days of Life: The Pediatrician on the Side of the Weakest. Current Obesity Reports, v. 13, n. 2, p. 338-351, 2024.

3. SALVATTE, Keronlainy et al. High serum folate concentration, vitamin b12 deficiency, and anthropometric nutritional status in brazilian children aged 6–59 months: Data from the Brazilian national survey of child nutrition. The Journal of Nutrition, v. 153, n. 7, p. 2094-2104, 2023.

4. SAXENA, Chahat et al. Therapeutic response to sublingual methylcobalamin in children with vitamin B12 deficiency anemia. Indian Pediatrics, v. 60, n. 11, p. 913-916, 2023.

5. SHARAWAT, Indar Kumar et al. Nutritional vitamin B12 deficiency-associated Infantile epileptic spasms syndrome: Clinico-neurophysiological presentation, response to treatment, and neurodevelopmental outcome. Seizure: European Journal of Epilepsy, v. 110, p. 93-98, 2023.

6. SOCHA, Daniel S. et al. Severe megaloblastic anemia: Vitamin deficiency and other causes. Cleveland clinic journal of medicine, v. 87, n. 3, p. 153-164, 2020.

7. TANDON, Rahul et al. Parenteral vs oral vitamin B12 in children with nutritional macrocytic anemia: A randomized controlled trial. Indian Pediatrics, v. 59, n. 9, p. 683-687, 2022.

8. WIRTHENSOHN, Miriam et al. Biochemical, nutritional, and clinical parameters of vitamin B12 deficiency in infants: A systematic review and analysis of 292 cases published between 1962 and 2022. Nutrients, v. 15, n. 23, p. 4960, 2023.