



## **Malaria and Nutritional Status of Children in Anambra State, Nigeria**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors OOP, EJE and OFC designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OBU and ICA managed the analyses of the study. Authors UCU, AGU, UNP and AMI managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Malaria is a major cause of morbidity especially in children less than five years of age. This study was conducted to determine the relationship between malaria infection and nutritional status of some purposely selected children aged 0–36 months from hospitals in Anambra State, Nigeria. Data were collected on nutritional status using anthropometric data – age, height, weight and mid-upper arm circumference (MUAC). Malaria infection status was obtained through microscopic examination of thick films blood smears. The prevalence of malnutrition (weight-for-height Z - scores) among malaria uninfected in the community and hospital surveys was 26.7% and 9.2% respectively, while the prevalence among the malaria parasite infected children was 21.4% and 7.4% in the community and hospital respectively. The average number of malnourished children

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with Z-scores <-2SD were slightly higher than WHO standard. More malaria infected boys had Z-scores <-2SD compared to the WHO standard. Prevalence of malnutrition based on MUAC among malaria parasite infected children was very high (100% and 98.1% in community and hospital, respectively). The average number of stunted (height-for-age Z-score) children in both community and hospital survey was very high compare to WHO standard. It may be concluded that there is a high rate of malnutrition based on MUAC among malaria infected children in Anambra State.

**Keywords:** Malaria; nutritional status; children; Anambra State.

## 1. INTRODUCTION

Malaria is a major problem to public health especially in the tropical and sub-tropical regions of the world. It is transmitted by *Plasmodium* parasites namely *P. falciparum*, *P. malariae* and *P. ovale*. The most dangerous and predominant specie is *P. falciparum* (68.19% prevalence), followed by *P. Malariae* (6.51%) [1]. In 2018, 11 million pregnant women in sub-Saharan Africa were infected by malaria, and children under 5 years accounted for 67% of all malaria deaths [2]. According to the WHO malaria report [2], African Region still bears the largest burden of malaria morbidity, with 213 million cases (93%) in 2018, over 50% of all cases globally were accounted for by Nigeria (25%), followed by the Democratic Republic of the Congo (12%), Uganda (5%), and Côte d'Ivoire, Mozambique and Niger (4% each). Globally, 272 000 (67%) malaria deaths were estimated to be in children aged less than 5 years and Nigeria accounted 24% of the global malaria deaths. Malarial disease results from multiple complex parasite-host interactions during the asexual, blood stage of infection. Clinical manifestations of disease are related to parasite modification of the erythrocyte and parasite-induced inflammation. Severe anaemia is characterized by haemoglobin concentration  $\leq 5$  g/dL or a hematocrit of  $\leq 15\%$  in children less than 12 years of age while in children  $\geq 12$  year old is 7 g/dL, and less than 20%, respectively [3].

In high transmission areas, partial immunity to the disease is acquired during childhood. In such settings, the majority of malarial disease, and particularly severe disease with rapid progression to death, occurs in young children without acquired immunity. Severe anaemia, hypoglycaemia and cerebral malaria are features of severe malaria more commonly seen in children than in adults [4,5]. Young children manifest this disease in many different ways, but the classic picture of malaria, with periodic fever, shivering, and sweating, is not observed. Malaria can mimic any febrile illness and should be

suspected in any febrile child who has recently been in a malarious area [6].

General danger signs of malaria in children may be one of these: not able to drink or breast feed, vomiting everything, recent history of convulsion, lethargic or unconscious state and unable to sit or stand up. Features of severe malaria are cerebral malaria (unrousable coma), severe normocytic anemia (Hb  $< 5$  g/dL), renal failure (serum creatinine  $> 3$  mg/100 mL), pulmonary oedema, hypoglycaemia ( $< 40$  mg/100 mL), circulatory collapse/Shock (Systolic blood pressure less than 50 mmHg in children below 5 years), spontaneous bleeding/disseminated intravascular coagulopathy, repeated generalized convulsions, academia/acidosis and macroscopic hemoglobinuria. Other manifestations are impaired consciousness but rousable, prostration, hyperparasitemia ( $> 5\%$  RBC infected), jaundice (total serum bilirubin  $> 3$  mg/dL) and hyperpyrexia (axillary temperature  $> 39.5^\circ\text{C}$ ) [7].

WHO defined malnutrition as the cellular imbalance between supply of nutrient and energy and the body's demand for them to ensure growth, maintenance, and specific functions. According to [5] malnutrition in all its forms includes under nutrition (wasting, stunting, and underweight), inadequate vitamins or minerals, overweight, obesity, and resulting diet – related non-communicable disease. Nutrition plays a major role in maintaining health and malnutrition appears to generate vulnerability to a wide variety of diseases and general ill health. Exposure to *Plasmodium* infection has a significant impact on the nutritional status of under-five children, particularly in malaria-endemic areas [8]. WHO and UNICEF recommend the use of a cut-off for weight-for-height of below -3 standard deviations (SD) for the WHO standard to identify infants and children as having severe acute malnutrition (SAM) [9]. Malnutrition is globally the most important risk factor for illness and death, contributing to more than half of deaths in children in thirty-six

countries [10]. Malnutrition is caused by a deficiency in the intake of nutrients by the cells of the body. A combination of two factors can be responsible. These are insufficient intake of proteins, calories, vitamins, minerals and frequent infections from diseases such as measles, malaria, diarrhoea (frequent stooling) and respiratory disorder which can cause loss of nutrients in the body. The reduced appetite and food intake, contributes invariably to malnutrition [11] Children suffer malnutrition most because they are in a period of rapid growth that increases the demand for calories and proteins.

Opinions are mixed on the role of under nutrition in susceptibility to malaria illness and mortality. [12,13] observed a strong seasonal pattern of both malaria incidence and admission to the therapeutic nutritional program, Half of the children at admission presenting with a positive HRP2 RDT and the number of monthly incident malaria cases temporally overlapped with monthly admissions to the nutritional program and there was statistically significant effect of malaria infection on reduced height gain. Furthermore, the presence of stunting in some communities significantly augmented the prevalence and clinical presentation of *Plasmodium* infection. Also it has been argued that malnutrition enhanced the severity of anaemia in malaria parasite negative children hence, their health and growth potential needs to be improved upon [14]. Chronic malnutrition was relatively consistently associated with severity of malaria such as high-density parasitaemia and anaemia [15].

Nigeria as a country is characterized by two major nutritional problem which includes under nutrition and micronutrient malnutrition. Malaria and malnutrition are two of the leading causes of illness and death in children under five years of age living in Nigeria. Both malaria and malnutrition are highly seasonal. Across northern Nigeria, childhood morbidity and mortality from malaria spike during the rainy season, typically a 2–4month period beginning in July or August of each year. This has been compounded by the internal crisis in these regions. In a study on the relationship between protein – energy malnutrition and malaria in children in North-western Nigeria, [16] concluded that malnourished children experienced more malaria than well – nourished ones. The study on the prevalence of malaria, anaemia and malnutrition and their co-existence in children 10 years and below among Internally Displaced Persons

(IDPs) in Nigeria showed that malnutrition prevalence was 41.2% with wasting [17]. Also it has been reported that the presence of stunting significantly augmented the prevalence and clinical presentation of *Plasmodium* infection. This can enhanced the severity of anaemia in malaria parasite negative children hence, their health and growth potential needs to be improved upon [14].

Malaria, anaemia and malnutrition are still of public health concern in the Mount Cameroon area, there is a strong association between malaria and anaemia but not malnutrition. A review of the studies on the complex interactions between malaria and malnutrition concluded that the evidence on the effect of malnutrition on malaria risk remains inconclusive. Clarification on malaria-malnutrition interactions would also serve as a basis for designing future trials and provide an opportunity to optimise antimalarial treatment for the vulnerable and neglected population [15]. Due to the little information in the literatures on the effects of malaria on the nutritional status of children in Anambra State, Nigeria, this study is aimed at finding the relationship between both in children less than five years.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study was conducted in Anambra State in the South- eastern part of Nigeria. It has a population of about 4 million people made up of 2,117,984 males and 2,059,844 females (population estimation of 2006) [18]. The State is made up of twenty-one local government areas.

### 2.2 Study Population

The present study was conducted between the months of April and March and involved a total of 248 children. This study was conducted in thirteen communities purposively selected from thirteen local government areas in Anambra State. These communities have an average of 1 or 2 General or Comprehensive Health Centres located in them.

### 2.3 Sampling Technique

Stratified random sampling was used. All hospitalized or non-hospitalized patients (children 0 - 14.9 years) with acute febrile illness were randomly sampled two times in a month from April 2012 to March 2013. Blood sample of

children (both febrile and clinically well) were collected from purposely selected hospitals. All sampled children were weighed with standard scale; their heights measured so as to obtain the Weight-for-age, height-for-age and weight-for-height z scores. Arm circumference insertion tape was used to measure the mid upper arm circumference of malaria infected children and none infected. The communities were visited two times in a month. Blood samples from both groups were tested for malaria parasite. Negative blood samples served as control.

### 2.4 Collection of Blood Sample

1mL venous blood was obtained after cleaning the site with spirit and was put in ethylenediamine tetra-acetic disodium acid (EDTA) vacutainers to avoid clotting and ensure preservation of the samples. Thick blood films were stained with Giemsa and examined for malaria parasites by standard microscopy.

### 2.5 Analysis

Z - Scores were calculated according to WHO Health Statistics standards with the use of EPI INFO version 6.

## 3. RESULTS

Table 1 summarized the nutritional status of malaria infected and none infected children from the hospitals and communities in Anambra State, Nigeria. Based on weight-for-height Z-scores, malaria uninfected boys had the highest prevalence (38.5%) of acute and moderate

malnutrition followed by infected boys (33.3%) all in the communities. The infected and uninfected boys and girls from the hospitals had the lowest prevalence of acute and moderate malnutrition compared to their counter parts in the communities. Combined sex of malaria uninfected children in the communities had the highest prevalence of acute malnutrition (26.7%). Comparison of the distribution of acute malnutrition in the malaria infected and uninfected with the WHO standard in Figs. 1 and 2 showed that there was a slight shift of the distribution curve of infected and uninfected children from the communities towards the left of the WHO standard curve signifying deviation from the standard while the distribution of their counter parts from the hospitals moved to the right. Sex and weight-for-height Z-scores distribution curve of acute malnutrition in the communities and hospitals showed that the infected children from the hospitals and uninfected boys and girls from the communities had a positive distribution because their curves shifted to the right of the WHO standard curve, (Figs. 3 and 4). Only 5.7% girls and 7.4% of combined sex of malaria infected children from the hospital had severe acute malnutrition.

Using MUAC cut offs', there was 100% acute malnutrition (<125mm) among malaria infected and uninfected children in the communities, while the highest (98.9%) acute malnutrition was observed among the infected and uninfected boys and girls in the hospitals. There was no moderate and severe malnutrition in both communities and hospitals malaria infected and uninfected children (Table 1).

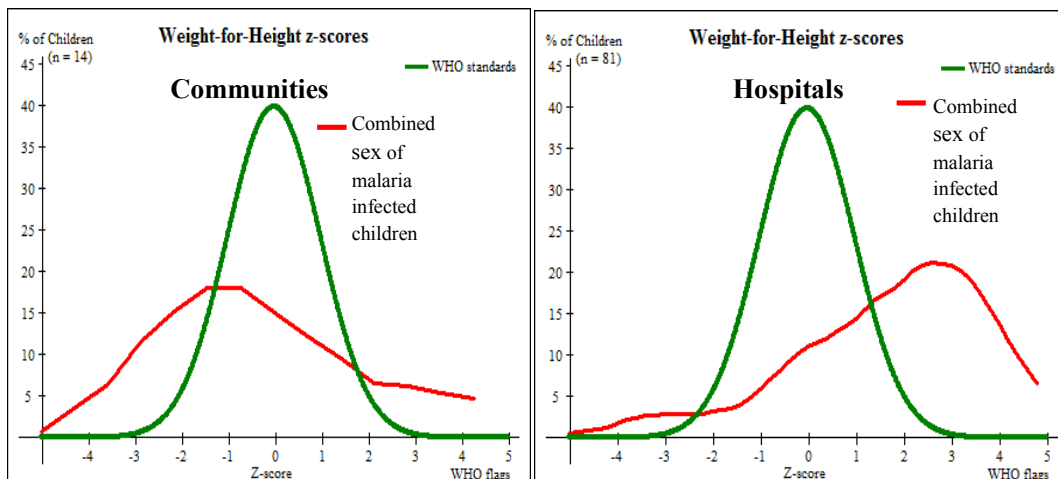
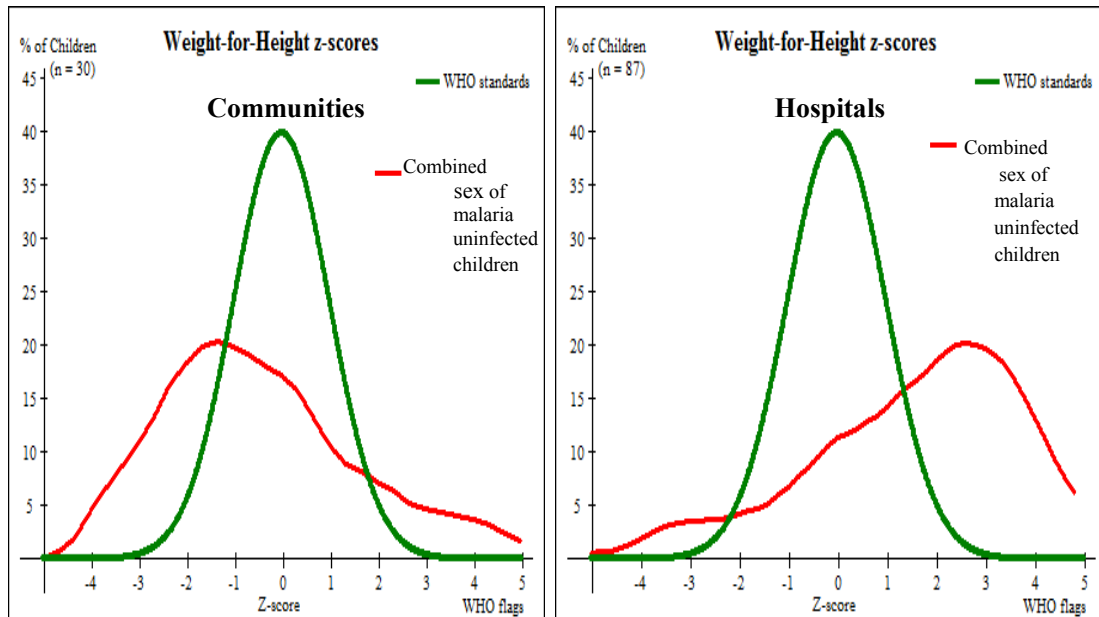


Fig. 1. Distribution of weight-for-height Z-scores among malaria infected children in Anambra State, Nigeria

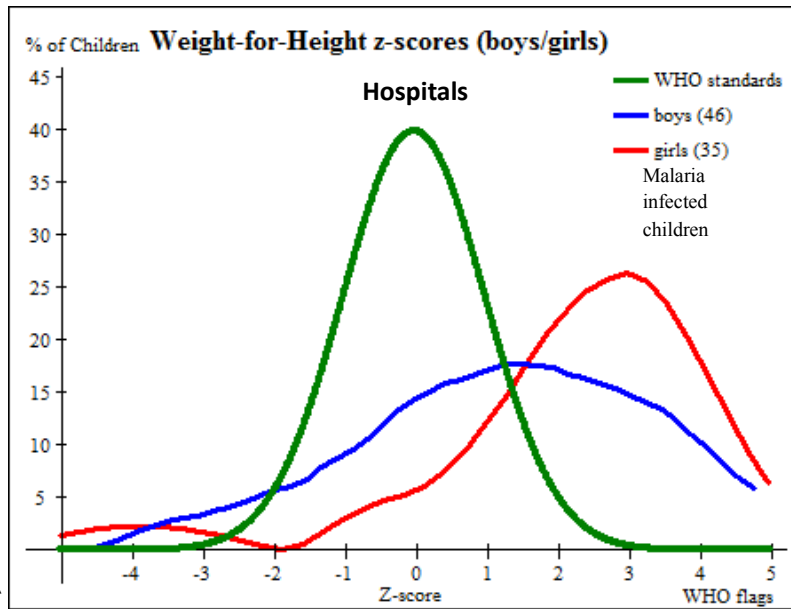
**Table 1. Nutritional characteristics of malaria infected and uninfected children from communities and hospitals in Anambra State, Nigeria**

	Communities						Hospitals					
	Infected			Uninfected			Infected			Uninfected		
	Boys	Girls	Combined sex	Boys	Girls	Combined sex	Boys	Girls	Combined sex	Boys	Girls	Combined sex
Categories Malnutrition-weight-for-height Z- scores	n= 3	n=11	n=14	n =13	n=17	n=30	n=46	n=35	n=81	n=50	n=37	n=78
Acute malnutrition (<2 Z-scores).	1(33.3)	2(18.2)	3(21.4)	5(38.5)	3(17.6)	8(26.7)	4(8.7)	2(5.7)	6(7.4)	5(10.0)	3(8.1)	8(9.2)
Moderate malnutrition(<-2 Z-scores and >=3 Z-scores)	1(33.3)	2(18.2)	3(21.4)	5(38.5)	2(11.8)	7(23.3)	4(8.7)	0(0.0)	4(4.9)	5(10.0)	1(2.7)	6(6.9)
Severe malnutrition (<-3 Z-scores)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(5.9)	1(3.3)	0(0.0)	2(5.7)	2(2.5)	0(0.0)	0(0.0)	0(0.0)
Normal nutrition	1(33.3)	7(63.6)	8(57.1)	3(23.1)	11(64.7)	14(46.7)	38(82.6)	31(88.2)	69(85.2)	40(80)	33(89.2)	64(82.1)
Malnutrition based on MUAC cut off's	n = 16	n =32	n = 38	n = 39	n = 43	n =82	n =90	n= 67	n = 157	n = 95	n = 71	n= 166
Acute malnutrition (< 125mm)	16(100)	22 (68.8)	38(100)	39(100)	43(100)	82(100)	89(98.9)	65(97.0)	154(98.1)	94(98.9)	69(97.2)	163(98.2)
Moderate malnutrition (< 125mm and >= 115)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Severe malnutrition (<115mm)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Normal MUAC	0(0.0)	10(31.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.1)	0(0.0)	3(1.9)	1(1.1)	2(2.8)	0(0.0)
Under weight-weight-for-age Z-scores	n = 14	n = 18	n = 32	n = 33	n = 38	n = 71	n = 73	n = 50	n = 123	n =78	n = 52	n = 130
Under weight (< -2 Z- score)	2(14.3)	2(11.1)	4(12.5)	5(15.2)	2(5.3)	5(7.0)	7(9.6)	2(4.0)	9(7.3)	7(9.0)	2(3.8)	9(6.9)
Moderate under weight (<2 Z-scores and > =- 3z score)	1(7.1)	1(5.6)	2(6.3)	4(12.1)	1(2.6)	5(7.0)	6(8.2)	0(0.0)	6(4.9)	6(7.7)	0(0.0)	6(3.6)
Severe under (<-3 Z-scores) weight	1(7.1)	1(5.6)	2(6.3)	1(3.0)	1(2.6)	2(2.8)	1(1.4)	2(4.0)	3(2.4)	0(0.0)	0(0.0)	0(0.0)
Normal weight-for-age	10(71.4)	14(77.6)	24(75)	23(69.7)	34(89.5)	59(83.1)	59(80.8)	46(92)	105(85.1)	65(83.3)	50(96.2)	55(88.5)
Stunting based on height-for-age Z-scores	n = 14	n = 20	n = 34	n = 36	n = 38	n = 74	n = 78	n = 61	n = 139	n = 85	n = 63	n = 146
Stunting (< - 2 Z-score)	3(21.4)	4(20.0)	7(20.6)	5(13.9)	4(10.5)	9(12.2)	24(30.8)	12(19.7)	36(25.9)	24(28.9)	12(19.0)	36(24.7)
Moderate stunting (< -2 Z-scores and > - 3 Z-scores)	2(14.3)	3(15.0)	5(14.7)	4(11.1)	3(7.9)	7(9.5)	10(12.8)	7(11.5)	17(12.2)	10(21.0)	7(11.1)	17(11.6)
Severe stunting (< - 3 Z-scores)	1(7.1)	1(5.0)	2(5.9)	1(2.8)	1(2.6)	2(2.7)	14(17.9)	5(8.2)	19(13.7)	14(16.9)	5(7.9)	19(13.0)
Normal height-for-age	8 (57.1)	12(60)	20(58.8)	26(72.2)	30(78.9)	56(75.7)	30(38.5)	37(60.7)	67(48.2)	37(43.5)	39(61.9)	74 (50.7)

Figures in parentheses = %



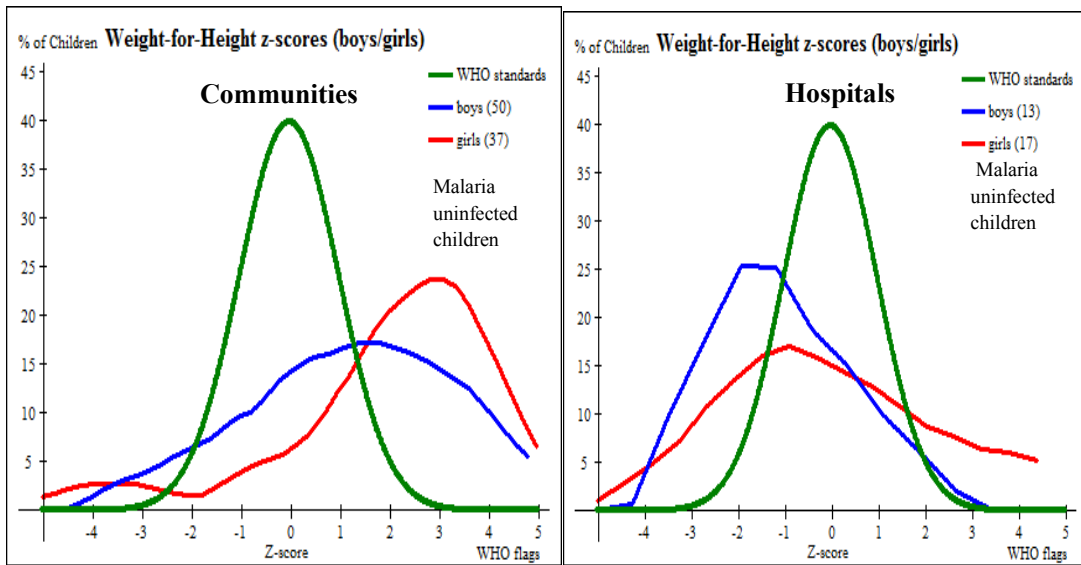
**Fig. 2. Distribution of acute malnutrition (weight-for-height) among malaria uninfected children in Anambra State, Nigeria**



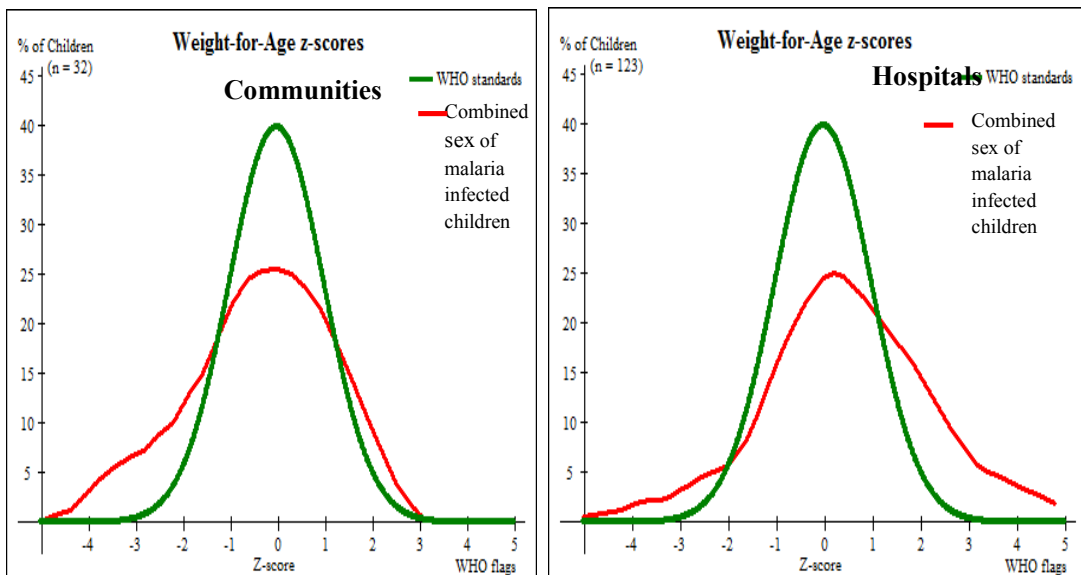
**Fig. 3. Sex distribution of acute malnutrition (weight-for-height Z-scores) among malaria infected children across government hospitals in Anambra State, Nigeria**

The highest prevalence (15.2%) of underweight (weight-for-age Z-scores) was observed among malaria uninfected boys in the communities, while the least prevalence (3.8%) was observed in the uninfected girls in the hospitals. Combined sex of infected children in the communities had the highest

(6.3%) severe underweight (< -3 Z-score). WHO Z-scores distribution graph showed that combined sex of malaria infected and uninfected children (boys and girls) in the communities and hospitals had a positive distribution of weight-for-age Z-scores (Figs. 5, 6, 7 and 8).



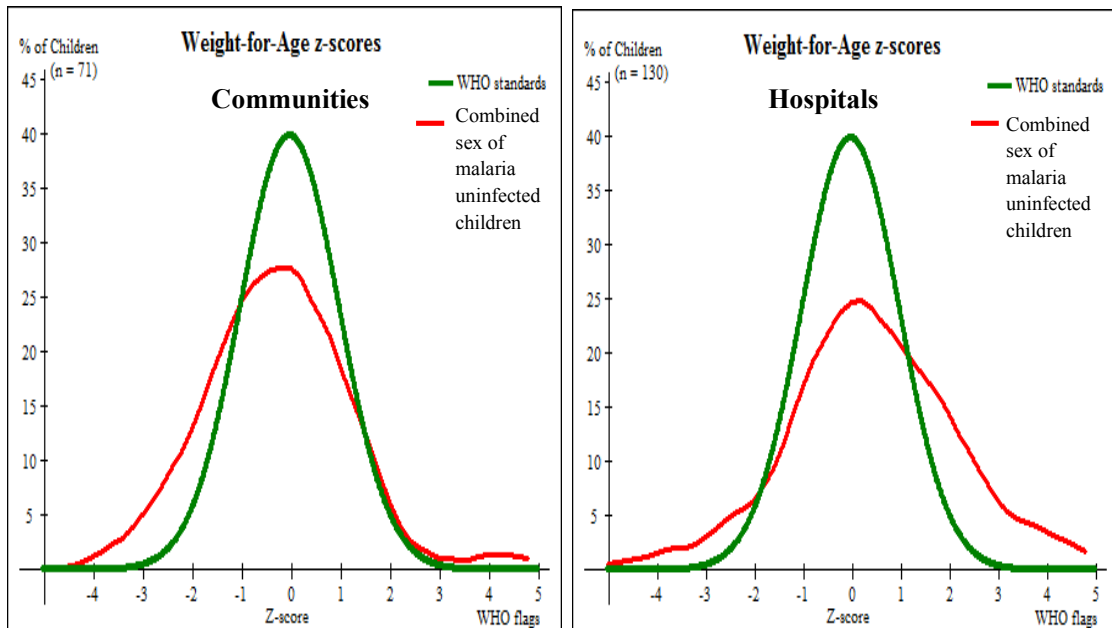
**Fig. 4. Sex distribution of acute malnutrition (weight-for-height) among malaria uninfected children in Anambra State, Nigeria**



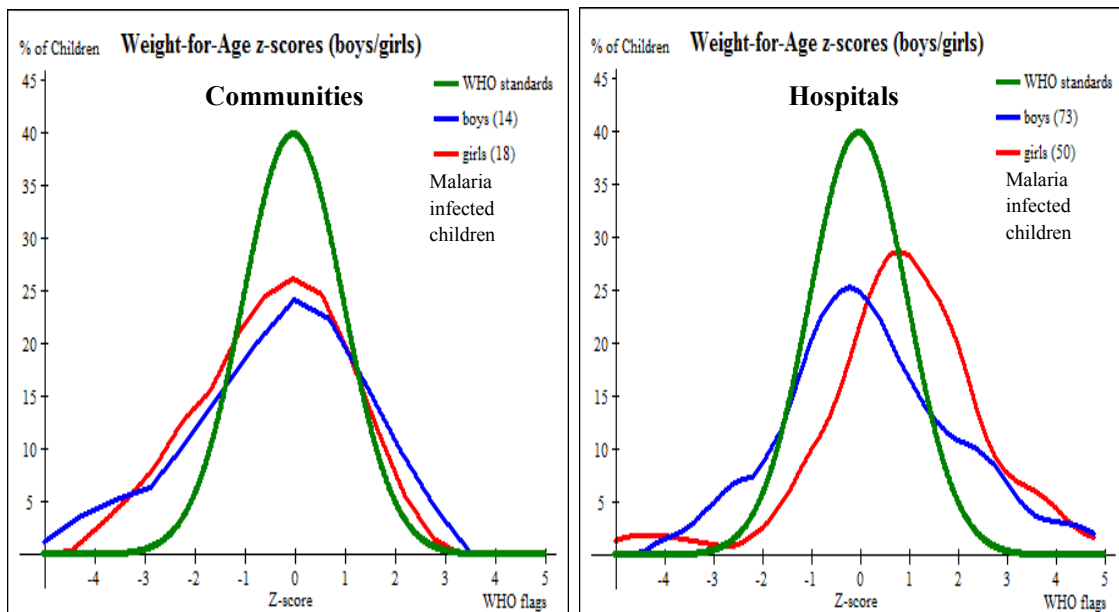
**Fig. 5. Weight-for-age z-scores distribution (underweight) among malaria infected children in Anambra State, Nigeria**

Similarly, the highest prevalence of stunting was observed among malaria infected boys followed by uninfected boys both in the hospitals (28.9%). The lowest prevalence of stunting was 10.5% in malaria uninfected girls in the communities. Severe stunting ( $< -3Z$ -scores) of 16.9% was observed among malaria uninfected boys in the hospitals (Table 1). Comparison of the height-for-age Z-scores of the children with WHO standard reference graph

showed that malaria infected and uninfected children from communities and hospital had a negative distribution because some of the population shifted to the left of the WHO standard reference curve. Also there was a shift of the gender height-for-age Z-scores distribution of malaria infected and uninfected boys and girls population to the left of the WHO standard Z-scores distribution (Figs. 9, 10, 11 and 12).



**Fig. 6. Distribution of underweight (weight-for-age Z-scores) among malaria uninfected children in Anambra State, Nigeria**



**Fig. 7. Sex distribution of weight-for-age Z-scores (underweight) among malaria infected boys and girls from homes and hospitals in Anambra State, Nigeria**

#### 4. DISCUSSION

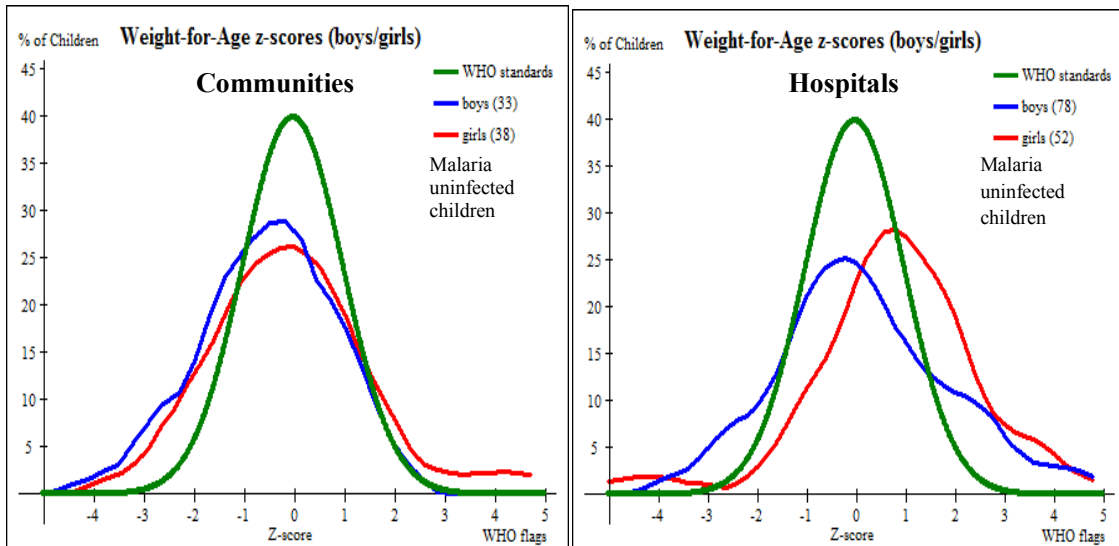
Reduction of childhood mortality is the 4th agenda on the eight point Millennium Development Goals (MDGs) and the attainment of a comprehensive set of development goals

can be accelerated if given a nutritional perspective and approach [19,20]. A malnourished child is one who has failed to attain the expected values for any of the nutritional indicators (e.g. height-for-age, weight-for-height or weight-for-age) as compared with a healthy

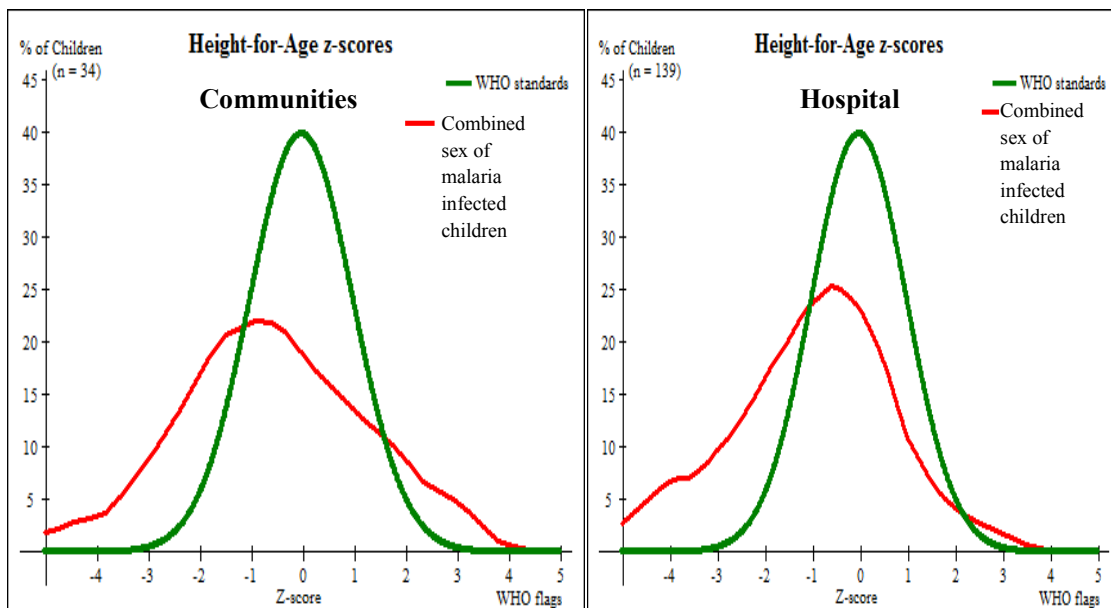


child of the same sex and age in the reference population [9]. The nutritional status of malaria uninfected children in both community and hospital surveys showed acute malnutrition prevalence of 26.7% and 9.2%, respectively. This is lower than 32% and 46% reported in Africa and Southeast Asian regions [21]. This is in conformity with [11] statement that an estimated 2 million children in Nigeria suffer from

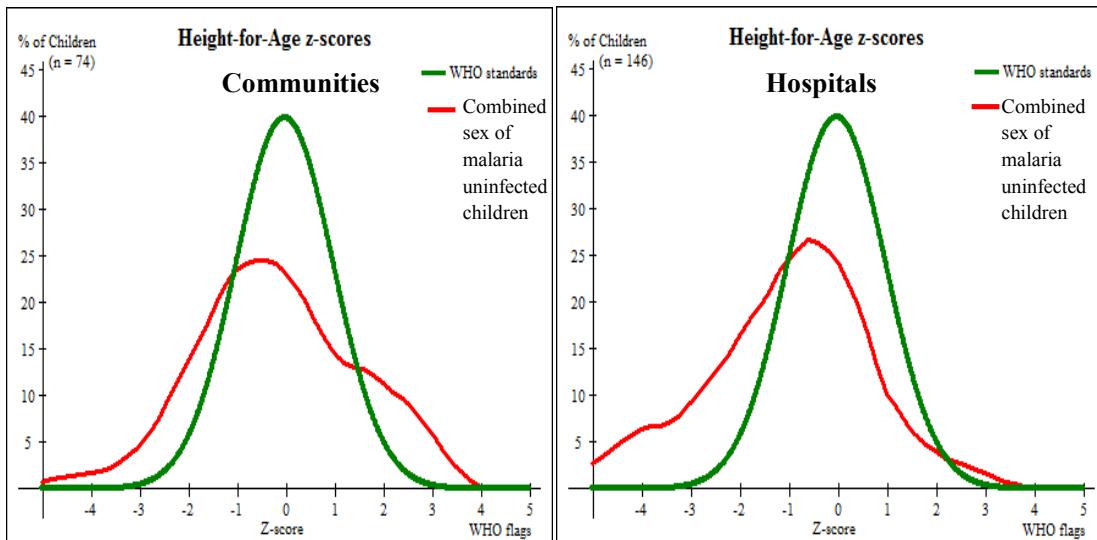
severe acute malnutrition. Chronic malnutrition was relatively consistently associated with severity of malaria especially in high density parasitaemia and anaemia in a review of 33 articles and publications on interactions between malnutrition and malaria [15]. Similarly, a higher risk of malaria infection among malnourished children was reported in Lagos, Nigeria [22].



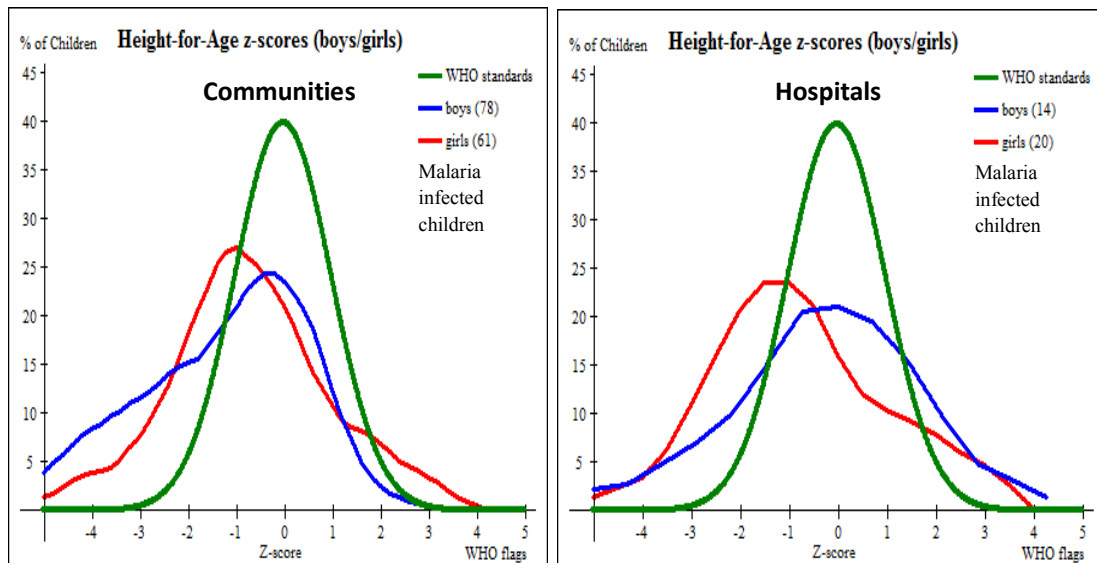
**Fig. 8. Sex distribution of weight-for-age Z-scores (underweight) among malaria uninfected boys and girls from homes and hospitals in Anambra State, Nigeria.**



**Fig. 9. Height-for-age Z-scores (stunting) among malaria infected children in Anambra State, Nigeria**



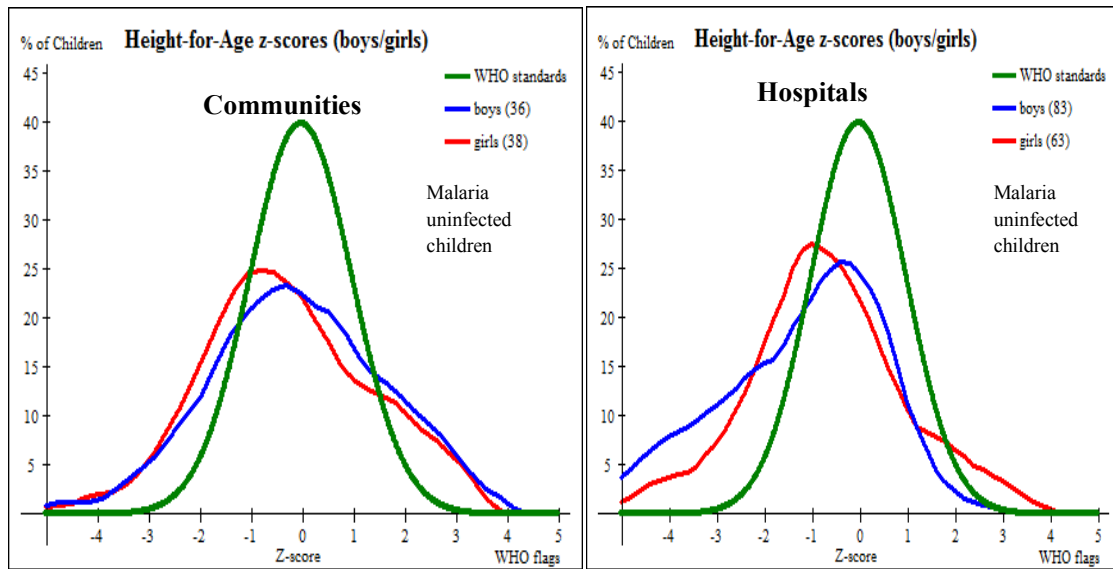
**Fig. 10. Distribution of height for-age Z-scores (stunting) among malaria uninfected children from communities and hospital in Anambra State, Nigeria**



**Fig. 11. Sex distribution of stunting among malaria infected children in Anambra State, Nigeria**

According to WHO standard, the average Z-scores were negative for the communities and positive for hospitals. The result of this study showed lower prevalence of severe acute malnutrition (SAM) in both boys and girls, respectively. The prevalence of malaria was not equally significantly affected by age, sex and SAM in children in Kano State, Nigeria [16] but higher (30%) acute malnutrition has been reported in Anambra State and some parts of Northern Nigeria [23,24]. In Northern Nigeria from July to September 2012 about 296,500

(145, 285 male and 151, 215 female) children under 5 years had Severe Acute Malnutrition (SAM) and in August 2013 a total of 18, 974 children with SAM were on admission [24]. The high disparity may be attributed to the security crisis in the Northern part of Nigeria. Nutrition plays a major role in maintaining health, and malnutrition appears to generate vulnerability to a wide variety of diseases and general ill health [25]. Opinions are mixed on the effects of nutritional status of children and their susceptibility to malaria illness and mortality. In



**Fig. 12. Sex distribution of height-for-age Z-scores (stunting) among malaria uninfected children from homes and hospital in Anambra State, Nigeria**

this study, malaria infected children (communities and hospitals) had a lower acute and moderate malnutrition compared to the national (42%) malnutrition status of Nigeria, however, the infected boys had a relatively higher acute malnutrition compared to the girls. Comparison of the distribution with the WHO Z-score also showed that a smaller number of malaria parasite infected children had Z-scores  $<-2SD$ , therefore, malaria had no effect on their malnutrition status. This result is in line with [26]. This may be attributed to the low number of sampled children.

Weight-for-age is used to assess underweight as an indicator of under nutrition because of its availability and its ability to capture both stunting (generally associated with long term under nutrition) and its wasting (manifestation of recent and acute under nutrition) [25]. There is substantial evidence that malaria contribute to impaired weight and height gain in children but the impact of under nutrition on malaria is complex [19]. The prevalence of underweight in the community (7.0%) and hospital (6.9%) among malaria uninfected sampled population was low, and the infected boys had the highest prevalence. Moderate and severe underweight were also low compared to 25% national prevalence and 8.5% reported in south-eastern Nigeria [27].

Comparison of the prevalence of underweight to WHO Z-score showed a low prevalence. This is

in disagreement with [28] and [26] who reported a higher prevalence of (44.2% and 24.1%, respectively) underweight among malaria infected children. Being wasted and underweight contributed to the magnitude of malaria and affected the health and nutrition related response [29]. The World Health Organization's Comparative Risk Assessment project found that children who were moderately to severely underweight had an increased, but not statistically significant risk of a clinical malaria attack, as compared with those who were better nourished [30]. Children who are underweight are thought to have increased susceptibility to malaria for variety of reasons, most notably through a reduction in the function of the immune system. The undernourished child may not be unable to mount an appropriate immune response to malaria parasite due to reduction in T lymphocytes, impairment of antibody formation, decreased compliment formation and atrophy of thymus and other lymphoid tissues [31].

Stunting can be defined as failure to achieve one's genetic potential for height. Many genetic and environmental factors modify stature: growth hormone deficiency, impaired kidney function, psychological deprivation and under-nutrition. In this study acute stunting, moderate stunting and severe stunting in both community and hospital survey were generally lower than the national stunting (42%) and 20% in south-eastern Nigeria [27], but higher than 6.8% prevalence in some selected towns in Anambra south senatorial

zone, 7.7% in Aguata Local Government Area and 0.8% in Ozubulu all in Anambra State [32, 33,20]. Significant proportion (42.2%) of the participants were stunted (height- for-age, Z-score <-2) in Lagos State, Nigeria [34]. However, a higher number (hospital and community) of children had Z-score <-2 SD. [5] estimated that Nigeria has the highest burden of stunted children in the World (32% national prevalence, however, not generally as a result of malaria). Malnutrition in children is associated with socio-economic status of the parents. People from low income groups seldom feed meat, eggs or fish to their infants because of socio-economic factors. The lack of vitamins and minerals results in irreversible impairment to child physical and mental development [35].

A high proportion of the malaria infected children (communities and hospitals) were malnourished based on the anthropometric measurement - Mid-upper arm circumference (MUAC) in this study. This is in line with [28] and [33]. Malaria infected children had no severe MUAC as well as the uninfected children. In Brazil children from the Amazonian region who had at least one episode of malaria presents lower mean anthropometric index scores compared to children who did not have malaria [36]. In some studies no evidence of an association between anthropometry and malaria infection was found [37,38].

The risk factors for low MUAC were poor health, lack of meat and cow milk consumption, low intake of energy from fat and less well educated and old mothers [28]. While arm circumference measures both muscle and fat, some populations would be expected to have very little subcutaneous fat on their arms. A low or decreasing arm circumference for these populations would signal the loss of muscle mass, a serious sign, possibly indicative of protein-energy malnutrition or starvation. MUAC is usually unaffected by oedema common in famine, and is a sensitive reflection of tissue loss and is independent of height.

## 5. CONCLUSION

Protein energy malnutrition and malaria have so much effect on the quality of life and likelihood of survival in children in endemic Africa. It may be conclude that there is a high rate of malnutrition based on MUAC among malaria infected children in Anambra State however, underweight may not be associated with malaria infection. Majority of

the malaria infected children were stunted but may not be strongly associated with current malaria infections. Understanding the direct and indirect consequences of protein energy malnutrition on malaria and vice versa in Anambra State is important, as these findings may help guide the choice of public health interventions in settings of limited resources.

## CONSENT AND ETHICAL APPROVAL

The study was carried out as part of a larger project on the 'Effects of Home and Hospital Managements of Childhood Malaria on the Biochemical, Haematological and Nutritional Changes in Anambra State, Nigeria, for which ethical clearance was obtained from the University of Nigeria Teaching Hospital Ituku - Ozalla in Enugu State. Also permission was obtained from the management of the selected General Hospitals and individual written informed consent was obtained from the parents of all study participants. Only participants who gave written and/or verbal consent or assent took part in the study. Participation was strictly voluntary. All cases of malaria and those with moderate to severe anaemia as well malnutrition was referred to the nearest health centre for appropriate treatment and follow up. There were no ethical issues throughout the period of survey.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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