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Paediatrics Section

Clinical Profile, Aetiological Assessment and Treatment Response of Nutritional Anaemia in Children based on IAP 2022 Guidelines: A Cross-sectional Observational Study

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ABSTRACT

Introduction: Nutritional anaemia remains a significant public health concern in India, particularly affecting children due to inadequate dietary intake and increased physiological demands. The Indian Academy of Paediatrics (IAP) 2022 guidelines provide updated criteria for diagnosis and management of nutritional anaemia in the paediatric population. Despite the high prevalence of nutritional anaemia in India, there is limited data on the clinical profile, aetiological distribution, and treatment outcomes based on these updated guidelines in tertiary care settings.

Aim: To assess the prevalence, aetiological profile, clinical characteristics, and therapeutic response of nutritional anaemia in children aged six months to 14 years based on the IAP 2022 guidelines at Dhiraj Hospital, a tertiary care centre in Vadodara, Gujarat, India.

Materials and Methods: The present prospective interventional study was conducted at the Department of Paediatrics, Dhiraj Hospital, SBKS Medical Institute and Research Centre, Sumandeep Vidyapeeth Deemed to be University, Vadodara, Gujarat, India from January 2023 to June 2024 (18 months). A total of 92 children aged six months to 14 years diagnosed with nutritional anaemia as per IAP 2022 criteria were enrolled. Detailed clinical history, anthropometric measurements, dietary assessment, and laboratory investigations including complete blood count, peripheral smear examination, serum ferritin, vitamin B12, and folate levels were performed. Treatment was initiated as per IAP guidelines and response was assessed at four weeks and three months. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 26.0 with Chi-square test, t-test, and Analysis of Variance (ANOVA) as appropriate. A p-value of <0.05 was considered statistically significant.

Results: The mean age of the study population was 4.82±2.67 years with female predominance (77/92, 83.7%). Iron deficiency anaemia was the most common type observed in 53.3% (n=49) of patients, followed by vitamin B12 deficiency anaemia in 27.2% (n=25), and mixed/dimorphic anaemia in 16.3% (n=15). Majority of children (70.7%, n=65) had moderate anaemia while severe anaemia was observed in only 3.3% (n=3). Urban predominance was noted in 83.7% (n=77) of children, which reflects the catchment area of Dhiraj Hospital, an urban tertiary care centre primarily serving the urban population of Vadodara. Lower-middle socioeconomic status was observed in 72.8% (n=67). Significant risk factors identified included vegetarian diet (81/92, 88%), malnutrition (73/92, 79.3%), delayed initiation of complementary feeding (66/92, 71.7%), and short duration of exclusive breastfeeding (53/92, 57.6%). Treatment response was good (defined as haemoglobin rise ≥1 g/dL or haemoglobin normalisation) in 96.7% (n=89) of patients with mean haemoglobin rise of 1.87±0.54 g/dL at 4 weeks and 2.72±0.68 g/dL at three months (p <0.001).

Conclusion: Iron deficiency anaemia is the predominant type of nutritional anaemia in children, followed by vitamin B12 deficiency. The IAP 2022 guidelines provide an effective framework for diagnosis and management with excellent treatment response rates when combined with dietary counselling and compliance monitoring.

Keywords: Dietary assessment, Haemoglobin, Indian Academy of Paediatrics 2022 Guidelines, Micronutrient deficiency, Paediatric nutrition, Serum ferritin

INTRODUCTION

Anaemia is a global health problem affecting approximately 1.62 billion people worldwide, with the highest burden in developing countries [1]. In India, the National Family Health Survey-5 (2019-21) reported that 67.1% of children aged 6-59 months are anaemic, highlighting the magnitude of this public health challenge [2]. Nutritional anaemia, resulting from deficiencies of iron, vitamin B12, and/or folate, accounts for the majority of anaemia cases in the paediatric population [3].

The Iron Deficiency Anaemia (IDA) is the most common type of nutritional anaemia globally, responsible for approximately 50% of all anaemia cases [4]. The pathophysiology involves depletion of iron stores, followed by iron-deficient erythropoiesis, and finally manifest anaemia with microcytic hypochromic red blood cells [5]. Vitamin B12 deficiency anaemia has gained increasing recognition in the Indian paediatric population, particularly in vegetarian communities, presenting with megaloblastic changes and neurological manifestations [6,7]. Mixed or dimorphic anaemia, characterised by concurrent deficiency of multiple micronutrients, poses diagnostic and therapeutic challenges [8].

The IAP released updated guidelines in 2022 for the diagnosis and management of nutritional anaemia in children [9]. These guidelines incorporate age-specific haemoglobin cut-offs, standardised diagnostic algorithms, and evidence-based treatment protocols. The guidelines recommend haemoglobin cut-offs of <11 g/dL for children 6-59 months, <11.5 g/dL for children 5-11 years, and <12 g/dL for children 12-14 years [9,10]. Key updates in the IAP 2022 guidelines include emphasis on serum ferritin as the preferred initial test for iron deficiency, revised dosing protocols for oral iron therapy (3-6 mg/kg/day of elemental iron), mandatory screening for vitamin

B12 deficiency in vegetarian populations, and a standardised follow-up algorithm with assessment at four weeks and three months to evaluate treatment response [9].

Previous studies from India have documented varying prevalence rates and aetiological patterns of nutritional anaemia in children [11-14]. Kapur D et al., studied iron status of children in Delhi and reported IDA prevalence of 51.5% [11]. Pasricha SR et al., evaluated determinants of anaemia in rural India, while Sinha N et al., documented epidemiological correlates of nutritional anaemia in central India [12,15]. However, most of these studies were conducted before the publication of the IAP 2022 guidelines and did not incorporate the updated diagnostic criteria and treatment protocols. Furthermore, there is limited data from Gujarat, a predominantly vegetarian state where vitamin B12 deficiency may contribute significantly to nutritional anaemia. The present study is novel in that it is among the first to evaluate the clinical applicability and treatment outcomes of the IAP 2022 guidelines in a tertiary care setting, providing evidence on their practical utility in clinical practice. Understanding the regional variations in aetiological patterns and treatment response is crucial for developing targeted intervention strategies [15].

Also, in present study, age group of six months to 14 years was chosen as this period represents the critical window of vulnerability for nutritional anaemia, encompassing the transition from exclusive breastfeeding to complementary feeding (6 months onwards), rapid growth phases in toddlers and school-age children, and the increased nutritional demands of adolescence [3,4]. With this background, the present study was conducted to assess the prevalence, aetiological profile, clinical characteristics, and therapeutic response of nutritional anaemia in children aged six months to 14 years based on the IAP 2022 guidelines at Dhiraj Hospital, a tertiary care centre in Vadodara, Gujarat, India.

MATERIALS AND METHODS

The current prospective interventional study was conducted at the Department of Paediatrics, Dhiraj Hospital, SBKS Medical Institute and Research Centre, Sumandeep Vidyapeeth Deemed to be University, Vadodara, Gujarat, India from January 2023 to June 2024 (18 months). The study was approved by the Institutional Ethics Committee (Approval No: SVIEC/ON/PEDIA/SRP/22050, dated 2022). Written informed consent was obtained from parents/guardians of all participants, and assent was obtained from children above seven years of age. The study was conducted in accordance with the Declaration of Helsinki.

Sample size calculation: The sample size was calculated using the formula: $n=Z^2\times p\times(1-p)/d^2$, where Z=1.96 (for 95% confidence interval), p=0.50 (expected prevalence of iron deficiency anaemia among anaemic children based on previous literature [11]), and d=0.10 (10% absolute precision). This yielded a minimum sample size of 96. Accounting for 10% non-response rate, the required sample size was 106 patients [16]. However, 92 patients who met the inclusion criteria and completed the follow-up period were included in the final analysis.

Inclusion criteria:

- Children aged 6 months to 14 years;
- Haemoglobin <11 g/dL (6-59 months), <11.5 g/dL (5-11 years), or <12 g/dL (12-14 years) as per IAP 2022 guidelines [9,10] ;
- Parents/guardians willing to provide informed consent.

Exclusion criteria:

- Known cases of haemoglobinopathies or congenital haematological disorders;
- Children who received haematinic supplements within the preceding three months;
- History of blood transfusion within three months;
- Chronic infections, malignancies, or chronic kidney disease;
- Haemolytic anaemia.

Study Procedure

All enrolled children underwent detailed clinical evaluation including history of dietary intake, breastfeeding practices, developmental milestones, and presenting complaints. Anthropometric measurements including weight, height, and Mid-Upper Arm Circumference (MUAC) were recorded. Nutritional status was assessed using WHO growth standards and IAP growth charts [17]. Malnutrition was defined using WHO Z-scores: weight-for-age Z-score <–2 SD (underweight), height-for-age Z-score <–2 SD (stunting), and BMI-for-age Z-score <–2 SD (wasting). MUAC cut-off of <13.5 cm for children aged 6-59 months was used as an additional screening criterion [17,18].

Socioeconomic status was assessed using the Modified Kuppuswamy Socioeconomic Scale (2022 update), which classifies families based on education, occupation, and family income into five categories: upper, upper-middle, lower-middle, upper-lower, and lower [19].

Laboratory investigations included complete blood count with red cell indices {Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Haemoglobin Concentration (MCHC), Red Cell Distribution Width (RDW)}, peripheral blood smear examination, reticulocyte count, serum ferritin, serum vitamin B12, and serum folate levels (where available). Complete blood count was analysed using an automated haematology analyser. Serum ferritin was estimated by Chemiluminescent Immunoassay (CLIA) method. Serum vitamin B12 and serum folate levels were measured by Electrochemiluminescence Immunoassay (ECLIA) method. Iron deficiency anaemia was diagnosed based on low serum ferritin (<12 ng/mL) with microcytic hypochromic picture. Vitamin B12 deficiency was diagnosed with serum B12 <200 pg/mL with macrocytic picture. Folate deficiency was diagnosed with serum folate <3 ng/mL. Mixed anaemia was diagnosed when features of both deficiencies co-existed [9].

Severity of anaemia was classified based on IAP 2022 criteria as follows: For children 6-59 months - mild (10.0-10.9 g/dL), moderate (7.0-9.9 g/dL), severe (<7.0 g/dL); for children 5-11 years - mild (11.0-11.4 g/dL), moderate (8.0-10.9 g/dL), severe (<8.0 g/dL); and for children 12-14 years - mild (11.0-11.9 g/dL), moderate (8.0-10.9 g/dL), severe (<8.0 g/dL) [9,10].

Risk factors for nutritional anaemia were assessed based on established literature and included: type of diet (vegetarian/non-vegetarian), duration of exclusive breastfeeding, timing of initiation of complementary feeding, nutritional status, and dietary diversity [3,4,15].

Dietary diversity was assessed using the Minimum Dietary Diversity (MDD) indicator recommended by World Health Organization (WHO) and Food and Agriculture Organization (FAO), which evaluates consumption across seven food groups in the preceding 24 hours. A child consuming food items from ≥4 out of seven food groups was considered to have adequate dietary diversity, while <4 food groups was classified as low dietary diversity [18].

Good treatment response was operationally defined as haemoglobin rise of ≥1 g/dL at four weeks of therapy or normalisation of haemoglobin to age-appropriate levels by three months of treatment. Partial response was defined as haemoglobin rise of 0.5-0.9 g/dL at four weeks, and non-response was defined as haemoglobin rise <0.5 g/dL at four weeks [9].

Treatment Protocol

Treatment was initiated as per IAP 2022 guidelines. For iron deficiency anaemia, oral elemental iron 3-6 mg/kg/day in two divided doses was prescribed for a duration of three months after

haemoglobin normalisation. Vitamin B12 deficiency was treated with parenteral cyanocobalamin 1000 µg intramuscularly weekly for 4 weeks followed by monthly injections, or oral vitamin B12 supplementation in mild cases. Mixed anaemia was treated with combination therapy. Dietary counselling was provided to all families. Follow-up was scheduled at day 7 (for severe anaemia), day 14 (for moderate/mild anaemia), and monthly thereafter until haemoglobin normalisation [9].

STATISTICAL ANALYSIS

Data was entered in Microsoft Excel and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages, while continuous variables were expressed as mean±standard deviation. Chi-square test was used for comparison of categorical variables, while student's t-test and ANOVA were used for continuous variables. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 92 children with nutritional anaemia were enrolled in the study. The mean age of the study population was 4.82±2.67. The demographic and baseline characteristics are presented in [Table/Fig-1].

Characteristic	n	Percentage
Gender		
Female	77	83.7
Male	15	16.3
Residence		
Urban	77	83.7
Rural	15	16.3
Socioeconomic Status (Modified Kuppuswamy)		
Upper middle	8	8.7
Lower middle	67	72.8
Upper mower	17	18.5
Diet Type		
Vegetarian	81	88.0
Non-vegetarian	11	12.0

[Table/Fig-1]: Demographic and baseline characteristics of study population (n=92).

The aetiological distribution of anaemia showed that IDA was the most common type observed in 53.3% (n=49) of patients, followed by vitamin B12 deficiency anaemia in 27.2% (n=25), mixed/dimorphic anaemia in 16.3% (n=15), and folate deficiency in 3.3% (n=3) [Table/Fig-2].

Type of Anaemia	n	Percentage
Iron deficiency anaemia	49	53.3
Vitamin B12 deficiency anaemia	25	27.2
Mixed/dimorphic anaemia	15	16.3
Folate deficiency anaemia	3	3.3
Total	92	100

[Table/Fig-2]: Aetiological distribution of nutritional anaemia (n=92).

The mean serum ferritin, vitamin B12, and folic acid levels across different types of anaemia are presented in [Table/Fig-2a].

Regarding severity of anaemia based on IAP 2022 criteria, moderate anaemia was the most common (70.7%, n=65), followed by mild anaemia (26.1%, n=24) and severe anaemia (3.3%, n=3) [Table/Fig-3].

Risk factor analysis revealed that malnutrition was present in 79.3% (n=73) of children, delayed initiation of complementary feeding (>6 months) in 71.7% (n=66), and short duration of exclusive breastfeeding (<6 months) in 57.6% (n=53) [Table/Fig-4].

Type of anaemia	Serum ferritin (ng/mL) Mean±SD	Serum vitamin B12 (pg/mL) Mean±SD	Serum folate (ng/mL) Mean±SD
IDA (n=49)	6.84±3.21	342.56±124.78	8.12±3.45
Vit B12 Deficiency (n=25)	28.34±12.56	118.42±52.34	7.86±2.98
Mixed (n=15)	9.12±4.56	156.78±68.92	3.24±1.56
Folate Deficiency (n=3)	22.45±8.78	298.34±102.56	2.12±0.78

[Table/Fig-2a]: Mean serum ferritin, vitamin B12, and folic acid levels by type of anaemia (n=92).
The above values are from available data. Serum folate levels were not available in all patients due to logistical constraints

Severity	n	%
Mild	24	26.1
Moderate	65	70.7
Severe	3	3.3

[Table/Fig-3]: Severity of anaemia based on IAP 2022 criteria (n=92).

Risk factor	n	%
Vegetarian diet	81	88.0
Malnutrition	73	79.3
Delayed complementary feeding (>6 months)	66	71.7
Short exclusive breastfeeding (<6 months)	53	57.6
Low dietary diversity score	68	73.9

[Table/Fig-4]: Risk factors associated with nutritional anaemia (n=92).

Treatment response assessment showed excellent outcomes with 96.7% (n=89) achieving good response (haemoglobin rise ≥1 g/dL at 4 weeks or normalisation at 3 months). The mean haemoglobin at baseline was 8.74±1.23 g/dL, which increased to 10.61±0.89 g/dL at four weeks (mean rise 1.87±0.54 g/dL) and 11.46±0.72 g/dL at 3 months (mean rise 2.72±0.68 g/dL). The improvement was statistically significant (p<0.001) [Table/Fig-5].

Time Point	Haemoglobin (g/dL)	p-value
Baseline	8.74±1.23	-
4 Weeks	10.61±0.89	<0.001*
3 Months	11.46±0.72	<0.001*

[Table/Fig-5]: Treatment response-Haemoglobin levels at different time points (n=92).
*Statistically significant (p<0.05); Values expressed as Mean±SD

Factors significantly associated with good treatment response included good treatment compliance (p<0.001), absence of adverse effects (p=0.012), single nutrient deficiency versus mixed deficiency (p=0.024), normal nutritional status (p=0.008), and good dietary diversity (p=0.015).

DISCUSSION

The present study evaluated the clinical profile, aetiological distribution, and treatment response of nutritional anaemia in children based on the IAP 2022 guidelines. Our findings revealed that IDA was the most common type (53.3%), followed by vitamin B12 deficiency (27.2%) and mixed anaemia (16.3%). These findings are consistent with global estimates and previous Indian studies [4,11].

The predominance of iron deficiency anaemia in our study is similar to findings reported by Kapur D et al., who found IDA in 51.5% of anaemic children in Delhi [11]. Similarly, Kotapuri S et al. reported that nutritional anemia was present in 52.08% of hospitalised children, with 94% of affected children demonstrating low serum iron levels [20]. The high prevalence of vitamin B12 deficiency (27.2%) in the present study is notable and reflects the predominantly vegetarian dietary practices in Gujarat. This finding aligns with the study by Kvestad I et al., who reported significant B12 deficiency in Indian children with vegetarian diets [21].

The female predominance (83.7%) observed in the current study differs from some previous studies reporting equal or male

predominance [12,13]. This could be attributed to the referral patterns at our tertiary care centre and the cultural practices of preferential healthcare seeking for male children in some communities. This unusually high female predominance (83.7%) is acknowledged as a potential sampling/selection bias. Being a single-centre hospital-based study, the gender distribution may not be representative of the general population. Possible explanations include referral bias, cultural healthcare-seeking patterns in the study area, and the fact that boys with anaemia may be preferentially treated at primary care level or through private practitioners. This should be considered while interpreting the results of the study. The high proportion of urban residents (83.7%) reflects the catchment area of our hospital, which is an urban tertiary care centre primarily serving the urban population of Vadodara city and surrounding areas.

Malnutrition was present in 79.3% of our patients, highlighting the close association between undernutrition and anaemia. Kumar A et al., reported similar findings with 72% malnutrition prevalence among anaemic children [14]. The high prevalence of vegetarian diet (88%) and its association with both iron and B12 deficiency underscores the need for dietary diversification and supplementation strategies in predominantly vegetarian populations [22].

The treatment response in our study was excellent with 96.7% achieving good response (defined as haemoglobin rise ≥1 g/dL at four weeks or haemoglobin normalisation at 3 months). The mean haemoglobin rise of 1.87 g/dL at four weeks and 2.72 g/dL at three months is consistent with expected response to appropriate haematinic therapy [9,23]. Factors associated with good response included treatment compliance, absence of adverse effects, and normal nutritional status, which are well-established predictors of therapeutic success [24].

The IAP 2022 guidelines provide a systematic approach to diagnosis and management of nutritional anaemia [9]. The present study demonstrates the practical applicability of these guidelines in a tertiary care setting with excellent treatment outcomes. The emphasis on identifying the specific type of deficiency and targeted therapy, combined with dietary counselling, appears to be an effective approach. The strength of the current study lies in the systematic evaluation of all patients using standardised protocols based on the updated IAP 2022 guidelines, comprehensive laboratory workup including serum ferritin, B12, and folate levels, and systematic follow-up with documentation of treatment response. This provides reliable data on the effectiveness of the IAP 2022 guidelines in clinical practice.

Limitation(s)

The study has certain limitations. First, being a single-centre study from a tertiary care hospital, the findings may not be generalisable to the community or primary care settings. Second, the sample size was limited, and larger multi-centre studies would provide more robust data. Third, serum folate levels were not available in all patients due to logistical constraints. Fourth, long-term follow-up beyond three months was not performed to assess sustainability of treatment response and recurrence rates. Finally, dietary assessment was based on recall methods which are subject to recall bias. Additionally, the unusually high female predominance (83.7%) suggests potential selection/referral bias, and the results should be interpreted with caution regarding gender-specific generalisability.

CONCLUSION(S)

IDA is the predominant type of nutritional anaemia in children aged 6 months to 14 years, followed by vitamin B12 deficiency anaemia. The high prevalence of vitamin B12 deficiency in the predominantly vegetarian population of Gujarat highlights the need for awareness and targeted supplementation. The IAP 2022 guidelines provide an effective framework for diagnosis and management of nutritional anaemia with excellent treatment response rates when combined with dietary counselling and compliance monitoring. Early identification of at-risk children and implementation of preventive strategies including dietary diversification and appropriate supplementation are essential to reduce the burden of nutritional anaemia.

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