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Original Research Article

Unmasking Megaloblastic Anaemia in Children: Clinical Clues, Haematological Signatures, and Disease Burden in a Tertiary Care Hospital in Tamil Nadu, India

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Abstract

Introduction: Megaloblastic anaemia (MA) is an important cause of macrocytic anaemia and pancytopenia among children in developing countries. Deficiency of vitamin B12 and folate remains a significant nutritional problem in India, particularly among socioeconomically disadvantaged populations. Early diagnosis is essential because MA is potentially reversible with appropriate supplementation.

Aim: To determine the prevalence, clinical presentation, haematological profile, and etiological factors associated with megaloblastic anaemia among children aged 1–14 years attending a tertiary care teaching hospital.

Materials and Methods: This retrospective observational study was conducted in the Department of Biochemistry, Swamy Vivekanandha Medical College Hospital and Research Institute, Namakkal, Tamil Nadu, India, from January 2025 to December 2025. Medical records of children aged 1–14 years diagnosed with megaloblastic anaemia were reviewed. Diagnosis was based on macrocytosis, peripheral smear findings, bone marrow examination, and serum vitamin B12 and folate levels. Demographic, clinical, laboratory, and treatment outcome data were analysed using descriptive and inferential statistics. Statistical significance was considered at $p<0.05$.

Results: Among 524 anaemic children screened, 150 fulfilled the diagnostic criteria for MA, yielding a prevalence of 28.6%. The mean age was 5.2±2.8 years and 52% were males. Pallor (98%), anorexia (85.3%), weakness (72%), irritability (65.3%), and knuckle hyperpigmentation (45.3%) were common clinical manifestations. Macrocytosis was observed in all patients with a mean haemoglobin of 6.8±1.5 g/dL and mean MCV of 102.4±8.2 fL. Pancytopenia was present in 68% of cases. Vitamin B12 deficiency accounted for 78% of patients, folate deficiency for 15.3%, and combined deficiency for 6.7%. Haematological recovery following supplementation occurred in 95.3% of children.

Conclusion: Megaloblastic anaemia constitutes a major cause of nutritional anaemia in children and is predominantly related to vitamin B12 deficiency. Characteristic peripheral smear findings and early biochemical evaluation facilitate prompt diagnosis and effective treatment.

Keywords: Children, Macrocytic anaemia, Megaloblastic anaemia, Pancytopenia, Vitamin B12 deficiency, Folate deficiency.

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Introduction

Anaemia continues to be a major public health challenge worldwide, affecting approximately 1.6 billion individuals, with children constituting one of the most vulnerable groups [1-3]. The World Health Organization (WHO) estimates that nearly 40% of preschool-aged children globally are anaemic [4]. In India, nutritional anaemias remain highly prevalent because of inadequate dietary intake, poverty, recurrent infections, and micronutrient deficiencies [5-6]. Megaloblastic anaemia is characterised by defective DNA synthesis resulting from vitamin B12 and/or folate

deficiency. Impaired nuclear maturation leads to ineffective haematopoiesis and characteristic morphological changes in bone marrow and peripheral blood [7-9]. Clinically, patients present with pallor, weakness, anorexia, growth retardation, recurrent infections, and neurological manifestations. The disease frequently manifests with pancytopenia, creating diagnostic confusion with haematological malignancies and aplastic anaemia [10].

Vitamin B12 deficiency is particularly common in India because of vegetarian dietary habits and socioeconomic factors limiting access to animal-source foods [11]. Folate deficiency contributes further to disease burden, especially among children from nutritionally deprived backgrounds [12-14]. Although several studies have reported megaloblastic anaemia among adults, paediatric data from South India remain limited. Understanding the clinical and haematological spectrum of the disease is essential for timely diagnosis and prevention of complications.

Aim and Objectives

Aim: To evaluate the prevalence and clinicohaematological profile of megaloblastic anaemia among children aged 1–14 years.

Objectives

1. To estimate the prevalence of megaloblastic anaemia among anaemic children.
2. To identify demographic and nutritional factors associated with megaloblastic anaemia.
3. To evaluate clinical manifestations and haematological findings.
4. To assess biochemical deficiencies and treatment outcomes.

Materials and Methods

This retrospective observational study was conducted in the Department of Biochemistry, Swamy Vivekanandha Medical College Hospital and Research Institute, Namakkal, Tamil Nadu, India, from January 2025 to December 2025 after obtaining approval from the Institutional Ethics Committee. Hospital records of children aged 1–14 years diagnosed with megaloblastic anaemia during the study period were reviewed. A total of 524 anaemic children were screened, among whom 150 fulfilled the inclusion criteria.

Inclusion Criteria

Children aged 1–14 years with:

- Haemoglobin below WHO age-specific cut-off values.
- Macrocytic anaemia (MCV >95 fL).
- Hypersegmented neutrophils on peripheral smear.
- Bone marrow evidence of megaloblastic erythropoiesis.
- Low serum vitamin B12 (<200 pg/mL) and/or folate (<3 ng/mL).

Exclusion Criteria

- Thalassaemia syndromes.
- Haemolytic anaemia.
- Leukaemia and marrow infiltrative disorders.
- Drug-induced macrocytosis.
- Chronic kidney disease.
- Incomplete medical records.

Data Collection: Information regarding demographic profile, socioeconomic status, dietary habits, presenting symptoms, physical findings, laboratory investigations, treatment administered, and clinical outcomes was extracted using a structured proforma.

Laboratory Investigations

- Complete Blood Count using automated haematology analyser.
- Peripheral Blood Smear examination.
- Reticulocyte count.
- Serum Vitamin B12 assay by Chemiluminescence Immunoassay.
- Serum Folate estimation.
- Serum Homocysteine.
- Bone marrow aspiration where indicated.
- Liver Function Tests.

Statistical Analysis: Data were analysed using Statistical Package for Social Sciences (SPSS) version 26.0. Continuous variables were expressed as mean±standard deviation and categorical variables as frequency and percentage. Chi-square test or Fisher's exact test was used for comparison. A p-value <0.05 was considered statistically significant.

Results

Among 524 anaemic children screened, 150 were diagnosed with megaloblastic anaemia, yielding a prevalence of 28.6%.

Table 1: Demographic Characteristics of Study Participants

Variable	Frequency (n=150)	Percentage (%)
Male	78	52.0
Female	72	48.0
Age 1–5 years	92	61.3
Age 6–10 years	42	28.0
Age 11–14 years	16	10.7

The majority of patients belonged to the 1–5-year age group and were from low socioeconomic backgrounds.

Table 2: Clinical Manifestations

Clinical Feature	Frequency	Percentage (%)
Pallor	147	98.0
Anorexia	128	85.3
Weakness	108	72.0
Irritability	98	65.3
Knuckle hyperpigmentation	68	45.3
Glossitis	48	32.0
Failure to thrive	45	30.0
Icterus	22	14.7
Neurological manifestations	15	10.0

Pallor was the predominant presenting feature followed by anorexia and weakness.

Table 3: Haematological Parameters

Parameter	Mean ± SD
Haemoglobin (g/dL)	6.8 ± 1.5
MCV (fL)	102.4 ± 8.2
MCH (pg)	32.1 ± 4.5
Pancytopenia (%)	68.0
Neutropenia (%)	63.3
Thrombocytopenia (%)	58.7
Hypersegmented neutrophils (%)	92.0

Macrocytosis and hypersegmented neutrophils were universal diagnostic hallmarks.

Table 4: Etiological Profile and Outcomes

Variable	Frequency	Percentage (%)
Vitamin B12 deficiency	117	78.0
Folate deficiency	23	15.3
Combined deficiency	10	6.7
Dietary deficiency	138	92.0
Malabsorption	8	5.3
Congenital causes	4	2.7
Haematological recovery	143	95.3

Vitamin B12 deficiency emerged as the most common cause of megaloblastic anaemia.

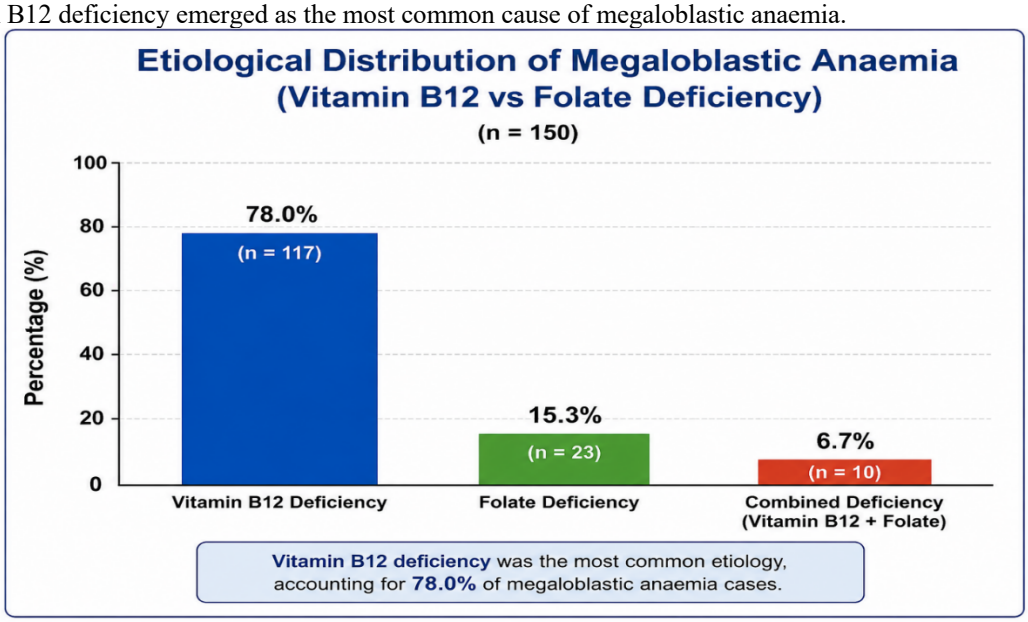

Figure 1: Vitamin B12 vs Folate deficiency distribution

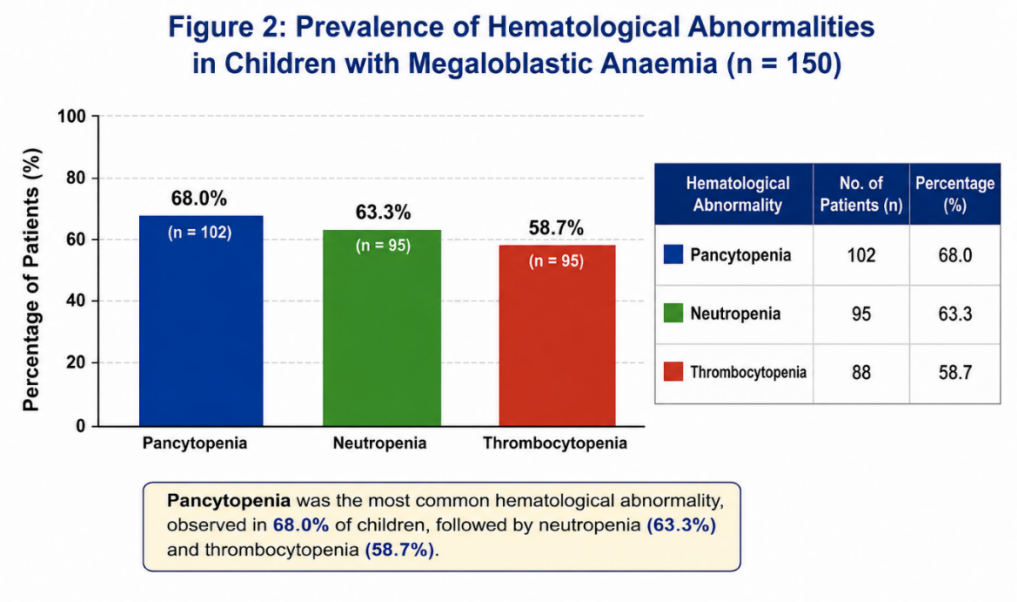

Figure 2: Prevalence of haematological abnormalities in children with megaloblastic anaemia (n=150)

Discussion

The present study demonstrated a prevalence of 28.6% for megaloblastic anaemia among anaemic children, highlighting its substantial contribution to childhood anaemia in South India. Similar prevalence rates have been reported by Gomber et al., Bhatnagar et al., and Premkumar et al., who identified nutritional deficiencies as the principal etiological factor [15-17].

The predominance of children aged below five years is consistent with the rapid growth requirements during early childhood, which increase demand for micronutrients [18]. The slight male predominance observed in the present study was comparable to observations by Kumar et al., although gender distribution varies across regions [19-22].

Pallor was the most frequent clinical manifestation, observed in nearly all patients. Similar findings have been documented by Unnikrishnan et al., who reported pallor in more than 95% of patients with megaloblastic anaemia. Hyperpigmentation and glossitis, classical manifestations of vitamin B12 deficiency, were observed in a substantial proportion of children [23-26].

The mean haemoglobin level of 6.8 g/dL reflects the severe nature of anaemia in this population. Pancytopenia was present in 68% of cases, supporting earlier studies by Bhatnagar et al. and Premkumar et al., which demonstrated ineffective haematopoiesis as a major pathological mechanism [27-28]. Vitamin B12 deficiency accounted for 78% of cases and was significantly associated with vegetarian dietary practices. This finding is consistent with previous Indian studies that have identified dietary inadequacy as the leading cause of cobalamin deficiency [29-30]. A notable finding was the excellent treatment response, with 95.3% of children demonstrating haematological recovery following supplementation. This underscores the importance of early recognition and intervention, particularly in resource-limited settings.

The findings reinforce the need for routine vitamin B12 screening in children presenting with macrocytosis, pancytopenia, or unexplained anaemia. Public health initiatives focusing on nutritional education, dietary diversification, and food fortification may substantially reduce disease burden.

Limitations: This study was limited by its single-centre, retrospective design and relatively small sample size, which may affect the generalizability of the findings. Long-term neurological outcomes could not be assessed due to limited follow-up, and advanced biomarkers such as methylmalonic acid were not measured to confirm subclinical vitamin B12 deficiency.

Conclusion

Megaloblastic anaemia remains a common and potentially reversible cause of childhood anaemia in India. Vitamin B12 deficiency was the predominant etiological factor, largely related to nutritional inadequacy. Pallor, macrocytosis, hypersegmented neutrophils, and pancytopenia were characteristic findings. Early diagnosis and prompt supplementation resulted in excellent recovery. Screening programmes, nutritional counselling, and food fortification strategies are essential for prevention.

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