Middle-East Journal of Scientific Research 14 (4): 461-470, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.14.4.7321

Haematological Status and Anaemia Prevalence Among Children Aged 5 to 11 Years in School Canteens in Abidjan (Côte D'ivoire)

[1]Baudouin A. Kokore, [1]Mathieu N. Bleyere, [1]Léandre K. Kouakou, [2,3]Dinard Kouassi and [1]Paul A. Yapo

[1]Laboratory of Physiology, Pharmacology and Phytotherapy (Training and Research Unit of Natural Sciences)/ University of Abobo-Adjamé; 02 BP 801 Abidjan 02
[2]Laboratoire of haematology (Training and Research Unit of the Biological and Pharmaceutical Sciences)/ University of Cocody; 21 BP 632 Abidjan 21
[3]Medical Analysis Laboratory and Biological Research, National Institute of Public Health (INSP), BP V 47 Abidjan, Côte d'Ivoire

Abstract: In Côte d'Ivoire, as in most developing countries, anaemia is a public health problem. The country possesses 5259 canteens in more than 8000 primary schools. Children attending schools with canteens are they concerned with public health problem that is anaemia? Their haematological profile conforms to the standards set by international organizations? To answer these questions, a study was conducted and aimed to determine the prevalence of anaemia in a school population and to study the typology. The work has focused initially on 350 subjects and 310 children (172 girls and 138 boys) aged 5 to 11 years were selected from three municipilities of Abidjan. Blood samples were taken from each child in order to search for the parameters of the blood count and the electrophoretic profile of hemoglobin. The results of study revealed that 82.9 % of children have indicated that at least a parameter of the blood count was abnormal. The prevalence of anaemia (hemoglobin < 11.5 g/dl) was 30.3 % with 33.3 % of males and 29.1 % for girls. Moreover, the mean values parameters of the blood count were compared in accordance with standards established by international organizations. In addition, haemoglobinopathies was found in these children (16.1 %), including sickle cell trait and hemoglobin C traitThe prevalence of anemia among school children selected in Abidjan is more considerable. This could be explained by a deficiency of micronutrients.In view of the results obtained, it is important to extend the work to all school canteens in order to assess the factors of anaemia and to determine normal values parameters of the blood count of children in such environment.

Key words: Anaemia · Typology · Norms Of Blood Cells Count · Children · School Canteens/Abidjan (Côte d'Ivoire)

INTRODUCTION

In Côte d'Ivoire for several years, children benefit from meals at schools like some nations in the world. The number of school canteens to 5259, is for these children a strong opportunity which should guarantee good nutrition in over 8000 primary schools in the country. To this end, school canteens should resolve the concerns of nutritional deficiency and overload. Nutritional deficiencies and overloads represent in school children a real concern for public health [1]. They may lead to anaemia and obesity [2-6]. Anaemia is the most common health problem in the world [7, 8]. It is the greatest common nutritional disorder worldwide and particularly in Africa, where pregnant women, infants and young children are most affected [9-12]. The prevalence of anaemia in the world is 24.8 % [13]. The preschool children are most affected with a prevalence of 47.4 %, followed by pregnant women (41.8 %), non pregnant women (30.2 %) and school age children (25.4 %). In each

Corresponding Author: Bleyere Mathieu Nahounou, Senior Lecturer, Physiology and Pathophysiology, Training and Research Unit of Natural Sciences, Nangui Abrogoua University; 02 BP 801 Abidjan 02 (Côte d'Ivoire),02 BP 801 Abidjan 02. Tel: +225-45-439-944. +225-60-418-108.

age group and sex studied, the highest prevalence is found in Africa [14]. Anaemia has multiple consequences which can be extremely severe [13, 15, 16]. This is the disturbance of physical and mental development often irreversible in infants and children, of least resistance to infections, tiredness and decreased physical and intellectual abilities [17-21]. Despite the multiple consequences of this disease, few investigations are conducted at schools in Côte d'Ivoire. The aim of this study was to determine the prevalence of anaemia and its typology in a population of children aged 5 to 11 years in three municipalities of Abidjan. The study has also conducted the possible changes in the complete blood count of these children in schools. Studies have equally indicated the sex was most exposed to anaemia. In addition, the investigations have proposed standards for parameters blood cell counts among this fringe of school children. Moreover, the investigations have evenly presented hemoglobin profile of these children.

MATERIALS AND METHODS

Setting and Study Population: In total 350 school children were selected to achieve a definitive size of 310 pupils including 172 girls and 138 boys (Fig. 1). The sex ratio of 1.2 the mean age of the study population was 7.7±0.1 years and ranged from 5 to 11 years (Table 1). The investigation was a cross sectional and descriptive study in school children living in three municipalities in Abidjan. This study occurred at the school group "Libanais Yopougon Ananeraie", primary school "BAD Cocody Belle Côte" and the School Group "Agbékoi Abobo" (Fig. 1). The Investigations have begun to the new school year and lasted for three months. This work was carried out for this purpose during a period from September 2010 to December 2010. The collection of anthropometric data of this study was done from a questionnaire sent to children with free and informed consent of parents, following an explanation of the interest o f the study. For the requirements of handling, criteria for inclusion and exclusion have been applied for subject selection. It comes to mainly hematological and gastrointestinal complications and inflammation in the three months preceding the study. All these observations were carried out by a medical team from the National Institute of Public Health (INSP) in Abidjan (Côte d'Ivoire).

Blood Samples and Determination of Biological Parameters: Samples of venous blood from each child are taken into tubes containing an anticoagulant, ethyl diamine tetra acetic acid (EDTA) in the morning. These blood samples are transported within 12 hours of the day, the day of collection at the biological laboratory of the National Institute of Public Health to carry out the blood counts. The determination of haematological parameters was performed immediately after homogenization to Coulter, by an automatic analyzer “Sysmex KX 21N”. Moreover, in order to establish the standards parameters

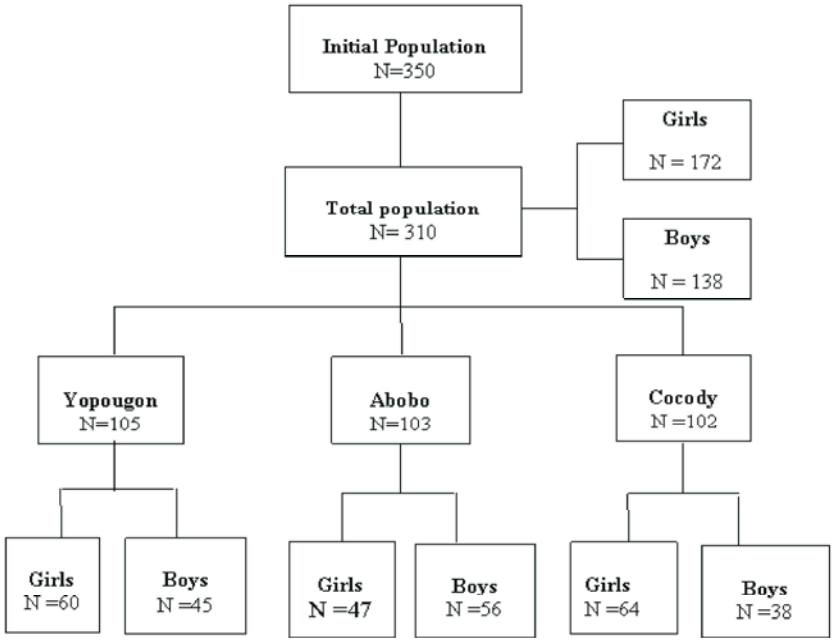

Fig. 1: Size of selected populations for the study N: Size of subject groups

Table 1: Characteristics of study population

General characteristics	Total population N=310	Girls N=172	Boys N=138
Age (ans)	7,7±0,1	7,8±0,1	7,6±0,2
5 - 6	27,3 % (99)	27,3 % (47)	37,7 % (52)
7 - 11	68,1 % (211)	72,7 % (125)	62,3 % (86)
Height (cm)	124,5±0,6	125,9±0,9	122,8±0,2
Weight (kg)	22,7±0,3	23,3±0,4	21,8±0,04
Wasting (W/A)			
(Z-score rated, mean)	-0,9±0,6	-0,8±0,1	-1,1±0,1
< -2Z	15.5 % (48)	13.4 % (23)	18.1 % (25)
= –2Z	84.5 % (262)	86.6 % (149)	81.9 % (113)
> -2Z	0 % (0)	0% (0)	0 % (0)
Stunting (T/A)			
(Z-score rated, mean)	-0,14±0,01	0,0±0,1	-0,3±0,1
< -2Z	5.5 % (17)	4.1 % (7)	8 % (11)
= –2Z	87.7 % (272)	86.1 % (148)	89.1 % (123)
> 2Z	6.8 % (21)	9.9 % (17)	2.9 % (4)
BMI			
(Z-score rated, mean)	-1,3±0,01	-1,2±0,1	-1,5±0,1
< -2Z	26.8 % (83)	23.8 % (41)	30.4 % (42)
= –2Z	72.9 % (226)	75.6 % (130)	69.6 % (96)
> 2Z	0.3 % (1)	0.6,% (1)	0 % (0)

(): Observed numbers in each group of subjects are in brackets; N: Size of subject groups

of the blood count, all anaemic children were excluded in the second phase of data processing. Criteria defined by the World Health Organization (WHO) were used to estimate different prevalences of the main haematological parameters. In addition, an electrophoretic profile of hemoglobin for each child was conducted from a volume of packed red blood cells. The machine like “Helena” was used to assess the types of hemoglobin electrophoresis at alkaline pH to cellulose acetate.

Statistical Analysis of Haematological Parameters: For statistical analysis, data were entered and analyzed by the STATISTICA software (Windows version 7.1). The mean values of different investigated parameters in school children were compared using the non parametric Mann Whitney U. The comparisons of different proportions of the main obtained biological parameters from the blood count and hemoglobin electrophoresis were performed by the test Loglikelihood ratio (Test "G") with the statistical software "R" version 2.0.1 Windows. A probability level (p) of less than 0.05 was chosen for the significance of all statistical analysis of data.

Ethics: Experimental procedures and protocols used in this study were approved by ethical committee of Health Sciences and the University of Abobo-Adjamé (Abidjan/Côte d’Ivoire). These guide line were in accordance with the internationally accepted principles for laboratory use and care.

Then, this study was approved by the Ministry of Higher Education and Scientific Research, the Ministry of Education and the Ministry of Health and Public Hygiene in the Republic of Côte d'Ivoire.

RESULTS

Changes in Haematological Parameters: The mean values of the different haematological parameters associated with the standard error of the mean (SEM) are presented in Table 2. These values were in accordance with the normal physiological reference values from the literature except for the rate of lymphocytes (51.3±0.5) which is higher overall and by sex (Table 2). All the parameters did not indicate significant differences between girls and boys ($p > 0.05$). In contrast, mean corpuscular volume and mean corpuscular hemoglobin have been statistically different by sex ($p < 0.05$). These two haematological parameters were higher in girls compared to boys (77.9±0.4 fl and 76.6±0.5 fl, 25.2±0.2 pg and 24.6±0.2 pg, respectively). The set of 216 non anemic school children showed normal mean values compared the standards established by international organizations (Table 3). However, the proportion of lymphocytes has been sufficiently high relative to the reference value (Table 3). Furthermore, no significant differences were observed between girls and boys for all the parameters of the blood count. Conversely, a significant difference ($p = 0.04$) was shown at the mean corpuscular hemoglobin

Table 2: Mean values of haematological parameters in total population

	Total population N=310			Girls N=172			Boys N=138				
Haematological parameters	Mean ± SEM	Min	Max	Mean ± SEM	Min	Max	Mean ± SEM	Min	Max	p value	Reference values
Red blood cells (10^{12}/l)	4.8±0.02	3.6	6.5	4.2±0.003	3.7	6.5	4,9±0,004	3.6	5.9	0,3(NS)	3,5 - 5
Hemoglobin (g/dl)	11,9±0,1	8.6	14.3	12,04±0,1	8.7	14.3	11,8±0,1	8.6	14.2	0,09(NS)	11,5 - 16
Hematocrit (%)	37.2±0.2	27.8	42.7	37.4±0.2	27.8	42.7	37±0.2	30.2	42.4	0,3(NS)	36 - 44
MCV (fl)	77.3±0.3	56	90.6	77.9±0.4	56	88.4	76.6±0.5	64.5	90.6	0,01(S)	70 - 86
MCH (pg)	24.9±0.1	16.6	37.9	25.2±0.2	17.6	37.9	24.6±0.2	16.6	33.6	0,01(S)	24 - 31
MCHC (g/dL)	32.1±0.8	25	35.5	32.2±0.1	27.6	35.5	31.9±0.1	25.1	35	0,1(NS)	32 - 36
Leucocytes (10^6/l)	6.04±0.1	3.1	13.1	6±0.1	3.5	13.1	6.1±0.1	3.1	10.4	0,4(NS)	4 - 12
Neutrophils (%)	41.5±0.5	21	75	40.8±0.5	23	75	42.3±0.8	21	63	0,1(NS)	40 - 70
Eosinophils (%)	2.1±0.1	1	5	2.1±0.1	1	5	2.1±0.1	1	5	0,4(NS)	1 - 5
lymphocytes (%)	51.3±0.5	15	75	52.02±0.5	15	72	50.4±0.9	26	75	0,2(NS)	20 - 40
Monocytes (%)	5.2±0.1	2	8	5.1±0.1	2	8	5.2±0.1	2	8	0,2(NS)	4 - 10
Thrombocytes (10^6/l)	324.1±5.1	87	589	328.1±7	100	589	319.2±7.6	87	575	0,3(NS)	150 - 400

N: Total number of each subjects group; MCV: Mean Corpuscular Volume; MCH: Mean corpuscular hemoglobin; MCHC: Mean corpuscular hemoglobin concentration; SEM: Standard error of mean; Min: Minimum; Max: Maximum; S: Statistically different for p value < 0.05; NS: Not statistically significant for p value < 0.05

Table 3: Normal haematological mean values in non anaemic subjects

	Total population N=216			Girls N=122			Boys N=94				
Haematological parameters	Mean ± SEM	Min	Max	Mean ± SEM	Min	Max	Mean ± SEM	Min	Max	p value	Reference values
Red blood cells (10^{12}/l)	4.9±0.03	4.3	6.02	4.9±0.04	4.27	6.02	4.9±0.04	5.13	5.91	0,3 (NS)	3.5 - 5
Hemoglobin (g/dl)	12.5±0.1	11.5	14.3	12.5±0.1	11.5	14.3	12.4±0.1	11.5	14.2	0,1 (NS)	11.5 - 16
Hematocrit (%)	38.4±0.1	33.7	42.7	38.5±0.2	33.7	42.7	38.3±0.2	34.8	42.4	0,5 (NS)	36 - 44
MCV (fl)	78.3±0.3	66.6	90.6	78.7± 0.5	66.9	88.4	77.8±0.5	66.6	90.6	0,1 (NS)	70 - 86
MCH (pg)	25.4±0.1	19.5	30.3	25.7±0.2	19.6	29.6	25.1±0.2	19.5	30.3	0,04 (S)	24 - 31
MCHC (g/dL)	32.4±0.1	28.7	35	32.6±0.1	28.7	35	32.3±0.1	28.8	35.2	0,1 (NS)	32 - 36
Leucocytes (10^6/l)	6±1	3.2	12.4	6±0.1	3.5	12.4	6±0.2	3.2	10.4	0,8 (NS)	4 - 12
Neutrophils (%)	41.7±0.6	21	64	41.2±0.7	23	64	42.4±0.9	21	63	0,3 (NS)	40 - 70
Eosinophils (%)	2.1±0.6	1	5	2.1±0.1	1	4	2.1±0.1	1	5	0,6 (NS)	1 - 5
lymphocytes (%)	50.9±0.6	26	75	51.5±0.8	26	72	50.1±0.9	26	75	0,4 (NS)	20 - 40
Monocytes (%)	5.2±0.1	2	8	5.2±0.1	2	8	5.31±0.1	3	8	0,4 (NS)	4 - 10
Thrombocytes (10^6/l)	321.5±5.8	87	570	324.8±7.7	109	570	318.1±8.6	87	556	0,5 (NS)	150 - 400

N: Total number of each subjects group; MCV: Mean Corpuscular Volume; MCH: Mean corpuscular hemoglobin; MCHC: Mean corpuscular hemoglobin concentration; SEM: Standard error of mean; Min: Minimum; Max: Maximum; S: Statistically different for p value < 0.05; NS: Not statistically significant for p value < 0.05

between the two sexes. In this context, girls reported a mean value of mean corpuscular hemoglobin more increased compared to boys (25.7±0.2 pg and 25.1±0.2 pg).

Prevalence, Typology of Anaemia and Hemoglobin Phenotype: The results of the study showed that 82.9 % of school children reported that at least one parameter of the blood count, was abnormal (Table 4). The haematological status was the same for girls (82.6 %) than in boys (83.3 %) with no statistically significant difference between these two groups of children (Table 4). The prevalence of anaemia (hemoglobin < 11.5 g/dl) was 30.3 % (94 cases) of the total population (Table 4). It was observed in 33.3 % of boys and 28.1 % of girls with no statistically significant difference (p > 0.05). Anaemia in this population of children was 58.2 % light and 41.5 % moderate. Light and moderate anaemias were reported respectively 64 % and 36 % in girls against 52.3 % and 47.7 % for boys. Moreover, the proportions showed significant differences by sex. Among these anaemias, 57.5 % are hypochromic (18.1 % microcytic hypochromic anaemia and normocytic hypochromic anaemia 39.4 %), 18.1 % are microcytic (microcytic hypochromic anaemia) and 4.3 % macrocytic (macrocytic normochromic anaemia). In addition, normocytic anaemia was observed in 77.7 % of children and normochromic anaemia in 42.6 %.

Table 4: Proportions (%) of the main erythrocyte parameters

Erythrocytes parameters	Total population N=310		Girls N=172		Boys N=138	
Haematological status	n	% (CI 95 %)	n	% (CI 95 %)	n	% (CI 95 %)
Normal	53	17.1 (12.9-21.3)	30	17.4 (11.7-23.1)	23	16.7 (10.5-22.9)
Abnormal	267	82.9 (78.7-87.1)	142	82.6 (76.9-88.2)	115	83.3 (77.1-89.5)
Hemoglobin (g/dl)						
8.6 - 11.5	94	30.3 (25.2-35.4)	50	29.1 (22.3-35.9)	44	31.9 (24.12-39.7)
11.5 – 14.3	216	69.7 (64.6-74.5)	122	70.9 (64.1-77.7)	94	68.1 (60.32-75.88)
Types of anaemia						
Light	55	58.5 (48.5-68.5)	32	64** (50.7-77.3)	23	52.3 (37.5-67.0)
Moderate	39	41.5 (31.5-51.5)	18	36** (22.7-49.8)	21	47.7 (32.9-62.5)
MHA	17	18.1 (10.31-25.9)	6	12 (2.9-21.0)	11	25* (12.21-37.8)
NHA	37	39.4 (29.5-49.3)	18	36 (22.7-49.3)	19	43.2 (28.6-57.9)
NNA	36	38.3 (24.5-48.1)	24	48* (34.1-61.8)	12	27.3 (14.1-40.5)
mNA	4	4.3 (0.2-8.4)	2	4 (-1.4-9.4)	2	4.5 (-1.63-10.6)
Hematocrit (%)						
27.8 - 36	91	29.4 (24.3-34.5)	48	27.9 (21.2-34.6)	43	31.2 (23.47-38.9)
36 – 42.7	219	70.7 (65.6-75.8)	124	72.1 (65.4-78.8)	95	68.8 (61.1-76.5)
MCV (fl)						
56 - 70	32	10.3 (6.9-13.7)	12	07 (3.2-10.8)	20	14.5 (8.63-20.4)
70 - 86	262	84.5 (80.5-88.5)	151	87.8 (82.9-92.7)	111	80.4 (73.78-87.0)
86 – 90.6	16	5.2 (2.7-7.7)	9	05.2 (1.9-8.5)	7	05.1 (1.43-8.77)
MCH (pg)						
16.6 - 24 and 31 – 37.9	110	35.5 (30.2-40.8)	47	27.3*(20.6-33.9)	63	45.7*(37.39-54.0)
24-31	200	64.5 (59.2-69.8)	125	72.7 (66.04-79.4)	75	54.4 (46.1-62.7)

N: Total number of each subjects group; n: subjects number observed in each group; CI: Confidence interval; MCV: Mean Corpuscular Volume; MCH: Mean corpuscular hemoglobin; *: Groups with differences were significant at $p < 0.05$, **: Groups with differences were significant at $p < 0.01$; MHA: Microcytic Hypochromic Anaemia; NHA: Normocytic Hypochromic Anaemia; NNA: Normocytic Normochromic Anaemia; mHA: macrocytic Hypochromic Anaemia

Table 5: Proportions of main white blood cells and thrombocytes parameters

Leukocytes and thrombocytes Parameters	Total population N = 310		Girls N = 172		Boys N = 138		p values
Leucocytes (10^6/l)	n	% (CI 95 %)	n	% (CI 95 %)	n	% (CI 95 %)	
3,1 - 4	13	4.2 (2-6.5)	5	1.6 (0.2-3.5)	8	2.6 (-0.1-5.3)	0.6 (NS)
4 - 12	295	94.2 (91.6-96.8)	165	53.2 (45.7-60.7)	130	41.9 (33.7-50.1)	0.2 (NS)
12 - 13,1	2	0.7 (0.2-1.5)	2	0.7 (-0.6-1.9)	0	0.00 (0-0)	0.3 (NS)
Neutrophils (%)							
21- 40	139	44.8 (39.3-50.4)	78	25.2 (18.7-31.7)	61	19.7 (13.1-26.3)	0.4 (NS)
40 - 70	170	54.8 (49.3-60.4)	92	29.7 (22.87-36.5)	78	25.2 (17.9-32.4)	0.5 (NS)
70 - 75	1	0.3 (0.1-1)	1	0.3 (-0.5-1.1)	0	0 (0-0)	0.5 (NS)
Eosinophils (%)							
1 - 5	310	100	172	100	138	100	-
Lymphocytes (%)							
15 - 20	1	0.3 (0.3-1)	1	0.3 (-0.5-1.1)	0	0 (0-0)	0.5 (NS)
20 - 40	34	11 (7.5-14.5)	12	3.9 (1.0-6.8)	22	7.1 (2.8-11.4)	0.3 (NS)
40 - 75	275	88.7 (85.2-92.2)	159	51.3 (43.8-58.8)	116	37.4 (29.3-45.5)	0.1 (NS)
Monocytes (%)							
2 - 4	20	6.5 (3.7-9.2)	8	2.6 (0.2-4.9)	12	3.9 (0.7-7.1)	0.6 (NS)
4 - 10	290	93.6 (90.8-96.3)	164	52.9 (45.4-60.4)	126	40.7 (32.5-48.9)	0.2 (NS)
Thrombocytes (10^6/l)							
87 - 150	6	1.9 (0.4-3.5)	4	1.3 (-0.4-2.9)	2	0.7 (-0.7-2.1)	0.6 (NS)
150 - 400	242	78.1 (73.5-82.7)	130	41.9 (34.5-49.3)	112	36.1 (28.1-44.2)	0.5 (NS)
400 - 589	62	20 (15.6-24.5)	38	12.3 (7.4-17.2)	24	7.7 (3.3-12.1)	0.3 (NS)

N: Total number of each subjects group; SEM: Standard error of mean; NS: Not statistically significant for p value < 0.05

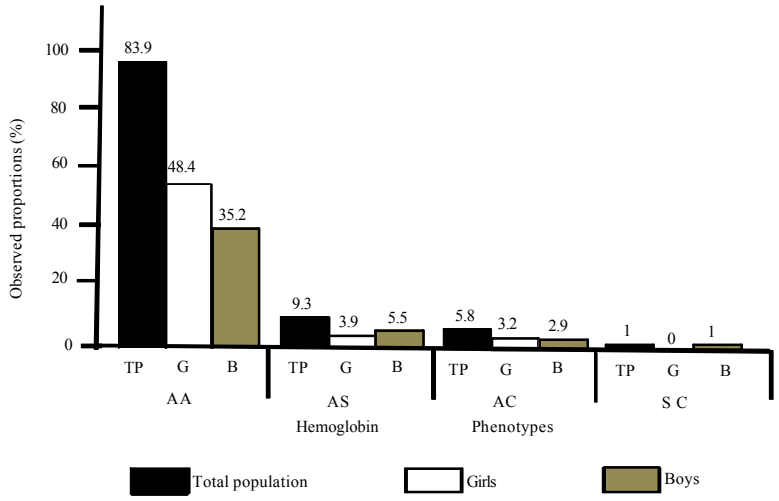

Fig. 2: Evolution of Hemoglobin phenotypes in different groups of subjects TP: Total population; G: Girl; B: Boys; AA: Normal form of hemoglobin; AS, AC and SC: Forms of haemoglobinopathies

The distribution of anaemia according to the typology and sex is summarized in Table 4. The microcytic hypochromic anaemia in boys (25 %) was significantly ($p = 0.03$) higher compared to girls (12 %). Normocytic hypochromic anaemia and macrocytic normochromic anaemia were also more observed in boys (42.3 % and 4.5 % respectively) than girls (36 % and 4 % respectively) with no significant difference ($p > 0.05$). However, normocytic normochromic anaemia was higher among girls (48 %) than boys (27.3 %) with a significant difference ($p = 0.02$). Macrocytosis and microcytosis were indicated respectively in 5.2 % and 10.3 % of subjects with no significant difference ($p > 0.05$) between the two sexes. But hypochromia was observed in 35.5 % of children with a significant difference between girls and boys ($p < 0.05$). The proportion of subjects whose hematocrit was below 36 % is 29.4 %. These rates do not change significantly ($p > 0.05$) by sex. The results of studies have also shown in Table 5 that 4.2 % and 0.7 % respectively of the children had leukopenia and leukocytosis. Similarly, high neutropenia, lymphocytosis and thrombocytosis were reported respectively in 44.8 %, 88.7 % and 20 % of study subjects. In contrast, the total population of the investigations has reported normal levels of eosinophils, low proportions of lymphopenia (0.3 %), of monocytopenia (6.5 %) and thrombocytopenia (1.9 %). In the two groups of children, no significant differences were reported for all proportions of leukocyte and thrombocyte parameters. However, girls presented slightly higher proportions of leukocytosis (0.7 % vs 0 %), neutropenia (25.2 % vs 19.7 %), lymphocytosis (51.3 % vs 37.4 %) and thrombocytosis (12.3 % vs 7.7 %) compared to boys. In contrast, boys reported more or less elevated rates of leukopenia (2.6 % vs 1.6 %) and monocytopenia (3.9 % vs 2.6 %) compared to girls.

Screening for hemoglobin disorders in school children revealed that 16.1 % of them are carriers of these anomalies (Figure 2). The most observed abnormalities were the sickle cell trait AS (9.3 %), hemoglobin C trait (5.8 %) and sickle cell trait SC (1 %). The observed deficiencies have not significantly different between sex (Fig. 2).

DISCUSSION

This study examined the extent of anaemia and its typology in a population of school children aged 5 to 11 years and attending school canteens in three municipalities of Abidjan. This work also helps to design appropriate monitoring in order to avoid the early onset of anaemia among children in schools. To do this, a description of the data of blood count was performed to define anaemia, to specify the typology and to give the aetiologies. In this context, the different mean values of haematological parameters are similar to physiological values reported in the literature by the standards of the World Health Organization (WHO) except the rate of lymphocytes. These different means are similar to those obtained in Saudi Arabia among children of school age [22]. According to these authors Saudis no significant differences between girls and boys for all the parameters of the blood count were observed. The mean value of hemoglobin obtained in the case of the study is similar to that indicated in a rural population of school children in

Vietnam [23]. The same results were also reported on a similar population of children with the same age group in Dublin (Ireland) [24].

From the data available in accordance with the literature, anaemia is very common among school age children and these investigations confirm this. The prevalence of anaemia in the study population was 30.3 %. This rate is relatively lower than that obtained in Côte d'Ivoire in children with the same age (46 %) [25]. This decrease could be explained by the fact that the study was extended to the rural population with different demographic characteristics from those of these subjects. In addition, other studies reported higher prevalences of anaemia in school children [26- 28]. In the same vein, urban African Cameroon recorded a rate of anaemia (42.8 %) among children aged 5-10 years by considering the pathological rate of hemoglobin to 11g/dl [29]. Conversely, the prevalence of anaemia in this study is higher than that specified elsewhere. Such is the case from work which indicated a lower rate of anaemia (12.2 %) in a population of children in Morocco, but no significant difference between girls and boys as in this study [30]. This could be explained by the socioeconomic and cultural development of children in each study areas [31, 32]. Moreover, the presence of canteens in schools selected for needs of our study may reflect the low observed prevalence in children. Anaemias are classified according to the hemoglobin, the mean corpuscular volume and mean corpuscular hemoglobin. Also the mean values of MCV and MCH are statistically different by gender. These values are higher for girls than for boys. This result is contrary to that revealed no significant difference between girls and boys [33]. The prevalence of anaemia in school boys is slightly to 58.2 % and moderate to 41.5 %. The difference was not statistically significant according to sex. There is no severe anaemia in this study group. This result is similar to that carried out among school children in India [26].

Anaemias in this study population were 57.4 % hypochromic, 18.1 % microcytic and 4.3 % macrocytic. The hypochromia and microcytosis in this population are higher in boys than in girls. The disruption of erythrocyte parameters (MCV, MCH) precedes the final stage of anaemia with the fall in hemoglobin levels below the limit. This decrease in MCV and MCH might indicate a deficiency in micronutrients including iron and vitamins in this population [5, 34]. Anaemia has multifactorial causes [35, 36]. The main reason for the onset of anaemia is of a food [9]. Food in populations of developing countries is deficient in micronutrients [4, 37, 38]. The content and composition of meals in canteens could explain the reduction in the prevalence of anaemia in subjects of the study compared to the work above mentioned [1, 39, 40]. All nutrients (macronutrients and micronutrients) that could include the daily diet are the cause of the decline in the rate of hemoglobin in children of these investigations [2, 41, 42].

However, the changes in leukocyte and thrombocyte parameters are modified compared to standards. Côte d'Ivoire is situated in an area with high malaria endemicity such as certain throughout the world [38, 43- 45]. Furthermore, the influence of malaria on anemia in populations is demonstrated [46]. The infectious and inflammatory syndromes and haemoglobinopathies degrade haematological status of populations [47-52]. In this vein, screening for haemoglobinopathies in children revealed that 16.1 % of children are carriers of these anomalies in this study. This is lower than that observed respectively 19 % and 22.5 % in Côte d'Ivoire [20, 25]. This could explain the alteration of haematological parameters of children in this study. In addition, the proposed standards parameters of the blood count should consider all these factors and represent those obtained in the case of the study. It would be judicious to extend this study to 5259 canteens in over 8000 primary schools in Côte d'Ivoire.

CONCLUSION

The investigations carried out among school children in Abidjan indicate that the prevalence of anaemia is significant with established standards. However, the rate of anaemia is low compared to previous work by other authors in Côte d'Ivoire. It is also clear from this study that the haematological status of these children is strongly altered. In selected circumstances of the study, the different blood count parameters of children in school canteens should be better than the results reported in other investigations elsewhere in developing countries. The crisis that the country has experienced since 2002 has had to reduce the efforts of officials in charge of school meals supported by international agencies (World Food Programme, World Bank). It is suitable for us to regain the growth dynamics of school meals which should be maintained in any school in the Côte d'Ivoire. Moreover, it must be determined through several work standards parameters of blood count, even if we have given up only those children in three municipalities of Abidjan. We intend to participate in a larger project including all 5259 school canteens for one hand to obtain a true

prevalence of anaemia involving the standards of the blood count and also to indicate the micronutrient status (minerals and vitamins), nutritional status and the bioavailability of nutrients in the meals served to children. This advised us to avoid the early onset of nutritional deficiency and overload in children that can impede their physical and intellectual capacity.

ACKNOWLEDGEMENTS

The authors are grateful to Dr Léonie Clémence KOUONON, all laboratory managers and staff of National Institute of Public Health Abidjan/Côte d'Ivoire (INSP) for their support during our investigations. Our thanks are also due to the children and their parents, also the inspectors, directors and headmasters of schools in which our study has been realized.

Funding: This research did not receive any specific grant from any funding agency in the public, commercial, or not for profit sector.

Authors' Contributions: Baudouin A. KOKORE, Mathieu N. BLEYERE and Léandre K. KOUAKOU developed the concept and designed experiments under supervision of Duni SAWADOGO, Dinard KOUASSI, Etienne E. EHILE and Paul A. YAPO.

Baudouin A. KOKORE, Mathieu N. BLEYERE, Léandre K. KOUAKOU Mama KONE and André B. KONAN analysed the data and wrote the first draft of the paper. All the coauthors contributed to the revision and the finalization of the paper.

Declaration of Interest: The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

REFERENCES

1. El-Hioui, M., A.O.T. Ahami, Y. Aboussaleh, S. Rusinek, K. Dik and A. Soualem, 2008a. Iron Deficiency and Anaemia in Rural School Children in a Coastal Area of Morocco. Pakistan Journal of Nutrition, 7: 400-403.
2. Kuyumcu, A., E. Karabudak, M. Tayfur, F. Elmacioglu, A.O. Ozcelik and H.T. Besler, 2007. Short-Term Effects of Energy-Reduced Dieting on Weight Loss, Body Composition and Metabolism in Overweight Turkish Men. Pakistan Journal of Nutrition, 6: 582-589.
3. Handa, R., F. Ahamad, K.K. Kesari and R. Prasad, 2008. Assessment of Nutritional Status of 7-10 Years School Going Children of Allahabad District: A Review. Middle-East Journal of Scientific Research, 3(3): 109-115.
4. Mohamed, M.S., 2008. Assessment of the Nutritional Status of Adult Patients with Asthma. Pakistan Journal of Nutrition, 7: 266-272.
5. Ramzan, M., I. Ali and A. Salam, 2009. Iron Deficiency Anemia in School Children of Dera Ismail Khan, Pakistan. Pakistan Journal of Nutrition, 8: 259-263.
6. Mirhosseini, N.Z., S. Shahar, N.A.M. Yusoff, M.M. Ghayour-Mobarhan, A.R. Derakhshan and M.T. Shakery, 2011. Lower Level of Physical Activity Predisposes Iranian Adolescent Girls to Obesity and its Metabolic Consequences. Pakistan Journal of Nutrition, 10: 728-734.
7. Maitland, K., A. Pamba, G. Fegan, P. Njuguna, S. Nadel, C.R.J.C. Newton and B. Lowe, 2005. Perturbations in Electrolyte Levels in Kenyan Children with Severe Malaria Complicated by Acidosis. Clinical Infectious Diseases, 40: 9-16.
8. Al-Assaf, A.H., 2007. Anemia and Iron Intake of Adult Saudis in Riyadh City-Saudi Arabia. Pakistan Journal of Nutrition, 6(4): 355-358.
9. Dillon, J.C., 2000. Prevention of iron deficiency and iron deficiency anaemia in the tropics. Medecine Tropicale, 60: 83-91.
10. Gur, E., I. Yildiz, T. Celkan, G. Can, S. Akkus A. Arvas, S. Güzelöz and S. Çifçili, 2005. Prevalence of Anemia and the Risk Factors Among Schoolchildren in Istanbul. Journal of Tropical Pediatrics, 51(6): 346-350.
11. Hazarika, J., I. Saikia and P.J. Hazarika, 2012. Risk Factors of Undernutrition Among Women in the Reproductive Age Group of India: An Evidence from NFHS-3. American-Eurasian Journal of Scientific Research, 7(1): 05-11.
12. Chhabra, S., Preetinder Kaur, Chandan Tickoo and Prashant Zode, 2012. Study of Fetal Blood With Maternal Vaginal Bleeding. Asian Journal of Scientific Research, 5(1): 25-30.
13. WHO, 2008. Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia. WHO, Geneva, Switzerland, pp: 40.
14. McLean, E., M. Cogswell, J.E. Egli, D. Wojdyla and B.D. Benoist, 2006. Report of the World Health Organization Technical Consultation on prevention and control of iron deficiency in infants and young children in malaria-endemic areas. Food and Nutrition Bulletin, 28(4): S489- S631.

15. Goudarzi, A., M.R. Mehrabi and K. Goudarzi, 2008. The Effect of Iron Deficiency Anemia on Intelligence Quotient (IQ) in under 17 Years Old Students. Pakistan Journal of Biological Sci., 11(10): 1398-1400.
16. Ahmadi, A., N. Enayatizadeh, M. Akbarzadeh, S. Asadi and S.H.R. Tabatabaee, 2010. Iron Status in Female Athletes Participating in Team Ball-Sports. Pakistan Journal of Biological Science, 13(2): 93-96.
17. Hadipour, R., A.K. Norimah, B.K. Poh, F. Firoozehchian, Raheleh Hadipour and A. Akaberi, 2010. Haemoglobin and Serum Ferritin Levels in Newborn Babies Born to Anaemic Iranian Women: a Cross-Sectional Study in an Iranian Hospital. Pakistan Journal of Nutrition, 9(6): 562-566.
18. Colomer, J., C. Colomer, D. Gutierrez, A. Jubert and A. Nolasco, 1990. Anaemia during pregnancy as a risk factor for infant iron deficiency: Report from the Valencia Infant Anaemia Cohort (VIAC) study. Paediatric and Perinatal Epidemiology, 4: 196-204.
19. Scholl, T.O. and M.L. Hediger, 1994. Anernia and iron deficiency anemia: Compilation of data on pregnancy outcome. American Journal of Clinical Nutrition, 59: 492s-50 IS.
20. Sakande, J., D. Sawadogo, E.W.C. Nacoulma, G. Tiahou and A.C. Gnagne, 2004. Iron metabolism and erythrocyte values of ivorian newborn: Relationship with iron status of the mother. Cahiers d'études et de recherches francophones/Santé, 14(1): 17-20.
21. Unsal, A., O. Bor, M. Tozun, E.C. Dinleyici and G. Erenturk , 2007. Prevalence of anemia and related risk factors among 4-11 Months Age Infants in Eskisehir, Turkey Journal of Medical Science, 7: 1335-1339.
22. El-Hazmi, M.A. and A.S. Warsy, 2001. Normal reference values for hematological parameters, red cell indices, HB A2 and HB F from early childhood through adolescence in Saudis. Annals of Saudi Medicine, 21: 165-169.
23. Le, H.T., I.D. Brouwer, H. Verhoef, K.C. Nguyen and F.J. Kok, 2007. Anaemia and intestinal parasite infection in school children in rural Vietnam. Asia Pacific Journal of Clinical Nutrition, 16: 716-723.
24. Taylor, M.R., C.V. Holland, R. Spencer, J.F. Jackson, G.I. O'Connor and J.R. O'Donnell, 1997. Haematological reference ranges for schoolchildren. Clinical Laboratory Haematology, 19: 1-15.
25. Asobayire, S.F., P. Adou, L. Davidsson, J.D. Cook and R.F. Hurrell, 2001. Prevalence of iron deficiency with and without concurrent anemia in population groups with high prevalences of malaria and other infections: a studiy in Côte d'Ivoire. American Journal of Clinical Nutrition, 74: 776-82.
26. Sudhagandhi, B., S. Sivapatham, W.E. William and A. Prema, 2011. Prevalence of anemia in the school children of Kattankulathur, Tamil Nadu, India. International Journal of Nutrition, Pharmacology Neurological Diseases, 1(2): 184-188.
27. Verma, M., J. Chhatwa and G. Kaur, 1998. Prevalence of anemia among urban school children of Punjab. Indian Journal of Pediatric, 35: 1181-1186.
28. Gomber, S., S. Kumar, U. Rusia, P. Gupta, K.N. Agarwal and S. Sharma, 1998. Prevalence and etiology of nutritional anaemias in early childhood in an urban slum.. Indian Journal of Medical Research, 107: 269-73.
29. Mbanya, D., C.T. Tagny, A. Akamba, M.O. Mekongo and E. Tetanye, 2008. Etiology of anaemia in African children from 5 to 10 years. Sante, 18(4): 227-230.
30. El-Hioui, M., A.O. Ahami, Y. Aboussaleh, S. Rusinek, K. Dik, A. Soualem, F.Z. Azzaoui, H. Loutfi and M. Elqaj, 2008b. Risk Factors of Anaemia Among Rural School Children in Kenitra, Morocco. East African Medical Journal, 5(2): 62-66.
31. UNICEF/WHO/UNU/MI, 1998. Preventing iron deficiency in women and children: Technical consensus on key issues and resources for programme advocacy, planning and implementation. New York: Unicef. http://www.inffoundation.org/pdf/prevent_iron_def.pdf.
32. Singh, V.P. and N. Sachan, 2011. Vitamin B_{12}-A Vital Vitamin for Human Health: A Review. American Journal of Food Technology, 6: 857-863.
33. Rakoto, A.O., M. Ratsitorahina, P. Pfister, R. Laganier and J.A. Dromigny, 2000. Estimating normal values of the hemogram in Madagascar. Archives de l'Institut Pasteur de Madagascar, 66(1-2): 68-71.
34. Ugwuja, E.I., K.O. Nwosu, N.C. Ugwu and M. Okonji, 2007. Serum Zinc and Copper Levels in Malnourished Pre-School Age Children in Jos, North Central Nigeria. Pakistan Journal of Nutrition, 6: 349-354.
35. Veghari, G.R., A.R. Mansourian and A.J. Marjani, 2007. The Comparison of the Anemia in Pregnant and Non-Pregnant Women in the Villages of the South-East of Caspian Sea-Gorgan-Iran. Journal of Medical Sciences, 7: 303-306.

36. Porniammongkol, O., U. Yamborisut, T. Intajak and P.P. Sirichakwal, 2011. Iron Status of Hill Tribe Children and Adolescent Boys: A Cross Sectional Study at a Welfare Center in Chiang Mai, Thailand. Pakistan Journal Nutrition, 10: 903-909.
37. Oguntona, R.C. and I.O. Akinyele, 2002. Food and nutrient intakes by pregnant Nigerian adolescents during the third trimester. Nutrition, 18: 673-679.
38. Yapi, H.F., H. Ahiboh, D. Monnet and A.E. Yapo, 2005. Intestinal parasites, haematological profile and anthropometric status of school children in the Cote d'Ivoire. Sante, 15: 17-21.
39. Zaidi, S.B., N. Abbas, A.H. Gilani, M.T. Javed, S. Bukhari and A. Habib, 1999. Study on Children with reference to malnutrition and its effect on haematology and serum total Proteins. Pakistan Journal of Biological Science, 2: 308-311.
40. Mamat, M., S.K. Deraman, N.M.M. Noor and Y. Rokhayati, 2012. Diet Problem and Nutrient Requirement using Fuzzy Linear Programming Approach. Asian Journal of Applied Sci., 5: 52-59.
41. Amuta, E.U. and R.S. Houmsou, 2009. Assessment of Nutritional Status of School Children in Makurdi, Benue State. Pakistan Journal of Nutrition, 8: 691-694.
42. Kooshki, A., T. Towfighian, F.R. Rahsepar and A. Akaberi, 2010. The Relationship Between the Antioxidants Intake and Blood Indices of the Children with Thalassemia in Sabzevar and Mashhad. Pakistan Journal Nutrition, 9(7): 716-719.
43. Mfonkeu, J.B.P., I. Gouado, H.F. Kuate, O. Zambou, G. Grau, V. Combes and P.H.A. Zollo, 2008. Clinical Presentation, Haematological Indices and Management of Children with Severe and Uncomplicated Malaria in Douala, Cameroon. Pakistan Journal of Biological Science, 11: 2401-2406.
44. Yapi, H.F., H. Ahiboh, K. Ago, M. Ake and D. Monnet, 2005. Protein profile and vitamin A in children of school age in Ivory Coast. Ann. Biol. Clin., 63: 291-295.
45. Yapi, H.F., A. Hugues, K. David, Y. Adou, B.K. Brice, M. Dagui and D.A. Joseph, 2010. Assessment of inflammatory and immunity proteins during falciparum malaria infection in children of Côte d'Ivoire. American Journal of Scientific and Industrial Research, 1: 233-237.
46. Umar, R.A., N.M. Jiya, M.J. Ladan, M.K. Abubakar, S.W. Hassan and U. Nataala, 2007. Low Prevalence of Anaemia in a Cohort of Pre-School Children with Acute Uncomplicated Falciparum Malaria in Nigeria. Trends in Medical Research, 2: 95-101.
47. Odebunmi, J.F., O.A. Adefioye and O.A. Adeyeba, 2007. Hookworm Infection among School Children in Vom, Plateau State, Nigeria. American-Eurasian Journal of Scientific Research, 2(1): 39-42.
48. Pourfallah, F., S. Javadian, Z. Zamani, R. Saghiri, S. Sadeghi B. Zarea, F. Mirkhani, N. Fatemi and T. Kordi, 2011. Evaluation of Serum Levels of Essential Trace Elements in Patients with Pulmonary Tuberculosis Before and After Treatment by Age and Gender. Pakistan Journal of Biological Science, 14(10): 590-594.
49. Ahmed, S.G., J. Umana and U.A. Ibrahim, 2006. Haematological Parameters of Sickle Cell Disease Patients with Menstruation Induced Vaso-Occlusive Crises. Pakistan Journal of Biological Science, 9(15): 2912-2915.
50. Shehu, S.A., N.D.G. Ibrahim, K.A.N. Esievo and G. Mohammed, 2006. Neuraminidase (Sialidase) Activity and its Role in Development of Anaemia in Trypanosoma evansi Infection. Journal of Applied Science, 6: 2779-2783.
51. Singotamu, L., R. Hemalatha, P. Madhusudhanachary and M. Seshacharyulu, 2006. Cytokines and Micronutrients in Plasmodium vivax Infection. Journal of Medical Science, 6: 962-967.
52. Inocent, G., D.N. Marceline, P.M.J. Bertrand and F.K. Honore, 2008. Iron Status of Malaria Patients in Douala - Cameroon. Pakistan Journal of Nutrition, 7: 620-624.