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ORIGINAL RESEARCH
Pediatric Hematology and Oncology

Clinical and hematological impact of vitamin B12 deficiency in pediatric patients: A retrospective analysis from a tertiary care center

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ABSTRACT

Objective: Vitamin B12 deficiency is a significant public health concern in pediatrics, as it affects multiple physiological systems, particularly the hematological and neurological systems. This study aims to evaluate the clinical and laboratory characteristics of pediatric patients diagnosed with vitamin B12 deficiency. By conducting a retrospective analysis of a large pediatric cohort, our study provides a comprehensive overview of the clinical presentations and hematological findings associated with vitamin B12 deficiency.

Material and Methods: This retrospective study analyzed cases of children aged 0–18 years with a preliminary diagnosis of vitamin B12 deficiency, identified using the International Classification of Diseases (ICD) code, who were diagnosed at the Pediatric Health and Diseases Clinic of Istanbul Medipol University Mega Hospital between 4 January 2019 and 1 January 2024. A total of 2,303 patients were initially identified. Among these, 133 patients were confirmed to have vitamin B12 deficiency, defined as serum B12 levels <200 pg/mL, in accordance with the Turkish Society of Hematology guidelines. Data were collected from the patients' electronic health records.

Results: The cohort consisted of 53% females and 47% males, with a mean age of 25.6 months. The highest incidence of deficiency was in children under two (87.2%). Common symptoms included pallor (46.6%), decreased appetite (43.6%), and fatigue (36.8%). No significant and strong correlation was noted between vitamin B12 and other hematological parameters.

Conclusion: Vitamin B12 deficiency is prevalent among young children, especially those under two years old. Although our cohort did not observe cases in adolescents, clinicians should remain aware that deficiency can also emerge during adolescence. The study emphasizes the need for comprehensive diagnostic approaches and further research to explore causes and preventive strategies, including dietary influences.

Keywords: Anemia; hematologic tests; nutritional deficiencies; pediatrics; signs and symptoms; statistics; vitamin B12 deficiency.

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Pediatrik hastalarda vitamin B12 eksikliğinin klinik ve hematolojik etkileri: Üçüncü basamak sağlık merkezinden retrospektif bir analiz

ÖZET

Amaç: Vitamin B12 eksikliği, başta hematolojik ve nörolojik sistemler olmak üzere çeşitli fizyolojik sistemleri etkileyerek pediatrik yaş grubunda önemli bir halk sağlığı sorunu oluşturmaktadır. Bu çalışma, vitamin B12 eksikliği tanısı almış pediatrik hastaların klinik ve laboratuvar özelliklerini değerlendirmeyi amaçlamaktadır. Geniş bir pediatrik hasta kohortuna yönelik yapılan retrospektif analiz ile vitamin B12 eksikliğine bağlı gelişen klinik tablolar ve hematolojik bulgulara dair kapsamlı bir bakış sunulmaktadır.

Gereç ve Yöntemler: Bu retrospektif çalışma, 4 Ocak 2019–1 Ocak 2024 tarihleri arasında İstanbul Medipol Üniversitesi Mega Hastanesi Çocuk Sağlığı ve Hastalıkları Kliniği'nde vitamin B12 eksikliği ön tanısı konulan 0–18 yaş arası çocukları kapsamaktadır. Vitamin B12 eksikliği, Türk Hematoloji Derneği'nin kılavuzlarına göre serum B12 <200 pg/mL olarak tanımlanmıştır. ICD tanı kodlarına göre belirlenen 2.303 hastadan, serum B12 düzeyi <200 pg/mL olan ve kriterlere uyan 133 hasta çalışmaya dahil edilmiştir. Veriler elektronik sağlık kayıtlarından elde edilmiştir.

Bulgular: Çalışmaya katılan hastaların %53'ü kız, %47'si erkekti ve ortalama yaş 25,6 ay idi. Eksiklik en sık 2 yaş altı çocuklarda görüldü (%87,2). En yaygın başvuru semptomları solukluk (%46,6), iştahsızlık (%43,6) ve yorgunluk (%36,8) idi. Vitamin B12 ile diğer hematolojik parametreler arasında anlamlı ve güçlü bir korelasyon saptanmadı.

Tartışma: Vitamin B_{12} eksikliği, özellikle iki yaş altındaki küçük çocuklarda yaygındır. Çalışma grubumuzda ergenlik döneminde eksiklik saptanmamış olsa da, klinisyenlerin bu dönemde de eksiklik görülebileceğinin farkında olması gerekir. Bu çalışma, kapsamlı tanısal yaklaşımların uygulanmasının ve potansiyel diyet etkileri de dahil olmak üzere eksikliğin nedenlerini ve önleme stratejilerini araştıracak daha fazla çalışmanın gerekliliğini vurgulamaktadır.

Anahtar Kelimeler: Anemi; belirti ve bulgular; beslenme yetersizlikleri; hematolojik testler; istatistik; pediyatri; vitamin B12 eksikliği.

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INTRODUCTION

For the healthy growth and development of children, it is essential to ensure adequate nutrition. It is well known that significant and long-lasting health complications are prone to develop in case of the deficiency of vital nutrients, such as vitamin B12. Vitamin B12 deficiency is particularly concerning due to its known relation to developmental disorders (1). Vitamin B12, cobalamin, is essential for red blood cell formation, DNA synthesis, and proper functioning of the nervous system (2).

Malnutrition, dietary restrictions, absorption disorders, and maternal conditions are among the factors that contribute to vitamin B12 deficiency by affecting the intake, absorption, and metabolism of this essential nutrient in children (3, 4). Maternal deficiency during pregnancy, as one of the leading causes of vitamin B12 deficiency in children, has increased prevalence among mothers who follow vegan or vegetarian diets with inadequate vitamin B12 supplementation. It is emphasized by several studies that infants of mothers with adequate vitamin B12 intake are better protected against vitamin B12 deficiency during the first 4 months of life. Therefore, infants who have been breastfed by B12-deficient mothers may be prone to deficiency in their first year of life (4, 5). Similar outcomes to a strict vegetarian diet are also seen in infants of breastfeeding mothers with untreated pernicious anemia (4, 6).

Vitamin B12 is important in synthesizing and maintaining healthy red blood cells (RBC). Therefore, lack of this vitamin might lead to various changes in blood parameters and hematological functions. Macrocytic anemia, characterized by increased mean corpuscular volume (MCV), is a common consequence of vitamin B12 deficiency due to impaired DNA synthesis and red blood cell (RBC) maturation. This results in reduced hemoglobin (Hgb) levels and a lower RBC count. Although less prominent, white blood cell (WBC) and platelet (PLT) counts may also be affected. Some studies report neutropenia, while others suggest compensatory mechanisms may lead to normal or elevated PLT levels (7–9). These connections highlight how vitamin B12 is linked to different parameters.

While the prevalence of this deficiency is well documented, there is still a need for more comprehensive studies that evaluate both clinical presentations and associated hematological parameters together. Our study offers a more holistic view of the clinical and hematological manifestations of vitamin B12 deficiency by providing a retrospective analysis with a large cohort of pediatric patients. This research provides valuable insights for healthcare providers in the diagnosis and management of nutritional deficiencies in pediatric populations. Our aim in this research was to evaluate the clinical status and laboratory parameters of pediatric patients with vitamin B12 deficiency who were attending our clinic.

MATERIAL AND METHODS

Study Design

This retrospective cross-sectional study was conducted at the Pediatric Health and Diseases Clinic of Istanbul Medipol University Hospital. It involved children aged 0–18 diagnosed with vitamin B12 deficiency between January 2019 and January 2024. The study design adheres to the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines.

Ethics

This research study was conducted in accordance with ethical principles and was approved by the İstanbul Medipol University Non-Interventional Clinical Research Review Board (number: 147 date: 01.02.2024). All procedures performed in this study conformed to the ethical standards of the Declaration of Helsinki. Patient privacy was ensured by anonymizing all data prior to analysis. As the study was retrospective, obtaining informed consent from individuals was not required.

Data Collection

Data were collected through a retrospective review of medical records for 2,303 pediatric patients who were initially diagnosed with vitamin B12 deficiency. Among these, 2,030 patients underwent serum vitamin B12 testing. Of those tested, 133 patients were confirmed to have vitamin B12 deficiency, defined by serum levels <200 pg/mL, in accordance with the diagnostic criteria established by the Turkish Society of Hematology (10). Patients included in the study had a documented diagnosis of vitamin B12 deficiency based on the relevant ICD codes.

Patients with incomplete data or with laboratory results not meeting the established diagnostic thresholds were excluded from the analysis. The collected data encompassed demographic variables such as age and sex, presenting symptoms at admission, and findings from physical and laboratory examinations. Laboratory parameters included serum vitamin B12 levels, complete blood count (CBC), hemoglobin, hematocrit, mean corpuscular volume (MCV), 25-hydroxyvitamin D, ferritin, and total iron-binding capacity (TIBC) (Fig. 1).

Data Processing

Raw data were processed to identify and address outliers and ensure data quality. Normalization and data transformation techniques were applied as necessary to facilitate analysis.

Summarizing Data

Data were analyzed by employing descriptive statistics. Continuous variables were expressed as mean±standard deviation (SD) while categorical variables were reported as counts and percentages.

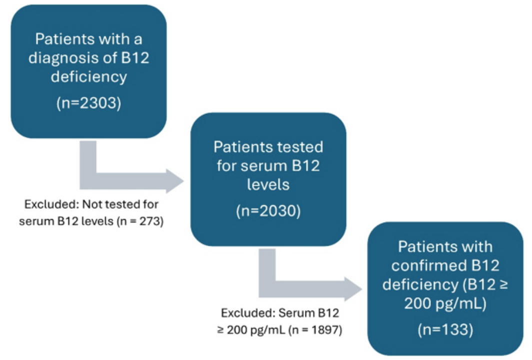

Figure 1. Patient Selection Flowchart for the Study on Vitamin B12 Deficiency.

Flowchart depicting the selection process of pediatric patients diagnosed with vitamin B12 deficiency. Out of 2 303 initially identified cases, 2 030 patients underwent serum B12 testing. Among those tested, 133 patients were confirmed to have vitamin B12 deficiency (serum B12 < 200 pg/mL). Patients with incomplete data or test results not meeting the diagnostic criteria were excluded from the analysis.

Statistical Analysis

Statistical analyses were performed using GraphPad Prism version 9.5.0 (GraphPad Software, San Diego, CA, USA). Assumptions of normality were assessed using the Shapiro-Wilk test, and variance homogeneity was tested using Levene's test. To explore associations between vitamin B12 levels and hematological parameters, two-tailed Pearson correlation coefficients were calculated. A p-value<0.05 was considered statistically significant.

RESULTS

The study population included 53% (n=70) females and 47% (n=63) males, with an average age of 25.6 months (SD: 48.80). Analysis of the age at diagnosis reveals that 87.2% of children diagnosed with vitamin B12 deficiency were under the age of two years.

The majority of cases were diagnosed in children between 6 and 9 months of age, accounting for 46.6% of the total population. Infants under 6 months comprised 12% of the cases, while 16.5% were diagnosed between 9 and 12 months. Children aged 12 to 24 months represented 12%, and those between 2 and 12 years accounted for only 4.4%. Of the total population, 8.27% were diagnosed at 12 years or older (Fig. 2).

The number of vitamin B12 deficiency diagnoses exhibited a fluctuating trend from 2019 to 2023, with the highest number of cases reported in 2019 and the lowest in 2020. From 2021 onwards, the number of diagnoses gradually increased each year (Fig. 3).

Detailed medical histories and physical examination findings, along with hemogram results, blood iron profiles, and vitamin D levels, were obtained from 133 patients. Chief complaints and accompanying symptoms were recorded. The physical examination findings were unremarkable, with no pathological abnormalities observed in any of the cases. Many patients

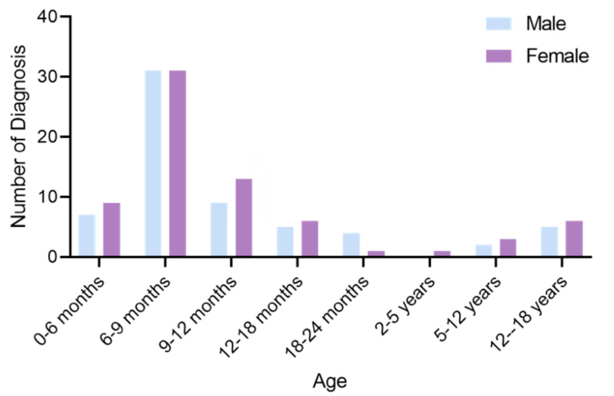

Figure 2. Age at diagnosis of B12 deficiency (in months).

Age distribution at diagnosis among pediatric patients with vitamin B12 deficiency. The majority of cases (62/133, 46.6%) were diagnosed between 6–9 months of age, followed by 9–12 months (22/133, 16.5%) and 0–6 months (16/133, 12%). Diagnosis beyond infancy was less frequent, with 12–18 months (11/133, 8.3%), 18–24 months (5/133, 3.8%), 2–5 years (1/133, 0.8%), 5–12 years (5/133, 3.8%), and 12–18 years (11/133, 8.3%). Male-to-female distribution varied slightly across age groups, with an overall total of 63 males and 70 females. The bars represent the number of diagnosed cases in each age group, with blue indicating males and purple indicating females.

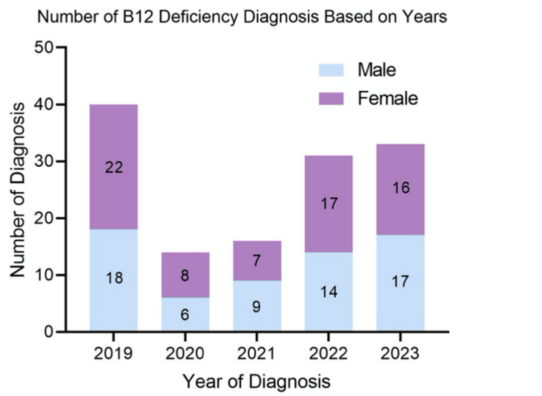

Figure 3. Number of B12 deficiency diagnosis based on years.

This bar graph illustrates the distribution of B12 deficiency diagnoses from 2019 to 2023, categorized by gender. In 2019, there were 40 cases, with 22 females (55%). In 2020, 14 cases were recorded, including 8 females (57%). In 2021, 16 cases were diagnosed, with 7 females (44%). In 2022, there were 31 cases, of which 17 were female (55%). Finally, in 2023, 33 cases were identified, with 16 females (48%). The bars represent the number of diagnoses per year, with males in light blue and females in purple.

exhibited multiple symptoms simultaneously, indicating various clinical manifestations associated with vitamin B12 deficiency. The clinical findings according to their prevalence were as follows: pallor (46.6%) and decreased appetite (43.6%). Other symptoms included fatigue (36.8%), excessive sweating (32.3%), restlessness (11.2%), and fever (6.7%). Gastrointestinal disturbances and other symptoms such as convulsions, hypotonia, erythema, insomnia, pruritus, myalgia, dysuria, and rhinorrhea were less frequently reported, each accounting for less than 10% of the cases (Table 1).

The correlations between B12 and several hematologic parameters were investigated, including Hgb, hematocrit (Hct), RBCs, WBCs, PLT, MCV, TIBC, and ferritin levels. Pearson correlation analysis revealed weak and statistically insignificant positive correlations of vitamin B12 with Hgb, MCV, vitamin D, Hct, WBC, and RBC levels ($p>0.05$, Pearson $r<0.5$). Similarly, weak and statistically insignificant negative correlations of vitamin B12 were observed with ferritin, TIBC, and PLT ($p>0.05$, Pearson $r>-0.5$).

The laboratory results for the study cohort showed a mean hemoglobin level of 11.3±1.3 g/dL and a hematocrit of 33.2±3.7. The mean corpuscular volume (MCV) was 73.8±5.7 fL, indicating anemia with microcytic red blood cells. The mean value for TIBC was 305.5±70.42 µg/dL, and for ferritin, it was 44.8±22.9 ng/mL; not indicating severe iron deficiency (Table 2).

DISCUSSION

It is demonstrated by our study that vitamin B12 deficiency is a particularly significant concern during early childhood. The non-specific clinical findings we observed in the cases highlight the importance of paying close attention to this condition during routine health monitoring of children. Furthermore, the results emphasize the critical need for laboratory testing, especially during high-risk periods, to ensure early detection and intervention.

In our study, the prevalence of a definitive diagnosis in patients with a preliminary diagnosis of vitamin B12 deficiency was 5.77%, which is consistent with previous reports from Türkiye (11) and slightly more common compared to the pediatric population of the United States (12). The male-to-female ratio in the cohort exhibited a relatively balanced distribution, with no statistically significant gender differences observed in the overall prevalence of the deficiency, consistent with previous reports (11, 12). This suggests that vitamin B12 deficiency may affect both genders equally in this population. However, this may be attributed to the specific demographic and regional characteristics of the sample. Furthermore, our hospital is a private institution, and the patients evaluated here are considered to come from socioeconomically advantaged backgrounds compared to the general population. This indicates that the population served by the hospital has greater access to superior nutritional intake and more regular healthcare services. These factors may have influenced the findings and should be taken into account when interpreting the results.

According to the diagnostic criteria, subclinically it affects an important part of the general population, even though clinical deficiency with traditional hematological and neurological symptoms is rather uncommon (13). Our analysis found that among the pediatric population, vitamin B12 deficiency is increased in incidence in children under one year of age, with a considerable number of cases occurring between 6 and 9 months of age. A study conducted in India also aligns well with our findings, reporting high incidence rates of vitamin B12 deficiency in the pediatric population under five (14–16). As supported by the reports, they are particularly prone to develop deficiency under 5 years of age due to their rapid growth and development. Moreover, a retrospective study in Türkiye found that vitamin B12 deficiency peaked not

Table 1. Distribution of admission symptoms

Symptoms of admission	Case (%) (n=91)	Male to female ratio	Mean Age±SD (in months)	Vitamin B12±SD (pg/mL)	Hemoglobin (g/dL)±SD
Pallor	N=62 (46.6%)	35:25	17.7±35.6	171.1±21.8	11.1±1
Decreased Appetite	N=58 (43.6%)	35:23	15.6±29.7	173.6±19.7	11.1±1.1
Fatigue	N=49 (36.8%)	29:20	25.8±51.4	170±20.5	11.2±1.4
Excessive sweating	N=43 (32.3%)	28:15	10.6±14	171.2±20.8	10.9±0.9
Restlesness	N=15 (11.2%)	8:7	6.4±2.7	169.9±18.7	11.8±1
Fever	N=9 (6.77%)	4:5	71.8±71.6	175±16.5	12.6±1.5
Gastrointestinal disturbances (nausea, vomiting, diarrhea, constipation)	N=7 (5.2%)	1:6	55.5±80.5	165±21.1	12.5±1.3
Convulsion	N=1 (0.7%)	0:1	206	196.5	13.1
Others (cough, erythema, insomnia, hypotonia, dysuria, myalgia, headache)	N=25 (18.7%)				

SD: Standard deviation. The table presents the frequency and percentage of cases for each symptom, along with the male-to-female ratio, mean age at admission (in months), serum vitamin B12 levels (pg/mL), and hemoglobin levels (g/dL), expressed as mean±standard deviation.

Table 2. Hematological parameters of the patients

Laboratory values	Mean±SD
Hemoglobin	11.3±1.3 g/dL
Hematocrit	33.2±3.7
MCV	73.8±5.7
PLT	367.3±108.3
RBC	4.5±0.4
WBC	9.3±2.4
TIBC	305.5±70.42
Ferritin	44.8±22.9
25-Hydroxy vitamin D	29.33±13.50

SD: Standard deviation. Hemoglobin levels averaged 11.3±1.3 g/dL, while hematocrit values were 33.2±3.7%. Mean corpuscular volume (MCV) was 73.8±5.7 fL. Platelet (PLT) counts averaged 367.3±108.3×10^9/L, and red blood cell (RBC) counts were 4.5±0.4×10^{12}/L. White blood cell (WBC) counts were 9.3±2.4×10^9/L. Total iron-binding capacity (TIBC) was 305.5±70.42 µg/dL, while ferritin levels averaged 44.8±22.9 ng/mL. Additionally, 25-Hydroxy Vitamin D levels were 29.3±13.5 ng/mL.

only in infants but also in adolescents aged 12–17 years (17). Maintaining adequate vitamin B12 levels is crucial for healthy physical and cognitive development of children, as supported by a randomized controlled trial conducted in India demonstrating that vitamin B12 and folate supplementation enhances functional and critical thinking skills in affected individuals (18). Additionally, it is revealed by a meta-analysis that the deficiency is related to structural and functional brain damage across all age groups, as evidenced by magnetic resonance imaging. Notably, vitamin B12 treatment has been shown to lead to partial or complete recovery in damaged brain regions, highlighting its importance for cognitive function (19).

Our data demonstrate notable fluctuations in the incidence of vitamin B12 deficiency diagnoses from 2019 to 2023. A peak was observed in 2019, followed by a decline in 2020 and 2021, and a subsequent increase in 2022 and 2023. This trend aligns with existing research indicating a significant reduction in pediatric hospital admissions globally and in Türkiye during the COVID-19 pandemic (20, 21). During this period, parental hesitancy to seek medical care, lockdown measures, and healthcare system constraints might have led to decreased routine hospital visits and delayed diagnoses of various conditions. The observed rebound in diagnoses in 2022 and 2023 may therefore reflect a normalization of healthcare access, allowing previously undiagnosed cases to be identified. Additionally, increasing awareness of vitamin B12 deficiency and its clinical implications, alongside dietary habits and socioeconomic changes, may have contributed to this trend. These findings emphasize the importance of continuous nutritional monitoring and proactive screening to ensure early detection and intervention, particularly in vulnerable pediatric populations.

Since the rising trend of diets excluding animal products often results in inadequate vitamin B12 intake (22–25), several studies have shown that even though these diets support a healthier cardiovascular risk profile, plant-based diets increase the risk of deficiencies including vitamin B12 and developmental delays (26). Although this study did not include information on the eating habits of our patients, further studies are required to gain better insight into this increasing pattern and address the issue effectively.

While our initial objective was to investigate potential correlations between vitamin B12 levels and hematologic parameters as early indicators of deficiency, our findings suggest that these parameters may not be reliable diagnostic markers in pediatric patients. This calls for a broader approach in assessing B12 deficiency, incorporating clinical presentation, risk factors, and additional biochemical markers beyond standard hematologic indices.

In this research, we anticipated observing a negative correlation between B12 levels and MCV, since B12 deficiency is recognized as a leading cause of megaloblastic macrocytic anemia. According to the literature, this is primarily caused by pernicious anemia, which results from the inability to absorb B12 due to lack of sufficient intrinsic factor (Komine, 2000; as cited in Nagao & Hirokawa, 2017) (27). Vitamin B12 plays a critical role in the cell cycle, not only by being directly involved in DNA replication and cell division but also by acting as a coenzyme in reactions that convert folic acid into its active form, which is essential for DNA synthesis. Consequently, deficiencies in vitamin B12 disrupt DNA replication and cell division, which can be expected to lead to megaloblastic anemia characterized by increased MCV values (28–30).

Contrary to established knowledge, our study revealed a weak and statistically non-significant positive correlation between MCV and vitamin B12 levels. Moreover, the observed MCV values suggest microcytic anemia, which initially raises suspicion of iron deficiency anemia. However, blood iron panel results (TIBC, ferritin) do not indicate severe iron deficiency anemia, prompting consideration of thalassemia trait as a potential underlying factor. This possibility is further supported by epidemiological data, as thalassemia trait is a recognized public health concern in Türkiye, with an overall carrier rate reported at 2.1% in 2009. Additionally, studies indicate that β-thalassemia carrier rates are notably higher in certain regions, particularly coastal areas, highlighting the need to consider this condition in our patient population (31–34).

Even though deviation from the anticipated association between vitamin B12 deficiency and macrocytic anemia was surprising, this result was also found in a study from Türkiye, which retrospectively analyzed blood hemogram and B12 in 121 individuals—67 with the deficiency and 54 without. This study also reported no significance in the MCV and B12 relationship in both the deficient cohort and the normal cohort (35). Another study in India, which analyzed records from a larger cohort, found that out of nearly 800 individuals with the deficiency, the majority had normal MCV (80–100 fL).

The lack of correlation suggests possible variation in MCV measurements or the impact of additional variables on MCV levels that might not be directly connected to B12. The literature indicates that the reliability of MCV is insufficient to use it as the sole parameter for diagnosing vitamin B12 deficiency. Additionally, when individuals are being evaluated for anemia, MCV is not the only factor to be considered for suspecting B12 deficiency (36, 37).

Additionally, we expected to observe a positive correlation between vitamin B12 and vitamin D, as previous studies have highlighted a potential interrelationship between these two vitamins (38). According to the current literature, anemia may be linked to the regulation of hepcidin and ferroportin pathways, as well as the inhibition of related gene expression in various cells in cases of vitamin D deficiency (39, 40). Studies also suggest that vitamin D supplementation may be beneficial in managing individuals with anemia (39). Therefore, monitoring both vitamin B12 and vitamin D levels is important, particularly in children with chronic conditions and those at risk of anemia, due to their regulatory roles in erythropoiesis. However, in contrast to these findings, the correlation between these two values in our study was neither strong nor significant.

In summary, our research highlights the significant presence of vitamin B12 deficiency in young children and the complex relationship between this vitamin and other nutritional parameters. It also identifies the most common symptoms, which could aid in early recognition. Furthermore, our findings emphasize the importance of parental cooperation during routine hospital visits to ensure that easily detectable issues are not overlooked, as they can significantly impact a child's development. Future research should explore the mechanisms behind the increasing diagnosis of vitamin B12 deficiency, particularly in relation to socioeconomic factors or dietary causes. It is crucial to obtain a detailed nutritional history from both the mother and the child, with treatment initiated based on the underlying cause. As our study was retrospective in design, a comprehensive examination of socioeconomic factors and dietary habits was not feasible. Nevertheless, it is of paramount importance that nutritional patterns, access to food, and other potential risk factors be subjected to thorough evaluation during the patient history in pediatric health assessments. This approach will facilitate the identification of children at risk, particularly those with selective eating habits or limited access to quality nutrition. This allows for the implementation of early intervention and the prevention of deficiencies such as vitamin B12.

Limitations

Our study includes certain limitations. As a retrospective analysis, it is limited by the available data, which may not capture all relevant clinical details. While the study population covered all pediatric age groups, more studies involving long-term follow-up are required to confirm the outcomes and explore the causal functions of vitamin B12 deficiency in greater depth. Future research should aim to collect more detailed and longitudinal data, allowing for a more nuanced understanding of the condition and its long-term effects on pediatric health.

CONCLUSION

Our study underscores the growing recognition of vitamin B12 deficiency throughout childhood and its profound effects on hematologic health and development. Because B12 is vital for cognitive and physical growth, rapid detection—especially in high-risk groups such as infants, young children, and adolescents—is crucial. Healthcare providers should therefore integrate routine serum B12 monitoring into pediatric assessments (particularly under age five), remain alert to non-specific clinical signs, and perform comprehensive laboratory testing. Clinicians should note that, while serum B_{12}<200 pg/mL defines deficiency, levels of 200–300 pg/mL are borderline and still merit careful attention.

Future research must elucidate the factors driving the growing incidence of B12 deficiency, such as shifts in dietary habits, and establish age-appropriate screening and treatment guidelines through a proactive, multidisciplinary approach. Although our study population had healthcare access, many children worldwide do not; ensuring equitable B12 evaluation and intervention for all pediatric patients remains a shared responsibility.

Ethics Committee Approval: The Istanbul Medipol University Non-Interventional Clinical Research Ethics Committee granted approval for this study (date: 01.02.2024, number: 147).

Informed Consent: Written informed consent was obtained from the families of the patients who participated in this study.

Conflict of Interest: The authors declare that there is no conflict of interest.

Financial Disclosure: The authors declared that this study has received no financial support.

Use of AI for Writing Assistance: The authors declare that all scientific content and analysis were performed by the authors, and no artificial intelligence-based tools were used in the preparation of this manuscript.

Authorship Contributions: Concept – FFM, NYS; Design – FFM, BSK; Supervision – FFM, NZÖ; Resource – FFM, BSK, NYS; Materials – NYS; Data collection and/or processing – NYS, FFM; Analysis and/or interpretation – FFM, BSK; Literature search – FFM, BSK, NZÖ; Writing – FFM, BSK, NZÖ; Critical review – FFM, BSK, NZÖ.

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Hasta Onamı: Yazılı hasta onamı bu çalışmaya katılan hastaların ailelerinden alınmıştır.

Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Mali Destek: Yazarlar bu çalışma için mali destek almadıklarını beyan etmişlerdir.

Yazma Yardımı için Yapay Zeka Kullanımı: Yazarlar, tüm bilimsel içerik ve analizlerin yazarlar tarafından gerçekleştirildiğini ve bu makalenin hazırlanmasında yapay zeka tabanlı hiçbir araç kullanılmadığını beyan eder.

Yazarlık Katkıları: Fikir – FFM, NYS; Tasarım – FFM, BSK; Denetleme – FFM, NZÖ; Kaynaklar – FFM, BSK, NYS; Malzemeler – NYS; Veri Toplanması ve/veya İşlemesi – NYS, FFM; Analiz ve/veya Yorum – FFM, BSK; Literatür Taraması – FFM, BSK, NZÖ; Yazıyı Yazan – FFM, BSK, NZÖ; Eleştirel İnceleme – FFM, BSK, NZÖ.

Hakemli inceleme: Harici olarak hakemli.

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