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Original Research Article

A study of clinical spectrum of vitamin B12 deficiency in pediatric age group in a tertiary care hospital

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ABSTRACT

Background: Vitamin B12 deficiency is a major preventable issue in children, often leading to severe neurological and hematological problems. In regions with high vegetarianism and malnutrition, it remains underreported. This study aims to examine the clinical manifestations and contributing factors of vitamin B12 deficiency in affected children.

Methods: This cross-sectional survey at Basaveshwar Teaching and General Hospital and Sangameshwar Teaching and General Hospital, attached to Mahadevappa Rampure Medical College and Private Hospitals in Kalaburagi, from August 2022 to January 2024 included 75 children (0-18 years) with vitamin B12 deficiency. Data collection involved dietary patterns, appetite, neurological symptoms, and co-morbid conditions. Laboratory investigations assessed hemoglobin, peripheral smear, vitamin B12 levels, and platelet count. Informed consent was obtained from all participants' guardians.

Results: The study of 75 cases revealed a mean age of 6.16 years, with 37.3% under 1 year, 36% adolescents, and 20% aged 1-4 years. Vitamin B12 deficiency was widespread, affecting 85.3% with levels ≤200 pmol/l. A vegetarian diet was significantly associated with higher deficiency rates ($p<0.05$). Significant nutritional deficiencies and comorbidities were observed, including developmental delays and anemia. Lower vitamin B12 levels correlated with increased malnutrition severity ($p=0.001$).

Conclusions: This study highlights the critical role of vitamin B12 in maintaining health among children and adolescents. It reveals high deficiency rates, particularly in infants, those with delayed complementary feeding, and vegetarians. Maternal vitamin B12 levels significantly impact breastfed infants' health. An inverse correlation between vitamin B12 levels and nutritional status emphasizes the need for early detection, monitoring, and intervention.

Keywords: Vegetarian diet, Malnutrition, Developmental delays, Maternal vitamin B12 levels

INTRODUCTION

Vitamin B12 deficiency in children is a significant preventable public health issue, with the potential for long-term neurological consequences if left undiagnosed. It is often underreported in developing countries, where prevalence rates range from 21-45%. Factors such as maternal deficiency, delayed complementary feeding, limited intake of animal products, poverty, and malnutrition contribute to the deficiency. Vitamin B12, a water-soluble vitamin containing a cobalt atom, exists in biologically active forms like methylcobalamin and adenosylcobalamin, which play crucial roles in metabolic processes such as the conversion of homocysteine to methionine and methylmalonyl-CoA to succinyl-CoA, supporting DNA, RNA, and protein synthesis. Since B12 is synthesized only by microorganisms, its primary dietary sources are animal products like meat, eggs, fish, and milk. While older children and adults have B12 stores lasting 3-5 years, infants of mothers with low stores may exhibit deficiency symptoms within 6-18 months.[1]

In the acidic environment of the stomach, vitamin B12 (Cbl) is released from food proteins and binds to haptocorrin (R binder) present in saliva and gastric juice. In the duodenum, pancreatic proteases free Cbl to bind with intrinsic factor (IF), which then attaches to ileal receptors for absorption. Typically, 1.5–2.5 µg of Cbl is absorbed per meal, along with some passive absorption. Inside enterocytes, Cbl binds to transcobalamin II (TC II) for transport, while one-third of the body's stores are located in the liver, delaying the onset of deficiency symptoms.[2]

Vitamin B12 status is commonly assessed by measuring serum or plasma levels, with most laboratories defining deficiency as values below 200 or 250 pg/ml. Serum methylmalonic acid (MMA) serves as a sensitive marker for deficiency, with levels exceeding 0.271 micromol/l indicating a potential deficiency, although elevated MMA can also result from renal insufficiency. Additionally, total plasma homocysteine levels increase as B12 status declines, with levels above 15 micromol/l suggesting deficiency. However, homocysteine is a less specific marker, as its levels can also be influenced by low folate levels and impaired kidney function.[2]

According to World Health Organization (WHO) guidelines, vitamin B12 deficiency was defined as serum vitamin B12 <203 pg/ml, and folate deficiency was defined as serum erythrocyte folate level <151 ng/ml.[3]

The average vitamin B12 level in the breast milk of women with vitamin B12 intake above the RDA is 0.44 mcg/l.[13] The bioavailability of vitamin B12 from food varies with dose, as absorption significantly decreases when intrinsic factor capacity is exceeded (at 1–2 mcg).[4] Dairy products offer about three times more bioavailability than meat, fish and poultry. While vitamin B12 from dietary supplements provide 50% higher bioavailability than food sources.[5,6]

Approximately 70% of B12 transported across the placenta is bound to transcobalamin in contrast to only about 30% in maternal blood, and higher placental transcobalamin concentrations correlate with higher cord-blood B12 levels.[5,7]

Maternal B12 deficiency (due to, e.g., a vegan diet or B12 malabsorption) leads to limited intrauterine supply, resulting in low neonatal B12 stores. Since females with B12 deficiency also have low B12 in breast milk, breastfed infants may not replenish their B12 stores sufficiently.[7]

Vitamin B12 deficiency affects approximately 10% of the population globally, with children in developing countries being particularly vulnerable.[18] In developed countries like the United States and Europe, vitamin B12 deficiency in children is relatively low, ranging from 0.3% to 1.5%.[19] In contrast, developing countries face higher prevalence, with up to 30% of children affected due to dietary and socioeconomic factors.[8]

In India, vitamin B12 deficiency affects 14% of preschool children, 17% of school-age children, and 31% of adolescents, with boys at 35% and girls at 27%. The prevalence of vitamin B12 deficiency ranged from 2% in West Bengal to 29% in Gujarat among children aged 1-4 years, from 0% in Nagaland and 1% in Kerala to 31% in Uttar Pradesh and 32% in Punjab among children aged 5-9 years, and from 2% in Kerala and Nagaland to 45.5% in Karnataka among adolescents aged 10-19 years.[9]

Vitamin B12 deficiency in children can result from three primary causes: insufficient intake, impaired absorption, and inborn errors of transport and metabolism. Insufficient intake is commonly seen in breastfed infants whose mothers have undiagnosed deficiencies, often due to strict vegetarian diets or conditions like pernicious anemia. Impaired absorption can occur when there is a lack of intrinsic factor, competition for absorption in the ileum, or issues related to gastric acid, such as prolonged use of acid-suppressing medications. Inborn errors of metabolism involve defects in the synthesis of the active forms of cobalamin required for essential metabolic processes. A clear understanding of these underlying causes is crucial for the accurate diagnosis and effective treatment of vitamin B12 deficiency in children.[10]

Children often present with nonspecific manifestations such as weakness, lethargy, feeding difficulties, failure to thrive, and irritability. Pallor, glossitis, vomiting, diarrhea, and icterus are other common findings.[1] It can also cause a wide range of neurological problems such as developmental delays, muscle weakness, cognitive impairments, and neuro regression.[11]

The hematologic manifestations of vitamin B12 and folate deficiencies are similar, characterized by macrocytic anemia with macro-ovalocytosis and hypersegmented neutrophils. Advanced cases may show neutropenia and thrombocytopenia, mimicking aplastic anemia or leukemia. Serum vitamin B12 levels are low, while methylmalonic acid and homocysteine are elevated. Serum iron and folate levels are typically normal or high, with increased lactate dehydrogenase indicating ineffective erythropoiesis. Urinary methylmalonic acid excretion (normal: 0-3.5 mg/24 hours) serves as a sensitive index for B12 deficiency, particularly when serum levels are low-normal. Elevated serum homocysteine can also indicate folate deficiency, homocystinuria, and renal failure.[1]

Vitamin B12 therapy for children varies by age, with dosages ranging from 100 µg to 1000 µg for both oral and parenteral routes, depending on the severity of deficiency. Oral B12 should be taken on an empty stomach, with infants receiving 500 µg and older children 1000 µg, initially daily and then tapering over three months. Parenteral therapy starts with 25 µg daily, escalating to 100 µg, and then 1000 µg weekly as needed, especially for malnourished or severely anemic children. In cases of infantile tremor syndrome, vitamin B12 supplementation is essential, and severe tremors may necessitate additional medications like propranolol or phenytoin.[12,13]

Vitamin B12 deficiency in children is a significant preventable public health problem with potential long-term neurological consequences if left undiagnosed.[14]

Being a predominantly vegetarian region, and also having a high prevalence of severe acute malnutrition and delayed complementary feeding, this study will be pertinent in our region. Hence, the present study is undertaken.

Aims and objectives

Aims and objectives of the study were: to study the various clinical manifestations of vitamin B12 deficiency, and to study the factors affecting vitamin B12 deficiency.

METHODS

This cross-sectional survey was conducted at a tertiary care hospital over 18 months, from 01 August 2022, to 31 January 2024 at Department of Pediatrics, Sangameshwar Teaching and General Hospital, Basaveshwar Teaching and General Hospital affiliated to Mahadevappa Rampure Medical College and Private Hospitals in Kalaburagi, Karnataka, India.

Sample size calculation for a continuous outcome measure was done.

Sample size was 75.

A total of 75 children aged 0-18 years who were admitted to the hospital with vitamin B12 deficiency were included in the study. The sample comprised children with vitamin B12 deficiency either as a stand-alone condition or in conjunction with other diseases. Participants were selected consecutively based on their admission records during the study period.

Upon enrollment, each child's data were recorded using a pre-designed proforma. Written consent was obtained from the parents or guardians before the collection of data. The following variables were systematically evaluated.

Dietary pattern

Information on the child's dietary habits was collected through a detailed dietary recall and assessment. This included dietary intake frequency and types of foods consumed, focusing on sources of vitamin B12.

Appetite

The child's appetite was assessed based on parental reports and clinical observations, noting any deviations from normal eating patterns.

Neurological symptoms

A detailed clinical evaluation was performed to identify any neurological symptoms associated with vitamin B12 deficiency, such as developmental delays, tremors, or other cognitive and motor dysfunctions.

Co-morbid conditions

Any additional health conditions that might affect vitamin B12 levels or be associated with its deficiency were recorded.

Laboratory investigations

Hemoglobin levels

It was measured to assess the severity of anemia.

Peripheral smear

A peripheral blood smear was performed to identify any hematological abnormalities associated with vitamin B12 deficiency.

Vitamin B12 levels

Serum vitamin B12 concentrations were measured to confirm the deficiency.

Platelet count

Platelet counts were recorded to evaluate any related hematological manifestations.

Statistical analysis

Data were analyzed to determine the vitamin B12 deficiency among the study population and to explore its association with various clinical and laboratory parameters. Statistical methods were employed to assess correlations between vitamin B12 levels and variables such as dietary patterns, neurological symptoms, and co-morbid conditions. Descriptive statistics were used to summarize the findings, and inferential statistics were applied to determine the significance of observed associations.

Statistical data will be analysed statistically using IBM statistical package for the social sciences (SPSS) 20.0 version software. For qualitative data analysis, the Chi-square test will be applied for the test of significance.

A p value of <0.05 will be considered as significant.

Inclusion criteria

Children admitted with signs and symptoms of vitamin B12 deficiency were included.

Exclusion criteria

Non-nutritional causes of vitamin B12 deficiency were excluded.

RESULTS

A total of 75 children aged 0-18 years who were admitted to the hospital with vitamin B12 deficiency were included in the study. The sample comprised children with vitamin B12 deficiency either as a stand-alone condition or in conjunction with other diseases. Participants were selected consecutively based on their admission records during the study period.

The study observed that, out of 75 cases, 28 (37.3%) were under 1-year-old, 27 (36%) were between 10 and 18 years old, and 15 (20%) were between 1 and 4 years old. The minimum age of a case was 3 months, while the maximum age was 17 years, with a mean age of 6.16 years which is depicted in Table 1.

Table 1: Age-wise distribution of cases.

Age in years	Number of cases	Percentage
<1	28	37.3
1-4	15	20.0
5-9	5	6.7
10-18	27	36.0
Total	75	100.0
Mean±SD	6.16±6.27	-

Out of 75 study samples; 38 (50.7%) cases were males and 37 (49.3%) of cases were females. Male to female sex ratio was 1.03:1.

Table 2 depicts presenting complaints-wise distribution of cases.

Table 2: Presenting complaints-wise distribution of cases.

Presenting complaints	Number of cases	Percentage
General weakness	20	26.7
Poor appetite	8	10.7
Comorbidities	52	69.3
Failure to thrive	8	10.7

Table 3 depicts distribution of cases based on their dietary history.

Table 4 depicts distribution of cases based on the diet history of the mother.

Figure 1 shows the distribution based on nutritional status among the children.

Figure 2 shows clinical presentation-wise distribution of cases.

Table 3: Distribution of cases based on diet history of cases.

Dietary history	Number of cases	Percentage
Veg	52	69.3
Mixed	11	14.7
Exclusive breastfeeding	12	16.0
Total	75	100.0

Table 4: Distribution of cases based on the dietary history of the mother.

Dietary history	Number of mothers	Percentage
Vegetarians	27	96.4
Mixed	1	3.6
Total	28	100.0

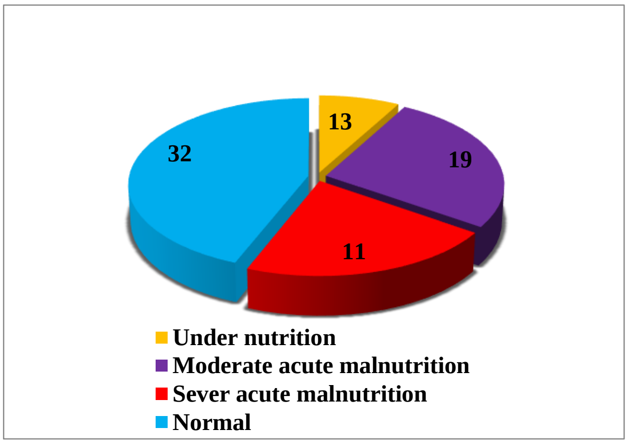

Figure 1: Nutritional status among children.

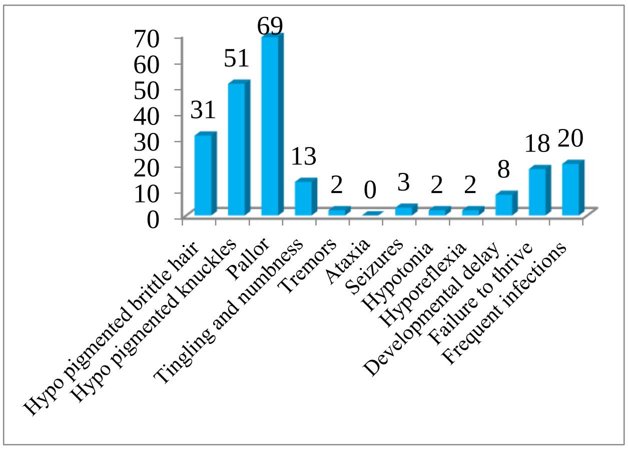

Figure 2: Clinical presentation-wise distribution of cases.

Out of the 75 cases, 31 (41.3%) displayed a microcytic hypochromic picture on the peripheral smear, 24 (32.0%)

exhibited dimorphic anemia, and 12 (16.0%) showed a macrocytic hypochromic picture.

The study observed that the majority of cases, 64 (85.3%), had vitamin B12 levels in the range of 100–200 pmol/l. The mean vitamin B12 level in the children was 165.34 pmol/l which is shown in Table 5.

Table 5: Distribution of cases based on serum vitamin B12 levels in children.

Variables	Number of cases	Percentage
Vitamin B12 levels		
<100	4	5.3
100-200	64	85.3
200-250	7	9.4
Total	75	100.0
Mean±SD	165.34±29.98	-
Vitamin B12 levels in mothers		
≤200	5	41.7
200-250	7	58.3
Total	12	100.0
Mean±SD	246.53±111.9	-

In the study, among 28 mothers, 12 consented to testing for serum vitamin B12 levels. Among these, 5 mothers had vitamin B12 levels ≤200 pmol/l, while 7 mothers had levels between 200 and 250 pmol/l. The mean vitamin B12 level among the tested mothers was 246.53 pmol/l which is depicted in Table 5.

The study found that out of 75 cases, 69 (92.0%) were new diagnoses of co-morbidities, while 6 (8.0%) were pre-existing co-morbid conditions.

Neurological manifestations were observed in 4% (n=3) of cases in the <2 years age group. Tremors, seizures, and hypotonia were each noted in 2 cases. Developmental delay was reported in 2 cases, while hyporeflexia and neuroregression were seen in 1 case each.

The study found that out of 75 cases, 6 (8.0%) had global developmental delays. Of these, 4 cases (66.7%) had pre-existing developmental delays, while 2 cases (33.3%) developed global developmental delay as a result of severe acute malnutrition.

As depicted in Table 6, individuals on a vegetarian diet exhibited a higher prevalence of vitamin B12 deficiency compared to those on a mixed diet, indicating a statistically significant association between a vegetarian diet and vitamin B12 deficiency (p<0.05).

As depicted in Table 7, the study reveals a statistically significant association between mothers' vitamin B12 levels and the vitamin B12 levels in their exclusively breastfed (EBF) infants (p<0.05).

Correlation between vitamin B12 with nutritional status demonstrates a significant inverse correlation between vitamin B12 levels and the severity of nutritional status which is depicted in Table 8.

Table 6: Association of diet and vitamin B12 levels.

Dietary history	Number of cases	Vitamin B12 levels		
		<100	100-200	200-250
Veg	52	3	46	3
Mixed	11	0	7	4
Total	63	3	53	7
X^2 test and p value	X^2_{yates}=8.948, p=0.0114, significant			

Table 7: Association of mother's and EBF infants sr. vitamin B12 levels.

Mother's vitamin B12	Number of cases	Vitamin B12 levels		
		<100	100-200	200-250
≤200	5	1	4	0
200-250	7	0	2	5
Total	12	1	6	5
X^2 test and p value	X^2_{yates}=6.514, p=0.038, significant			

Table 8: Correlation between vitamin B12 with nutritional status.

Nutritional status	Number of cases	Vitamin B12 (mean±SD)
Normal	32	177.63±25.90
Undernutrition	13	172.57±22.55
Moderate acute malnutrition	19	161.49±22.96
Severe acute malnutrition	11	138.41±38.30
Total	75	165.34±29.9
ANOVA test, p value	F=6.018, p=0.001, highly significant	

In infants aged 3–12 months, the mean age was 8.75 months, with 71.4% male. Key issues included 100% pallor, 42.8% failure to thrive, and 42.8% frequent infections. Anemia was widespread, with 46.6% having microcytic hypochromic anemia. Infantile Tremor syndrome was observed in 2 cases (7.1%) magnetic resonance imaging (MRI) revealed hypomyelination in one case. The high prevalence of anemia and infections highlights significant nutritional and health challenges.

In preschoolers aged 1–4 years, the mean age was 1.94 years, with 66.7% male. Key issues included 80% pallor and 40% frequent infections. Nutritional deficiencies were prevalent, with 66.7% having microcytic hypochromic anemia. Infantile Tremor syndrome was observed in 1 case

(6.7%), and MRI showed diffuse cortical thinning in 1 case (6.7%).

In school-aged children (5–10 years), with a mean age of 6.7 years, 100% were underweight and 100% had pallor. Nutritional deficiencies were evident, with 60% having microcytic hypochromic anemia. Notable comorbidities included dengue fever, viral fever, and Down's syndrome, each affecting 20%.

In adolescents aged 11–17 years, with a mean age of 14.2 years, 77.8% were female. The dietary data for adolescents reveals that a significant majority, 81.5%, follow a vegetarian diet, while 18.5% have a mixed diet. 85.2% had pallor and 55.6% had a generalized weakness. Tingling and numbness were seen in 44.4% of cases. Nutritional deficiencies were notable, with 33.3% having microcytic hypochromic anemia and 25.9% underweight. Comorbidities included dengue fever and viral fever (7.4% each), and 22.2% had pancytopenia.

DISCUSSION

The present study shows similarities with previous research by Umasanker et al, Shalini et al, and Goyal et al.[14-16] In presenting symptoms such as generalized weakness and poor appetite, aligning closely with Umasanker et al and Goyal et al.[14-16] It also highlights a broad age range with a notable focus on infants and adolescents. Gender distribution is comparable, though the present study has a slightly more balanced ratio. Dietary patterns show high vegetarian prevalence among mothers, with a similar trend in children. Undernutrition rates are significant across studies, with the present study indicating 65.9% undernutrition and considerable stunting. Physical manifestations such as hyperpigmentation and hypo-pigmented hair are observed, with varying prevalence across studies. Neurological symptoms are notably high in the present study (66.7% with tremors). Laboratory findings indicate lower mean hemoglobin and vitamin B12 levels compared to other studies, emphasizing more severe deficiencies. Overall, the present study reflects consistent trends with previous research but reveals more severe neurological and nutritional deficits.

In comparing the findings of Goraya et al with the present study, the gender distribution is similar, with males predominating in both studies (68.3% versus 66.7%).[17] Exclusive breastfeeding rates are high but slightly lower in the present study (85.7% versus 100%). 100% of the mothers in Goraya et al were vegetarian, while 92.7% of mothers in the present study were vegetarian. The percentage of vegetarian mothers is also high in both studies, though slightly lower in the present study (92.7% versus 100%). Undernutrition is reported in 74% of cases by Goraya et al, compared to 65.9% in the present study.[17] Clinical manifestations such as pallor, were consistently reported at 100% in both studies, though the prevalence of hypopigmented hair and knuckles is slightly lower in the present study. Neurological manifestations show a higher prevalence of hypotonia and tremors in the Goraya et al study (78% and 66.7%) compared to the present study (21% and 4.9%).[17] Laboratory findings indicate anemia in all cases in the present study and 83% of cases in Goraya et al, with macrocytosis being more prevalent in Goraya et al (71% versus 14.6%).[17] Both studies document diffuse cerebral atrophy and delayed myelination on neuroimaging.[18] Overall, both studies highlight severe vitamin B12 deficiency-related issues.

Limitations

Lack of comprehensive biomarker analysis

The study was constrained by the inability to measure additional biomarkers such as methylmalonic acid, homocysteine, and folate, which are crucial for a thorough evaluation of vitamin B12 deficiency and its metabolic effects, especially when vitamin B12 levels are normal but they show clinical features of B12 deficiency.

Small sample size

The limited sample size may affect the generalizability of the results. A larger cohort would enhance the robustness and applicability of the findings regarding vitamin B12 deficiency and its associations with nutritional and dietary factors.

CONCLUSION

This study emphasizes the vital role of vitamin B12 in maintaining the nutritional and neurological health of children and adolescents, with key findings highlighting several vulnerable groups. Vitamin B12 deficiency is particularly prevalent among infants, those with delayed complementary feeding, and adolescents, all of whom are at higher risk for neurological issues, underlining the importance of early detection and intervention. The study also identifies a significant association between vegetarian diet and lower vitamin B12 levels, with vegetarians showing a higher prevalence of deficiency compared to those on mixed diets, suggesting the need for monitoring and possible supplementation. Additionally, maternal vitamin B12 levels have a direct impact on the nutritional status of exclusively breastfed infants, emphasizing the importance of maternal health. Furthermore, an inverse correlation between vitamin B12 levels and the severity of malnutrition was found, with children suffering from acute malnutrition exhibiting significantly lower levels, highlighting the need for comprehensive nutritional assessments and interventions. North Karnataka exhibits the highest prevalence of vitamin B12 deficiency among the pediatric population compared to other regions in India.

Overall, these findings highlight the importance of adequate vitamin B12 intake and monitoring, especially in vulnerable populations such as infants and those on vegetarian diets.

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