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Anemia Associated with *Plasmodium falciparum* and Intestinal Parasitosis in Malnourished Children Aged 0 to 5 Years in N'Djamena Province, Chad

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Abstract

Objective: Malaria and intestinal parasitosis represent real public health problems in the world, in Africa and in Chad. They remain common diseases affecting many people, particularly malnourished children, who remain the most vulnerable. The objective of this study was to determine the prevalence of malaria and intestinal parasitosis in malnourished children with anemia. **Material and methods**: This study included 325 malnourished children aged 0 to 5 years admitted to the Therapeutic Nutrition Units of the two hospitals in the province of N'Djamena. The children were sampled and diagnosed with malaria by thick drop and intestinal parasitosis by the Willis method, and the hemoglobin dosage was carried out using the HemoCue Hb 301 + analyzer. **Results:** Of the 325 malnourished children with a mean age of 16.59 months, 273 (84%) were diagnosed positive for malaria and intestinal parasitosis, 52 (16%) were malnourished children due to nutrient deficiencies unrelated to parasites (ρ = 0.001). Of the 273 malnourished children with parasites, 187 (68.5%) were diagnosed positive for *Plasmodium falciparum* malaria associated with different types of anemia, 48 (17.6%) harbored intestinal parasites in association with different types of anemia and 38 (14%) cases of malaria-

intestinal parasitosis coinfection. The parasitic index showed a predominance of protozoa 46% of *Entamoeba histolytica*. **Conclusion:** This study determined high prevalence's of intestinal and blood parasites associated with anemia in malnourished children. Malnutrition is an aggravating factor for parasitosis, but treatment in specialized units with antiparasitic, iron Malnutrition is an aggravating factor in parasitic infections, but periodic deworming with antiparasitic and antimalarial drugs in cases of fever could have contributed to the reduction in the prevalence of digestive parasitic infections and malaria in malnourished children in the province of N'Djamena.

Keywords

Malnourished Child, Anemia, Malaria, Intestinal Parasitosis, N'Djamena

1. Introduction

Malnutrition is a pathological condition resulting from the deficiency or excess of one or more essential nutrients. This condition manifests clinically or is detectable by biochemical, anthropometric or physiological analyses [1]. Malnutrition can have irreversible effects on the growth, development and well-being of children. Stunting during the first 1000 days of life is associated with poorer educational outcomes, not only because malnutrition impairs brain development but also because malnourished children are more likely to fall ill and miss school [2]. WHO estimates that more than 3.5 billion people are infected with one or more species of digestive parasitic infections and 216 million (196 - 263 million) cases of malaria in 2016 [2]. Malaria and intestinal parasitic infections are the major causes of malnutrition in Chad and Africa [3].

Plasmodium falciparum is the most prevalent malaria parasite in Africa. According to the latest World Health Organization report in 2020; the number of malaria cases worldwide was estimated at 241 million and the number of deaths at 627,000 of which 95% occurred in Africa. Children under five years of age were the most vulnerable group, with 80% of all deaths [4] [5].

Anemia is a major public health problem and has been a concern of the World Health Organization (WHO) since 1949. It affects a significant proportion of the population at different ages. Approximately 35% of the world's population suffers from anemia. It is significantly more common in developing countries, where approximately 47% of the affected population is affected, while in developed countries, the prevalence is around 10% [6]. The regions with the highest prevalence of anemia are South Asia and Africa [7]. The estimated prevalence rate for all groups, except adult males, reaches more than 40% in both regions [8].

In Chad, the prevalence of malaria is 40.9% in the population and 40.9% in children aged 6 to 59 months. The prevalence of anemia is 49.9% in children and 17% in pregnant women aged 15 to 49 years [9] [10].

The objective of this study was to evaluate the correlation between malaria,

digestive parasitosis and anemia in order to better manage malnourished children in the province of N'Djamena in Chad.

2. Materials and Methods

2.1. Site and Recruitment of the Target Population of the Study

This hospital-based study is a prospective, observational, analytical study and took place over a period of ten (10) months from June 2022 to March 2023 at the University Hospital Center for Mothers and Children (CHU-ME) and the Chad-China Friendship Hospital (HATC) in the city of N'Djamena and its surroundings. It involved 325 children aged 0 to 5 years, admitted for severe acute malnutrition in the nutritional and therapeutic units of the two aforementioned hospitals. A questionnaire containing information on the origin, level of education, profession, type of toilets, and the use or not of long-lasting insecticide-treated mosquito nets (LLINs) was administered to the parents of eligible children.

2.2. Eligibility Criteria

2.2.1. Inclusion Criteria

The following were included in this study:

- ✓ Children aged 0 to 5 years admitted to the therapeutic nutritional units of the Chad-China Friendship Hospital and the University Hospital Center for Mothers and Children of N'Djamena;
- ✓ Informed consent signed by the child's parents or guardian is obtained.

2.2.2. Non-Inclusion Criteria

The following were not included in this study:

- ✓ Children over 5 years old;
- ✓ The absence or refusal of parents to participate in the study.

2.2. Laboratory Analysis Procedures: Sample Collection, Parasitological Analyses and Hemoglobin Measurement

For each patient, 5 mL of blood was collected by venipuncture by a nurse in an EDTA tube labeled with the identifier of each child. Thick drops and blood smears were made on the same slide from the blood samples. These were stained in a 10% GIEMSA solution for reading under a microscope with immersion oil at 100 magnifications. For positive cases, the identification of the plasmodial species was carried out on a thin smear, and the parasite densities were evaluated using a thick drop for 200 or 500 leukocytes. Individual values for parasitemia were finally reduced to 1 µL of blood based on 8,000 leukocytes by multiplying the number of parasites obtained by 40 or 16, respectively, for 200 or 500 leukocytes [9].

Hemoglobin measurement was performed with the HemoCue Hb 301 + analyzer. Anemia was detected as mild (Hb (10.0 - 10.9 g/dL), moderate Hb (7.0 - 9.9 g/dL) and severe Hb < 7 g/dL).

In addition, a stool sample was requested from each patient. The collection was done in 125 mL plastic pots. The stools emitted in the morning were received,

labeled with a unique identifier and transmitted to the parasitology unit of the Laboratory of Research, Diagnostic and Scientific Expertise (Labo-ReDES) of the Faculty of Human Health Sciences (FSSH) of the University of N'Djamena for parasitological examination. They underwent a series of examinations, including direct microscopy between slide and coverslip and analysis by the Willis technique, which consists of using a saturated NaCl solution to take advantage of the adherence of the parasites to the glass. It was done in the manner of diluting in a conical stemmed glass 10 g of stools in 200 mL of NaCl solution, homogenizing, sieving then pouring into a tube until the liquid was flush with the edge of the tube. A coverslip was applied to the tube, avoiding leaving air bubbles between the coverslip and the liquid and removed after 15 to 45 minutes then observed under a microscope at magnifications ×10 and ×40 to search for parasite eggs. The number of eggs of each species of helminth was marked; the presence of a species of protozoan was indicated by + signs. The number of + varies from 1 to 3 depending on the intensity of the parasite: 1 + corresponds to 1 - 5 parasites per microscopic field analyzed, 2 + to between 5 - 10 parasites per microscopic field and 3 + to more than 10 parasites per microscopic field.

2.3. Written and Signed Informed Consent

Sir/Madam,

We would like to take a blood and stool sample from your child, this is a procedure usually done to find the cause of your child's illness.

The sample will be used to identify the parasite(s) responsible for the disease and at the same time assess the hemoglobin level to determine whether or not the child is exposed to anemia (mild, moderate and/or severe). We will also measure the child's anthropometric parameters (height, weight and weight/height ratio) to determine whether he or she is exposed to malnutrition (mild, moderate and/or severe). The results obtained will allow the authorities of the Ministry of Public Health of Chad to take corrective measures to prevent children from being at risk of exposure to malnutrition and anemia from parasitic diseases.

You will be informed of any change in the purpose of the research on the samples and you will be able to object.

Sir/Madam, agreeing to provide your child's blood and stool samples is essential for the completion of this study, which will contribute to improving child health in Chad.

Patient's signature

2.4. Statistical Analysis of Data

The results including parasitological data and those from the information forms were recorded from a table in MS-EXCEL. The descriptive analysis consisted of describing the data collected in the form of numbers, percentages and means. Statistical tests were carried out with SPSS software. For this purpose, the chi-square test (x^2) allowed us to assess the link between the occurrence of malaria and/or

intestinal parasitosis and exposure factors (age, use or not of impregnated mosquito nets, socio-economic conditions). The probability value (p) was used to show the degree of significance of the links at the threshold of 0.05.

3. Results

3.1. Mapping of Survey Sites in the City of N'Djamena

Figure 1 illustrates the two hospitals that house the Therapeutic Nutrition Units (University Hospital Center for Mothers and Children (CHU-ME), the Chad-China Friendship Hospital (HATC) where the surveys were conducted, and the parasitology unit of the Laboratory for Research, Diagnostics and Scientific Expertise (Labo-ReDES) of the Faculty of Human Health Sciences (FSSH) of the University of N'Djamena where the parasitological analyzes were carried out in the province of N'Djamena The city of N'Djamena is surrounded by two rivers (Chari and Logone) coming from the South of Chad. However, due to the similarities of climatic conditions, it is also attached to the Sahelian countries. The geolocation of the city of N'Djamena would certainly have contributed to the transmission of parasitic diseases.

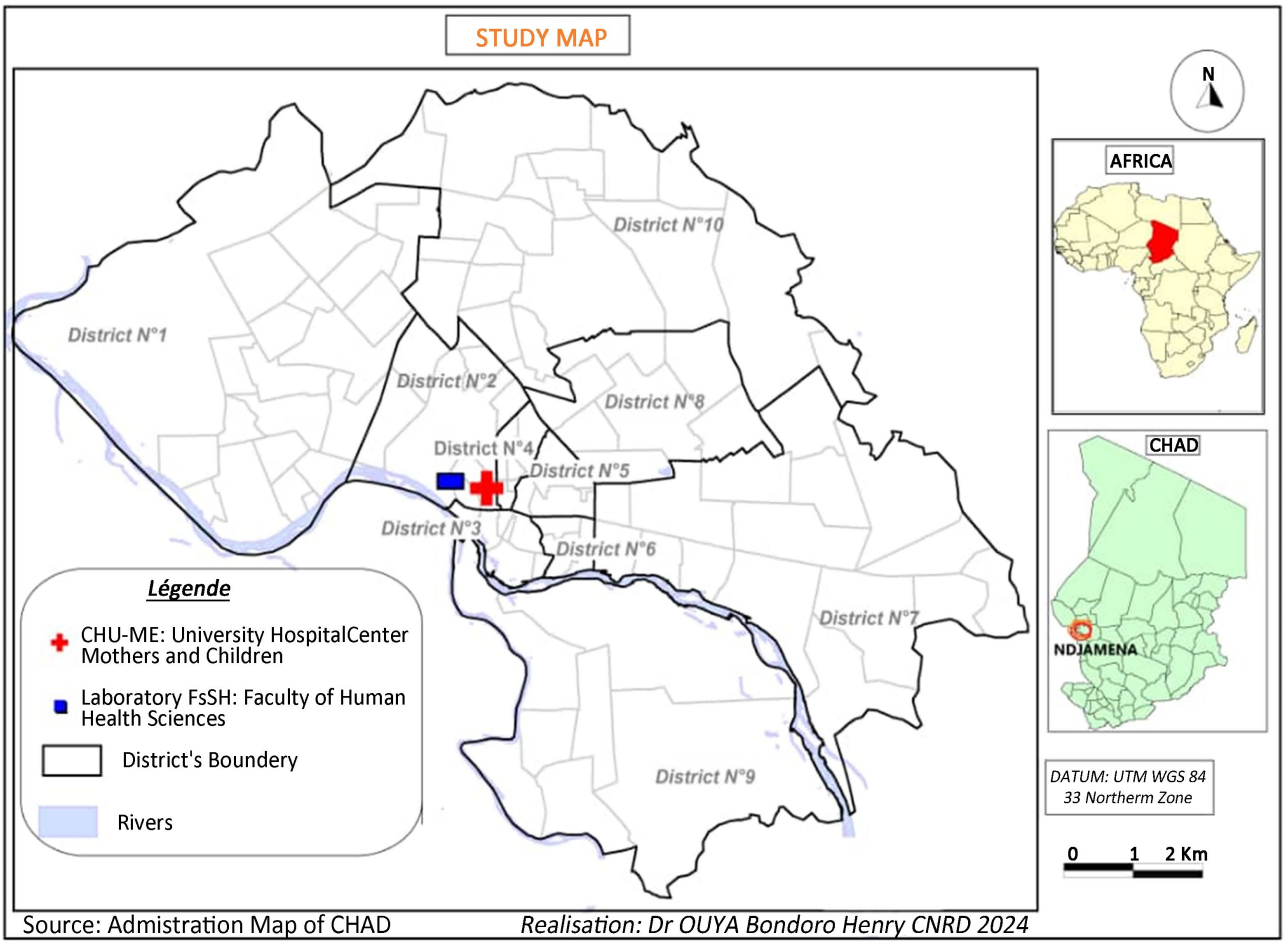


Figure 1. Site mapping and study framework.

3.2. Overall Prevalence of Blood and Intestinal Parasitosis Associated with Anemia in Malnourished Children

A total of 325 malnourished children were included in this study. These were 175 (54%) girls and 150 (46.15%) boys (ρ = 0.20). The mean age was 16.59 months.

Of the 325 malnourished children who underwent parasitological screening, 273 (84%) were diagnosed positive for malaria and intestinal parasitosis and 52 (16%) were malnourished children due to nutrient deficiencies unrelated to parasites (ρ = 0.001).

Among the 273 malnourished children with parasites, 187 (68.5%) were diagnosed positive for *Plasmodium falciparum* malaria associated with different types of anemia, 48 (17.6%) harbored intestinal parasites in association with different types of anemia and 38 (14%) cases of malaria-intestinal parasitosis coinfection in association with different types of anemia.

3.3. Distribution of Patients According to *Plasmodium falciparum* Parasite Density

Carriers of *Plasmodium falciparum* alone whose parasite density was less than 500 parasites/µL of blood were the most numerous with a rate of 68% followed by those whose parasite density was between 500 - 1000. Carriers of both *Plasmodium falciparum* and intestinal parasitosis whose parasite density was greater than 1000 parasites/µL of blood were the most represented (Table 1).

Table 1. Distribution in number and percentage of malnourished children infected with parasites according to parasite density and coinfestation.

Parasite Density	n malaria	%	n coinfestation	%
<500	127	68	8	21.05
500 – 1000	41	22	9	23.68
>1000	19	10.2	21	55.26
Total	187	100	38	100

n malaria = effective of malaria patients only; n coinfestation = effective of patients infected with malaria and intestinal parasitosis; % = percentage.

3.4. Distribution in Number and Percentage of Species of Intestinal Parasites and Coinfestation

Table 2 shows the distribution of number and percentage of parasites found in the stools of malnourished children and coinfestation. *Entamoeba histolytica* (46%) were the most commonly found parasites followed by *Giardia intestinalis* (27.1%) and *Trichomonas intestinalis* (19%). Malaria-intestinal parasitosis coinfestation was much more pronounced in malnourished children parasitized by *Entamoeba histolytica* (39.47%) followed by *Trichomonas intestinalis* (31.57%).

Table 2. Distribution in number and percentage of species of intestinal parasites found.

Parasitic species	n parasite	%	n Coinfestation	%
Entamoeba histolytica	22	46	15	39.47
Giardia intestinalis	13	27.1	8	21.05
Trichomonas intestinalis	9	19	12	31.57
Hymenolepis nana	2	6.2	1	2.63
Schistosoma mansonii	2	6.2	2	5.26
Total	**48**	**100**	**38**	**100**

n parasite = effective of parasite patients only; n coinfestation = effective of patients infected with malaria and intestinal parasitosis; % = percentage.

Table 3. Prevalence of anemia associated with parasitosis in malnourished children under 5 years of age.

Percentage of malnourished children aged 6 - 59 months with parasites and anemia, according to selected socio-demographic characteristics					
	Anemia according to hemoglobin concentration				
Socio-demographic characteristics	Light (10,0 - 10,9 g/dL) n malaria-anemia (%)	Moderate (7,0 - 9,9 g/dL) n PI-anemia	Severe (<7,0 g/dL) n malaria-PI-anemia	**%** cumulative of anemia	Effective of children
Age group (month)					
6 - 11	19 (28.3)	23 (34.3)	25 (37.3)	24.5	67
12 - 23	15 (27)	19 (34)	19 (**34**)	20.5	56
24 - 35	16 (30)	17 (31.5)	23 (**42.4**)	20	54
36 - 47	20 (38)	15 (28.3)	18 (34)	19.4	53
48 - 59	13 (30.2)	14 (32.5)	16 (37.2)	16	43
	83 (30.4)	**88 (32.3)**	**102 (37.4)**	**100.4**	**273**
Gender					
Male	31 (25)	39 (31.2)	55 (55.2)	46	125
Female	37 (25)	42 (28.4)	69 (47)	54.2	148
	68 (29)	**81 (30)**	**124 (45.4)**	**100.2**	**273**
Residence					
Urban N'Djamena	77 (44)	62 (35.2)	37 (21.0	64.5	176
Rural N'Djamena	23(24)	36 (37.1)	38 (39.2)	35.5	97
	100 (37)	**98 (36)**	**75 (27.5)**	**100**	**273**
Collection site					
CHU-ME	25 (21.4)	49 (42)	43 (37)	43	117
HATC	41 (26.3)	47 (30.1)	68 (43.5)	57.1	156
	66 (24.2)	**98 (36)**	**111 (41)**	**100.1**	**273**

n = effective; % = percentage; PI-anemia = intestinal parasitosis-anemia; Malaria-PI-anemia = malaria-intestinal parasitosis coinfestation-anemia; cumulative percentage of anemia; CHU-ME = University Hospital Center for Mothers and Children; HATC = Chad-China Friendship Hospital.

3.5. Distribution of 273 Malnourished, Parasitized and Anemic Children According to Certain Socio-Demographic Characteristics

Anemia is defined as a "lack of blood", a blood disorder characterized by an abnormal decrease in the number of red blood cells (erythrocytes) or the hemoglobin level. There is a decrease in the hemoglobin (Hb) level below physiological values. Blood and intestinal parasitosis associated with anemia constitutes one of the most serious public health problems.

The results presented in Table 3 show the percentages of malaria and intestinal parasitosis in association with the different types of anemia in malnourished children aged 0 to 5 years. Malaria alone with mild anemia was 30.4%, intestinal parasitosis alone was associated with moderate anemia (32.3%) and malaria-intestinal parasitosis coinfection was 37.4%.

Overall, according to age group, there is a prevalence of anemia of 24.5% in malnourished children aged 6 - 11 months, 20.5% in children aged 12 - 23 months, 20.0% in children aged 24 - 35 months and 19.4% in children aged 36 - 47 months and 16% in those aged 48 - 59 months. It has been observed that anemia in all its forms is much more increased, especially in malnourished children aged 6 - 11 months and 12 - 23 months than in those of older ages. Anemia is very severe in children whose malnutrition generally results from *Plasmodium* infections and intestinal parasites (Table 3).

The results by gender show a prevalence of 46% in boys versus 54.2% in girls.

According to the residential area, it was 64.5% in urban areas and 35.5% in rural areas.

According to the survey area, the highest prevalence level was observed at the Chad-China Friendship Hospital (67.1%) while the lowest rate was observed at the University Hospital Center for Mothers and Children (43%).

3.6. Distribution of Infestation Patients According to the Level of Education of the Guardians of Malnourished Children

Table 4 shows that 51.33% of mothers with no education had malnourished, anemic children infected with malaria and 42.10% co-infected with malaria-intestinal parasitosis in this study.

Table 4. Distribution of infestations according to the level of education of guardians of malnourished children.

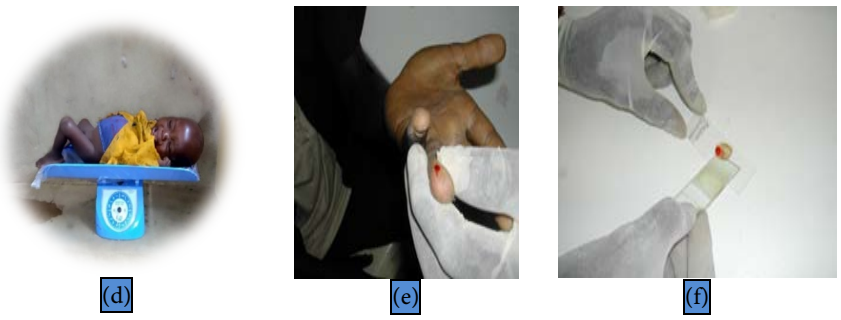
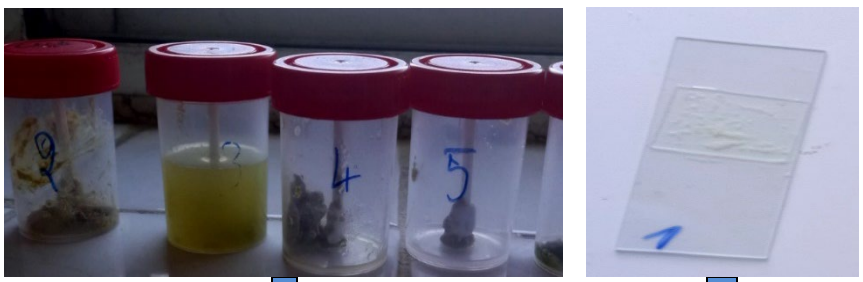
	Malaria		Intestinal parasitosis		Coinfestation	
N I M	**n**	**%**	**n**	**%**	**n**	**%**
Uneducated	96	51.33	27	56.25	16	42.10
Primary	57	30.48	11	23	13	34.21
Secondary	24	13	6	12.5	7	18.42
University	10	5.34	4	8.33	2	5.26
Total	**187**	**100**	**48**	**100**	**38**	**100**

N I M = level of education.

3.7. Biotechnological Steps in the Detection of *Plasmodium falciparum* and Intestinal Parasitosis in Malnourished Children Aged 0 - 5 Years

Table 5 shows the illustration of field photos on the measurement of weight (e), arm circumference (b) clinical symptoms such as (edema: a), the height chart (c) and blood samples (d) for the preparation of the thick drop (GE: f), the slides stained with Giemsa (g), microscopic observation (h), the result of the GE (i) and the stool samples (j) and stool spread (k).

Table 5. Biotechnological steps in the detection of *Plasmodium falciparum* and intestinal parasitosis in malnourished children aged 0 - 5 years.

1	a: Foot edema in a polymicrobial malnourished child b: arm circumference measurement c: the height chart  (a) (b) (c)
	d: weight measurement e: blood sampling f: preparation of a thick blood drop (BG) and a thin blood smear  (d) (e) (f)
	g: Giemsa rapid stained slides (10%) h: preparation of a thick blood drop (BG) and a thin blood smear i: Ring-shaped *Plasmodium* trophozoites  (g) (h) (i)
	j: stool samples k: stools spread on blade  (j) (k)

4. Discussion

During the 10 months of study, 325 children with severe acute malnutrition were sampled for malaria and intestinal parasitosis. All severely malnourished patients have infections, often multiple. The study area is endemic to malaria with a long transmission period because the child is more exposed than adults. Out of 17 national surveys conducted in sub-Saharan Africa between 2014 and 2016, the proportion of feverish children who had a blood sample taken from the finger or heel (suggesting that a malaria screening test had been carried out) was higher (34% - 59%). Screening of suspected malaria cases has increased in the public sector since 2010 in most WHO regions. The most pronounced increase in prevalence is observed in sub-Saharan African regions according to WHO with screening rates increasing from 36% in 2010 to 87% in 2016. The study area is endemic to malaria with a long transmission period, because the child is more exposed than adults. The prevalence of malaria infection is 74.6%, which is higher than that of WHO. Of 17 national surveys conducted in sub-Saharan Africa between 2014 and 2016, the proportion of feverish children who had a blood sample taken from the finger or heel (suggesting that a malaria test had been performed) was higher (34% - 59%). Screening of suspected malaria cases has increased in the public sector since 2010 in most WHO regions. The most pronounced increase in prevalence is observed in sub-Saharan African regions according to WHO with a screening rate increased from 36% in 2010 to 87% in 2016 [11].

Speaking of malaria, the prevalence obtained in this study was 68.5%. This prevalence was higher than those obtained by: WHO, (2017), Doutoum *et al.* [12] in the city of Abéché in Chad in 2019 and Diarra [13] in the locality of Douguia in 2017 which were 36.57% and 26.5% respectively. In 2019, Niaré *et al.*, in Mali had obtained a prevalence of 22.09% [14], and Ademowo in Nigeria had obtained in 2014, 46.7% [15]. This high prevalence reported in this study could be explained by the significant vulnerability of malnourished children to this parasitosis and also by the endemic nature of *Plasmodium falciparum* malaria in Chad. Malnourished children aged 2 to 3 years were more parasitized, followed by those aged 1 to 2 years. This could be explained by the fact that during this age group, the child could stay awake at night, play for hours, and be a victim of mosquito bites. Moreover, it is during this age group that the child acquires his immunity, which would result in fevers and repeated malarial manifestations. In this study, the prevalence of intestinal parasitosis was 17.6%. This prevalence is lower than that of Bessimbaye *et al.* who found a prevalence of 50% in the children category during a study conducted in two provinces in southern Chad [16]. It is also lower than those of Hamit *et al.* in 2020 and Bechir *et al.* in 2012 who reported 64.5% and 60% respectively [17] [18]. The gap between the prevalence of this study and that of the other authors cited could be explained by the effectiveness of the management of malnourished children, which is based on a protocol including systematic treatments (antibiotics, antifungals, antiparasitic and nutritional treatment).

Regarding co-infection, the study had obtained a rate of 14% of malaria and

intestinal parasitoses linked to malnutrition. This result is lower than that of Ademowo *et al.* in 2014 in Nigeria who found 18% of helminthic and plasmodial co-infestation but similar to that of Eyong *et al.* in Cameroon in 2021 [19] who found a prevalence of co-infection of 14.5% in the category of children under 5 years old and Njunda *et al.* in 2015 in Cameroon who found 11.9% [20]. Gbenoudon Satoguina *et al.*, in 2016 in Togo found 15.32% of *Plasmodium falciparum* and nematode co-infection [21]. These studies differ in terms of the inclusion criterion and sample size. This coexistence of *Plasmodium falciparum* and intestinal parasites may be due to the frequent presence of larval breeding sites (ensuring the development of malaria vectors) and unfavorable hygiene conditions (ensuring the transmission of intestinal parasites) in the same study site [22].

In terms of gender distribution, there is no significant difference. In both girls and boys, the frequency of malaria was 25% compared to the total population (68.5% malaria and 45.4% co-infection). This result provided us with a chi-square of 0.0135, which was below the critical threshold (3.811) at the margin of error of 5%. This allowed us to affirm that the occurrence of malaria in a malnourished child is not linked to gender.

Regarding the age group, the prevalence of plasmodial carriage reveals that there is a high positivity in the group children whose age varies from 2 to 3 years are more parasitized, followed by those whose age varies from 1 to 2 years. This could be explained by the fact that during this age group the child could stay awake at night have fun for hours and be a victim of mosquito bites. Moreover, it is during this age group that the child acquires his immunity, which would result in fevers and repeated malarial manifestations. Coulibaly in 2017 in Bamako [23] obtained a high prevalence in the age group of 0 to 12 months followed by the age group of 13 to 24 months with prevalence's of 41.5% and 32.5% respectively. The result provided us with a chi-square of 5.018, which was lower than the critical value at the margin of error of 5%, and allowed us to affirm that the occurrence of malaria in malnourished children is not linked to age. We can explain these predominant rates in the age groups of 14 to 25 months and 2 to 13 months by the major population size of these two age groups within the total population. This large number would be linked to the increased vulnerability of children to malnutrition between the ages of 0 and 25 months, the age which corresponds to the period of strong growth of the child with higher food needs [24].

The prevalence of intestinal parasitosis according to gender is remarkable in girls with 28.4% (47% for malaria-intestinal parasitosis co-infection) and 31.2% for boys. This result provided us with a chi-square of 1.833 which was lower than the critical threshold (3.811) at the margin of error of 5%. This allowed us to affirm that the occurrence of intestinal parasitosis in a malnourished child is not linked to gender. This result corroborates that of Kapiteni *et al.* who reported in 2019 in the Democratic Republic of Congo (DRC) that there is no statistically significant difference between the sex of children and the age group in the development of digestive parasitosis [25].

Compared to the total population, the high positivity of intestinal parasitosis is 34% in the age group of 12 to 23 months followed by 31.5% in the age group of 24 to 35 months. Kapiteni *et al.* in 2019 in the Democratic Republic of Congo had found 28.6% in the age group of 18 to 29 months [25], Enoka *et al.* in 2022 in Cameroon who had found a frequency of 52.33% and 76.12% in children whose age varies from 3 to 4 years and 4 to 5 years respectively [26]. The differences between the frequencies obtained in this study and in those of Kapiteni *et al.* and Enoka *et al.* could be explained by the fact that the frequency in this study is determined in relation to all malnourished children, it was in relation to infested children in the cases of the authors cited. However, they all reported that the occurrence of intestinal parasitosis is not related to age [26].

According to the parasites identified, protozoa were the most common in this study. *Entamoeba histolytica* predominated at 46%, followed by Giardia intestinalis at 27.1%. This observation is consistent with those made by other authors including Camara *et al.* in 2019 in Bamako [27] who obtained 73.1% for *Entamoeba histolytica* and 15.18% for *Giardia intestinalis*.

Lango-yaya *et al.* reported that in 2021, the Central African Republic had a predominance of 30.37% for *Entamoeba histolytica* [28]. The specific prevalence of parasites varies depending on the study and the region. The high frequency of protozoa compared to helminths is favored by poor personnel and food hygiene, to which are added climatic conditions conducive to the development of these parasites. These species are transmitted in cystic forms through poorly washed raw foods (fruits, vegetables, salads) and drinking water most often drawn from sources polluted by human excreta. There were no systematic tests for pinworms.

The parasitic association is present in both sexes, with approximately equal proportions, 55.2% for males and 47% for females.

According to the origin: we divided the children into two groups: 176 (64.5%) of the children lived in the urban area of N'Djamena against 97 (35%) from rural areas ($p = 0.001$: there is a significant difference in favor of patients from the urban area). This can be explained by the wide availability of Therapeutic Nutritional Unit (UNT) in rural areas, which means that children are only transferred in case of complications.

In total, 51.33% of mothers with no education had malnourished, anemic children infected with malaria and 42.10% co-infected with malaria-intestinal parasitosis in this study (**Table 4**). This result is lower than that of Yandaï *et al.* in 2016 in Chad who had obtained 71.13% of uneducated mothers [29]. This schooling rate is close to those of Tandina *et al.* in 2016 in Mali [30]. Malaria with 19.33% and intestinal parasitosis with 2% for the uneducated, and 27% and 2.67% for those who have completed primary education. A prevalence of 9.33% and 3.33% were found to be positive for malaria and intestinal parasitosis. The analysis we make is that parents have better monitoring of hygiene measures favorable to the reduction of parasite carriage of their child; thus illiteracy would not be a hindrance to general knowledge of fecal peril.

5. Conclusion

Anemia in association with malaria and intestinal parasitosis is common with high prevalence in malnourished children aged 0 to 5 years. The parasitic association is more widespread among subjects from peripheral districts than in the city center districts of N'Djamena. Malnourished children whose age vary from 23 to 35 months and from 11 to 22 months were the most parasitized. *Entamoeba histolytica* (intestinal parasite) and *Plasmodium falciparum* (hemoparasite) were the most predominant parasites. It is therefore imperative to continue investigations in all provinces of Chad to identify the different factors that contribute to the onset or worsening of anemia and to know how to better combat them in the future.

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Conflicts of interest

The authors declare no conflict of interest regarding the publication of this article.

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