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Clinical, Hematological Parameters and Social Determinants of Nutritional Anaemia in Paediatric Patients: A Prospective Observational Study

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ABSTRACT:

Introduction: Nutritional anaemia is a global health concern, particularly in developing countries, affecting millions of children. It is primarily caused by deficiencies in iron, vitamin B12, and folate, leading to reduced red blood cell numbers. In India, 58.4% of children aged 6 to 59 months are anaemic, with factors like poor dietary intake, frequent infections, and socio-economic factors contributing to the high prevalence. Clinical manifestations include pallor, fatigue, and poor growth.

Aims and Objectives: The study aims to estimate nutritional anaemia prevalence in children aged 6-14, study clinical and hematological parameters, identify social determinants, and determine treatment outcomes.

Material and Methods: A prospective observational study was conducted on 100 children aged 6 months to 14 years at Dhanalakshmi Srinivasan Medical College and Hospital in Perambalur District, Tamilnadu. The children were assessed for nutritional anaemia following IMNCI guidelines. The study documented the findings on a structured questionnaire. If symptoms were present, blood investigations were conducted, including CBC, peripheral smear, reticulocyte count, CRP, iron profile, and stool occult blood. Children with microcytic hypochromic anaemia were given oral iron syrup for three months, followed by hemoglobin and reticulocyte count. If peripheral smear showed macrocytic anaemia, serum vitamin B12 and folic acid as says were conducted. If folic acid deficiency was found, oral supplementation was given.

Results: The median age of the children was 30 (IQR – 60) months and majority 53% were male. Around 35% had mild anaemia, 59% moderate, and 6% severe. Peripheralsmear examination revealed 55% normocytic normochromic, 33% normocytic hypochromic, and 92% microcytic hypochromic anaemia. The mean baseline hemoglobin levels were 9.48±1.26 g/dL, with an increase after oral folic acid supplementation. The mean hemoglobin levels were significantly higher between the first and third months of follow-up visits. The mean reticulocyte count was higher during follow-up visits, with a difference of less than 0.05. The study highlights the importance of addressing anaemia in children.

Conclusion: The study evaluated pediatric nutritional anaemia in children aged 12-60 months. Moderate anaemia was the most common, with symptoms like lethargy and

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dizziness. Examination revealed pallor, glossitis, cheilitis, and hepatosplenomegaly. Peripheral smear showed microcytic hypochromic anaemia. The study emphasizes the importance of early detection and treatment for improved clinical outcomes and overall health.

INTRODUCTION

Nutritional anaemia is a significant public health concern worldwide, especially in developing countries. It is a 'condition where a deficiency of essential nutrients, particularly iron, vitamin B12, and folate, leads to a reduction in the number of red blood cells or hemoglobin in the blood [1]'. This condition can severely impact the growth, development, and overall health of children. In India, nutritional anaemia isa prevalent issue, affecting millions of children and contributing to a high burden of morbidity and mortality.

Anaemia is defined by the World Health Organization (WHO) as a hemoglobin concentration lower than the established cut-off for age and sex. For 'children aged 6 to 59 months, anaemia is defined as a hemoglobin level less than 11.0 g/dL, while for children aged 5 to11 years, it is less than 11.5g/dL, 12 to14 years, it is less than 12g/dL'. Among the various types of anaemia, nutritional anaemia is the most common, primarily resulting from deficiencies of iron, vitamin B12, and folate [2].

Iron deficiency anaemia (IDA) is the predominant type of nutritional anaemia, accounting for approximately 50% of all anaemia cases globally. Iron is crucial for the production of hemoglobin, and its deficiency leads to reduced oxygen-carrying capacity of the blood, manifesting as fatigue, weakness, and impaired cognitive and physical development in children [3]. Vitamin B12 and folate deficiencies, although less common, are also significant contributors to nutritional anaemia. These vitamins are essential for DNA synthesis and red blood cell production, and their deficiency This can lead to megaloblastic anaemia, which is a condition of having both abnormally large and immature red blood cells [4].

Nutritional anaemia is alarmingly prevalent among people in India. According to NFHS-4, it is estimated that approximately 58.4% of children aged between 6 and 59 months were anaemic [5]. Factors such as poor dietary intake, frequent infections, and socio-economic determinants such as poverty, illiteracy, and lack of access to healthcare have contributed to such a relatively high prevalence.

Several studies have highlighted the burden of nutritional anaemia in children and the causes leading to such a high prevalence rate. A cross-sectional study conducted in rural India showed that 74.3% of children between 6 months to 5years suffered from anaemia with iron deficiency as the main cause [6]. A study in the urban slums of Delhi reported a prevalence of 59.2%, and it highlighted the socio-economic factors in the causation of anaemia [7].

Nutritional anaemia in children shows clinical presentation in the form of pallor, fatigue, irritability and poor growth. Hematological abnormalities generally include reduced hemoglobin levels, reduced MCV, and reduced MCH. Hypochromic microcytic anaemia is predominantly related to iron deficiency anaemia while vitamin B12 and folate deficiency is associated with megaloblastic anaemia with high MCV [8].

The factors that cause nutritional anaemia are multifaceted. Among them, dietary intake in low security, lack of nutrition education, and cultural dietary practices are the major ones. Infections like malaria, helminthiasis, and chronic diseases sometimes lead to anaemia due to blood loss, haemolysis, or impaired nutrient absorption. Besides, other socio-economic risks of anaemia include lower family income, illiterate parents and limited access to health-care services are also among the risk factors of anaemia [9].

MATERIALS AND METHODS

Study Design

A Prospective observational study to estimate the prevalence of nutritional anaemia, its clinical and hematological parameters and to determine the treatment outcome of nutritional anaemia in children between 6 months to 14 years of age attending pediatric OPD at Dhanalakshmi Srinivasan Medical College and hospital from December 2022 to June 2024.

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Sample Collection

According to Naik R. R. K [10] et al study, considering the prevalence of the prevalence of anaemia among children aged 6 months-14 yearsas52% with a precision of 10% and 95% confidence interval, the sample size is calculated as-

$$N = Z^2_{1-\alpha/2} * p * (1 - p) / d^2$$

Z1-α/2 - two tailed probability for 95% confidence interval =1.96

p (%)- prevalence of the anaemia among children aged 6 months-14 years = 0.5

d (%)-precision oral low able error for the prevalence of anaemia among children aged 6 months-14 years = 0.1

N=1.96^2 *0.52* (1-0.52)/0.1^2 N = 95.88

Thus, the total sample size required for the study is 100.

Inclusion Criteria

- Children in the age group of 6 months to 14 years with haemoglobin levels less than the cut-off values for the age as per WHO guidelines

Exclusion Criteria

- Child <6 months and >14 years of age.
- Children of parents who do not give consent for the study.
- Children of parents who are not willing for follow up.
- Children with Chronic diarrhea.
- Children with renal disease.

Methodology

After getting permission from the institutional Ethics committee, children attending pediatric OPD were assessed for signs and symptoms of nutritional anaemia as per IMNCI guidelines [11]. The history and examination findings were documented on a structured questionnaire. If signs and symptoms present, such children will undergo blood investigations –CBC, peripheral smear, reticulocyte count, CRP, iron profile and stool occult blood. Children with microcytic hypochromic anaemia will be given oral iron syrup in the dose of 3mg/kg/day once daily for 3 months and follow up will be done at the end of 1st and 3rd month.

During follow up, hemoglobin and reticulocyte count was done. If peripheral smear shows macrocytic anaemia, serum vitamin B12 and folic acid assay will be done. Depending upon serum assay reports, if folic acid deficiency was found, those children were given oral folic acid supplementation.

Dose of folic acid:

- 7 months to 13 years—1mg/day for 2–3weeks, then 0.1–0.5mg/day;
- >13 years—1 mg/day for 2–3 weeks, then 0.5mg/day

If Vit B12 deficiency was found, those children were given Vitamin B12 supplementation

- 500–1,000 μg/day orally daily for 4–6 weeks, then once a week (or)
- 1,000 μg/day intra muscular/intravenous for 2 weeks or thrice weekly for 2 weeks followed by weekly for another six doses till hematocrit returns to normal.

If there is no improvement in hemoglobin level, other causes were ruled out.

Blood Sample Collection:

- Blood samples were collected under strict a septic pre cautions.
- About 2 mL of blood was collected in EDTA tube for complete blood count and peripheral smear examination.
- Around 3 mL of blood was collected in 2 separate serum containers-one container was used for spectrophotometric assay of serum iron, TIBC, serum ferritin and the other container for assessment of Vitamin B12and folic acid by chemi luminescent assay.

Stool Sample Collection:

- Patient was instructed to eat a well-balanced diet including fiber such as cereal, fruits and vegetables.
- Red meat and excess of vitamin C and iron supplements more than 250mg per day were avoided 3 days before collection of samples.
- Stool was collected in a separate container.

Laboratory Techniques:

Complete blood count was done using automated cell counter from Beckman Coulter with trilevel Quality control from Bio-Rad for measuring the following values such as haemoglobin, red blood count, white cell count, PCV, MCV, MCH, MCHC, RDW, MPV and platelet count.

A peripheral blood smear was prepared, stained using Leishman stain and examined under the microscope. Reticulocyte count was calculated manually after supra vital staining. Serum iron and serum unsaturated iron binding capacities (UIBC) were quantitatively determined on Roche/Hitachi Cobas c 311 systems using spectrophotometric immune-turbidimetric assay. TIBC was derived from the sum of serum iron and UIBC.

Statistical Analysis:

The data were entered using Microsoft Office Excel 2013 and analysed using SPSS software version 17.

Descriptive Statistics

Shapiro-Wilk test was used to find the normal distribution. Continuous variables follow normal distribution like age was expressed as mean and standard deviation. Continuous variables not following normal distribution were expressed as median and Interquartile range. Description of categorical variables like Age Category, Sex Distribution, Classification of anaemia, General History distribution, Gestational age at birth, Dietary habit distribution, Socio economic class, General and systemic examination, Peripheral smear examination report. CRP and stool occult blood report distribution was expressed as frequency and proportion.

Test of Significance

Repeated measures ANOVA were used for Hemoglobin estimation before and after intervention. Paired t test was used to compare reticulocyte count estimation before and after intervention. Chi square test was employed to compare the distribution of qualitative variables between the groups. All tests were two tailed and results were considered statistically significant if the p-value is <0.05 at 95% confidence interval.

Ethical Consideration

Ethical principles such as respect to the patient, beneficence and justice were strictly adhered. Ethical committee approval was obtained before starting the study. The approval to conduct the present study was obtained from the Institutional Ethical Committee (IECHS/IRCHS/NO:260). Confidentiality of the study participants was maintained throughout the study.

RESULTS

The median age of the children was 30 (IQR – 60) months. The minimum age reported was 6months and the maximum age observed was144 months. Majority of the participants belong to the age category more than 12 to 60 months which is 26% as in Figure 1. Out of 100 children, 53 (53%) were males and 47(47%) were females as in table 1.

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Table 1. Gender Distribution Among Study Population

Gender	Number	Percentage
Male	53	53 %
Female	47	47 %
Total	**100**	**100 %**

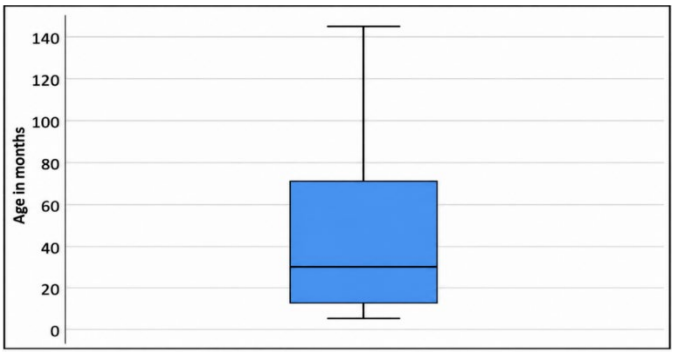


Figure 1: Box whisker diagram shows age distribution among study participants

Among 100 children, 35 (35%) had mild anaemia, 59 (59%) had moderate anaemia and 6 (6%) had severe anaemia as in table 2.

Table2: Classification of anaemia based on haemoglobin levels

Classification of anaemia	Frequency	Percentage
Mild anaemia	35	35.0 %
Moderate anaemia	59	59.0 %
Severe anaemia	6	6.0 %
Total	**100**	**100.0 %**

Out of 100 children, 26 % had a history of lethargy, 23% had easy fatigability, 26 % had dizziness, 12% had breath lessness, 1% had chest pain, 13% had irritability, 19% had PICA, 24% had passing worms in stools, 3% children's reported poor school performance and 3% had blood in stools as given in figure 2.

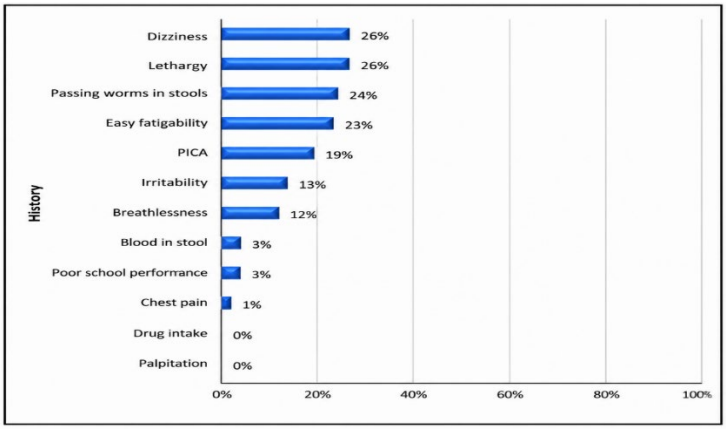


Figure 2: Bar Diagram shows general history distribution among study participants

On examination all children had pallor, 1 % had clubbing, 16% had lymphadenopathy, 20% had glossitis, 20% had cheilitis, 27% had Koilonychia, 27% had leukonychia, 4% had hemic murmur and 22% had hepatosplenomegaly shown in figure 3.

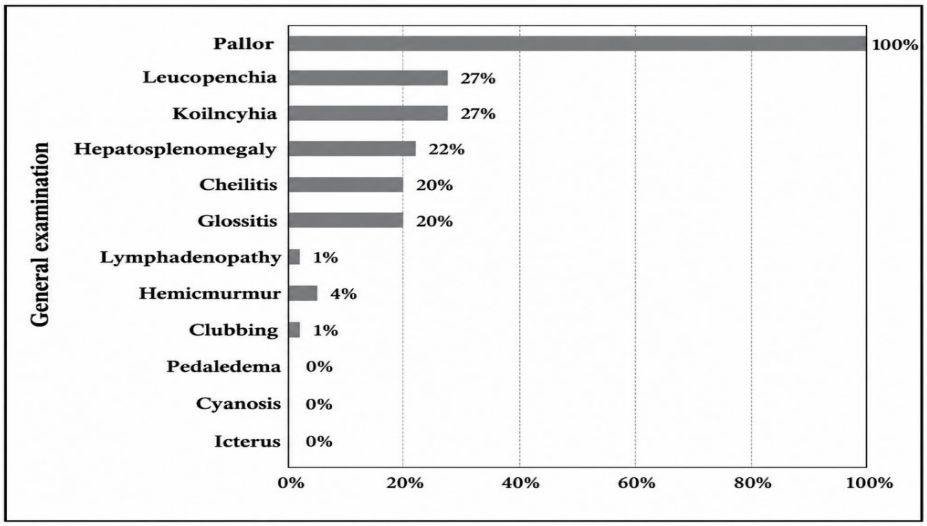


Figure 3: Bar Diagram shows General and systemic examination among study participants

The mean baseline hemoglobin level among children were 9.48±1.26g/dL, The mean follow up first month hemoglobin level was 10.55 ± 1.22 g/dL and the mean follow up third month hemoglobin level was 11.55 ± 1.20 g/dL. The mean first- and third-month hemoglobin level was increased after getting oral folic acid supplementation and it was significant with the p value of 0.001as in figure 4.

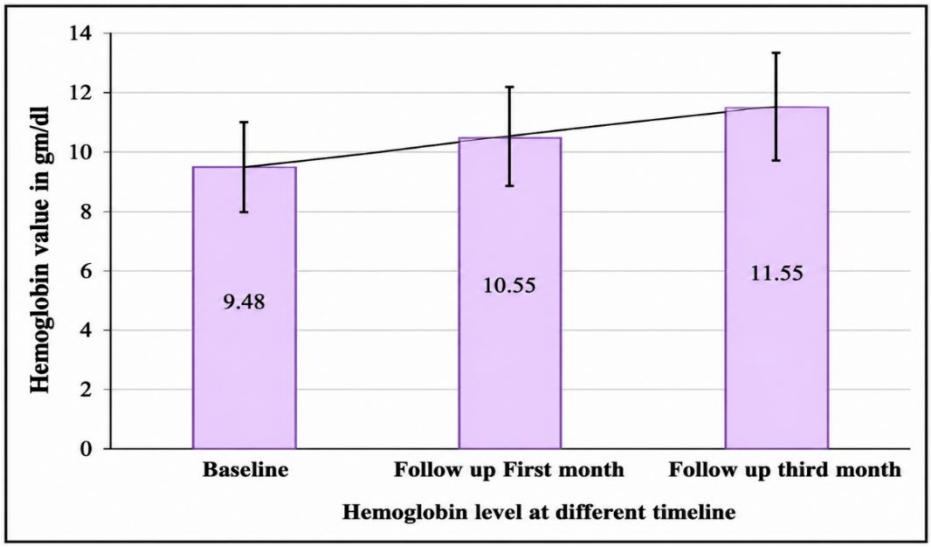


Figure 4: Error bar diagram shows Hemoglobin estimation before and after intervention

There is significant increase in hemoglobin level observed between first and third month follow up hemoglobin level when compared to base line hemoglobin level with the p value less than 0.05. The mean hemoglobin level was significantly higher in third follow visit when compared to first month follow up visit and it is statistically significant with the p value shows less than 0.05.

DISCUSSION

Nutritional anaemia, particularly iron deficiency anaemia, remains a significant public health issue among pediatric populations in developing countries. This prospective observational study aimed to evaluate the clinical and hematological parameters in pediatric patients diagnosed with nutritional anaemia. The results provide a comprehensive over view of the demographic

distribution, general history, gestational history, feeding practices, dietary habits, socioeconomic status, general and systemic examination findings, peripheral smear examinations, blood investigation reports, CRP and stool occult blood results, and the impact of intervention on hemoglobin and reticulocyte counts.

Age Distribution

In the present study, the majority of the pediatric patients with nutritional anaemia were in the age category of more than 12 to 60 months, comprising 47% of the study population. This finding is consistent with previous studies indicating that children in this age group are at a higher risk for developing nutritional anaemia due to rapid growth and increased nutritional requirements. For instance, a study by Pasricha et al [12] also reported a high prevalence of anemia in children under five years of age, with a peak in the 1-3 years age group.

Gender Distribution

The gender distribution in our study showed a slightly higher prevalence of anaemia in males (53%) compared to females (47%). This aligns with the findings of Magnus etal[1], which reported a similar male predominance in pediatric anaemia cases. The slight male predominance could be attributed to cultural and dietary practices that may Favor male children in some regions.

Classification of Anaemia

In the present study categorized anaemia based on hemoglobin levels into mild (35%), moderate (59%), and severe (6%). The majority of children had moderate anaemia. This distribution is comparable to the findings of Patrick et al [13], which also reported a higher prevalence of moderate anaemia in their study population. The high prevalence of moderate anaemia suggests a significant public health issue, indicating the need for targeted interventions to address moderate anaemia to prevent progression to severe stages.

General History

Common symptoms observed in our study included lethargy (26%), easy fatigability (23%), and dizziness (26%). These symptoms are typical manifestations of anaemia and are corroborated by the study conducted by Sowmitra et al [14], which reported similar prevalence rates of these symptoms in anaemic children. Additionally, 19% of our study participants had PICA, which is consistent with the findings of Pallavi et al [15], who reported PICA as a common behaviour in anaemic children due to iron deficiency.

Gestational Age at Birth

In this study, 93% of the children were born at term, while 7% were pre term. This distribution is in line with the study by Catherine [16], which reported a higher prevalence of anaemia in term infants compared to preterm infants. However, the role of gestational age in the development of nutritional anaemia needs further investigation as preterm infants are also at risk due to their higher nutritional needs and potential feeding difficulties.

Duration of Exclusive Breast feeding

The mean duration of exclusive breast feeding among the study participants was found to be 5.57 ± 1.20 months, with a range from 2 to 9 months. However, some deviations from this ideal were observed, with some infants being exclusively breastfed for as little as 2 months. These variations can have significant implications on the nutritional status and hematological health of infants. Studies have shown that prolonged exclusive breast feeding beyond six months can reduce the risk of infections and improve overall health outcomes in infants [17].

Time of Introduction of Complementary Feeding

The introduction of complementary feeding among the participants had a mean time of 7.00 ± 0.83 months. This timing aligns well with global guidelines suggesting the introduction of complementary foods around six months while continuing breast feeding. Early or delayed introduction of complementary foods can affect growth and nutritional status. For instance, introducing complementary feeding too early may lead to increased morbidity due to infections, while delaying it could result in nutrient deficiencies [18].

Time of Introduction of Artificial Feeds

The study observed that the mean time for introducing artificial feeds (cow's milk/formula feeds) was 6.86 ± 1.37 months. The range observed was from 3 to 12 months. Early introduction of cow's milk, particularly before the age of one year, is not recommended as it may lead to iron deficiency anaemia due to low iron content and poor iron bioavailability in cow's milk [19]. The observe dearly introduction in some cases (as early as 3 months) could potentially contribute to the development of nutritional anaemia.

Dietary Habits

A significant majority of the children (91%) in the study were non-vegetarian, while only 9% were vegetarian. The dietary patterns can influence the type and bio availability of nutrients the children receive. Non-vegetarian diets typically provide more bio available iron compared to vegetarian diets, which can help in preventing anaemia. However, the type of meat and the method of preparation also play a crucial role in the nutritional value of the diet [20].

Socio-Economic Status

The socio-economic status of the participants pre dominantly belonged to class II (66%) and class III (33%), with only one participant from class I. Socio-economic status is a crucial determinant of health outcomes, including nutritional status. Lower socio-economic status is often associated with poorer dietary diversity and higher risk of nutritional deficiencies [21]. The predominance of participants from lower socio-economic classes in this study might have influenced the prevalence of nutritional anaemia observed.

General and Systemic Examination

In the present study, all 100 pediatric patients with nutritional anaemia exhibited pallor, which is a hallmark sign of anaemia. Similar findings were reported by Haleemath et al [22]. (2017), who found that 100% of anaemic children showed pallor in their study. Clubbing was present in 1% of our study participants, aligning with findings by Gomber et al [23]. (2017), who noted a low prevalence of clubbing in their cohort. Lymphadenopathy was observed in 16% of our participants, which is consistent with the results from a study by Deshmukh et al [24]. (2015), where 14% of children had lymphadenopathy. Glossitis and cheilitis were both present in 20% of the children, echoing the findings of the study by Anjana et al [25]. which reported similar prevalence rates.

Koilonychia and leukonychia were noted in 27% of our participants, aligning with observations made by Priyanka et al [26]. Who found that these nail changes are common in children with iron deficiency anaemia. Hemic murmur was present in 4% of our participants, a finding corroborated by Ekta et al [27]. Who reported a 5% prevalence. Hepatosplenomegaly was observed in 22% of the children, consistent with the findings of Shally et al [28]. where 20% of anaemic children had hepatosplenomegaly.

Peripheral Smear Examination

Peripheral smear analysis revealed that 92% of our participants had microcytic hypochromic anaemia, 5% had normocytic normochromic anaemia, and 3% had normocytic hypochromic anaemia. These results are in line with the findings of Ekta et al [27]. (2012), who reported a high prevalence of microcytic hypochromic anaemia in pediatric patients. The dominance of microcytic hypochromic anaemia is indicative of iron deficiency, which is the most common cause of nutritional anaemia in children, as supported by the study conducted by Samuel et al [29]. (2013).

Blood Investigation Report

The baseline mean hemoglobin level in our study was 9.56 ± 1.25 g/dL, with a range of 4.7 to 11.4 g/dL. These values are comparable to those reported by Emily et al [30]. who also reported similar hemoglobin levels in anaemic children. The mean PCV, MCV, MCH, MCHC, and RDW values in our research were consistent with the findings of Patrick et al [13] as they reported similar hematological parameters in their cohort of anaemic children.

The mean serum iron, TIBC, serum transferrin, transferring saturation and serum ferritin values in the present study are similar to the values of the Cappellini et al [31]. This suggests that iron status and iron metabolism are the same in pediatric patients with nutritional anaemia.

CRP and Stool Occult Blood Report

CRP was positive in 41% of our participants, which depicted an inflammatory response as was also the case in study Miguel et al [32]. The stool occult blood was absent in all the participants, which ruled out gastrointestinal bleeding as a cause of anaemia as also observed by Rockey et al [33] in his study.

Estimation of Hemoglobin and Reticulocyte Count Before and After Intervention

The mean hemoglobin levels have increased significantly from baseline (9.48 ± 1.26g/dL) at first month (10.55 ± 1.22 g/dL) and third months after intervention with oral folic acid supplementation. The results are in agreement with those of Palika et al [34]. (2019), who showed statistically significant improvement in the hemoglobin levels after nutritional intervention.

Similarly, the mean reticulocyte count increased significantly from 0.47±0.21% at baselineto0.61±0.19%at follow-up, indicating an effective response to treatment [35]. This finding is in line with the study conducted by Christian et al [36]. (2020), which also observed a significant increase in reticulocyte counts post-intervention.

CONCLUSION

This study evaluated clinical and hematological parameters in children with nutritional anaemia. Most of the children were more than 12 to 60 months old, and average age was42.91 months. Both genders were almost equally distributed. Moderate type was present in the majority (59%), mild type in 35%, and in one of the six children, anaemia was severe. General symptoms observed were lethargy, dizziness, and easy fatigability. Examination revealed that all the children had pallor apart from other notable findings like glossitis in 20%, cheilitis in 20%, and hepatosplenomegaly in 22%. Peripheral smear was predominantly mounted by microcytic hypochromic anaemia. Mean pre-treatment hemoglobin was at 9.56g/dL; however, after the treatment it has been improved at 11.55 g/dL on third-month follow-up. This improvement of hemoglobin along with a marked increase in reticulocyte count in deed shows a good response to oral folic acid administration. The study focuses on the early and appropriate diagnosis of nutritional anaemia through timely treatment to produce better clinical outcomes and general health of children.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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