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Hematological and Biochemical Profile of Severely Acutely Malnourished Children Aged 6 to 59 Months upon Admission to the CRINE, Regional Hospital of N'Zerekore, Guinea

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Abstract

Introduction: Malnutrition is a major public health problem, particularly in developing countries where it affects children's growth and development. In Guinea, the high prevalence of severe acute malnutrition (SAM) is frequently accompanied by anemia, exacerbating child morbidity and mortality. This study aimed to evaluate the hematological and biochemical profiles associated with anemia in malnourished children aged 6 to 59 months admitted to the Center for Rehabilitation and Internal Nutritional Education (CRINE) at the regional hospital of N'Zerekore. **Methods:** A descriptive cross-sectional study was conducted from April to July 2024 on 49 severely malnourished children. Anthropometric, hematological (hemoglobin, hematocrit, platelets), and biochemical (blood glucose, ALT and AST transaminases, creatinine) data were collected and analyzed using Mindray BC-30S and BS-230 automated analyzers. The values were compared to WHO reference standards, and statistical correlations were established at a significance threshold of $p < 0.05$ and ANOVA statistical analyses on R were performed. **Results:** Of the 49 children studied, 53% were girls and 47% were boys, with a predominance of the 12–23 months age group. Mean hemoglobin and hematocrit levels were significantly below normal ($p < 0.0001$), confirming severe anemia. A strong correlation was ob-

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served between these two parameters ($p < 0.0001$). The platelet profile was heterogeneous, 41% of children had normal platelet counts 51% thrombocytopenia and 8% thrombocytosis. Biochemically, elevated transaminases were observed, indicating probable liver dysfunction, while creatinine levels remained generally normal. **Conclusion:** Severe acute malnutrition is accompanied by marked hematological and biochemical disorders, indicating anemia and possible liver damage. These findings underscore the need for integrated nutritional and medical care, including regular biological monitoring and the promotion of a diversified diet from weaning onwards, in order to reduce morbidity related to child undernutrition in Guinea.

Keywords

Severe Acute Malnutrition, Anemia, Hematological Parameters, Biochemical Parameters, Children Under Five Years of Age

1. Introduction

Malnutrition is a multifactorial pathological condition that can result from deficiencies, excesses, or profound imbalances in a person's specific energy and/or nutritional intake [1]-[3] potentially exposing them to other noncommunicable diseases linked to poor nutrition [4]-[6]. It remains one of the major challenges for global public health today, particularly in developing countries, especially in sub-Saharan Africa where resources are limited. Rapid population growth, insufficient food production, poverty, regional conflicts, and social, political, and educational factors play an important role in malnutrition [7] [8]. The health environment and access to care are the underlying causes of malnutrition [9]. Malnutrition is thus the expression of a profound imbalance between physiological needs and nutritional intake, reflecting social, economic, and environmental inequalities.

Globally, nutritional indicators remain alarming. In 2024, approximately 149 million children under the age of five were stunted, 45 million were wasted, and 37 million were obese [1] [10] [11]. Severe acute malnutrition (SAM), which is the most extreme form, is responsible for 500,000 to 1 million child deaths each year, mainly in low-income countries [12] [13]. Nearly half of all deaths among children under five are directly or indirectly related to undernutrition [14] [15]. In sub-Saharan Africa, hospital mortality linked to SAM remains particularly high, reflecting the fragility of healthcare systems [16].

Regional disparities illustrate the scale of the problem. In 2021, 11% of children under five in Burkina Faso were emaciated, including 2% severely, while in Benin, this proportion reached 5% [17]. At the continental level, Asia, Africa, and Oceania had the highest rates of severe acute malnutrition and stunting, reaching 31.6%, 35.8%, and 52.3%, respectively [5] [18] [19]. In West Africa, the situation remains particularly worrying, with 6.7% of children under five suffering from acute malnutrition, making this region the most affected by wasting [20]. These figures highlight the urgent need to strengthen food security, nutrition, and child health policies.

In Guinea, malnutrition remains a major public health problem. In 2011, nearly one-third of children under five (31%) suffered from chronic malnutrition, including 14% in severe form; 10% were acutely malnourished, and 20% were underweight [21]. Subsequent studies reveal even more alarming rates: 94.3% of children under five are emaciated, 97.1% are underweight, and 60.8% are stunted [22]. According to the 2022 SMART Survey, the national prevalence of global acute malnutrition is estimated at 6.7%, with marked regional disparities: from 3.3% in N'Zerekore to 8.3% in Kankan and Kindia, and severe acute malnutrition (1.3%) concentrated mainly in the regions of Labe and Mamou. These disparities reflect persistent regional inequalities and increased nutritional vulnerability.

Despite efforts made, epidemiological and biological data on anemia associated with malnutrition remain limited and/or underutilized. However, hematological and biochemical values play a crucial role in understanding the metabolic mechanisms linked to undernutrition and enable the assessment of tissue nutritional deficiencies.

It is in this context that the present study was conducted at the Center for Recovery and Intensive Nutritional Education (CRINE), regional hospital of N'Zerekore, in the forest region of Guinea. It aims to characterize the hematological and biochemical profiles of children aged 6 to 59 months suffering from severe acute malnutrition (SAM) in order to better understand the biological determinants of this condition. The objective is twofold: to identify hematological and biochemical disturbances during severe acute malnutrition and to assess the severity of these conditions in order to improve prevention and management strategies. This approach will enable evidence-based nutritional interventions to be targeted, thereby contributing to the reduction of infant morbidity and mortality in Guinea.

2. Materials and Methods

This study was conducted in N'Zerekore, the capital of Guinea's forest region. The Internal Rehabilitation and Nutritional Education Center (CRINE) of the pediatrics department and the biomedical laboratory of the regional hospital served as the study setting.

This was a descriptive cross-sectional study that lasted three months, from April 30 to July 30, 2024. Sampling was random, and the sample size was calculated to be 49 children under the age of five using Schwartz's formula [23]. The estimated prevalence of overall SAM among children under 5 years of age in the N'Zerekore region, the study area, is 3.3%. The confidence level is 95% (standard value of 1.96). For this study, we included all children under 5 years of age suffering from malnutrition admitted to the CRINE at the N'Zerekore regional hospital with a Z-score of −3, which determines malnutrition as the difference, in number of standard deviations, between the observed anthropometric value and the median of the reference population [3].

The variables used were anthropometric data [13] [24] [25], hematological and biochemical parameters in children included in this study. Based on a questionnaire, anthropometric data were collected according to the admission criteria defined by the World Health Organization. The weight-for-height ratio W/H ≤ −3 Z-score and/or PB ≤ 115 mm [3] [15] or by the presence of edema were recorded. The age of the children was expressed in months based on the child's health record or on the statements of the mother or accompanying person and was then recorded on the questionnaire form. Edema was checked in both lower limbs by gently pressing down with the thumb for a few seconds on the top of each lower limb. The child had edema if a mark remained on the feet when the thumb was removed.

Height was measured using a UNICEF height rod. For children under 2 years of age, the measurement was taken in a lying position, with the measuring rod placed horizontally on a flat surface parallel to the floor. For children over 2 years of age, the measurement was taken in a standing position, with the measuring rod placed vertically.

The children were weighed naked using a UNICEF baby scale for those under 2 years of age, and for those over 2 years of age, weight was measured using a SECA electronic scale with a capacity of 150 kg and an accuracy of 0.1 g.

The brachial perimeter (B/P) was measured on the left hand using a non-elastic tape measure at midway between the acromion and the olecranon. The B/P measurement is recorded with an accuracy of 1 mm.

To determine hematological and biochemical parameters, a venous blood sample was taken from each child and sent to the biomedical laboratory for analysis using Mindray BC-30S and Mindray BS-230 automated analyzers. The main indicators of these parameters selected for biological analyses were hemoglobin level, hematocrit, thrombocytes (platelets), blood glucose, transaminases (ALT and AST), and creatinine. These parameters were assessed according to reference values [26]-[28] with emphasis in children: hemoglobin (11.0 - 14.0 g/dL); hematocrit (35% - 45%); thrombocytes (150 to 450 G/L); blood sugar (fasting 0.70 - 1.26 g/L or after meals < 1.40 g/L); ALT (<45 IU/L), AST (<35 IU/L); creatinine (0.4–0.6 mg/dL).

The data collected using the kobocollecte.2.4 application configured on a tablet was exported via a server in Excel format. Statistical analysis of this data was then performed using R-Studio software (R.3.6, considering $p < 0.05$). We clarified the materials and methods as follows: To compare the mean values of the parameters according to gender (girls and boys), we used the Wilcoxon-Mann-Whitney test, and to compare the groups according to age group (G1, G2, G3, and G4), we performed analyses of variance (ANOVA) using the Kruskal-Wallis test. The relationships between hematological and biochemical parameters were studied using Spearman's correlation test (ρ).

3. Ethical Consideration

Ethical approval was obtained from the ethics committee of Gamal Abdel Nasser University in Conakry. The mothers or guardians of the children were informed about the objectives of this study and gave their free and informed consent before participating in the study.

4. Limitations and Difficulties

This study has limitations: it was conducted at the RNIC (Regional Nutrition and Integration Center) of the N'Zerekore Regional Hospital, and we only took into account the weight-for-height index; information on other forms of malnutrition is lacking. Therefore, these results cannot be generalized to all children under 5 years of age in the N'Zerekore region.

5. Results

5.1. The Workforce

The study included 49 children diagnosed with severe acute malnutrition, of whom 26 (53.06%) were girls and 23 (46.94%) were boys admitted to the CRINE of the N'Zerekore Regional Hospital, with a sex ratio of less than 1 (≈ 0.88), in favor of girls. The number of children in the 6 to 11 months age group (G1) was 10 (20.41%), from 12 to 23 months (G2) was 24 (48.98%), from 24 to 35 months (G3) was 13 (26.53%), and from 36 to 59 months (G4) was 2 (4.08%). The most affected group of children was those aged between 12 and 23 months ($p < 0.0001$). However, there were more boys in the first age group of 6 to 11 months. No boys older than 35 months were represented among the SAM children (**Figure 1**).

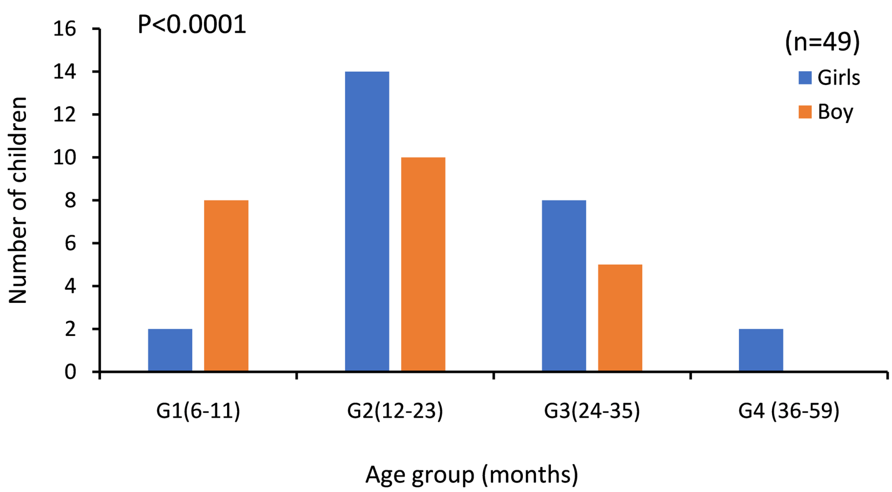

Figure 1. Graph showing the number of children studied by gender and age group at the CRENI of the regional hospital in N'Zérékoré, Republic of Guinea—G1: children aged 6 to 11 months, G2: children aged 12 to 23 months, G3: children aged 24 to 35 months, and G4: children aged 36 to 59 months.

5.2. Hematological Parameters

Blood tests performed on all pediatric patients highlight the physiological effects of SAM. Hemoglobin, hematocrit, and platelet counts were lower in these children than usual values (**Table 1**). For hemoglobin (Hb), the average levels, according to gender (Figure 2(a1)) and age groups (Figure 2(a2)), were very heterogeneous with a statistically significant difference (p < 0.0001). The lowest hemoglobin level was observed in a girl (7.78 g/dL). The majority of them had levels between 6 and 10g/dL. However, among boys, where levels were higher, the majority had values between 8 and 10g/dL (Figure 2(a1)). According to age groups, the lowest mean was observed in children in group G3 (7.92 g/dL) and the highest mean in children in group G1 (9.02 g/dL) (Figure 2(a2)) with a significant difference.

Table 1. Average hematological values recorded in malnourished children by gender and age group.

Parameters	Fille (n = 26)	Garçon (n = 23)	p	G1 (n = 10)	G2 (n = 24)	G3 (n = 13)	G4 (n = 2)	p
Hemoglobin (g/dL)	7.78 ± 2.84	8.74 ± 1.94	<0.0001	9.06 ± 2.99	8.20 ± 2.67	7.92 ± 1.85	8.80 ± 0.71	<0.0001
Hematocrit (%)	24.53 ± 8.56	27.66 ± 4.58	0.4110	28.96 ± 5.36	25.73 ± 8.44	23.84 ± 5.41	28.45 ± 2.05	0.0094
Thrombocyte (G/L)	216.98 ± 247.26	193.03 ± 148.43	<0.0001	188.15 ± 224.46	228.11 ± 241.66	194.24 ± 122.61	100.00 ± 63.64	<0.0001

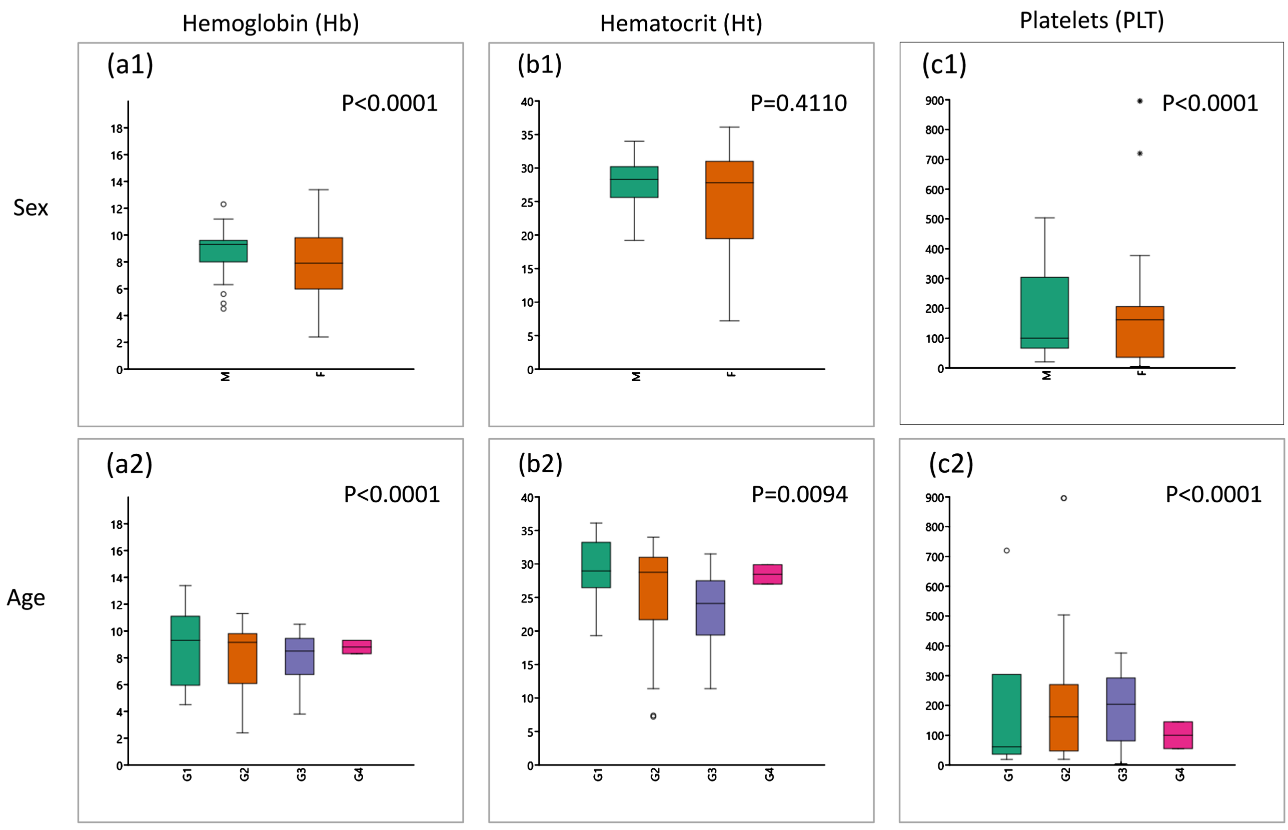

Figure 2. Bar plots showing the difference between the mean hematological values recorded in malnourished children by gender and age group—Hemoglobin by gender (a1), hemoglobin by age group (a2); hematocrit by gender (b1), hematocrit by age group (b2); thrombocytes (platelets) by gender (c1), thrombocytes (platelets) by age group (c2).

For hematocrit (Hte), the values observed in all children were significantly below normal values (p < 0.0001). According to gender (Figure 2(b1)), there was no significant difference in the average rates observed in girls and boys (24.53% vs. 27.66%). By age group (Figure 2(b2)), the lowest average rate was observed among children in group G3 (23.84%) and the highest average rate among children in group G1 (28.96%).

For thrombocytes (or platelets, PLT), 41% (n = 20) of children had normal platelet counts. Thrombocytopenia was present in 51% (n = 25) of cases, of which 44% (n = 11) were severe, and thrombocytosis was present in 8% (n = 4) of cases. The values of this parameter observed in these children were statistically the same (p = 0.7144). The mean platelet count was higher in girls than in boys (216.98 g/L vs. 193.03 g/L), with no significant difference (**Figure 2(c1)**). According to age groups (**Figure 2(c2)**), the lowest average was observed in children in group G4 (100.00 g/L) and the highest average in children in group G2 (228.11 g/L), no statistically significant difference observed (p = 0.7144). However, extremely low values (2 - 19 g/L) were observed in 4 (8.16%) children and extremely high values in 4 children (500 - 896 g/L). The extremely low values were mostly observed in 3 girls, and the extremely high values were also observed in 3 girls. Among the children with very low values, 2 belonged to group G2, 1 child to G1, and 1 to G3. And, for children with high values, 3 were from group G2 and 1 from G1.

Among all hematological parameters studied in these patients, a strong correlation was observed between variations in hemoglobin levels and hematocrit levels ($\rho = 0.55$; $p < 0.0001$). However, no correlation was observed between thrombocytes and hemoglobin levels or hematocrit levels.

5.3. Biochemical Parameters

Biochemical tests performed on blood samples taken from children participating in this study revealed different values for the parameters studied (**Table 2**).

Table 2. Average biochemical values recorded in malnourished children by gender and age group.

Parameters	Fille (n = 26)	Garçon (n = 23)	P	G1 (n = 10)	G2 (n = 24)	G3 (n = 13)	G4 (n = 2)	P
Blood glucose (g/L)	0.92 ± 0.32	0.94 ± 0.32	0.9600	0.95 ± 0.29	0.96 ± 0.31	0.86 ± 0.39	1.50 ± 0.04	0.6485
ALAT (UI/L)	110.05 ± 137.02	119.18 ± 206.20	0.8568	57.02 ± 74.95	129.62 ± 214.39	126.85 ± 146.26	136.20 ± 5.66	0.3118
ASAT (UI/L)	98.90 ± 71.14	140.92 ± 156.32	0.1792	113.27 ± 74.68	138.33 ± 156.46	88.83 ± 65.00	102.60 ± 21.50	0.6818
Creatinine (mg/dL)	2.18 ± 9.04	2.49 ± 9.49	0.4517	5.17 ± 14.35	2.30 ± 9.42	0.46 ± 0.35	0.45 ± 0.15	0.1322

With regard to blood glucose levels, the average values observed in all children (girls: 0.92 g/L and boys: 0.94 g/L) were below the upper pathological threshold. Overall, 16.33% of children had low blood glucose levels, including 21.74% (n = 5/23) of boys and 11.54% (n = 3/26) of girls. No significant differences were observed in blood glucose variation among these children based on gender and age group (p = 0.9600). There was no significant difference in these averages between girls and boys (**Figure 3(a1)**). Also, according to age, a slight, non-significant increase was observed in children in the G4 group (1.50 g/L) (**Figure 3(a2)**).

For transaminases, depending on gender, the average values were higher than the reference values. In girls, ALT and AST were 110.05 IU/L and 98.90 IU/L, respectively, and in boys, ALT and AST were 119.18 IU/L and 140.92 IU/L, respectively. Each of these two parameters shows statistically different values (ALT, p = 0.0069 and AST, p < 0.0001). According to age, the highest average was observed in children in group G4 (136.20 IU/L) for ALT transaminases (**Figure 3(b1)**) and in children in group G2 (138.33 IU/L) for AST transaminases (**Figure 3(c1)**). These averages did not show any statistically significant differences. However, a moderate correlation between the increase in ALT and AST values was observed ($\rho = 0.48$; p < 0.0001).

With regard to creatinine levels, the mean values observed in our sample were statistically significantly higher than the reference values (p < 0.0001). However, there was no statistical difference between creatinine levels according to gender (**Figure 3(d1)**) and age (**Figure 3(d2)**).

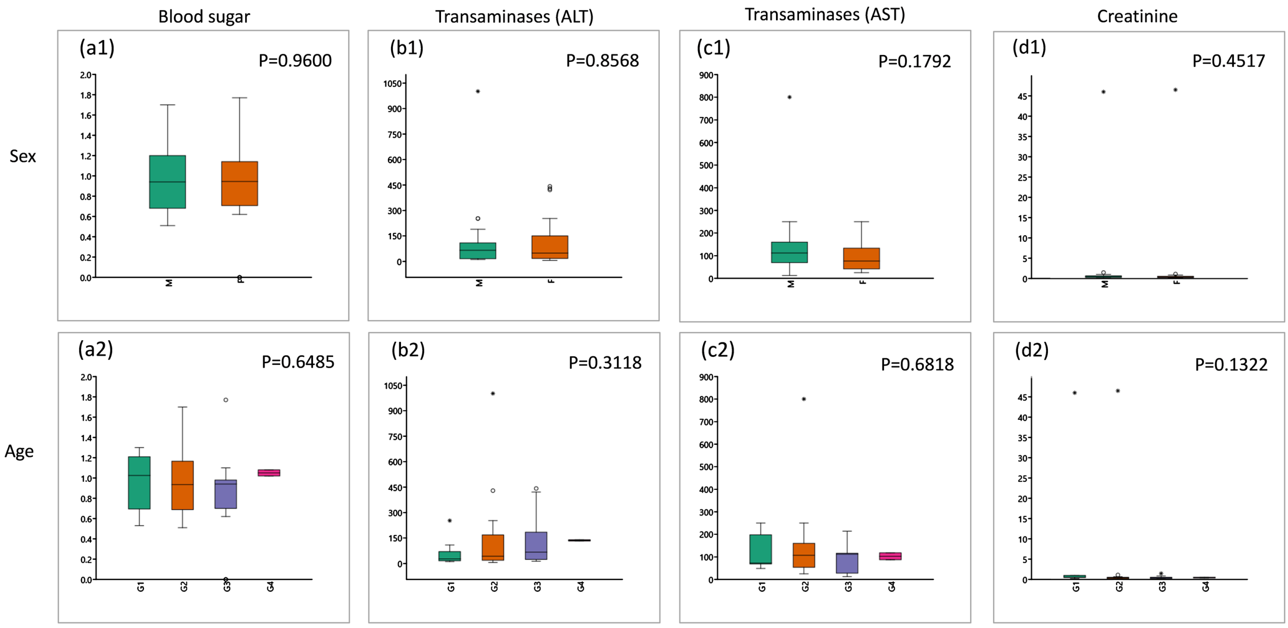

Figure 3. Bar plots showing the difference between the mean biochemical values recorded in malnourished children by gender and age group—Blood sugar by gender (a1), Blood sugar by age group (a2); transaminases (ALT) by gender (b1), transaminases (ALT) by age group (b2); transaminases (AST) by gender (c1), transaminases (AST) by age group (c2); creatinine by gender (d1), creatinine by age group (d2).

6. Discussion

6.1. General Condition

Anemia is a hematological disorder that has direct and indirect consequences on a person's health and development. These disorders are linked to nutritional deficiencies. Although anyone can be affected, women of childbearing age, children under 5, and the elderly are most at risk [29] [30].

This study directly assessed the severity of anemia through targeted biological parameters, including hematological and biochemical parameters in children under 5 years of age. Of the 49 malnourished children identified for this study, the majority were in the 12 - 23 months (G2) and 24 - 35 months (G3) age groups.

This could be explained by the fact that children become independent in terms of food at an early age, which is linked to their weaning being less or not compensated for in terms of nutrients, and also by the fact that breast milk alone is no longer sufficient to meet their iron, vitamin, and other micronutrient requirements. This period, which marks a transitional phase in a child's diet, may be characterized by an insignificant and inadequate food intake, depending on the living conditions of the child's parents.

The female sex was overrepresented among registered malnourished children, indicating that girls may be more vulnerable to this condition and consistent with findings from previous studies. [12] [31]. Most of these girls were in the 12 - 23 months (G2) and 24 - 35 months (G3) age groups and were only represented in the 36 - 59 months (G4) age group. However, in the 6 - 11 months (G1) age group, boys were more represented than girls. This could be related to the vulnerability of male children aged 6 - 12 months, who have an increased risk of iron deficiency anemia [11] [27].

6.2. Hematologic Profile

In all children in our study, hemoglobin levels were significantly below the normal threshold, thus proving to be one of the main indicators of anemia [32] [33]. According to age groups, the lowest hemoglobin levels observed in children in group G3 could be explained by the fact that at this age, children in developing countries are often exposed to poor-quality diets (in terms of diversity, protein intake, etc.) and associated infections, which can have a significant impact on hemoglobin levels [12] [34]. However, among children in group G1, hemoglobin levels were higher than in other age groups. This could be related to the transition from fetal hemoglobin (FHb) to adult hemoglobin (AHb), whereby newborns are born with high levels of fetal hemoglobin (FHb) which has a stronger affinity for oxygen and then decreases over time (a few months) [35] [36].

A significant decrease in hematocrit levels was observed in all children examined. This decrease clearly follows the distribution of hemoglobin levels according to gender and age group. A significant dependent correlation was observed between hemoglobin levels and hematocrit levels [37].

The platelet profile observed in our sample is heterogeneous, with normal platelet counts in 41% of children, thrombocytopenia in 51% of children, including 44% of children with severe thrombocytopenia, and thrombocytosis in 8% of children. This shows various pathologies associated with malnutrition in these children or a group subjected to significant physiological stress (malnutrition, infection, treatment, etc.). This confirms that malnutrition can significantly disrupt platelet levels (in both directions). These results are similar to those of several previous studies [38]-[40]. It should be noted that the a potentially disruptive disruptive effect of these hematological parameters was the presence of malaria infection, since more than 65% (n = 32) of children had been diagnosed with malaria.

Among all hematological parameters studied in these patients, a strong correlation was observed between variations in hemoglobin levels and hematocrit levels ($p < 0.0001$). However, no correlation was observed between thrombocytes and hemoglobin levels ($p = 0.149$) or hematocrit levels ($p = 0.142$).

6.3. Biochemical Profile

Differences in levels were observed in the biochemical parameters used in this study. This could be related to the composition of the population of children examined.

Blood glucose levels were on average below the usual maximum threshold. The slight increase observed in three children, if the measurements were postprandial, could be tolerable. They could therefore reflect metabolic stress, liver damage, an endocrine abnormality, recent glucose intake or infusion (false positive). Otherwise, they could be considered hyperglycemic (abnormal).

The assessment of liver function showed a variety of responses in specific markers (transaminases, ALT, and AST) in the patients (children) concerned. These different responses could be linked to the nutritional status of these children. A comparison of the values obtained against the reference threshold made it possible to distinguish between slightly elevated values (40 - 100 IU/L), moderate values (101 - 300 IU/L) and severe values (>300 IU/L). These transaminase disturbances have been observed in malnourished individuals in previous studies [41] [42]. These conditions are associated with malnutrition, mild infections, or liver damage. The significant correlation observed between increased ALT and AST values ($p = 0.0176$) would confirm this damage due to the presence of lesions [43] [44].

The renal function test revealed no significant difference between the creatinine levels observed in the children in our study ($p = 0.1322$). The creatinine levels observed in the children in group G2 were very similar to those observed in the children in group G1 ($p = 0.0229$). For both age groups (G1 and G2), the values observed were very high compared to normal values. The vast majority of children (90%) had creatinine levels between 0.2 and 0.7 mg/dL. A few slightly higher values (0.85 - 1.1 - 1.47 mg/dL) are borderline or moderately elevated, which may indicate temporary mild dehydration or a normal biological effect and, in isolated cases, more rarely, the onset of kidney damage.

7. Conclusions

The study conducted on children under five years of age highlighted the significant impact of malnutrition on hematological and biochemical status, reflecting the severity of anemia in this vulnerable population. The results show that anemia remains a major public health problem, particularly among children aged 12 to 35 months, a critical period of dietary transition when nutritional intake is often insufficient to meet increased physiological needs.

The hematological profile reveals a generalized decrease in hemoglobin and hematocrit levels, confirming the high prevalence of anemia, while the variations observed in platelet parameters reflect the combined effects of malnutrition and associated infections. Biochemically, transaminase abnormalities (ALT, AST) suggest moderate to severe liver damage, likely related to malnutrition, while the majority of creatinine values are within the normal range, indicating mild kidney damage.

These findings highlight the need to strengthen prevention and nutritional care from the first months of life, in particular by promoting a diverse and balanced diet after weaning, as well as by regularly monitoring the hematological and biochemical status of children at risk. An integrated approach, combining nutritional, educational, and health interventions, remains essential to reduce the prevalence of anemia and its consequences on child growth and development.

Authors' Contributions

Conceptualization: MS, MK; Investigation: MFO; Data Curation: MK, MS, MFO; Analyzed the data: MK, MFO; Writing-Review & Editing: MFO, MS, MK.

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Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this article.

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