Pyrex Journal of Nutrition and Metabolism

Vol 2 (1) pp. 1-14 March, 2017

http://www.pyrexjournals.org/pjnam

Full Length Research Paper

Assessing the Association between Nutritional Status and Asymptomatic Malaria Parasitaemia of Children Under Five Years in Ghana

Daniel Ayine Nyaaba[1*], Patricia K. Brown[2] and Jacob K. Agbenorhevi[3]

[1]College of Nursing and Midwifery, Nalerigu, Ghana.
[2]Department of Biochemistry and Biotechnology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
[3]Department of Food Science and Technology, College of Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Accepted 9th March, 2017

Abstract

Background: Undernutrition and malaria are major public health challenges and are the main causes of morbidity and mortality in low and/or middle income settings. To fulfil a research need, this study was conducted to determine the association between nutritional status including anaemia and asymptomatic malaria parasitaemia in children under five years old. Methods: This was a community-based cross-sectional study, conducted in four communities from randomly selected regions in Ghana. Blood samples and anthropometric measures of 250 children were collected for analyses. Parents of children involved in the study, also completed a questionnaire. Results: The prevalence of asymptomatic malaria parasitaemia was 14.8% and anaemia (Hb < 11.0 g/dl) was 58.8%. Binomial logistic regression analysis predicted no significant association between asymptomatic malaria parasitaemia and weight-for-height z-scores (p = 0.592; OR = 1.234; 95% CI: 0.573-2.658), height-for-age z-scores (p = 0.169; OR = 0.651; 95% CI: 0.353-1.200) and weight-for-age z-scores (p = 0.832; OR = 1.094; 95% CI: 0.478- 2.504). However, asymptomatic malaria parasitaemia was a significant predictor of anaemia (p = 0.04; OR = 2.419; 95% CI: 1.041-5.622) and ages beyond two years were risk factors for anaemia. Stunting however was associated with a significant lower odds of being anaemic (p = 0.003; OR = 0.484; 95% CI: 0.301- 0.778). Conclusions: Asymptomatic malaria parasitaemia may have no effect on anthropometric measurements of young children or asymptomatic malaria parasitaemia have no significant influence on anthropometric measures of young children in the short or long term. However, children with asymptomatic malaria parasitaemia are more likely to be anaemic especially after two years. Stunting however may reduce the risk of anaemia in children. This suggests that, asymptomatic malaria parasitaemia may be a contributory factor to the existing burden of anaemia in children from developing countries. Efforts should therefore be made to screen for asymptomatic malaria parasitaemia during routine growth monitoring sessions.

Keywords: Asymptomatic Malaria Parasitaemia, Nutritional Status, Anaemia, Anthropometric Measures.

INTRODUCTION

Undernutrition and malaria are the main causes of child death in sub-Saharan Africa (Caulfield *et al.*, 2004) and mortality due to malaria increases with increasing incidence of undernutrition in children younger than five years (Black *et al.,* 2008). According to the World Health

Corresponding author email: ndanielayine@yahoo.com

Organization, approximately one-half of the 10.6 million children under five years who die in low- and middle-income countries are malnourished (WHO, 2005). Malaria, predominantly caused by *Plasmodium falciparum* in sub-Saharan Africa, is estimated to cause 880,000 deaths each year, with majority of deaths occurring in children under 5 years of age (WHO, 2009). In Ghana, malaria is a prime cause of death, accounting for 35 percent of all hospital admissions and 34 percent of all deaths of children less than five years (NMCP, 2010). This implies that children at the early stages of life may be more vulnerable to malaria and its consequences, due to absence of immunity against malaria parasites (Laishram *et al.,* 2012).

Asymptomatic malaria refers to symptomless malaria due to lack of clinical manifestation of the malaria parasite at this stage. There is no benchmark definition for asymptomatic malaria and previous studies relied on diagnostic criteria (Lindblade *et al.,* 2013). Commonly used criteria for diagnosis of asymptomatic malaria is the presence of malaria parasite in thick blood smear of carriers, with axillary temperature less than 37.5 ^{O}C and absence of severe and mild (uncomplicated) malaria related symptoms (Laishram *et al.,* 2012).

Other criteria include follow-up of persons with the parasites for specified time (Cucunuba *et al.,* 2008; Harris *et al.,* 2010) and quantification of parasite load (Dalla *et al.,* 2007). Asymptomatic malaria infection is an obstruction to the complete eradication of malaria (Lindblade *et al.,* 2013; Ganguly *et al.,* 2013). This is because asymptomatic malaria carriers usually do not show symptoms of malaria infection, and hence do not seek treatment constituting a reservoir of the parasite and transmitting it to other uninfected persons. Asymptomatic malaria therefore remains a challenge for malaria control measures as it significantly influences malaria transmission dynamics.

This suggests significant reduction in asymptomatic malaria could results in a corresponding reduction in malaria transmission. Case identification and management of asymptomatic malaria parasitaemia is therefore the new approach towards malaria eradication (Laishram *et al.,* 2012).Hence there is the need for frequent asymptomatic malaria case identification and treatment of infectious persons to significantly reduce the parasite reservoir and greatly reduce malaria transmission. Although several research works have been conducted in an attempt to establish association between nutritional status; particularly undernutrition (wasting, stunting and underweight) and the incidence/prevalence of malaria in children, Olney *et al,* 2009; Ehrhardt *et al,* 2006; Friedman *et al,* 2005; Crookston *et al,* 2010; Ong'echa *et al,* 2006; Fillol [a]*et al,* 2009; Deribew *et al,* 2010; Genton *et al,* 1998; Fillol [b]*et al,* 2009 Arinaitwe *et al,* 2012), there is limited research on asymptomatic malaria, especially in relation to undernutrition in children. This research investigated the associations between undernutrition (including anaemia) and asymptomatic malaria parasitaemia in children from four rural communities in Ghana.

METHODS

This was a community-based cross-sectional study, conducted in four communities from randomly selected regions in Ghana. Multistage random sampling techniques were used in selecting the regions, communities and individual children from households for the study. Children who met the inclusion criteria (aged 1-5 years in the specified communities, with axillary temperature less than 37.5°C and without malaria related symptoms) were enrolled in each community for the study. Where more than one child in the same household met the inclusion criteria of the research, only one of them was randomly selected for the study. Data collected included anthropometric data, blood samples of children and a questionnaire completed by parents of the participating children. Children whose blood samples could not be obtained for any reason were excluded from the study.

On anthropometry, the weight, height or length and Mid-Upper Arm Circumference (MUAC) of the children were measured. The height and weight of their mothers were also measured. Two people were involved in measuring both height and weight. Weights were measured using an electronic scale. Microtoise was used to measure the height of mothers. UNICEF designed infantometer was used in measuring the height or length of all children. MUAC was measured using the MUAC tape. In taking weight, the child's shoes, clothing or hairs that may interfere with the reading were removed before weighing. Children who could stand stood on the scale and their weights were taken when the reading on the scale had finished. For children who could not stand on the scale alone, their mothers stood on the scale first, then it was zeroed, and they were reweighed with their children and the new reading was taken as the weight of the child.

In measuring height, the children stood or lay straight on the infantometer, shoulders level and arms by their sides, with their feet flat and together and their heels or head touching the feet or head board. The head or feet board was lowered onto their heads or feet and the reading taken at observer eye level. For children who could not stand or were less than two years, recumbent length was taken as they lay on their backs. The height of those who could stand was measured. In measuring mid-upper arm circumference, a child's left hand was bent at the elbow at a 90 degree angle, with the upper arm held parallel to the side of the body and the midpoint between the tips of the shoulder to the end of the elbow was

determined. The circumference of the child's left arm was measured at the midpoint with the arm hanging relaxed. About 5ml of each participating child's venous blood was drawn for full blood count and malaria parasite tests. About 2ml was collected into a vacutainer, containing ethylenediaminetetra - acetic acid for determination of haematological parameters and 3ml was used for parasitological tests for malaria.

The blood samples were transferred in a cold box to the haematology and biochemistry laboratories of the Bolgatanga regional hospital for analysis. Blood samples collected were properly sealed to prevent spillage during transportation. Full Blood Count was performed using the Sysmex KX-21N Automated Haematology Analyzer (Sysmex Corporation Kobe, Japan). The parameter of interest from the full blood count was Haemoglobin (Hb) concentration. Anaemia was defined as haemoglobin (Hb) concentration < 11.0 g/dl (Cheesbrough *et al.,* 2005).

On Parasitological tests for malaria, Blood film was prepared for each blood sample collected to determine the presence and load of malaria parasites. The Giemsa staining technique was used to determine malaria parasitaemia in a thick blood film. Thick blood films were obtained by smearing a drop of participant's blood on a microscope slide. The films were allowed to air-dry and afterwards stained with the Giemsa stain for 10 minutes. After the 10 minutes, the slides were washed and air-dried. The slides were then examined with the oil immersion lens and any parasitaemia determined was quantified by counting parasites against leukocytes (200), and then multiplied by a standard count of 8000 leukocytes per µl (Trape *et al,* 2002).Two biomedical scientists independently examined each slice and agreed on the presence or absence of malaria parasitaemia. The IBM SPSS software version 20 was used to do all statistical analysis. Parameters for demographic characteristics, nutritional assessment, test results for malaria and full blood count, among others were coded and entered into the software for analysis. However Z-scores for anthropometric measures were generated using the WHO Anthro. Software and then exported into SPSS for statistical analysis. Mild, moderate and severe undernutrition were defined by Z-scores of; -2 < Z-scores < -1, -3 < Z-scores < -2 and Z-scores < -3, respectively. Associations were tested using Pearson's chi-square test of significance and correlations. Furthermore, test of associations between asymptomatic malaria and anaemia, and other parameters or variables such as nutritional status were done using binomial logistic regression analysis to generate odds ratios at 95% confidence interval and test for statistical significance.

RESULTS AND DISCUSSION

A prevalence of 14.8% of asymptomatic malaria parasitaemia was recorded (Table 1). However, a prevalence of 31.8% of asymptomatic malaria was recorded in southern Ghana (Crookston *et al.,* 2010). This is about double of what was recorded in this study and this could be attributed to the fact that this study was conducted in the dry season where there is reduced malaria transmission due to decreased mosquito population and breeding sites (Orogade *et al,* 2002). The microscopy technique employed in this study could have also underestimated the asymptomatic malaria parasite burden, since PCR malaria detection technique is the gold standard (Mahajan *et al.,* 2012; Johnston *et al.,* 2006) However, 13.6% of asymptomatic malaria parasitaemia was recorded in newborns in southern Ghana using the PCR malaria detection technique (Wagner *et al.,* 1998). This is about the same prevalence as recorded in this study. Hence the prevalence of 14.8% asymptomatic malaria parasitaemia recorded in this study is in line with literature.

Regarding nutritional status, 19.4%, 16.5% and 12.0% were stunted, underweight and wasted respectively (Table 4). This research established no statistically significant association between undernutrition and malaria at the asymptomatic state, in children. Binomial logistic regression analysispredicted no significant association between asymptomatic malaria parasitaemia and weight-for-height z-scores (p = 0.592; OR = 1.234; 95% CI: 0.573-2.658), height-for-age z-scores (p = 0.169; OR = 0.651; 95% CI: 0.353-1.200) and weight-for-age z-scores (p = 0.832; OR = 1.094; 95% CI: 0.478- 2.504) (Table 2). It is however worth noting that, there were increased odds of asymptomatic malaria associated with weight-for-height and weight-for-age z scores; suggesting that these indicators may be associated with asymptomatic malaria. These associations were however not statistically significant, hence the conclusion that no association exist between them. Consistent with this finding, Crookston also found no association between chronic undernutrition (stunting) and asymptomatic malaria (Crookston *et al.,* 2010).

On the subject of anaemia, 58.8% of the children involved in this study were anaemic (Hb < 11.0 g/dl). The mean haemoglobin (Hb) level was 10.6 g/dl (SD = ±1.23) and the minimum and maximum Hb levels were 5.3 g/dl and 16.6 g/dl respectively. This implies that on the average, all children were mildly anaemic (Hb 7.0 - 10.9 g/dl) but none was severely anaemic (Hb < 5.0 g/dl). This research discovered that anaemia was significantly associated with asymptomatic malaria. Using binomial logistic regression analysis, asymptomatic malaria was a significant predictor of anaemia (p = 0.04; OR = 2.419; 95% CI: 1.041-5.622). (Table 3). This finding confirms that of Crookston (2010), that asymptomatic malaria parasitaemia may be a risk factor for anaemia in children (Crookston *et al.,* 2010). All other related researches considered anaemia and symptomatic malaria has also established that malaria was a risk factor for anaemia

Table 1: Distribution of Asymptomatic Malaria Parasitaemia and Statistical Test of Significance and Correlations

Characteristic		Asymptomatic Malaria Parasitaemia Test			Statistical Test	
		Positive (+) Num. (%)	Negative (-) Num. (%)	Total	P - value	Pearson correlation (R)
Overall		37 (14.8%)	213 (85.2%)	250 (100%)	–	–
Gender:	Male	18(14.0)	111(86.0)	129		
	Female	19(15.7)	102 (84.3)	121	0.697	-0.025
Age (years)	1	9(11.7)	68(88.3)	77		
	2	15(22.4)	52(77.6)	67		
	3	6(10.2)	53(89.8)	59	0.316	-0.001
	4	4(13.8)	25(86.2)	29		
	5	3(16.7)	15(83.3)	18		
Community:	Kejetia	8(12.9)	54(87.1)	62		
	Pomaa Krom	6(9.7)	56(90.3)	62	0.443	-0.081
	Tamale Metro	11(17.7)	51(82.3)	62		
	Nyariga	12(18.8)	52(81.2)	64		
Hb:	Anaemic	25(17.0)	122(83.0)	147	0.240	0.074
	Non anaemic	12(11.7)	91(88.3)	103		
Completed vitamin A supplementation for age:	Yes	18(12.5)	126(87.5)	144		
	No	15(16.5)	76(83.6)	91	0.289	-0.094
	No idea	4(26.7)	11(73.3)	15		
Took anti-malaria medication 2 or more weeks ago:	Yes	3(5.1)	56(94.9)	59	0.016	-0.152
	No	34(17.8)	157(82.2)	191		
Regular intake of anti-malaria herbal medications:	Yes	4(18.2)	18(81.8)	22	0.640	0.030
	No	33(14.5)	195(85.5)	228		
On vitamin or/and mineral supplementation:	Yes	20(15.0)	113(85.0)	133	0.910	0.007
	No	17(14.5)	100(85.5)	117		
Use mosquito net:	Yes	36(15.2)	201(84.8)	237		
	No	1(8.3)	11(91.7)	12	0.741	0.049
	Sometimes	0(0.0)	1(100)	1		

p-values < 0.05 means significant association

(Tine *et al.,* 2012; Manning *et al,* 2012; Magalhaes *et al.,* 2011; Verhoef *et al.,* 2002). The finding of this research therefore agrees with literature. However, other related researches on iron status (a predictor of iron deficiency anaemia) and malaria had varied findings. For example, Researchers found that iron deficiency had a protective effect on malaria (Jonker *et al.,* 2012). However, others found no correlation between iron deficiency and malaria (Snow *et al.,* 1991). Furthermore, Stunting however was associated with a significant lower odds of being anaemic (p = 0.003; OR = 0.484; 95% CI: 0.301- 0.778). This means that, children suffering from chronic nutritional deficits or are shorter for their age maybe less predisposed to anaemia. This finding contradicts most literature. For instance, it has been established that stunted children suffer more from anaemia (Tine *et al.,* 2012; Verhoef *et al.,* 2002). Although undernutrition is the primary cause of anaemia, (Osazuwa *et al.,* 2010; George *et al.,* 2000), this research howeverdid not find an association between anaemia and all indicators of undernutrition, except for stunting. Other researchers however found wasting as a risk factor for anaemia (Sumbele *et al.,* 2013) and established a correlation between underweight and anaemia (Biemba *et al.,* 2000). Asymptomatic malaria parasitaemia therefore persist in young children during the dry season but malaria at the

Table 2. Binomial Logistic Regression analysis to predict association between nutritional status indicators and asymptomatic malaria

Predictor variables	Variable coefficient	p - value	Odds Ratio (OR)	95% C.I for OR Lower	Upper
Weight-for-height z-score	0.210	0.592	1.234	0.573	2.658
Height-for- age z-score	-0.429	0.169	0.651	0.353	1.200
Weight-for-age z-score	0.090	0.832	1.094	0.478	2.504
Constant	2.132	0.001	8.436	-	-

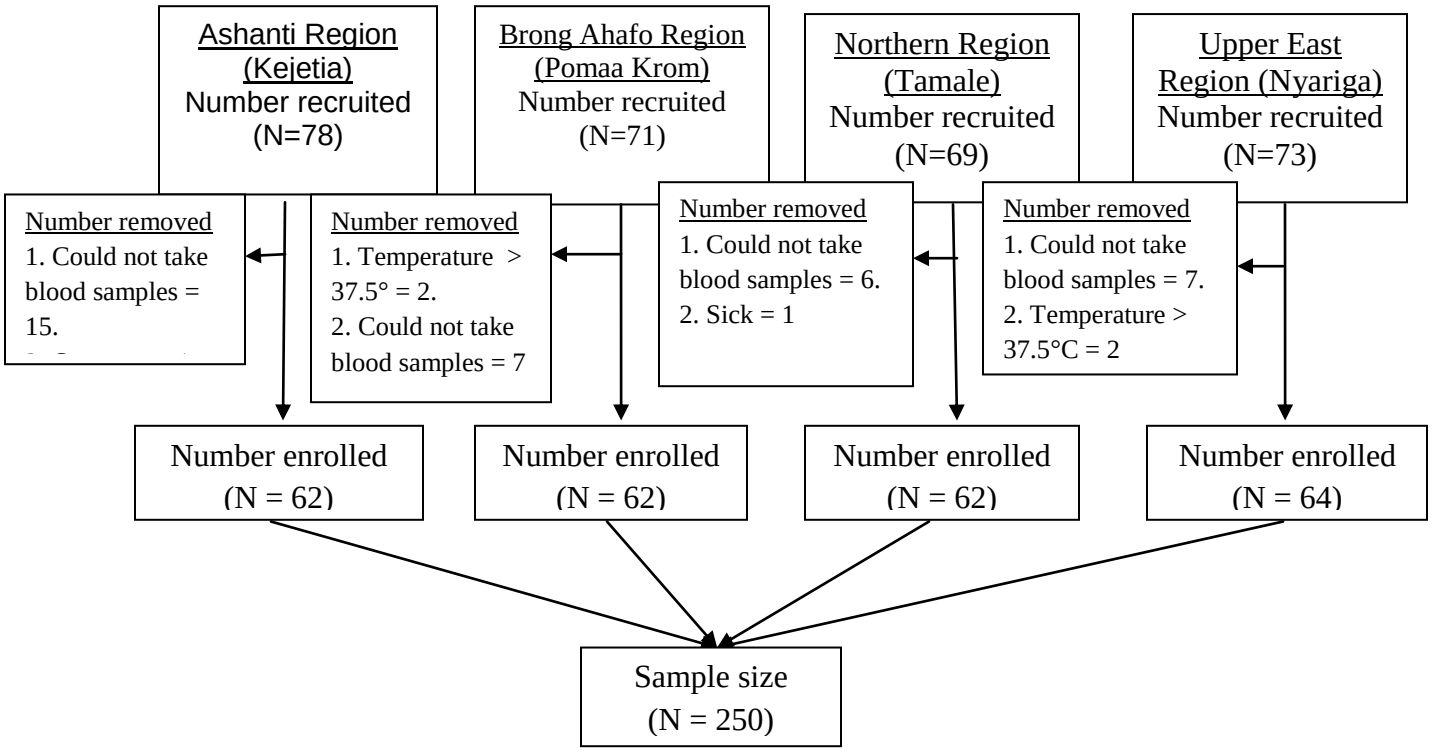
P-values statistically significant at p < 0.05

Table: 3: Binomial logistic regression analysis for predictor variables of anaemia and their statistical significance

Predictor variables [a]	Variable coefficient	p – value*	Odds Ratio (OR)	95% C.I for OR Lower	Upper
Weight-for-height z-score	-0.384	0.145	0.681	0.406	1.142
Height-for- age z-score	-0.726	0.003	0.484	0.301	0.778
Weight-for-age z-score	0.567	0.071	1.763	0.952	3.265
1	reference	0.0001	-	-	-
2	0.533	0.147	1.704	0.830	3.499
Age group (years) 3	1.150	0.002	3.158	1.526	6.535
4	1.324	0.004	3.757	1.533	9.210
5	2.369	0.0001	10.684	3.135	36.409
Asymptomatic malaria	0.883	0.040	2.419	1.041	5.622

a. Variable(s) entered: Step 1; WHZ, HAZ and WAZ. Step 2; Age groups. Step 3; Asymptomatic malaria
* P-values < 0.05 mean significant

Figure1. Participant Recruitment Flow Chart



asymptomatic state has no significant correlation with chronic and/or acute undernutrition. However, asymptomatic malaria parasitaemia, chronic undernutrition (stunting) and age beyond two years were significant predictors of anaemia in children under five years.

CONCLUSIONS

There was no significant association between asymptomatic malaria parasitaemia and chronic and/or acute undernutrition as defined by stunting, wasting and underweight in children, in this study. This implies that, asymptomatic malaria parasitaemia have no significant influence on anthropometric measures of young children in the short or long term. However, children with asymptomatic malaria parasitaemia are more likely to be anaemic and stunting has a protective effect on anaemia in young children. This suggests that, asymptomatic malaria parasitaemia may be a contributory factor to the existing burden of anaemia in children. Asymptomatic malaria screening should therefore be made part of malaria and anaemia control programmes or routine growth monitoring programmes for children, especially in communities with high rates of malaria transmission and malnutrition.

LIST OF ABBREVIATIONS

ASMP	Asymptomatic Malaria Parasitaemia
ATR	African Traditional Religion
BMI	Body Mass Index
CHRPE	Committee on Human Research Publications and Ethics
GSS	Ghana Statistical Service
H/A	Height-for-Age
HAZ	Height-for-Age Z-scores
Hb	Haemoglobin
HIV	Human Immunodeficiency Virus
IRS	Indoor Residual Spraying
ITN	Insecticide Treated Net
MICS	Multiple Indicator Cluster Survey
MPs	Malaria Parasites
MUAC	Mid-Upper Arm Circumference
NMCP	National Malaria Control Program
OR	Odds Ratio
PCR	Polymerase Chain Reaction
UNICEF	United Nations Children's Fund
W/A	Weight-for-Age
WAZ	Weight-for-Age Z-scores
W/H	Weight-for-Height
WHZ	Weight-for-Height Z-scores
WHO	World Health Organisation
SPSS	Statistical Package for the Social Science
KNUST	Kwame Nkrumah University of Science and Technology
KATH	Komfo Anokye Teaching Hospital

DECLARATIONS

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

Informed consent was sought from parents before enrolling their children into the study. The study protocol was reviewed and approved by the Committee on Human Research, Publications and Ethnic (Reference: CHRPE/AP/068/14), of the Kwame Nkrumah University of Science and Technology, School of Medical Science and Komfo Anokye Teaching Hospital Kumasi, Ghana.

COMPETING INTERESTS

We declare that we have no competing interest.

FUNDING

This research work was funded by the Authors of this manuscript. The nutrition unit of the Bongo district health directorate also lend us the UNICEF designed infantometer for measuring the height or length of the children.

AUTHORS' CONTRIBUTIONS

[1]DAN conceived the study, designed the study, drafted the research proposal and sort for ethical approval, assisted in data collection, performed statistical analysis and interpreted the results and drafted the manuscript. [2]PKB supervised data collection, statistical analysis, coordinated the physical examination and revised the manuscript. [3]JKA supervised data collection, statistical analysis, assisted in interpreting the results and edited the manuscript.

AUTHORS' INFORMATION

[1]DAN: Health Tutor, College of Nursing and Midwifery - Nalerigu, Ghana. [2]PKB**:**Lecturer,Department of Biochemistry and Biotechnology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.[3]JKA:Lecturer,Department of Food Science and Technology, College of Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Table 4. Distributions of Undernutrition

Nutritional Status Assessment Of Children

Distributions of Undernutrition according to Weight-for-Height (W/H), Height-for-Age (H/A) and Weight-for-Age (W/A)

	WASTING			STUNTING			UNDERWEIGHT		
	W/H	W/H	W/H	H/A	H/A	H/A	W/A	W/A	W/A
Background Characteristic	% below < -2 SD	% below < -3 SD	Mean z score	% below < -2 SD	% below < -3 SD	Mean z score	% below < -2 SD	% below < -3 SD	Mean z score
Overall (%)	8.3	3.7	-0.73	14.9	4.5	-1.15	12.0	4.5	-1.13
Gender									
Male	10(8.1%)	6(4.8%)	-0.68	19(15.3%)	5(4.0%)	-1.11	13(10.5%)	5(4.0%)	-1.03
Female	10(8.5%)	3(2.5%)	-0.79	17(14.4%)	6(5.1%)	-1.20	6(5.1%)	6(5.1%)	-1.22
Age (year group)									
1 – 1.9	7(9.1%)	4(5.5%)	-0.81	14(18.2%)	3(3.9%)	-1.18	12(15.6%)	3(3.9%)	-1.16
2 – 2.9	7(10.4%)	2(3.0%)	-0.71	10(14.9%)	6(9.0%)	-1.19	11(16.4%)	3(4.5%)	-1.12
3 – 3.9	6(10.2%)	1(1.7%)	-0.70	8(13.6%)	1(1.7%)	-1.17	3(5.1%)	4(4.5%)	-1.15
4 – 4.9	0(0.0%)	0(0.0%)	-0.41	4(14.3%)	1(3.6%)	-1.10	1(3.6%)	1(3.6%)	-0.94
5 – 5.9	0(0.0%)	2(18.2%)	-1.35	0(0.0%)	0(0.0%)	-0.75	2(18.2%)	0(0.0%)	-1.30
Community									
(Kejetia)	4(6.5%)	1(1.6%)	-0.57	10(16.1%)	3(4.8%)	-1.13	4(6.5%)	2(3.2%)	-1.01
(Pomaa Krom)	4(6.9%)	3(5.2%)	-0.95	10(17.2%)	0(0.0%)	-1.21	10(17.2%)	2(3.4%)	-1.31
(Tamale Metro)	7(11.7%)	3(5.0%)	-0.85	7(11.7%)	2(3.3%)	-1.00	4(6.7%)	3(5.0%)	-1.10
Nyariga	5(8.1%)	2(3.2%)	-0.58	9(14.5%)	6(9.7%)	-1.27	11(17.7%)	4(6.5%)	-1.10
Household Income (Gh¢)									
< 100	9(6.6%)	4(2.9%)	-0.67	28(20.4%)	5(3.6%)	-1.29	14(10.2%)	7(5.1%)	-1.15
100-300	9(11.4%)	5(6.3%)	-0.86	6(7.6%)	5(6.3%)	-0.96	13(16.5%)	2(2.5%)	-1.10
400-600	2(14.7%)	0(0.0%)	-1.06	2(14.3%)	1(7.1%)	-1.36	1(7.1%)	2(14.3%)	-1.52
700-900	0(0.0%)	0(0.0%)	-0.21	0(0.0%)	0(0.0%)	-0.69	0(0.0%)	0(0.0%)	-0.49
3000-4000	0(0.0%)	0(0.0%)	-0.70	0(0.0%)	0(0.0%)	-0.24	1(50.0%)	0(0.0%)	-0.60
Asymptomatic Malaria Parasitaemia Test									
Positive (+)	1(2.9%)	2(5.7%)	-0.46	5(14.3%)	5(14.3%)	-1.38	5(14.3%)	2(5.7%)	-1.07
Negative (-)	19(9.2%)	7(3.4%)	-0.78	31(15.0%)	6(2.9%)	-1.11	24(11.6%)	9(4.3%)	-1.14

ACKNOWLEDGEMENTS

To the Assemblymen, health committee members and women and children of communities involved in this research, we say thank you very much for availing yourselves and facilitating our data collection. The logistical support given us by the nutrition unit of Bongo district health directorate is also very much appreciated. The sacrifice and efforts of our Research Assistants; Mr. Emmanuel Adongo, Harold Anafo, Nicholas Atindama, Hannah Atindana, Sandra Nabil, Anastasia A. Nsobila and Alphonsus Nyaaba, are highly acknowledged. Thank you all.

CONSENT FOR PUBLICATION

Not applicable

REFERENCES

Arinaitwe E, Gasasira A, Verret W, Homsy J, Wanzira H, Kakuru A, Sandison TG: The association between malnutrition and the incidence of malaria amongyoung HIV-infected and-uninfected Ugandan children: a prospective study. *Malaria Journal 2012*, 11:90

Black RE, Allen LH, Bhutta, ZA, Caulfield LE, De Onis M, Ezzati M,Rivera J: Maternal and child undernutrition: global and regional exposures and health consequences. *The lancet 2008,*371(9608), 243-260

Biemba G, Dolmans D, Thuma PE, Weiss G, Gordeuk VR: Severeanaemia in Zambian children with *Plasmodium falciparum* malaria. *Tropical Medicine & International Health 2000*, *5*(1), 9-16.

Caulfield LE, De Onis M, Blössner M, Black RE: Undernutrition as anunderlying cause of child deaths associated with diarrhoea, pneumonia, malaria, and measles. *The American journal of clinical nutrition 2004*, 80(1), 193-198.

Cheesbrough M: District laboratory practice in tropical countries Part 2. Cambridge: *Cambridge University Press 2005*. pp. 274-286.

Crookston BT, Alder SC, Boakye I, Merrill RM, Amuasi JH, Porucznik CA, Ansong D: Exploring the relationship between chronic undernutrition and asymptomatic malaria in Ghanaian children. *Malaria Journal 2010,9*(39)

Cucunubá ZM, Guerra ÁP, Rahirant SJ, Rivera JA, Cortés LJ, Nicholls RS: Asymptomatic plasmodium spp. infection in Tierralta, Colombia. *Memórias do Instituto Oswaldo Cruz 2008*, *103*(7), 668-673.

Dalla Martha RC, Tada MS, Ferreira RGDM, Silva LHPD, WunderlichG: Microsatellite characterization of Plasmodium falciparum from symptomatic and non-symptomatic infections from the Western Amazon reveals the existence of non-symptomatic infection-associated genotypes. *Memórias do Instituto Oswaldo Cruz 2007*, 102(3), 293-298.

Deribew A, Alemseged F, Tessema F, Sena L, Birhanu Z, Zeynudin A,Biadgilign S: Malaria and under-nutrition: a community based study among under-five children at risk of malaria, south-west Ethiopia. *PLoS One 2010*, *5*(5), e10775.

Ehrhardt S, Burchard GD, Mantel C, Cramer JP, Kaiser S, Kubo M,Mockenhaupt FP: Malaria, anemia, and malnutrition in African children - defining intervention priorities. *Journal of Infectious Diseases 2006*, 194(1), 108-114.

Friedman JF, Kwena AM, Mirel LB, Kariuki SK, Terlouw DJ, Phillips-Howard PA, Ter Kuile FO: Malaria and nutritional status among pre-school children: results from cross-sectional surveys in western Kenya. *The American journal of tropical medicine and hygiene 2005,73*(4), 698-704.

Fillol F, Cournil A, Boulanger D, Cissé B, Sokhna C, Targett G,Simondon KB: Influence of wasting and stunting at the onset of the rainy season on subsequent malaria morbidity among rural preschool children in Senegal. *The American journal of tropical medicine and hygiene 2009,80*(2), 202-208.

Fillol F, Sarr JB, Boulanger D, Cisse B, Sokhna C, Riveau G, Remoué F:Impact of child malnutrition on the specific anti-Plasmodium falciparum antibody response. *Malaria journal 2009*, *8*(1), 116.

Ganguly S, Saha P, Guha SK, Biswas A, Das S, Kundu PK, Maji AK: A high prevalence of asymptomatic malaria in a tribal population in eastern India. *Journal of clinical microbiology 2013*, 51(5), 1439-1444

Genton B, Al-Yaman F, Ginny M, Taraika J, Alpers MP:Relation ofanthropometry to malaria morbidity and immunity in Papua New Guinean children. *AmericanSociety for Clinical Nutrition 1998*, 68:734–41

George KA, Kumar NS, Lal JJ, Sreedevi R: Anemia and nutritional status of pre-school children in Kerala. *The Indian Journal of Pediatrics 2000*, *67*(8), 575-578.

Harris I, Sharrock WW, Bain LM, Gray KA, Bobogare A, Boaz L, Cheng Q: A large proportion of asymptomatic Plasmodium infections with low and sub-microscopic parasite densities in the low transmission setting of Temotu Province, Solomon Islands: challenges for malaria diagnostics in an elimination setting. *Malaria Journal 2010*, 9(254), 29

Johnston SP, Pieniazek NJ, Xayavong MV, Slemenda SB, Wilkins PP, Da Silva AJ: PCR as a confirmatory technique for laboratory diagnosis of malaria. *Journal of clinical microbiology 2006*, *44*(3), 1087-1089.

Jonker FA, Calis JC, van Hensbroek MB, Phiri K, Geskus RB, Brabin BJ, Leenstra T: Iron status predicts malaria risk in Malawian preschool children. *PloS one 2012*, *7*(8), e42670.

Laishram DD, Sutton PL, Nanda N, Sharma VL, Sobti RC, Carlton JM, Joshi H: The complexities of malaria disease manifestations with a focus on asymptomatic malaria. *Malaria Journal 2012*, 11(1), 29

Lindblade KA, Steinhardt L, Samuels A, Kachur SP, Slutsker L: The silentthreat: asymptomatic parasitaemia and malaria transmission. *Expert review of anti-infective therapy 2013*, 11(6), 623-639

Nyakeriga AM, Troye-Blomberg M, Dorfman JR, Alexander ND, Bäck R, KortokM,Williams TN: Iron deficiency and malaria among children living on the coast of Kenya. *Journal of Infectious Diseases 2004*, *190*(3), 439-44

National Malaria Control Programme (NMCP): Annual Report 2010. Ghana HealthService (GHS) health facility data

Mahajan B, Zheng H, Pham PT, Sedegah MY, Majam VF, Akolkar N, Kumar S: Polymerase chain reaction–based tests for pan-species and species-specific detection of human Plasmodium parasites. *Transfusion 2012*, *52*(9), 1949-1956.

Manning L, Laman M, Rosanas-Urgell A, Michon P, Aipit S, Bona C, Davis TM: Severe anaemia in Papua New Guinean children from a malaria-endemic area: a case-control etiologic study. *PLoS neglected tropical diseases 2012*, *6*(12), e1972

Magalhães RJSand Clements AC: Mapping the risk of anaemia in preschool-agechildren: the contribution of malnutrition, malaria, and helminth infections in West Africa. *PLoS medicine 2011*, *8*(6), e1000438.

Olney DK, Kariger PK, Stoltzfus RJ, Khalfan SS, Ali NS, Tielsch JM,Pollitt E: Development of nutritionally at-risk young children is predicted by malaria, anaemia, and stunting in Pemba, Zanzibar. *The Journal of nutrition 2009,*139(4), 763-772

Ong'echa JM, Keller CC, Were T, Ouma C, Otieno RO, Landis-Lewis Z, Perkins DJ:Parasitaemia, anaemia, and malarial anaemia in infants and young children in a rural holoendemic *Plasmodium falciparum* transmission area. *The American journal of tropical medicine and hygiene 2006*, 74(3), 376-385

Orogade AA, Ogala WN, Aikhionbare HA: Asymptomatic malaria parasitaemia – A suitable index for evaluation of malaria vector control measures. *Nigerian journal of paediatrics 2002*, 29 (2); 23 - 26

Osazuwa Fand Ayo OM: Contribution of malnutrition and malaria to anaemia inchildren in rural communities of Edo state, Nigeria. *North American journal of medical sciences 2010*, 2(11), 532

Snow RW, Byass P, Shenton FC, Greenwood BM: The relationshipbetween anthropometric measurements and measurements of iron status and susceptibility to malaria in Gambian children. *Transactions of the Royal Society of Tropical Medicine and Hygiene 1991*, *85*(5), 584-589.

Sumbele IUN, Samje M, Nkuo-Akenji T: A longitudinal study on anaemia in children with Plasmodium falciparum infection in the Mount Cameroon region: prevalence, risk factors and perceptions by caregivers. *BMC infectious diseases 2013*, 13(1), 123.

Tine RC, Ndiaye M, Hansson HH, Ndour CT, Faye B, Alifrangis M, Gaye O: The association between malaria parasitaemia, erythrocyte polymorphisms, malnutrition and anaemia in children less than 10 years in Senegal: a case control study. *BMC research notes 2012*, *5*(1), 565.

Trape JF: Rapid evaluation of malaria parasite and standardisation of thick smear examination for epidemiological investigation. *Tropical medical hygiene 1985*. 79 (2), 181 – 184

Verhoef H, West CE, Veenemans J, Beguin Y, KokFJ: Stunting maydetermine the severity of malaria-associated anaemia in African children. *Pediatrics 2002*, *110*(4), e48-e48

Wagner G, Koram K, McGuinness D, Bennett S, Nkrumah F, Riley E: High incidence of asymptomatic malaria infections in a birth cohort of children less than one year of age in Ghana, detected by multicopy gene polymerase chain reaction. *The American journal of tropical medicine and hygiene 1998*, *59*(1), 115-123.

World Health Organization: World health report 2005. World Health Organization, Geneva,Switzerland. http://www.who.int/whr/2005/whr2005_en .Pdf.

World Health Organization: World malaria report 2009. World Health Organization,Geneva, Switzerland. http://whqlibdoc.who.int/publications 2009/9789241563901_eng.pdf.

AVAILABILITY OF DATA AND MATERIAL

Data on ASMP assessment, Anaemia Test results (Hb) and Z-scores of Anthropometric measures

CHILD I.D	MPs	HB (g/dl)	Weight for Height *Z*Scores	Height for Age *Z* Scores	Weight for Age *Z*Scores
➢ **Ashanti Region (Kejetia Community)**					
1	No MPs seen	10.70	-0.73	-0.49	-0.78
2	No MPs seen	9.00	-0.66	-2.15	-1.63
3	No MPs seen	9.10	-2.06	-1.00	-1.94
4	No MPs seen	11.30	-1.86	-0.75	-1.65
5	No MPs seen	10.20	-1.09	-5.15	-4.02
6	No MPs seen	11.40	0.36	-0.82	-0.17
7	No MPs seen	11.80	-1.03	0.34	-0.60
8	No MPs seen	10.20	-0.85	1.21	-0.09
9	No MPs seen	11.70	0.09	-0.84	-0.36
10	No MPs seen	10.80	-2.10	0.15	-1.34
11	No MPs seen	9.40	1.19	1.73	1.62
12	No MPs seen	10.30	-2.53	-1.07	-2.31
13	No MPs seen	10.50	0.28	-0.20	0.10
14	*P. f.* 342 (+)	10.80	1.34	0.12	1.00
15	No MPs seen	10.60	-1.95	-1.25	-1.99
16	No MPs seen	10.40	-1.84	-1.08	-1.86
17	*P. f.* 108 (+)	8.20	-1.79	1.29	-0.72
18	No MPs seen	10.80	0.32	-1.71	-0.72

19	No MPs seen	11.00	1.18	-3.29	-1.07
20	No MPs seen	10.40	-0.63	-0.99	-1.01
21	No MPs seen	11.20	-0.39	-0.49	-0.57
22	No MPs seen	11.00	0.55	-1.06	-0.08
23	No MPs seen	10.00	-4.25	-1.95	-4.07
24	No MPs seen	11.30	0.60	-1.98	-0.72
25	*P. f.* 119 (+)	8.70	-0.92	-3.26	-2.51
26	No MPs seen	9.70	-0.32	-0.95	-0.69
27	*P. f.* 347 (+)	10.30	-0.11	-1.51	-0.90
28	No MPs seen	10.90	-0.17	-0.93	-0.67
29	No MPs seen	10.30	-0.38	-2.62	-1.52
30	No MPs seen	9.70	-1.20	-2.13	-1.92
31	*P. f.* 518 (+)	10.20	-0.56	-1.19	-1.03
32	No MPs seen	11.30	-1.83	-2.53	-2.62
33	No MPs seen	10.40	-0.31	-0.88	-0.65
34	No MPs seen	12.40	0.42	-1.21	-0.40
35	No MPs seen	11.10	-0.40	-2.23	-1.65
36	No MPs seen	10.70	-0.76	-1.59	-1.29
37	No MPs seen	10.30	-0.79	0.37	-0.32
38	No MPs seen	10.60	0.07	-0.44	-0.20
39	No MPs seen	10.50	-1.94	-0.81	-1.77
40	No MPs seen	11.40	-0.43	-0.85	-0.71
41	*P. f.* 168 (+)	11.00	0.83	-1.18	-0.02
42	No MPs seen	11.70	-0.89	-1.54	-1.36
43	No MPs seen	11.30	-0.01	0.39	0.30
44	No MPs seen	11.70	-1.61	-0.27	-1.24
45	No MPs seen	10.60	-1.67	-1.52	-1.91
46	No MPs seen	11.20	-2.80	-0.42	-2.20
47	No MPs seen	10.00	0.93	-0.55	0.43
48	No MPs seen	9.80	0.16	-1.35	-0.69
49	No MPs seen	10.50	1.34	-1.99	-0.25
50	No MPs seen	10.10	0.24	-1.84	-0.66
51	No MPs seen	9.40	0.92	-2.73	-0.66
52	No MPs seen	10.10	-0.44	-1.39	-1.15
53	No MPs seen	10.90	-0.72	-2.04	-1.50
54	No MPs seen	10.30	-0.21	-0.33	-0.28
55	No MPs seen	9.90	0.27	-0.87	-0.36
56	No MPs seen	10.90	-1.66	0.27	-1.03
57	*P. f.* 452 (+)	10.70	-0.65	-2.06	-1.72
58	No MPs seen	10.30	0.51	-1.52	-0.41
59	No MPs seen	11.80	-0.21	0.01	-0.09
60	No MPs seen	10.00	-1.05	-2.15	-1.95
61	No MPs seen	10.70	-0.73	-.73	-0.73
62	*P. f.* 104 (+)	9.50	-0.89	-2.14	-1.65
➢ **Brong Ahafo Region (Pomaa Krom Community)**					
63	No MPs seen	9.40	-1.09	-1.08	-1.29
64	*P. f.* 127 (+)	9.40	-0.56	-0.54	-0.64
65	No MPs seen	10.40	-3.88	0.83	-2.48
66	No MPs seen	8.60	-3.29	0.03	-2.24
67	No MPs seen	12.50	-2.09	-2.95	-3.07
68	No MPs seen	10.60	-1.72	-1.54	-2.02
69	No MPs seen	10.60	-0.54	-1.36	-1.18
70	No MPs seen	10.90	-2.45	-.82	-2.03

71	No MPs seen	10.40	-0.38	-2.76	-1.82
72	No MPs seen	8.80	-0.89	-1.49	-1.33
73	*P. f.* 138 (+)	10.30	-1.66	-1.65	-2.05
74	No MPs seen	10.20	-0.89	-0.80	-1.03
75	No MPs seen	11.40	-0.10	-0.94	-0.65
76	No MPs seen	10.80	1.64	-1.58	0.49
77	No MPs seen	9.00	-0.70	-1.15	-1.09
78	No MPs seen	11.40	-0.29	-2.07	-1.33
79	No MPs seen	10.00	-0.31	-0.30	-0.31
80	No MPs seen	10.60	-0.66	-2.26	-1.75
81	*P. f.* 158 (+)	11.30	0.44	-2.75	-1.32
82	No MPs seen	5.30	-0.83	-1.79	-1.61
83	No MPs seen	10.10	0.19	0.96	0.65
84	No MPs seen	9.90	-0.20	-1.02	-0.65
85	No MPs seen	9.90	-0.11	-1.43	-0.85
86	No MPs seen	9.90	-0.09	-1.75	-1.00
87	No MPs seen	9.30	-0.12	-1.76	-0.89
88	No MPs seen	10.40	0.74	-0.61	0.19
89	No MPs seen	11.30	0.66	-0.66	0.17
90	No MPs seen	10.10	-2.03	-2.27	-2.65
91	No MPs seen	9.70	-1.16	-0.82	-1.27
92	No MPs seen	10.00	-1.44	-1.77	-1.91
93	*P. f.* 185 (+)	11.60	-1.25	-.91	-1.34
94	No MPs seen	12.00	-0.59	-1.19	-1.03
95	No MPs seen	11.10	-1.64	-0.94	-1.67
96	No MPs seen	9.30	-1.58	-3.00	-2.58
97	No MPs seen	11.20	-0.70	-1.65	-1.42
98	No MPs seen	9.50	-1.68	-2.05	-2.22
99	No MPs seen	16.60	-5.98	-2.53	-5.29
100	No MPs seen	7.50	-1.27	-1.21	-1.49
101	No MPs seen	12.20	0.45	-1.06	-0.36
102	*P. f.* 127 (+)	7.90	-0.12	-1.76	-0.89
103	No MPs seen	10.30	-0.75	-1.31	-1.25
104	No MPs seen	10.50	-	-	-
105	No MPs seen	9.10	0.05	-1.75	-0.98
106	No MPs seen	10.80	-1.15	-1.54	-1.67
107	No MPs seen	11.30	-1.96	-1.51	-2.21
108	No MPs seen	11.70	-1.59	-1.53	-1.91
109	*P. f.* 134 (+)	11.30	-	-	-
110	No MPs seen	10.10	-1.92	-2.43	-2.83
111	No MPs seen	10.90	0.29	-0.46	-0.08
112	No MPs seen	8.80	-0.32	-0.21	-0.30
113	No MPs seen	11.20	-	-	-
114	No MPs seen	10.70	-1.07	-0.70	-1.09
115	No MPs seen	11.20	-1.39	-0.74	-1.32
116	No MPs seen	10.70	-2.59	3.69	0.15
117	No MPs seen	10.30	-0.77	-1.44	-1.40
118	No MPs seen	12.40	-	-	-
119	No MPs seen	11.20	-0.56	-0.63	-0.71
120	No MPs seen	11.40	-0.11	-1.40	-0.82
121	No MPs seen	9.20	-0.22	-0.57	-0.42
122	No MPs seen	11.10	-0.68	-0.91	-0.98
123	No MPs seen	13.30	-1.65	-0.99	-1.68

124	No MPs seen	11.00	-0.70	-1.44	-1.30
➢ **Northern Region (Tamale Metro Community)**					
125	No MPs seen	10.20	-0.97	-2.13	-1.86
126	No MPs seen	11.00	-1.57	-2.21	-2.42
127	No MPs seen	13.20	-1.23	-1.36	-1.56
128	No MPs seen	10.70	1.13	-1.22	0.09
129	No MPs seen	10.90	1.13	-1.63	0.13
130	No MPs seen	11.60	-0.85	-0.40	-0.74
131	No MPs seen	13.00	-	-	-
132	No MPs seen	11.70	-3.52	1.40	-1.32
133	*P. f.* 107 (+)	10.80	-0.73	-1.66	-1.45
134	No MPs seen	10.90	-1.17	-0.95	-1.27
135	No MPs seen	8.70	-0.64	-2.00	-1.41
136	No MPs seen	9.50	-0.48	-1.19	-0.90
137	*P. f.* 208 (+)	11.20	-0.83	-1.83	-1.56
138	No MPs seen	11.30	-0.65	-1.05	-1.07
139	No MPs seen	11.10	-1.04	-.85	-1.21
140	No MPs seen	12.00	-0.63	0.57	-0.20
141	No MPs seen	12.10	-	-	-
142	*P. f.* 228 (+)	9.70	-3.01	-0.35	-2.06
143	No MPs seen	11.50	-0.64	-1.06	-1.06
144	No MPs seen	12.70	-0.20	-1.55	-1.10
145	*P. f.* 214 (+)	11.00	-0.73	-0.95	-1.06
146	No MPs seen	11.90	-0.62	-1.15	-1.09
147	*P. f.* 118 (+)	12.10	-1.46	-1.05	-1.62
148	No MPs seen	11.50	-2.35	-3.51	-3.38
149	No MPs seen	12.50	-2.52	-2.29	-3.11
150	*P. f.* 136 (+)	12.40	-0.28	-2.42	-1.61
151	No MPs seen	10.30	-0.56	-2.28	-1.47
152	No MPs seen	10.60	-1.70	-1.45	-1.94
153	No MPs seen	12.10	-2.08	0.17	-1.29
154	No MPs seen	12.70	-2.29	1.02	-1.03
155	No MPs seen	10.00	-0.62	-1.72	-1.28
156	*P. f.* 162 (+)	9.60	-1.15	-0.27	-0.89
157	No MPs seen	9.20	0.75	-1.43	-0.17
158	*P. f.* 193 (+)	12.70	-0.34	-0.21	-0.29
159	No MPs seen	12.50	-0.11	-0.13	-0.15
160	No MPs seen	7.60	-1.35	-1.69	-1.77
161	No MPs seen	11.50	-0.74	-1.00	-1.10
162	No MPs seen	11.70	-0.71	-0.64	-0.86
163	No MPs seen	9.50	-4.28	2.21	-1.69
164	No MPs seen	11.40	-0.99	-0.25	-0.78
165	*P. f.* 224 (+)	9.40	2.64	-1.31	1.46
166	No MPs seen	11.40	-0.41	0.54	-0.05
167	No MPs seen	11.20	-1.05	0.43	-0.45
168	No MPs seen	10.30	-2.03	-1.35	-2.06
169	No MPs seen	11.10	-1.52	-1.73	-1.98
170	No MPs seen	9.90	1.03	0.54	1.03
171	No MPs seen	12.50	0.47	-0.49	0.07
172	No MPs seen	12.20	-0.77	-0.83	-0.98
173	No MPs seen	13.20	0.53	0.01	0.46
174	No MPs seen	13.00	0.40	-1.75	-0.63
175	No MPs seen	14.30	-0.97	-0.98	-1.23

176	No MPs seen	7.50	0.01	-0.56	-0.24
177	No MPs seen	7.60	-1.07	-1.28	-1.44
178	No MPs seen	7.30	-2.15	-1.28	-2.22
179	No MPs seen	11.20	0.18	-1.08	-0.43
180	No MPs seen	10.30	-1.78	-1.21	-1.85
181	No MPs seen	9.00	0.88	-1.51	-0.01
182	No MPs seen	11.60	-0.19	-0.37	-0.36
183	No MPs seen	11.30	-0.42	-1.33	-0.98
184	*P f* : 191 (+)	11.00	-0.74	-0.58	-0.85
185	No MPs seen	9.20	-1.18	-2.16	-2.00
186	*P f*. 1090 (++)	9.90	-2.89	-3.79	-3.99
➢ **Upper East Region (Nyariga Community)**					
187	*P f*. 233 (+)	11.40	3.26	0.68	2.70
188	No MPs seen	11.30	-0.55	-1.79	-1.33
189	*P. f*. 183 (+)	9.80	0.72	0.18	0.60
190	No MPs seen	11.20	-1.06	-1.10	-1.35
191	No MPs seen	12.30	0.26	-0.89	-0.38
192	No MPs seen	11.30	-1.07	-1.17	-1.36
193	No MPs seen	11.50	-0.74	-1.46	-1.37
194	*P f*. 10970 (++)	10.90	-0.79	-5.77	-4.24
195	No MPs seen	10.40	-1.32	-0.21	-0.97
196	*P. f*. 183 (+)	10.80	-0.04	-1.14	-0.62
197	No MPs seen	9.50	-0.53	-0.70	-0.70
198	No MPs seen	10.50	-0.49	-2.69	-1.95
199	No MPs seen	11.30	-1.04	-1.38	-1.49
200	No MPs seen	10.90	-1.24	-3.12	-2.75
201	*P f*. 8313 (++)	11.20	-4.03	1.64	-1.55
202	No MPs seen	10.60	-1.15	-2.23	-2.02
203	*P f*. 783 (++)	9.70	0.48	-1.16	-0.26
204	*P f*. 661 (+)	9.10	0.05	-2.21	-1.32
205	No MPs seen	11.00	-0.06	-1.77	-0.97
206	*P. f*. 320 (+)	10.60	1.46	-1.22	0.24
207	No MPs seen	11.20	0.25	-0.48	-0.10
208	No MPs seen	9.10	2.10	-2.72	0.34
209	No MPs seen	10.50	1.98	-1.08	0.63
210	No MPs seen	9.50	-0.65	-3.98	-2.64
211	No MPs seen	11.60	0.55	-0.23	0.24
212	No MPs seen	10.10	-2.03	-1.20	-2.03
213	*P. f*. 120 (+)	9.00	-0.66	-3.61	-2.31
214	No MPs seen	11.50	-0.12	0.64	0.35
215	No MPs seen	10.50	-1.35	-2.39	-2.39
216	No MPs seen	10.70	-1.11	-1.39	-1.50
217	No MPs seen	8.70	-1.53	-0.40	-1.22
218	No MPs seen	11.30	-	-	-
219	*P.v*. 112 (+)	10.00	-1.81	0.44	-0.96
220	No MPs seen	10.50	-0.98	0.15	-0.70
221	No MPs seen	11.30	-0.10	-0.55	-0.41
222	No MPs seen	11.20	0.52	-0.94	-0.10
223	*P. f*. 309 (+)	10.50	-	-	-
224	*P. f*. 244 (+)	10.60	0.38	-4.51	-2.17
225	No MPs seen	11.60	-0.99	-0.28	-0.83
226	No MPs seen	10.50	-2.29	-1.49	-2.30
227	No MPs seen	11.90	-2.29	-2.37	-3.05

228	No MPs seen	9.20	0.09	0.49	0.28
229	No MPs seen	11.50	-0.40	-1.53	-1.20
230	No MPs seen	9.50	-1.00	-1.04	-1.26
231	No MPs seen	10.70	0.17	-1.62	-0.73
232	No MPs seen	11.70	0.98	-0.82	0.38
233	No MPs seen	11.00	0.99	-0.69	0.31
234	No MPs seen	10.50	-0.85	-2.29	-1.72
235	No MPs seen	10.70	-0.70	-1.18	-1.17
236	No MPs seen	10.00	-1.79	-0.94	-1.75
237	No MPs seen	13.40	-3.24	-0.49	-2.55
238	No MPs seen	10.60	0.32	1.06	0.81
239	No MPs seen	10.00	-0.75	-1.32	-1.24
240	No MPs seen	11.30	-1.68	-1.88	-2.09
241	No MPs seen	8.10	-1.88	1.25	-0.80
242	No MPs seen	11.90	-0.23	0.44	0.18
243	No MPs seen	10.70	-0.32	-1.13	-0.87
244	No MPs seen	10.80	-2.75	-2.85	-3.64
245	No MPs seen	11.20	-1.71	-3.10	-2.94
246	No MPs seen	10.40	-0.24	-1.79	-1.00
247	No MPs seen	12.00	0.21	-1.43	-0.67
248	No MPs seen	10.90	-0.38	0.56	0.06
249	No MPs seen	11.90	-2.86	-2.78	-3.46
250	No MPs seen	8.90	-0.50	-1.91	-1.28