Assessment of Serum Calcium, Serum Iron and Nutritional Status among Under-Five Children in Six Municipalities of Abidjan District, Côte d'Ivoire

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Abstract: Malnutrition occurs in various forms in the world, especially in African countries. It affects two-thirds of the children in sub-Saharan Africa. In addition to the protein-energy malnutrition (PEM), micronutrient deficiencies also affect many children. The aim of this study was to evaluate the nutritional status, serum iron and serum calcium among under-five children. This study was conducted on a cohort from 480 children in six municipalities of Abidjan: Abobo, Cocody, Koumassi, Marcory, Treichville and Yopougon. A blood sample and anthropometric measurements (weight, height) were performed to determine the hematological profile and nutritional status of children. The results showed that stunting was the most widespread form of malnutrition among children surveyed. Depending on age, children from 0 to 6 months have a low prevalence of PEM than those from 7 to 59 months: wasting (1.2% vs 3.5%), stunting (8.6% vs 25.2%) and underweight (3.4% vs 10.7%). Also, the results reveal a lowest serum iron (µmol/l) among children from low households income (9.77 ± 2.4), illiterate mothers (8.92 ± 1.3) compared to those from mothers with a high level of education (21.75 ± 4.1) and high living standard (21.28 ± 2.1). There was no notable difference ($p>0.05$) between serum calcium whatever socio-demographic parameters considered. The parameters under study such as nutritional status, serum calcium and serum iron have shown a variation of malnutrition in Abidjan.

Keywords: Malnutrition status, prevalence, wasting, stunting, underweight, serum iron and calcium.

1. INTRODUCTION

The prevalence of malnutrition among under-five children is very high in many developing countries of the World. In black Africa, the World Health Organization (WHO) in 2008 has recorded more than eight million children affected by protein-energy malnutrition (PEM) more or less severe. This deficiency may affect their physical and intellectual development and ultimately, their ability to take part to the development of their country.

As for children victims of micronutrient deficiency (mainly iodine, iron and vitamin A), they were estimated at eleven million in 2009 on West Africa [1]. Recent investigations in Niger, Mali, and Burkina Faso established that malnutrition of child remains a mayor public health problem [2-4]. In these three countries, stunting affects approximately 45 to 61% of children under 5 years, while the prevalence of underweight affects 32 to 64% [5].

Concerning the etiology of poor nutritional status of children, it has been shown that child characteristics such as age, gender and socio-economic status of his family have an influence on their nutritional status [6]. The studies conducted in Ghana [7] found out that stunting have affected more than 50% of children from households with low living standard and about 19% for children from households with high living standard. Furthermore [8] exposed that children from household with middle and poor economic status were more likely to be wasted compared to children living in household with high economic status.

Unfortunately, Côte d'Ivoire, mainly agricultural country is not spared by child malnutrition. The prevalence of PEM among children in some region of Côte d' Ivoire was estimated at more than 40% [9]. In addition, the clinical studies showed that over 60% of children under the age of 5 years suffer from anemia [10, 11]. The anemia can be due to various factors such as: sickle disease, cell intestinal parasites, but the major cause of this disease is iron deficiency. Data on serum calcium deficiencies are virtually nonexistent. However, whatever the iron or calcium deficiency in Côte d' Ivoire, fewer studies found out specific biological diagnosis. Most of these studies are limited to superficial clinical examinations without studying the child hematological profile and especially the contents of iron and calcium in the blood.

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The overall objective of this study was to improve the database of child malnutrition to better use in Abidjan's municipalities. Specifically it was to examine the diagnosis of the nutritional status of children aged of 0-59 months by anthropometric measurements (height, weight) and then evaluate the prevalence of wasting, stunting and underweight. We also identified socio-demographic characteristics likely to be the determinants of child nutritional status. Finally, serum calcium and serum iron among children under five years were discovered.

2. MATERIALS AND METHODS

2.1. Subjects and Study Design

This study was conducted on 480 children aged 0-5 years in six cities of Abidjan in Côte d'Ivoire. Children are randomly selected based on their health status and with the consent of their parents. The municipalities involved are: Abobo, Cocody, Koumassi, Marcory, Treichville, Yopougon, with 80 children by city. The survey was carried out in over a three-month period from 3 January 2013 to 3 March 2013, as regards nutritional status and anthropometric measurement. The collect of blood was performed from 20 March to 20 April 2013 for hematological measurement (serum iron and calcium).

2.2. Anthropometric Analysis and Assessment of Nutritional Status of Children

Anthropometric measurements are weight and height of children. The weight of children over 2 years was determined from direct weighing performed on digital weighing scales (Tefal, precision 100g). Children are weighed as many times as necessary to achieve three times the same value. For children less than 2 years, their weight was determined by the method of double weighing. Concerning the height of the children over 2 years, it was measured to the nearest mm using a stadiometer (graduated in cm) in the standing position. The measurements were repeated until three values obtained did not differ more than 3 mm and the means were determined. For children less than two years, their height was measured in the supine position. The nutritional status of children was assessed using the usual indices based on combinations of weight, height, age.

The term "wasting" refers to a situation where a child has failed to achieve sufficient weight for height (W/H). Wasting often result from recent and continuing severe weight loss due to inadequate energy intake, recent and continuing poor health, or a combination of both.

The term "stunting" is used to describe a condition in which children fail to gain sufficient height, given their age. Stunting is therefore an extremely low "height- for-age" (H/A) score. Stunting is often associated with long-term factors such as chronic malnutrition, especially protein-energy malnutrition, and sustained and frequent illness.

The term "underweight" is used to describe a situation where a child weighs less than expected, given his or her age. Underweight is thus, an extremely low "weight- for-age" (W/A) score.

2.3. Socio-Demographics Characteristic of Children

Socio-demographic data of children were collected by questionnaire giving information on: age of children, gender, household income (poor, middle, wealthy), the educational level of the mother (illiterate, primary, secondary and tertiary), household living standard.

2.4. Blood Collection

Blood tests was performed in the morning fasted for all children in order to avoid circadian variations in serum iron and serum calcium. For each child, two blood samples at a venipuncture have been made in the elbow crease and put in the glass tubes of 5 ml (Vacutainer). The first samples containing ethylene diamine tetra acetic acid (EDTA) are designed for complete blood count and the second without EDTA are stored at −20°C for respectively determination of serum calcium and serum iron.

2.5. Serum Calcium Assay

Two (2) ml of blood previously collected were centrifuged (3500xg, x10 min, 4°C). The plasma obtained after centrifugation is collected in Eppendorf tubes (1.5 ml) and deproteinized with sulfosalicylic acid. After shaking, the tubes were centrifuged (3500xg, x10 min, 4°C). The pellet containing the deproteinized plasma is mixed with oxalate buffer in the ratio 2/3. After standing for 30 minutes, the mixture was centrifuged as before. The resulting precipitate was dissolved in perchloric acid and the whole is stirred vigorously for 10 seconds. To determine the calcium, the flame photometer is set at the position of the filter calcium. The goal is to get the value zero for distilled water and 50 for the calcium chloride solution. Once

the calibration of the photometer made, the plasma concentration of ionized calcium in mg/100 ml is calculated by dividing the numerical value given by the flame photometer by 5.

2.6. Iron Serum Assay

The determination of serum iron was made with photo-colorimeter MEUNIER (Screen 49, 10-10 diaphragm sensitivity 1). The assay technique is the technique used to O-phenanthroline. Measurements were performed on colorimeter MEUNIER and the final value of the iron serum was given by the following equation:

$$S = \frac{1000 * 0.018 * v * y}{p * n}$$

y: gamma iron per ml read on the curve.

p: volume of serum (ml).

v: total serum + reagents.

n: Volume of aliquot after centrifugation.

Conversion factor: g/l x = 0.018 mol/l

2.7. Statistical Analysis

Collected data were entered into tables of ACCESS database specifically designed depending on the nature of the data before being transformed into EXCEL files. The Excel file containing anthropometric data file was converted into EpiInfo (version 6.04) to allow the calculation of anthropometric indices with the module Epinut of this software. The data set was then taken and analyzed using the Statview software, version 3.1. The prominent effects of various demographic factors on anthropometric characteristics and nutritional status of children were studied. When a factor own more than two levels or modes, the corresponding results are compared in pairs by the Chi-2 test to identify those among them which has a significant difference.

3. RESULTS

3.1. Assessment of Nutritional Status, Serum Iron and Serum Calcium for Children According to their Age

Figure **1** shows the prevalence of three forms of Protein energy malnutrition (wasting, stunting and underweight) among children aged 0-59 months. The result showed the significant difference (p=0.02) between children aged from 0-6 months and 7-24 months. On the other hand, there was no significant difference (P>0.05) among children 7-24 months and 24-59 months in each form. The low prevalence of malnutrition was observed among child aged 0-6 month. After 6 month, the prevalence increased at 290% and remains constant until 59 month. We could think that children who were exclusively breastfed for the first 6 months after birth had showed lower prevalence of malnutrition compared to their counterparts fed at 7-24 and 24-59 month.

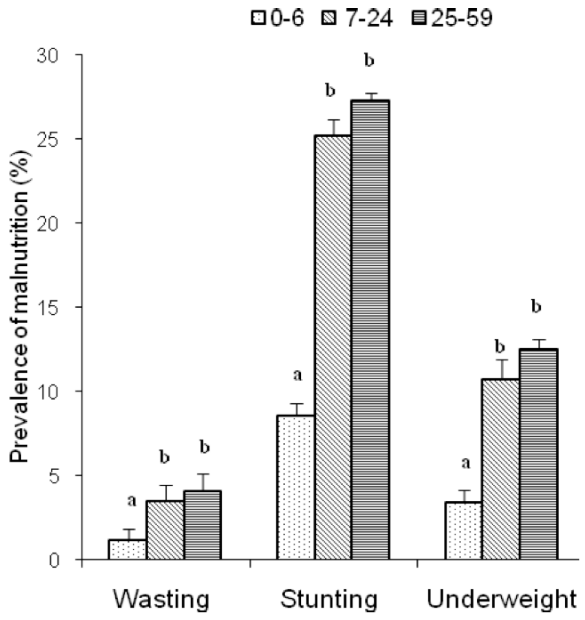

Figure 1: Status of malnutrition related to age.

We determined serum calcium and serum iron content of children according to their age (Table **1**). We did not observe significant differences (P>0.05) in serum calcium among children aged 0-59 months. This result showed a high iron content (19.29 µmol/l) among children aged 0-1 months. From 2 to 3 months, this content decreased drastically up to 63% and then remained stable until 59 months.

3.2. Prevalence of Malnutrition, Serum Iron and Serum Calcium of Children According to the Sex

Nutritional status (wasting, stunting and underweight) from children aged of 0 to 59 months did not differ (P>0.05) between the two groups of gender (Figure **2**). The rate of malnutrition affects in the same proportion both girls and boys. In addition, no real difference has been observed between hematological parameters (serum calcium and serum iron) among the girls and boys (Table **2**).

Table 1: Serum Calcium and Iron Serum in Relation to Age

	Serum calcium (mmol/l)	Serum Iron (µmol/l)
Age (month)		
0-1	2.44±0.4	19.29±3.2[a]
2-3	2.47±0.5	12.17±2.8[b]
4-6	2.46±0.3	11.92±3.1[b]
7-59	2.49±0.1	11.97±2.3[b]
	Ns (p=0.18)	*(p=0.04)*

a,b,c, = means in the same row bearing different superscripts differ significantly (p<0.05); NS = Not significant (p>0.05).

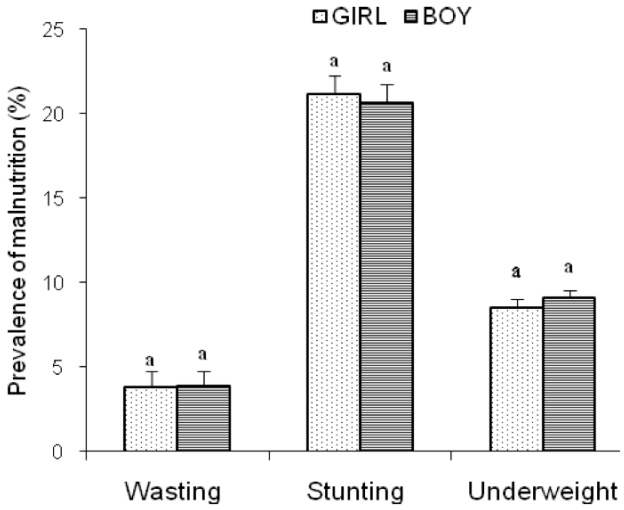

Figure 2: Status of malnutrition in relation to sex.

3.3. Prevalence of Malnutrition, Serum Iron and Serum Calcium of Children According to Household Living Standard

The analysis of Table **3** shows the rate of malnutrition status among children less than 5 year in six municipalities of Abidjan, Côte d'Ivoire. The results showed a high prevalence of malnutrition in Abobo 6.7%, 38.4% and 18.9% respectively for wasting, stunting and underweight compared to other municipalities. After Abobo, the most affected cities were Koumassi and Yopougon. Results showed no significant differences between the two municipalities. The three forms of malnutrition in Treichville vary but remain below than those of Abobo, Yopougon and Koumasi. Result showed the lowest prevalence in Cocody and Marcory compared to the others cities. There were no significant differences between Cocody and Marcory whatever the form of malnutrition study.

Concerning to hematological parameters, serum calcium content did not differ (p>0.05) between the cities considered whereas serum iron varies consequently (Table **4**). The results showed a lowest serum iron among children living in Abobo (8.37 µmol/l) compared to other cities. Result did no showed greater differences from iron content between the municipalities (Koumassi and Yopougon), but these values remain higher than those of Abobo. The rate of serum iron among children aged of 0-59 months is higher in Treichville compared to other three cities mentioned above, but remains lower than Marcory and Cocody. In terms of percentage, the rate of serum iron increased at 110%, 173% and 240% from respectively Abobo to Yopougon, Treichville and Cocody.

3.4. Prevalence of Malnutrition, Serum Iron and Calcium from Children Depending of Household Income

We established a significative relationship (P<0.05) between socio-economic household and nutritional

Table 2: Serum Calcium and Iron Serum Related to Sex

	Serum calcium (mmol/l)	Serum Iron (µmol/l)
Sex		
Girls	2.45±0.7	13.78±4.2
Boys	2.47±0.3	13.69±3.1
	Ns (p=0.22)	*Ns (p=0.01)*

NS = Not significant (p>0.05).

Table 3: Prevalence of Malnutrition, in Relation to Household Living Standard

	Wasting %	Stunting %	**Underweight %**
standard of living			
Abobo	6.7[a]	38.4[a]	18.9[a]
Koumassi	5.1[b]	34.9[b]	14.1[b]
Yopougon	5.3[b]	35.2[b]	14.3[b]
Treichville	3.2[c]	20.8[c]	7.3[c]
Marcory	2.1[d]	12.5[d]	4.2[d]
Cocody	1.7[d]	11.3[d]	3.9[d]
	(P=0.01)	(P=0.008)	(P=0.02)

a,b,c, = means in the same row bearing different superscripts differ significantly (p<0.05).

Table 4: Serum Calcium and Serum Iron of Children According to Household Living Standard

	Serum calcium (mmol/l)	**Serum Iron (µmol/l)**
standard of living		
Abobo	2.42±0.4	8.37±2.2 [a]
Koumassi	2.31±0.2	9.22±1.4 [b]
Yopougon	2.43±0.7	9.73±2.3 [b]
Treichville	2.49±0.9	14.55±3.8 [c]
Marcory	2.48±0.1	20.12±2.7 [d]
Cocody	2.49±0.5	20.55±4.1 [d]
	Ns (p=0.33)	*(p=0.02)*

a,b,c, = means in the same row bearing different superscripts differ significantly (p<0.05); NS = Not significant (p>0.05).

status of children aged less than 60 months (Figure **3**). The prevalence of malnutrition increases to more than 500% from households with high income to households with low income among children surveyed. We can suggest that the households in the high income quartile consume more calories and subsequently have a lower prevalence of under nourishment. Similarly, child nutritional status increase with increasing household income. Serum calcium from children aged of 0-59 months did not differ whatever household income, on the other hand, iron content increased significantly (p=0.003) with household income (Table **5**). Results showed that iron increase up to 177% and 217% respectively for households with middle income and high income compare to low income. Feeding children in poor households have a low iron content compared to rich households. This influence of economic well-being level could be due to the fact that poor households often live in precarious health conditions. It could have an impact on the presence of intestinal worms that inhibit iron absorption in children.

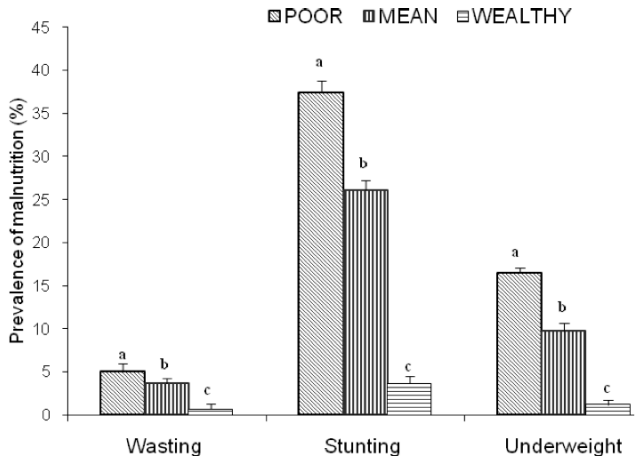

Figure 3: Status of malnutrition related to household income.

3.5. Malnutrition Prevalence of Serum Iron and Serum Calcium from Children Depending of the Educational Level of Mother

Our results showed that the high educational level of mother was deeply linked (p<0.05) with lower

Table 5: Serum Calcium and Iron Serum Related to Household Income

	Serum calcium (mmol/l)	Serum Iron (µmol/l)
Household income		
Poor	2.42±0.8	9.77±2.4 [a]
Mean	2.47±0.4	17.35±3.2 [b]
Wealthy	2.48±0.1	21.28±2.1 [c]
	Ns (p=0.55)	*(p=0.003)*

a,b,c, = means in the same row bearing different superscripts differ significantly (p<0.05); NS = Not significant (p>0.05).

Table 6: Prevalence of Malnutrition Related to Educational Level of Mother

	Wasting %	Stunting %	Underweight %
Education level			
Illiterate	5.1[a]	42.7[a]	19.1[a]
Primary education	5.2[a]	38.1[a]	17.3[a]
Secondary education	3.4[b]	27.2[b]	7.5[b]
Higher education	1.3[c]	3.5[c]	2.1[c]
	(P=0.002)	(P=0.007)	(P=0.03)

a,b,c, = means in the same row bearing different superscripts differ significantly (p<0.05).

prevalence in the three forms of malnutrition among children surveyed (Table **6**). The prevalence of wasting, stunting and underweight decreased to 25%, 8%, 10% respectively among children with mothers have low education compared to children with mothers have higher study. Hematological studies were showed that the rate of calcium in among children aged 0-59 months did not varies depending mother educational level, on the other hand, serum iron content increased significantly (p=0.005) (Table **7**). The result showed an increase of approximately 200% and 240% respectively for mothers with secondary and tertiary study level compared to mothers with low educational level.

4. DISCUSSION

The current study showed the prevalence of three forms of malnutrition (wasting, stunting and underweight) and hematological parameters (serum calcium and serum iron) among children less than 5 years in Abidjan, Côte d'Ivoire. Among the three forms of malnutrition, stunting was the most important prevalence from children surveyed. This result was in accordance with that observed by [12, 13] among child from Kwara State in Nigeria and Hidabu Abote district in Ethiopia respectively. However, several variabilities were observed when we established the link between various forms of malnutrition with child socio-

Table 7: Serum Calcium and Iron Serum Related to Educational Level of Mother

	Serum calcium (mmol/l)	Serum Iron (µmol/l)
Education level		
Illiterate	2.41±0.3	8.92±1.3 [a]
Primary education	2.40±0.7	9.18±2.5 [a]
Secondary education	2.46±0.6	18.24±4.6 [b]
Higher education	2.48±0.2	21.75±4.1 [c]
	Ns (p=0.42)	(P=0.007)

a,b,c, = means in the same row bearing different superscripts differ significantly (p<0.05); NS = Not significant (p>0.05).

demographic characteristics (age, sex, household income, mother's education level, Household living standard). The difference of nutritional status observe among children aged 0-6 months compare to those aged of 7-24 and 25-59 months could be explain by the high nutritional value of breast milk exclusively use for the first months. This result fit with those obtained by [14-17] who explained the low rate of malnutrition among children aged 0-6 months by the fact that from birth to age of 6 months, all the nutritional needs of the child are covered by breast milk. Also, children have through breast milk, all the nutrients necessary for their proper development. After 6 months, the milk becomes insufficient, the weaning food is often very varied and the diet of children lose quality but also quantity in relation to their age and weight. This is what explains that the PEM is very rare before 6 months and very common right after. It had been established that the inappropriate diet caused stunting and underweight among children aged 7-59 months [18]. The constant calcium level obtained in all age groups are in relation with those of [19, 20] who observe respectively children aged of 0-36 months and 6-59 months. The constant rate of serum calcium from children aged of 0-59 months could be caused by serum-regulating mechanism which holds serum calcium stable even in case of deficiency in bone tapping reserve.

The results showed the high iron content (19.29 µmol/l) from birth to age 1 month. From 2 to 3 months, this content decreased drastically up to 63% and then remained stable until 59th month. The changes in the serum iron content obtained in this study are similar to those of [19, 21] which reveal a decrease of 63% and 73% respectively after birth. In this result, the high iron content at birth is normal. This could be explained by the fact that iron stores at birth are naturally high. Indeed, the newborn inherits directly iron stores of this mother. Moreover, the drastic decrease in the iron from 2 to 3 months could be explained by the low breast milk iron content and a farinaceous regime too long. The variation of iron content among children aged 0-59 months could also be explained by the fact that among most infants, there exists a physiological anemia at the age of two months. Indeed, the fetal hemoglobin which carries iron will undergo destruction in favor of adult hemoglobin. When all fetal hemoglobin will disappear, the serum iron content stabilizes. Malnutrition affects in the same proportion both all the girls and boys surveyed. This result can be explained by the fact that there was no discrimination between girls and boys in Abidjan. The young girls enjoy the same privileges as the boys both in an education of food. The results obtained in this study are different from those of [8, 16, 17], in the district of Daloa showed that boys (39%) are more susceptible to malnutrition than girls (36%). On the other hand, [17] in the north of Côte d'Ivoire showed that malnutrition affects more girls (39%) than boys (26%). The differences between the results with our results could be explained by the fact that these authors used the logistic regression methods while we conducted a survey. This difference could also be explained by the localities or regions surveyed and/or the socio-demographic characteristics of children.

Concerning the serum calcium and serum iron, similar results to those of [19, 22] among children aged of 0 to 36 months and 6-59 months respectively have been obtained. The same level of serum calcium and serum iron observed in both girls and boys could be probably due to the fact that gender discrimination was low in Abidjan. In addition, at this age there is no biological difference between girls and boys. It is only after puberty that the iron status among girls is lower than boys because the loss of iron was associated with menstruation.

We established a low prevalence of malnutrition in Cocody compared to those researches, works demonstrated by [23]. These authors had established low levels of malnutrition in the residential areas of three African towns (Abidjan, Dakar and Yaoundé). The high prevalence of PEM obtained in Abobo compared to other municipalities could be explained by the fact that this municipality is full of many shantytowns and its poverty index is relatively high per head. According to the World Health Organization (WHO), poverty and casualization of habitat are classified as risk factors for malnutrition. The lowest malnutrition observed in Cocody and Marcory could be explained by the facts that, in these two municipalities are located residential neighborhoods which live high social classes. In the most households of these residential neighborhoods, undernourishment is scarce. The extreme differences between the two municipalities (Abobo and Cocody) are related firstly to health facilities that are much more important in Cocody than Abobo. Secondly, the index of well-being is lower in Abobo than Cocody.

As the case of PEM, children with the highest sign of iron deficiency reside in Abobo. These results are similar to those obtained by [20]. Iron deficiency is the most important because heme iron comes from animal protein whose price is not accessible to all households. Indeed, iron deficiency is lower in Cocody where many

wealthy households resides and can afford easily balanced and varied diet. While in Abobo or poverty index is high iron deficiency is highest because it is difficult to eat.

This result demonstrated the increase of malnutrition according to the living standard of the household. The results observe in this study are similar to those obtained by [24]. This author exposed an increase of 200% the three forms of malnutrition (washing, stunting and underweight) as well as in wealthy households than poor households. The work of [25] confirms our hypothesis by demonstrating that children from poor households in three countries of Africa (Cameroon, Burkina Faso and Togo) are more affected by malnutrition compared to wealthier households.

The increase in the prevalence of three forms of malnutrition of wealthy households to poor households could be explained by the fact that children from wealthier families have:-sufficient food consumption, - access to appropriate care, - good habit food compared to children from poor households. In addition, the poorer classes already in food insecure could show the highest rate of child malnutrition. The studies conducted by [26, 27] showed that household income is significantly associated with nutritional status in children. According to the World Health Organization (WHO), poverty is one of the risk factors for malnutrition to children.

Maternal education reveals an important association with the three form of malnutrition and it was higher among the children whose mothers were illiterate. Several studies have demonstrated negative correlation between the level of maternal education and various forms of malnutrition observed among children [18, 27-30]. In our results, the low prevalence of malnutrition among educated mothers may be explained by the fact that the high level of study is a factor of income improvement. It is clear that educational level of mothers is often associated to better income and a better understanding of a balance diet to prevent the risk of malnutrition. The relationship between hematological factors and the educational level of mother obtained in this study are consistent with those of [19, 22].

5. CONCLUSION

This study highlights the existence of a significative difference in child malnutrition (Wasting, stunting and underweight), which is still an alarming health problem among children under-five years in Côte d'Ivoire. Age, standard of living of the household, level of maternal education and household income influence nutritional status and serum iron .The living standard of the household and the maternal education are negatively correlated to the MPE from children aged 0-59 months. According to age, malnutrition occurs mainly to children older than six months. Abobo has a high rate of malnutrition compared to six other municipalities. Furthermore, malnutrition was found to be the result of familial, socio-economic and environmental factor. A consumer survey could be carried out to establish the relationship between the biological parameters of children and their nutritional status. The promotion of higher educational levels should help promote gender equality, empower women, and through better informed caregiving practices, reduce child malnutrition and, over long term, reduce the risk of child mortality.

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