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

THIS DISSERTATION IS PRESENTED TO THE DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MPHIL. (HONS) DEGREE IN HUMAN NUTRITION AND DIETETICS

BY

DANIEL AYINE NYAABA

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DECLARATION

I Daniel Ayine Nyaaba, hereby declare that this work submitted for a Master of Philosophy degree in Human Nutrition and Dietetics, was entirely and exclusively produced by me under the supervision of Dr. Patricia Brown and Dr. Jacob Agbenorhevi. The works of others which served as sources of information have been duly acknowledged by making references to the authors.

DANIEL AYINE NYAABA
(STUDENT)

SIGNATURE: ….……..... DATE: ……...

DR. PATRICIA BROWN
(SUPERVISOR)

SIGNATURE: …… DATE: …….....

DR. JACOB AGBENORHEVI
(SUPERVISOR)

SIGNATURE: …… DATE: …….....

HEAD OF DEPARTMENT

NAME:.....

SIGNATURE:.……..... DATE:…….....

DEDICATION

I dedicate this thesis to my senior sister Mary Ayinpogbila Nyaaba, my senior brothers Joseph Adugbire Nyaaba and Nuhu T. Akrugo Nyaaba and my father Mr. Stephen Nyaaba. Thank you for your financial support and inspiration in the course of my studies and research work.

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LIST OF ABBREVIATIOINS

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

ABSTRACT

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. This was a community-based cross-sectional study, conducted in four rural Ghanaian communities. Blood samples and anthropometric measures of 250 children were collected for analyses. Parents of children involved in the study, also completed a questionnaire.

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). This implies that, 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. Efforts should therefore be made to routinely screen for asymptomatic malaria parasitaemia.

CHAPTER ONE

1.1 BACKGROUND

Undernutrition is a form of malnutrition that is as a result of inadequate nutrition (short or long term) or sometimes associated with infections. Undernutrition is described as the 'outcome of insufficient food intake and repeated infectious diseases' (UNICEF, 2006). Undernutrition may result in stunting (low height-for age), wasting (low weight-for-height), underweight (low weight-for-age) or deficiencies of essential micronutrients.

Undernutrition and malaria are major public health challenges and are the main causes of ill health and death in low and/or middle income settings such as sub-Saharan Africa (Caulfield *et al*., 2004). According to the WHO, approximately one-half of the 10.6 million children under five years who die in low- and middle-income countries are malnourished (WHO, 2005). In West Africa, 37.7% (16.8 million) children less than five years are stunted; 4.3% (1.9 million) are severely wasted and 23.9% (10.7 million) are underweight (Black *et al.,* 2008). 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). 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 infection is an obstruction to the complete eradication of malaria (Lindblade *et al.,* 2013 and Ganguly *et al*., 2013). This is because persons with asymptomatic malaria usually do not seek treatment and the malaria parasites can be transmitted to others when female Anopheles mosquitoes pick up gametocytes from asymptomatic malaria infected people during a blood meal and transform them into sporozoites which they inject into uninfected persons in subsequent blood meals (Lindblade *et al.,* 2013). 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.

Malnutrition may predispose one to infections or diseases (Semba *et al.,* 2001 and Martorell *et al.,* 1999). This may be due to the suppressive effect of undernutrition on immunity (Barker *et al.,* 2011). Malnutrition during the early stages of life also has adverse effects later in adult life (Victora *et al.,* 2008). Adequate nutrition is therefore central to achieving and sustaining good health, and preventing mortalities especially in children. Though debatable, some significant predictors of undernutrition in children include low birth weight, gender, age, low maternal education, few household possessions, and community of residence among others (Kimani-Murage *et al.,* 2013, McDonald *et al.,* 2012 and Medhid *et al.,* 2010). Several research works have been conducted in an attempt to establish an association between nutritional status; particularly undernutrition (wasting, stunting and underweight) and the incidence/prevalence of malaria in children. However, there is limited research on asymptomatic malaria, especially in relation to undernutrition in children. This research therefore aims at investigating the relationship between undernutrition and asymptomatic malaria parasitaemia in children from four rural communities in the Upper East region of Ghana.

1.2 Problem Statement

Child undernutrition and malaria are endemic in developing countries especially in low-income and middle-income countries. Based on the WHO's child growth standards in UN regions and sub-regions in 2005, an estimated average of 32% (177.7 million), 3.5% (19.3 million) and 20.2% (112.4 million) of children younger than five years are stunted, wasted and underweight respectively, in all developing countries (Black *et al.,* 2008). The relationship between undernutrition and poor health is cyclical. Undernutrition may lead to a compromise of the immune system's response to infections or diseases which impairs the body's ability to function properly, especially in children (Caulfield *et al.,* 2004). Disease or infection may also result in undernutrition due to inadequate food/nutrient intake and increased energy requirements attributable to infections (Tomkins *et al.,* 2003). Malnourished children are therefore considered susceptible to malaria as well as other diseases. The 2008 Lancet report on maternal and child undernutrition estimates that, malaria mortality increases with decreasing odds ratios for underweight, wasting and stunting in children younger than five years in low or middle income countries (Black *et al.,* 2008). This suggests that malnutrition could increase the disease burden of malaria infected persons and could also result in increased child mortality. 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 in Ghana (NMCP, 2010). Asymptomatic malaria parasitaemia significantly contributes to malaria transmission, yet receives the least attention in malaria control strategies. It is a major obstacle to the complete eradication of malaria 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.

1.3 Research Objectives

1.4.1 Main Objective:

To determine the association between undernutrition and asymptomatic malaria parasitaemia in children

1.4.2 Specific objectives:

1. To determine the prevalence of malaria parasitaemia in asymptomatic children aged 1-5 years of age

2. To assess the nutritional status of children and determine its socio-demographic distribution.

3. To determine the association between asymptomatic malaria and undernutrition (stunting, wasting and underweight) and anaemia in children, aged 1-5 years of age.

4. To determine the prevalence of anaemia and its distribution (i.e. age, gender and community e.t.c.) in children from one to five years of age.

5. To establish association between anaemia and asymptomatic malaria in children from one to five years of age.

1.4 Justification

Asymptomatic malaria remains a challenge for malaria control interventions or measures as it significantly influences malaria transmission dynamics, and interventions targeted at this parasite reservoir are necessary to completely eliminate malaria in low and middle income countries. However, there is no national database on the prevalence of asymptomatic malaria in most regions and districts, and Ghana as a whole. This research seeks to determine the prevalence of asymptomatic malaria parasitaemia and its relationship with undernutrition (stunting, wasting and underweight) as well as anaemia in children, aged 1-5 years in the Bongo district of the Upper East region of Ghana. This research would provide information on the prevalence of asymptomatic malaria and undernutrition in children as well as their associations. The findings of this research would therefore inform the planning and implementation of malaria control strategies and nutrition interventions, in a bid to reduce or eliminate malaria transmission and enhance the nutritional status of children in the study region and Ghana at large.

1.5 Research Hypotheses

Ho: There is no association between nutritional status and asymptomatic malaria parasitaemia in children.

H_1: There is an association between nutritional status and asymptomatic malaria parasitaemia in children.

CHAPTER TWO

LITERATURE REVIEW

2.1 Child Undernutrition

Good nutrition is fundamental to attaining and maintaining optimal health. Malnutrition could predispose one to a wide range of diseases and infections (Tomkins *et al.,* 2003). Undernutrition is a form of malnutrition that is as a result of inadequate nutrition (short or long term) and/or infection (Black *et al.,* 2008). Inadequate dietary intake and infection/disease are recognised as the immediate causes of undernutrition. Food insecurity, inadequate care and unhealthy household environment and lack of health services are the underlying causes of malnutrition where as social, economic and political factors are the basic causes (Black *et al.*, 2008).

Undernutrition is very common in the world especially in low- and middle-income countries (Black *et al.,* 2008). In Africa, 40.1%, 3.9% and 21.9% of children younger than five years are stunted, severely wasted and underweight respectively (Black *et al.,* 2008). From this same report, other UN regions such as south-central Asia presented even higher prevalence of stunting, severe wasting and underweight of 40.7%, 5.7% and 33.1% respectively. These estimates are based on an analysis of 388 national surveys from 139 countries using the new WHO growth standards (WHO, 2006). According to the 2011 Multiple Indicator Cluster Survey (MICs) report, 22.8% of children less than five years in Ghana are moderately or severely stunted, 13.4% are either moderately or severely underweight and 6.2% are moderately or severely wasted (Ghana Statistical Service, 2011). The Upper East region presented higher incidence of malnutrition, recording 31.5% of children moderately or severely stunted and 9.8% severely stunted, 20.0% are moderately or severely underweight and 4.9% are severely underweight and 7.2% are moderately or severely wasted whilst 1.2%

are severely wasted (Ghana Statistical Service, 2011). Undernutrition in the short term can result in loss of life, morbidity and disability. Long term consequences include reduction in economic productivity, adult size, intelligence quotient among others (Black *et al.,* 2008). Therefore, undernutrition during childhood is a serious public health challenge. Undernutrition enormously contributes to mortality and morbidity of young children in the world. It's the principal cause of child mortality in the world especially subs Saharan Africa and some parts of Asia (Black *et al.,* 2008). A research to determine the percentage of death attributable to undernutrition established that, about 52.5% of child mortality globally from all cause of death could be attributed to low weight-for-age and there was a higher risk of death associated with decreasing low weight-for-age z-scores (Caulfield *et al.,* 2004). Globally, stunting, severe wasting and intrauterine growth retardations are the greatest contributors to the risk of death in children under five years of age (Black *et al.,* 2008). This indicates that malnutrition possess the greatest risk of death in this age group.

Undernutrition may lead to a compromise of the immune system's response to infections or diseases which impairs the body's ability to function properly, especially in children (Caulfield *et al.,* 2004). The interaction between undernutrition and health status is however complex because poor health could result in undernutrition and undernutrition on the other hand could increase one's vulnerability to diseases and infections. Disease or infection may also result in undernutrition due to inadequate food/nutrient intake and increased energy expenditure attributable to infections (Tomkins *et al.,* 2003). Malnourished children are therefore considered susceptible to many diseases, including malaria. A 2008 Lancet report on maternal and child undernutrition established that, malaria mortality increases with decreasing *Z* scores for underweight, wasting and stunting, in children younger than five years (Black *et al.,* 2008). This indicates that malnutrition could increase the disease burden of malaria and other illnesses, resulting in increased death toll associated with these illnesses.

Underweight posses more risk of death in children compared to stunting and wasting (Black *et al.,* 2008). Childhood undernutrition could have lifelong consequences. Undernourished children who are less than two years, have increased risk of contracting chronic diseases later in life when they gain excessive weight (Victora *et al.,* 2008). Undernutrition and malaria in children are therefore serious public health problems that threaten the development potential of less developed countries.

2.2 Undernutrition and Malaria

The nutritional status of someone may influence the effect of certain diseases, including malaria. Deficiencies in proteins and micronutrients especially vitamin A and zinc, significantly increase the disease burden of malaria and malaria related deaths (Shankar, 2000). This section reviews literature on the association between nutritional status, particularly undernutrition (wasting, stunting and underweight) and the prevalence of malaria in children.

A cross sectional study conducted in western Kenya investigated the association between undernutrition and parasitaemia, anemia, and malarial anemia in 374 infants and young children aged 0 to 3 years with symptoms of malaria (Ong'echa *et al.,* 2006). It was observed that nutritional status as defined by stunting, wasting and underweight were not associated with parasitaemia or anemia. Also, with the exception of wasting, stunting and underweight were not significantly associated with Malarial Anaemia (M.A). Multivariate analysis however, showed no association between wasting and M.A (Ong'echa *et al.,* 2006). Generally, this study suggests that undernutrition may not necessarily predispose one to malaria infection.

However, another cross sectional study conducted to investigate interactions between malaria, anaemia, and malnutrition in Tamale, on 12000 randomly selected children aged children 6 months to 9 years demonstrated that, malnutrition was independently associated with fever; OR, 1.59; 95% CI, 1.13–2.23 and clinical malaria OR, 1.67; 95% CI, 1.10–2.50 (Ehrhardt *et al.,* 2006). This research reported that underweight could increase the risk of clinical malaria by about 70% and is a risk factor for fever and anemia. Wasting and stunting were also correlated with an increased risk of malaria-associated morbidity. In multivariate models, however, these associations did not hold true.

Another study in western Kenya to determine the influence of undernutrition on risk of malarial associated morbidity in children aged 0 –36 months, found stunted children had more malaria parasitaemia, parasite load, clinical malaria, and severe malarial anemia than non-stunted children (Friedman *et al.,* 2005). The association was evident in children with mild-to-moderate (−3 < HAZ < −2) and severe stunting (HAZ < −3); implying that any form of stunting is associated with malaria. Wasting however was associated with an increased risk of only severe malarial anemia.

To determine if an association exists between chronic undernutrition and cases of asymptomatic malaria, a descriptive cross-sectional study of 214 Ghanaian children less than five years of age was conducted in 2010. This research found no significant association between chronic undernutrition (stunting) and presence of asymptomatic malaria (Crookston *et al.,* 2010). Stunted children were not more likely to have asymptomatic malaria compared to children who were not stunted. However, those with large spleen size and anaemia had an increased risk of asymptomatic malaria.

Furthermore, a studies in Zanzibari, (island of Tanzania, in the Indian Ocean), aimed at providing baseline information on the relationships between malaria infection, haemoglobin (Hb) concentration and chronic undernutrition, revealed that children who had higher malaria parasite load had significantly lower Length-for-age z-scores ($p < 0.001$) and lower Hb concentration (Olney *et al.,* 2009). This implies that malaria parasitaemia could be a predisposing factor for anaemia and stunting; an indicator of chronic undernutrition.

Another cross-sectional survey was carried out in an attempt to elucidate the relationship between malaria, malnutrition and specific immunity. It observed that, child malnutrition and particularly stunting, may suppress the anti-*Plasmodium falciparum* response (Fillol [a], *et al.,*

2009). This finding indicates that chronic malnutrition may compromise immune response to malaria and hence stunted children may be more prone malaria infections.

Finally, a cross-sectional study was conducted in southwest Ethiopia assessed the enormity of under-nutrition and its correlation with malaria among children under-five years. This study found no association between malaria and under-nutrition. However, children who had malaria were more likely to be anaemic (Deribew *et al.,* 2010).

Three cohort or longitudinal studies met the inclusion criteria for this sub-section. The first was conducted in 1998 in Wosera, East Sepik Province Papua New Guinean children. A cohort of 136 children aged 10 to < 120 months old were followed for one year to investigate the relation between anthropometric measurements and subsequent malaria morbidity (Genton, *et al.,* 1998). It was found that, stunting was protective against *P. falciparum* malaria. There was frequent *P. falciparum* malaria attacks associated with improvement in height-for-age z scores. However, wasted children were more prone to malaria than well-nourished children. Children who were stunted as well as wasted were less at risk of malarial infection. This finding reemphasises the protective role of stunting on malaria morbidity observed in this study.

Another 25 week longitudinal observational study followed-up a cohort of 874 rural preschool children in Senegal during one malaria transmission season to explore the impact of malnutrition on subsequent susceptibility to malaria. This study contradicted the findings of the Genton *et al.,* (1998). According to Fillol [b] *et al.,* (2009) stunting (height-for-age z-score < −2) or underweight (weight-for-age z-score < −2) is not associated with clinical malaria. Wasted children however had a lower risk of experiencing malaria attacks (Fillol [b] *et al.,* 2009). This implies acute undernutrition as defined by wasting was protective against clinical malaria.

The latest longitudinal study was conducted in Uganda to ascertain the association between malnutrition and the incidence of malaria among young HIV infected and uninfected children. Children aged 6 weeks to 1 year were recruited from an area of high malaria transmission intensity in rural Uganda and followed till they were 2.5 years (Arinaitwe *et al.,* 2012). This study found that, stunting was associated with an increased incidence of malaria in the cohort. This finding contradicts the finding by Genton *et al.,* (1998) that stunting was protective against malaria and that of Fillol [b] *et al.,* (2009) which found no association at all. Underweight was not associated with a significant difference in the incidence of malaria compared to children with ideal weight; confirming the finding by Fillol [b] *et al.,* (2009) regarding underweight.

Prospective cohort or longitudinal studies provide superior results compared to cross sectional studies because it's a stronger design. Of the three Cohort studies, only one reported on all indices of undernutrition Fillol [b] *et al.,* (2009), and found no association between malaria and undernutrition, except wasting which was reported to have a protective effect against malaria. Two studies reported on only two indices, stunting and wasting (Genton *et al.,* (1998); Arinaitwe *et al.,* (2012). Genton *et al.,* (1998) found stunting protective and against malaria and wasting a risk factor whilst according to Arinaitwe *et al.,* (2012) stunting was a risk factor to malaria but wasting had no association with malaria.

The findings obtained in these studies are considered more reliable compared to the cross sectional studies. Due to the limited number of studies obtained, the true picture of the relationship between undernutrition and malaria incidence still remains unclear due to the contradictions already highlighted above. However, the findings by Arinaitwe *et al.,* (2012) which projects no protective role of stunting on malaria incidence seems convincing because stunting as an indicator for chronic undernutrition, takes time to manifest and his study was conducted for a relatively longer period and had a larger sample size than that of Genton *et*

al. (1998). It is possible that, Fillol [b] *et al.,* (2009) did not find any association between stunting and malaria incidence because his study was conducted for a relatively shorter duration of 25 weeks.

Two studies found no significant association between all indices of undernutrition and malaria in children Ong'echa *et al.,* (2006) and Deribew *et al.,* (2010). Only a single study claimed significant associations between two indices of undernutrition (wasting and stunting) and malaria but did not report on underweight (Friedman *et al.,* 2005). Three out of seven (3/7), one out of four (1/4) and one out of three (1/3) reported significant association between stunting, wasting and under-weight and malaria in children respectively. Put together, the findings suggest a weaker link between undernutrition and malaria. Chronic undernutrition (stunting) however poses a relatively higher threat to developing malaria compared to acute undernutrition. The cross sectional design employed in these studies however limits inferences of causality on these studies; only associations can be established by these studies. Based on these conflicting findings provided by the researches, the association between undernutrition and malaria in children still remains unclear.

Table 2.1: summary of finding of cross-sectional and cohort studies on child undernutrition and malaria

Country or study site	Association between stunting and malaria	Association between Wasting and malaria	Association between Underweight and malaria	Reference
• Cross-sectional studies				
Western Kenya	X	X	X	Ong'echa *et al.*, 2006
Tamale, Ghana	X	X	♪	Ehrhardt *et al.*, 2006
Western Kenya	♪	♪	----	Friedman *et al.*, 2005
Kumasi, Ghana.	X	----	----	Crookston *et al.*, 2010
Tanzania	♪	----	----	Olney *et al.*, 2009
Senegal	♪	X	----	Fillol [a], *et al.*, 2009
Ethiopia	X	X	X	Deribew *et al.*, 2010
• Cohort studies				
Papua New Guinea	Stunting protects against malaria in a one year cohort study of 136 children aged 10 to < 120 months old.	Wasting doesn't protect against malaria.	----	Genton *et al.*, 1998
Senegal	stunting was not associated with clinical malaria in 874 children for 25 weeks	Wasted children were at lower risk of malaria attacks (i.e. wasting was malaria protective)	underweight was not associated with clinical malaria	Fillol [b], *et al.*, 2009
Ugandan	Stunting was associated with an increased incidence of malaria in a 2.5 years cohort study of children	----	underweight was not associated with a significant difference in the incidence of malaria	Arinaitwe *et al.*, 2012

X No significant association found

♪ Significant association found

---- Not considered/reported or included

2.3 Micronutrient Deficiencies and Malaria

Micronutrient deficiencies are common in Sub-Saharan Africa and may increase malaria morbidity and deaths (Shankar, 2000). Also, undernutrition may co-exist with certain diseases or infections such as malaria (Fishman *et al.,* 2004). This section considers relevant micronutrients that have been found to influence malaria parasitaemia or incidence of malaria morbidity or mortality in children. Literature or papers on Iron and vitamin A and/or their combinations were considered.

2.3.1 Malaria, Anaemia and Iron Deficiency in Children

Anaemia is a common health problem especially in Sub-Sahara Africa and it's usually associated with malaria and iron deficiency (Magalha'es *et al.,* 2011). Anaemia is also relatively more common in severely malnourished children (Veiga *et al.,* 2010). Anaemia is very prevalent in Ghana. According to the latest Multiple Indicator Cluster survey (MICs) report, 57.0% of Ghanaian children aged 6-59 months are anaemic; Hb < 11.0 g/dl (Ghana Statistical Service, 2011). From this same report, 77.5% of children from the Upper East region aged 6-59 months are anaemic. Anaemia can be caused by multiple factors; including undernutrition and infections such as malaria (Manning *et al.,* 2012). For instance chronic undernutrition (stunting) and malaria parasitaemia are associated with reduced haemoglobin concentration (Desai *et al.,* 2005). Also, according to Ronald *et al.,* (2006) *plasmodium falciparum* infection, the male sex and young age are significant predictors of anaemia. In addition, Iron deficiency is a risk factor for anaemia especially for children infected by malaria (Sumbele *et al.,* 2013). This section presents research findings on the relationship between malaria, anaemia and Iron status of children.

A case-control study involving 252 anaemic (cases) and non-anaemic (controls) children, less than ten years of age in Senegal revealed that malaria parasitaemia and stunting were major

causes of anaemia (Tine *et al.*, 2012). Anaemia was significantly associated with malaria parasitaemia and stunting among others.

Also, a cross-sectional study in the Eastern Province of Kenya involving 318 children aged 2-36 months, reported a reduction in haemoglobin (Hb) concentration in persons with malaria (Verhoef *et al.* 2002). A malaria-associated reduction in average haemoglobin (Hb) concentration was recorded for stunted children compared non-stunted children. This means that malaria is a risk factor for anaemia and stunting could make malaria associated anaemia more severe.

Furthermore, the causes of anaemia were investigated in Papua New Guinea. Severely anaemic hospitalized and healthy non-anaemic children aged 0.5-10 years were involved in the study. This study established that, *plasmodium falciparum* malaria infection was significantly associated with anaemia (Manning *et al.*, 2012).

In addition, a retrospective study that reviewed hospital records of 6200 children, reported that anaemia correlated strongly with malaria parasitaemia caused by *plasmodium falciparum* in Zambian children (Biemba *et al.*, 2000). Also, a national cross sectional surveys conducted in three West African nations; Ghana, Burkina Faso and Mali, involving 7,147 children aged 1-4 years, confirmed that *plasmodium falciparum* infection was significantly associated with anaemia risk especially, in 2-10 year old children (Magalha˜es *et al.*, 2011). Approximately 15% anaemia cases were attributable to malaria in this cohort.

On the contrary, Jonker *et al.*, (2012) in a one year cohort study of Malawian children reported a lower incidence of malaria parasitaemia and clinical malaria in Iron deficient children. This suggests Iron deficiency in young children may be protective against malaria parasitaemia and clinical malaria. This finding earlier on projected by Nyakeriga *et al.*, (2004) reported that, 'Incidence of clinical malaria was significantly lower among iron-

deficient children.' However, a longitudinal study conducted in Gambia involving 317 children aged 1-9 years reported no correlation between Iron deficiency and susceptibility to malaria infection (Snow *et al.*, 1991).

Case- control and cohort study designs employed in these studies are relatively weaker and causality deductions cannot be made. However, it is evident from the research findings that malaria infection is a risk factor for anaemia. Even with different study designs and varied sample sizes, basically the same results were obtained.

Evidence obtained from studies regarding iron deficiency and malaria is limited for any meaningful conclusion on the subject. Only three papers met the inclusion criteria of this section. One reported no association between iron deficiency and malaria (Snow *et al.*, 1991). The other two; Jonker *et al.*, (2012) and Nyakeriga *et al.*, (2004) obtained similar results; indicating that, iron deficiency is protective against malaria. Though all three studies were longitudinal/cohort studies which are relatively good designs, there is the need to employ stronger designs to establish clearer association between these variables.

Table 2.2: Summary of Findings on Malaria, Anaemia and Iron Deficiency in Children

• Malaria and Anaemia			
Research Site	Key Finding	Study Design	Reference
Senegal.	Malaria parasitaemia is a major causes of anaemia	Case- control study involving children aged 1 to 10 years	Tine *et al.*, 2012.
Kenya.	Malaria infected children suffered from more severe anaemia	a cross-sectional study in children aged 2 to 36 months without symptoms of malaria or anaemia	Verhoef *et al.*, 2002
Papua New Guinean	malaria caused by *P. falciparum* was associated with severe anaemia	A case-control cross-sectional study in 143 children aged 0.5–10 years	Manning *et al.*, 2012
Zambian	Malaria parasitaemia has a strong correlation with anaemia.	A retrospective study of the paediatric admissions of 6200 children of 72 months of age.	Biemba *et al*., 2000
Burkina Faso, Ghana, and Mali	*Plasmodium falciparum* infection was significantly associated with anaemia risk	Three cross-sectional surveys in three West African nations in 7,147 children aged 1-4 years	Magalha˜es *et al.*, 2011
• Malaria and Iron Deficiency Anaemia			
Malawian	Iron deficiency protects against malaria parasitaemia and clinical malaria in young children.	A one year cohort of 727 preschool	Jonker *et al.*, 2012
Coast of Kenya	Iron deficiency is associated with protection from mild clinical malaria	A cohort study of 240 children between the ages of 8 months and 8 years.	Nyakeriga *et al.*, 2004
Gambian	Susceptibility to malaria was not correlated with iron deficiency	A cohort study of 317 Fula children aged l-9 years	Snow *et al.*, 1991

2.3.2 Vitamin A Status or Supplementation and Malaria in Children

Vitamin A deficiency like malaria is a serious public health problem in low and middle income countries (Nankabirwa *et al.,* 2011). Vitamin A is a key immunity vitamin and supplementation has been demonstrated to decrease infections (Shankar *et al.,* 1999). Although the mechanism of action of vitamin A on malaria is unclear, in vitro studies have demonstrated that normal serum retinol levels suppress *plasmodium falciparum* (Davis *et al.,* 1998). Also, it has been established that Vitamin A enhances the effectiveness of quinine in clearing malaria parasites and halts the proliferation of *Plasmodium falciparum* in vitro (Serghides *et al.,* 2002). This section is a review of literature on the association between vitamin A supplementation or status and malaria.

A two year randomised trial conducted in Eastern Uganda found that vitamin A supplementation reduced malaria infection in children compared to a control group that did not receive the supplementation (Nankabirwa *et al.,* 2011). This study was aimed at investigating the association between vitamin A supplementation, anthropometric status and malaria parasitaemia among others, in 483 infants aged 3 to 12 months. Malaria prevalence reduced by half among children who received the supplementation and was associated with each unit increase in height-for-age z-scores. However, there was no association between HAZ scores and malaria parasitaemia in the non-supplemented group. This suggests that the observed decrease in malaria parasitaemia could have been an impact of the vitamin A supplementation. Another randomised trial investigated the effect of vitamin A supplementation on malaria morbidity was conducted in Papua New Guinea. 480 children aged 6-60 months were randomised to vitamin A supplements or a placebo every three months, for 13 months. The vitamin A supplementation resulted in a 30% reduction in *Plasmodium falciparum* febrile episodes (Shankar *et al.,* 1999). This study therefore confirms

the findings of Nankabirwa *et al.,* 2011, that a sound vitamin A status could be protective against malaria infection in children.

However, a double- blinded, randomised clinical trial in Tanzania among 546 children aged 6-60 months, to examine the effect of vitamin A supplementation on malaria parasitaemia, found no association between the two (Villamor *et al.,* 2003). After 4-8 months fellow up, the association between vitamin A supplementation and malaria parasitaemia was insignificant in this cohort.

Furthermore, to determine the effect of vitamin A supplementation as an additional treatment on outcomes of cerebral malaria, a seven day clinical trial involving 142 children aged 6-59 months, diagnosed with cerebral malaria was conducted in Uganda. This study discovered no difference in the rate of cerebral malaria parasite clearance in vitamin A supplemented and non-supplemented groups (Mwanga-Amumpaire *et al.,* 2012). However, fewer deaths occurred in the vitamin A group than placebo. This suggests that vitamin A deficient children may be at a higher risk of malaria associated deaths.

Finally, a study conducted in young Ghanaian children observed no impact of vitamin A supplementation on malaria in children (Binka *et al.,* 1994). These were two parallel studies to assess the impact of high-dose prophylactic vitamin A supplementation on child mortality (child survival studies) and morbidity (child health studies). There was no observed change in malaria mortality rates in children who received vitamin A supplements and those who did not. There was also no association between serum retinol levels and subsequent malaria infection at the beginning of the trial in children who had received placebo. This implies that vitamin A status had little or no influence on malaria incidence. Children who received the vitamin A however had relatively higher levels of retinol in their blood; indicating that, any benefit of vitamin A on malaria could have been realized provided it existed. This study

therefore does not support the findings of studies that associated low serum retinol with malaria Parasitaemia; Galan (1990) and Thurnham *et al.,* (1991).

Put together, three studies found no impact of vitamin A supplementation on malaria and two claim reductions in malaria parasitaemia with vitamin A supplementation. Evidence on the impact of vitamin A supplementation on malaria is therefore conflicting and deserves further research.

Table 2.3: Summary of findings Vitamin A status or Supplementation and Malaria

Research Site	Key Finding	Study Design	Reference
Eastern Uganda	Vitamin A supplementation protects against malaria in infants.	A one year cluster randomized trial	Nankabirwa *et al.,* 2011.
Tanzania	Vitamin A supplementation has no significant effect on malaria parasitaemia	A 4–8 months cohort study involving 546 children, aged 6–60 months.	Villamor *et al.,* 2003.
Papua New Guinea	Vitamin A supplementation can reduce malaria episodes by about 30%.	A 13 month randomised trial involving 480 children aged 6-60 months, for 13 months.	Shankar *et al.,* 1999.
Uganda	Vitamin A supplementation has no effect on the rate of malaria parasite clearance. However, fewer deaths occurred in the supplemented group than placebo.	A 7 day trial involving 142 children aged 6-59 months diagnosed with cerebral malaria.	Mwanga-Amumpaire *et al.,* 2012.
Ghana	No impact of vitamin A supplementation on malaria associated mortality and morbidity in children.	A trial involving 21906 children over 2 years in a mortality study and 1455 children over 1 year in a morbidity study	Binka *et al.,* 1994.

2.4 Asymptomatic malaria

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 and Harris et al., 2010) and quantification of parasite load (Dalla *et al.,* 2007).

Plasmodium falciparum is the most common human malaria species. Hence asymptomatic malaria due to *plasmodium falciparum* is commonly reported (Laishram *et al.,* 2012). Asymptomatic malaria due to *Plasmodium Vivax* is also relatively common (Harris *et al.,* 2010 and Suarez-Mutis *et al.,* 2007). Though rare, there are reported cases of asymptomatic malaria due to *Plasmodium Malariae* (Vinetz *et al.,* 1998 and Scuracchio *et al.,* 2011) and *Plasmodium Ovale* (Rojo-Marcus *et al.,* 2011). This implies that, all human malaria species can infect without causing symptoms and this can persist from several days/months (Felger *et al.,* 2012) to decades (Babiker *et al.,* 1998). Individuals with asymptomatic malaria are either able to carry the parasite without allowing its manifestation due to matured immune system or are able to suppress the parasite load at a certain stage of life, with frequent exposure to the parasite (Laishram *et al.,* 2012). There is evidence to suggest that, a significant number of asymptomatic blood stage malaria people eventually become symptomatic, although reinfection or new infections may occur (Magesa *et al.,* 2002; Da Silva-Nunes *et al.,* 2007; Bereczky *et al.,* 2004; Nsobya et al., 2004 and Kun *et al.,* 2002). It is however unclear what trigger the manifestation of symptoms (Lindblade *et al.,* 2013).

Asymptomatic malaria is an obstacle to malaria elimination (Ganguly *et al.,* 2013). This is because persons with asymptomatic malaria usually do not seek treatment and the malaria parasites can be transmitted to others when female Anopheles mosquitoes pick up gametocytes from asymptomatic malaria infected people during a blood meal and transform them into sporozoites which they inject into uninfected persons in subsequent blood meals (Lindblade *et al.,* 2013). 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 since malaria elimination using conventional strategies such as Insecticide Treated Nets (ITNs), Indoor Residual Spraying (IRS) and malaria case treatment is only possible in low transmission regions (Griffin *et al.,* 2010).

There is high prevalence of asymptomatic malaria in high malaria transmission regions such as Africa and Amazonian regions of Brazil (Eke *et al.,* 2006; Dal-Biance, 2007 and De-Andrade *et al.,* 1995). This could be due to exposure related immunity (Laishram *et al.,* 2012). There are also records of asymptomatic malaria in low malaria transmission regions (Roshanravan *et al.,* 2003; Branch *et al.,* 2005 and Cerutti *et al.,* 2007). The prevalence of asymptomatic malaria in Ghana and the Upper East region is unknown. However, Crookston *et al.,* (2010) recorded an asymptomatic malaria prevalence of 31.8% in young children and Wagner et al., 1998 recorded 13.6% asymptomatic malaria in newborns, both in southern Ghana using the Polymerase Chain Reactions (PCR) malaria detection techniques. Also there are usually seasonal differences in the prevalence of asymptomatic malaria with higher records in the raining (wet) season and relatively lower records in the dry seasons, due to increased mosquito population and malaria transmission in the wet seasons. For instance, Orogade *et al.,* 2002 recorded asymptomatic malaria prevalence of 22.5% and 14.9% in malaria peak (wet) season and dry season respectively.

CHAPTER THREE

METHODOLOGY

This chapter describes the study design and population, study site, sampling and data collection procedures employed in this study. Also, test procedures on blood samples and statistical analysis of data are also described. In addition, the ethical procedures employed in this research are also explained.

3.1 Study Design and Population

This was a community based cross-sectional study. This design was chosen based on its suitability for the objectives of the study and the resources available. Children from one to five years were the primary study population. The mothers of children involved in this study were the primary respondents to a pre-tested questionnaire (in appendix IV, page 87) used for the study. Mothers were informed by the research team including assemblymen and community health volunteers, to go to a particular clinic of their respective communities on a chosen date, with their children and their health records to be assessed and recruited for the study. All children were screened for symptoms of malaria and other diseases prior to their enrolment into the study using the medical assessment forms in appendix III, in page 85. Only children aged 1-5 years in the specified communities, with axillary temperature less 37.5°C and without malaria related symptoms were enrolled in each community for the study. This is because asymptomatic malaria is defined in this study as the presence of malaria parasite in thick blood smear of children, with axillary temperature < 37.5 ^{O}C and the absence of malaria related symptoms. Therefore children who reported with temperature > 37.5 ^{O}C or with malaria related symptoms or any form of illness were referred to a clinic for further assessment and possible treatment, using the research referral form in appendix V, page 93.

3.2 Study Site

The study was conducted in Bongo district of the Upper East region of Ghana, in four communities namely; Vea Central, Vea Tangapore, Gowrie and Bongo-Nyariga. These communities were chosen because of their proximity to the Vea dam which serves as breeding site for mosquitoes during the dry season. Bongo district is near Bolgatanga, the Upper East regional capital. It shares borders with Bolgatanga municipal in the south and the Kassena-Nankana district in the west. It has one district hospital in the district capital and six clinics. It has a total land area of 488 km^2 (4.7 square miles) and the landscape is generally flat with little vegetation. The climate is characterized by one rainy season from May/June to September/October and there is an average of 70 rain days per year, with a rainfall of 600-1400 mm. According to Ghana population census in 2010, the population of the Bongo district is 84,545 (Ghana Statistical Service, 2012).

3.3 Sample Size

The required sample size (n) of 245 children was determined using the Cochran's formula [$n=z^2$ (p (1-p))/e^2]. This was based on a confidence level of 95% (i.e. z = 1.96), 5% acceptable margin of error (e) and an estimated malaria infection rate (p) of 20% within the Bongo district (Key indicator for malaria report, 2013). The 20% malaria infection rate was assumed as the prevalence of asymptomatic malaria parasitaemia in the Bongo district. Two percent (2%) of the required sample size of children was added to make room for losses in the course of the study. Therefore, a total of 250 children were enrolled for the study.

3.4 Sampling Strategy and Subject Recruitment

Convenience sampling technique was employed in selecting the communities. However, individual children from these communities were randomly screened and recruited for the

study. Parents of children to be recruited for the study were informed through home visiting by the research team and community health volunteers, to bring their children to a community health centre or clinic at a specified date, to be assessed and recruited into the research. Children who met the inclusion criteria as stated above were recruited into the research. 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. Informed consent was sought from parents before enrolling their children in to the study. The figure below is an illustration of the participant recruitment process. The field work schedule/plan can be found on appendix I on page 79.

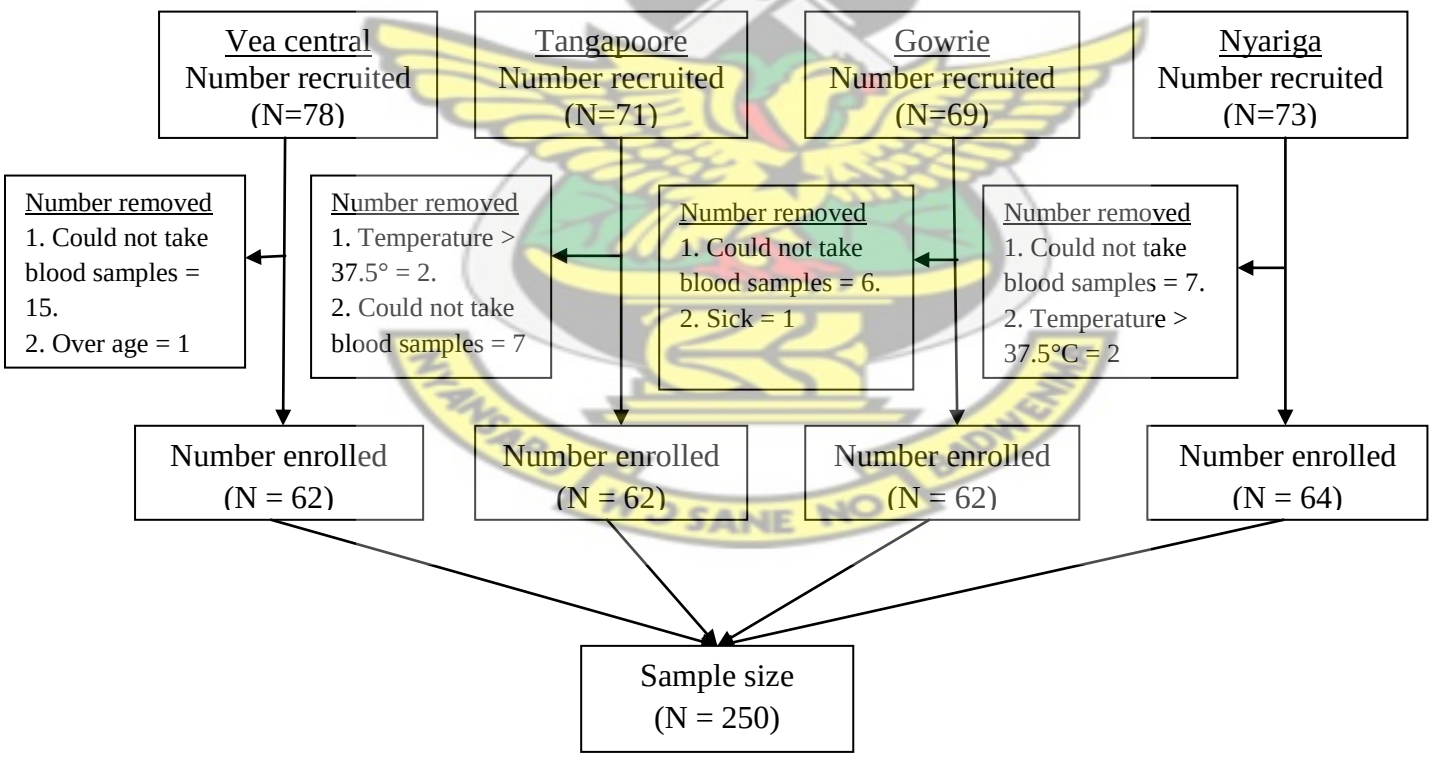

Figure 3.1: Participant Recruitment Flow Chart

3.5 Data Collection

The study was conducted in March through to July, 2014. Data was collected in April/May 2014. About a week was spent in each community on data collection, starting from Vea central, followed by Vea Tangapore, Gowrie and Nyariga. Data collected included a questionnaire completed by parents of the participating children, anthropometric data and blood samples of children. Children whose blood samples could not be obtained for any reason were excluded from the study.

3.5.1 Anthropometric Data

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 (Tian Shan -2003A). A 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 put at right angles 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.

3.5.2 Blood Sample Collection and Transfer

Only qualified laboratory technicians or biomedical scientist were allowed to take blood samples. 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.

3.6 Data Analysis

3.6.1 Haematological tests (Full Blood Count)

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, 2005). Others such as White Blood Cell (WBC), Haematocrit (HCT), Red Cell Distribution Width (RDW) e.t.c were however generated by the Analyzer. Results of haemoglobin concentration can be found in appendix VI, page 94.

3.6.2 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, 1985). Two biomedical scientists independently examined each slice and agreed on the presence or absence of malaria parasitaemia. Results of malaria parasite test can be found in appendix VI, page 94.

3.6.3 Statistical Analysis

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 (in appendix VI, page 94) 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 were done using binomial logistic regression analysis to generate odds ratios at 95% confidence interval and test for statistical significance.

3.7 Ethical Issues

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. Participant information leaflet (in appendix II, page 80) was given to parents whose children participated in the study to inform them of the study protocol. The research was also explained explicitly to parents of participants in a language of their choice. Oral and written consent and their thumb prints were obtained from parents whose children were involved in the study. Participants from whom information and samples were collected were given code numbers. No names were recorded. No name or identifiable indicator was used in this report or would be used in any publication of this study.

CHAPTER FOUR

RESULTS

This section provides information on the descriptive and inferential statistics of participants and all related indices or variables measured during the study and their analysis. Results are presented in tables for easy comprehension.

4.1 Descriptive Statistics

4.1.1 Socio-demographic characteristics of children

Table 4.1.1 presents the data on socio-demographic characteristics of the children. In terms of gender, 51.6% of the children were males while 48.4% were females. Majority (30.8%) of the children were between 1-1.9 year group and the least (7.2%) were within the 5-5.9 year group. Regarding birth positions of the children, majority (39.2%) were first borns and 14.4% were third borns. In addition, the majority (68.8%) of the children had not started schooling, 2.0% were in crèche and 28.0% in kindergarten. 0.8% and 0.4% were in primary one and two respectively. All the children belonged to the Frafra ethnic group in the upper east region of Ghana. The table also illustrates the distribution of children in the four study communities namely; Vea central, Vea-Tangapoore, Gowrie and Nyariga. There were 62 (24.8%) participants each from Vea central, Vea-Tangapoore and Gowrie, while 64 participants (25.6%) were from Nyariga. Majority of the children were Christians (78.4%), 13.2% were Muslims and 8.4% belonged to the African Traditional Religion (ATR).

Table 4.1.1 Socio-demographic characteristics of children

Variable		Frequency	Percentage (%)
Sex of child:	Male	129	51.6
	Female	121	48.4
	Total	250	100.0
Age of child (years):	1-1.9	77	30.8
	2-2.9	67	26.8
	3-3.9	59	23.6
	4.4.9	29	11.6
	5-5.9	18	7.2
	Total	250	100.0
Birth position of child:	1st	98	39.2
	2nd	66	26.4
	3rd	36	14.4
	4th and above	50	20.0
	Total	250	100.0
Child's level of schooling:	Crèche	5	2.0
	Kindergarten	70	28.0
	Primary 1	2	0.8
	Primary 2	1	0.4
	None	172	68.0
	Total	250	100.0
Ethnicity of child:	Frafra	250	100.0
	Total	250	100.0
Community:	Vea Central	62	24.8
	Vea Tangapoore	62	24.8
	Gowrie	62	24.8
	Nyariga	64	25.6
	Total	250	100.0
Child's religion:	Christianity	196	78.4
	Islam	33	13.2
	African Traditional Religion	21	8.4
	Total	250	100.0

Table 4.1.2 presents the descriptive statistics on socio-demographic characteristics of parents whose children took part in this study. For marital status, majority (84.0%) of the women were married while 1.6% was divorced. With regards to the father's level of education, majority (44.8%) of the fathers did not have any form of formal education, 25.2% had primary/elementary education and only a few (4.4%) fathers had tertiary education. The trend was similar for the female parents; majority (38.4%) had no formal education, 25.6% of had primary/elementary education and a few (1.2%) had tertiary education. Regarding parents occupation, 46.0% of the fathers were farmers and a few (0.8%) had retired. Also, 55.6% of the mothers were artisans while 3.2% were professionals (either a teacher, nurse e.t.c). Majority (95.2%) of the parents were living in residential facilities owned by their families (family houses) while 0.8% were residing in rented apartments. Most (58.8%) of the mothers involved in this study were between the ages of 20-29 years. Only a few (0.4%) were 50 years and above. Most (66.6%) homes in these communities had a household size of between 5-9 people. With regards to household income, majority (56.4%) of the parents received less than 100 Ghana cedis in the month with as few as 0.8% receiving between 3000-4000 Ghana cedis a month. Regarding the number of children for each mother, 34.0% of the mothers had one child while 1.6% had six or more children. Majority (78.4%) of the household heads were men and a few (10.8%) mothers were household heads.

Table 4.1.2: Socio-demographic characteristics of parents

Variable		Frequency	Percentage (%)
Marital status:	Single	36	14.4
	Married	210	84.0
	Divorced	4	1.6
	Total	250	100.0
Father's level of education:	Primary/elementary	63	25.2
	JHS	19	7.6
	SHS	31	12.4
	Post-secondary	14	5.6
	Tertiary	11	4.4
	None	112	44.8
	Total	250	100.0
Mother's level of education:	Primary/elementary	64	25.6
	JHS	35	14.0
	SHS	40	16.0
	Post-secondary	12	4.8
	Tertiary	3	1.2
	None	96	38.4
	Total	250	100.0
Father's occupation:	Artisan	55	22.0
	Professional	16	6.4
	Office worker	18	7.2
	Trader	15	6.0
	Unemployed	18	7.2
	Farmer	115	46.0
	Retired	2	0.8
	Not applicable	11	4.4
	Total	250	100.0
Mother's occupation:	Artisan	139	55.6
	Professional	8	3.2
	Trader	33	13.2
	Unemployed	37	14.8
	Farmer	33	13.2
	Total	250	100.0
Age of mother (years):	15-19	18	7.2
	20-29	147	58.8
	30-39	61	24.4
	40-49	23	9.2
	50 and above	1	0.4
	Total	250	100.0
Residential status:	Own house	10	4.0
	Family house	238	95.2
	Rented apartment	2	0.8
	Total	250	100.0

Household size:	1-4	47	18.8
	5-9	165	66.6
	10-14	32	12.8
	15-20	6	2.4
	Total	250	100.0
Household income (GH¢):	<100	141	56.4
	100-300	82	32.8
	400-600	15	6.0
	700-900	10	4.0
	1000-2000	2	0.8
	Total	250	100.0
Number of children of mother:	1 child	85	34.0
	2 children	69	27.6
	3 children	42	16.8
	4 children	28	11.2
	5 children	22	8.8
	6 and above	4	1.6
	Total	250	100.0
Head of Household:	Father	196	78.4
	Mother	27	10.8
	Grandfather	23	9.2
	Grandmother	4	1.6
	Total	250	100.0

Table 4.1.3 presents descriptive statistics on the dietary assessment of the children. As the table indicates, 49.6% of the total sample (n = 250) reported that their children ate three times a day. Also, 26.0% of participants asserted that their children ate four times, 10.4% reported their children ate twice and 6.0% reported their children ate five times in a day. Also, 68.8% of the participants affirmed there were reductions in the appetite of their children while 31.2% thought otherwise. Also, 70.0% of the respondents reported that they do not have access to food all year round. All children (100%) were breastfed at birth, 86.9% had taken colostrums at birth and 79.8% of children breastfed 6 or more times or on demand.

Furthermore, 94.0% of the parents reported their children were breastfed immediately after birth. Most of the children (93.6%) were on complementary feeds. Also, 53.2% of children were on vitamins or mineral supplements and 57.6% of children had completed vitamin A supplementation for their age.

Table 4.1.3 Dietary Assessment of children

Variable		Frequency	Percentage (%)
Number of times child eats in a day:	Once	7	2.8
	Twice	26	10.4
	Thrice	124	49.6
	Four times	63	26.0
	Five times	15	6.0
	Six and above	1	0.4
	Takes breast milk only	12	4.0
	Total	250	100.0
Reduction in appetite of the child in days/weeks:	Yes	78	31.2
	No	172	68.8
	Total	250	100.0
Access to food all year round:	Yes	75	30.0
	No	175	70.0
	Total	250	100.0
Child breastfed.	Yes	100	100.0
	No	0	0.00
	Total	250	100.0
Child took colostrums:	Yes	224	89.6
	No	26	10.4
	Total	250	100.0
Number of times child breastfed in a day:	Three times	12	4.8
	Four times	13	5.2
	Five times	28	11.2
	Six and above	197	79.8
	Total	250	100.0
Days after birth When child started Breastfeeding:	Immediately after birth	235	94.0
	Weeks after birth	12	4.8
	Total	3	1.2
		250	100.0
Child is on complementary Or wean feeding:	Yes	234	93.6
	No	16	6.4
	Total	250	100.0
Child is on vitamins or minerals supplements:	Yes	133	53.2
	No	117	46.8
	Total	250	100.0
Child completed vitamin A supplements for his/her age:	Yes	144	57.6
	No	91	36.4
	No idea	15	6.0
	Total	250	100.0

Table 4.1.4 presents descriptive statistics on factors that may indirectly influence nutritional status of children. Some of the factors considered were incidence of disease or disease history, medical care practices such as treatment options for children when they are sick and whether they were on any form of medications, among other factors. It was found that, only 38.0% compared to 62.0% of the 250 children had a disease history of malaria, convulsion, and rashes among others. Also, approximately half (49.2%) of the children had not suffered any form of disease for the past two weeks. The difference in disease history and incidence of disease within two weeks was due to multiple responses; where some children recorded more than one disease within two weeks. Diarrhoea was the most common disease, followed by fever, each recording 15.2% and 14.4% of cases respectively. Abdominal pain was the least prevalent (3.6%). Most children (57.6%) were left in the care of their grandmothers in the absence of their mothers. 32.8% were on non anti-malaria medications such as cough syrup, pain killers among others. Almost all children (99.4%) as well as their parents (93.2%) went to the hospital or clinic for treatment whenever they were sick. Self-medication was however common among parents but absent in children.

Table 4.1.4: Factors that Influence Nutritional Status of Children

Variable		Frequency	Percentage (%)
Child has ever suffered any kind of diseases:	Yes	95	38.0
	No	155	62.0
	Total	250	100.0
Diseases child suffered in 2 weeks ago:	Diarrhoea	38	15.2
	Malaria	34	13.6
	Fever	36	14.4
	Abdominal pain	9	3.6
	Others (rashes, piles, convulsion e.t.c)	10	4.0
	None	123	49.2
	Total	250	100.0
Alternative care for child in mother's absence:	House help	6	2.4
	Rivals	14	5.6
	Husband	58	23.2
	Child's siblings	26	10.4
	Grandmother	144	57.6
	Grandfather	2	0.8
	Total	250	100.0
Child is on non anti-malaria Medication:	Yes	82	32.8
	No	168	67.2
	Total	250	100.0
Where child got treatment when sick:	Hospital or clinic	249	99.4
	Herbalist	1	0.4
	Total	250	100.0
Where parent got treatment when sick:	Hospital or clinic	233	93.2
	Herbalist	1	0.4
	Self-medication	13	5.2
	Religious leaders	3	1.2
	Total	250	100.0

Table 4.1.5 presents statistics on anaemia and factors related to it. No signs of anaemia were observed on 206 (83.6%) of the children. However, 36 (14.4%) of them experienced body weakness as reported by parents. Also, 0.8% each complained of body itching and tiredness. Only 1 (0.4%) appeared pale. Also, significant number of the children 181 (72.4%) did not complain of any signs/symptoms of intestinal parasites. However, the symptoms reported were painful abdomen (15.2%), diarrhoea (7.6%), vomiting (3.2%) and body itching (1.6%).

Furthermore, more than half (63.6%) of the children were dewormed while 10% did not have any idea whether their children were dewormed, and most (49.2%) of the deworming took place in the clinics compared to other venues. In addition, 14.4 % of the parents indicated that their children were dewormed a month ago, while 7.6% asserted their children were dewormed a year ago. Two hundred and eleven (84.2%) of the study participants had their drinking water from boreholes and a few two (1.2%) drank from rivers/dams. Finally, the haemoglobin (Hb) concentration test indicated that, one hundred and forty seven (58.8%) were anaemic (Hb < 11.0 g/dl) and one hundred and three (41.2%) were non anaemic.

Table 4.1.5 Anaemia and associated factors

Variable		Frequency	Percentage (%)
Observed signs of anaemia:	Pale looks	1	0.4
	Body weakness	36	14.4
	Tiredness	2	0.8
	Body itching	2	0.8
	None	209	83.6
	Total	250	100.0
Signs and symptoms of Intestinal parasites:	Painful abdomen	38	15.5
	Diarrhoea	19	7.6
	Vomiting	8	3.2
	Body itching	4	1.6
	None	181	72.4
	Total	250	100.0
child has been dewormed:	Yes	159	63.6
	No	66	26.4
	Know idea	25	10.0
	Total	250	100.0
When child was dewormed:	1 month ago	36	14.4
	2 months ago	29	11.6
	3 months ago	23	9.2
	4 months ago	33	13.2
	1 year ago	19	7.6
	Not applicable	90	36.0
	No idea	20	8.0
	Total	250	100.0
Where child was dewormed:	School	5	2.0
	Home	31	12.4
	Clinic	123	49.2
	Others e.g. market	1	0.4
	Not applicable	90	36.0

	Total	250	100.0
Source of drinking water:	River/dam	3	1.2
	Pipe	28	11.2
	Borehole	211	84.2
	Others	8	3.2
	Total	250	100.0
Haemoglobin concentration (Hb):	Anaemic	147	58.8
	Non-anaemic	103	41.2
	Total	250	100.0

Table 4.1.6 presents descriptive statistics on malaria and factors associated with it, as it pertains in the communities. Malaria parasite test (MPs) for the children indicate that, 37 (14.8%) had malaria at the asymptomatic state, whereas 213 (85.2%) had no malaria parasite in their blood. The results also indicate that 96.0% of the total sample (n = 250) reported their households possess mosquito nets while 4.0% did not have. 94.2% used the mosquito nets they possessed while 5.8% do not use them. Also, 60.4% of the households did not use mosquito repellents at all while 29.6%, 4.0% and 6.0% used repellents daily, weekly and sometimes respectively weekly. All the research participants unanimously agreed that their communities were mass sprayed to get rid of mosquito breeding grounds and majority (99.6%) revealed that it was done a month ago while 0.4% indicated a year ago. Furthermore, 68.8% of the parents indicated there were no bushes and stagnant waters in their communities, 52.4% of the parents reported no family member had malaria, 26.8% reported at least one family member had malaria and 20.4% had no idea.

Furthermore, it was revealed that slightly more than half (53.6%) of malaria suspected cases were treated upon testing in the hospital and 16.8% were treated without testing. It's however worth noting that, most suspected cases of malaria are left untreated or reported, perhaps until the symptoms become severe. Also, a smaller proportion of the children took regular anti-malaria herbal preparations compared to medications or drugs.

Table 4.1.6: Malaria Transmission and Treatment

Variable		Frequency	Percentage (%)
Malaria parasite test (MPs)	Positive	37	14.8
	Negative	213	85.2
	Total	250	100.0
Household possesses mosquito nets	Yes	240	96.0
	No	10	4.0
	Total	250	100.0
Household uses mosquito nets	Yes	237	94.8
	No	12	4.8
	Sometimes	1	0.4
	Total	250	100.0
Household uses mosquito repellent	Not at all	151	60.4
	Daily	74	29.6
	Weekly	10	4.0
	Sometimes	15	6.0
	Total	250	100.0
Mass community spraying of mosquito	Yes	250	100.0
	No	0	0.0
	Total	250	100.0
When mass community spraying was done	Months ago	249	99.6
	Years ago	1	0.4
	Total	250	100.0
Stagnant water and bushes in the surrounding	Yes	78	31.2
	No	172	68.8
	Total	250	100.0
Members of the child's household with malaria	Yes	67	26.8
	No	131	52.4
	No idea	52	20.4
	Total	250	100.0
Treatment approach:	Malaria treated in hospital upon testing	134	53.6
	Malaria treated at hospital without testing	42	16.8
	Malaria medication bought	4	1.6
	Not treated	70	28.0
	Total	250	100.0
Child has taken anti-malaria drug:	Yes	59	23.6
	No	191	76.4
	Total	250	100.0
Child takes regular anti-malaria herbal medication:	Yes	22	8.8
	No	228	91.2
	Total	250	100.0

Table 4.1.7: Basic statistics on nutritional status, malaria and haemoglobin concentration

Characteristic	Number	Minimum	Maximum	Mean	Standard Deviation
Weight-for-Height z-score	242	-5.98	3.26	-0.73	1.188
Height-for-Age z-score	242	-5.77	3.69	-1.15	1.166
Weight-for-Age z-score	242	-5.29	2.70	-1.13	1.047
BMI of Mother	250	12.96	38.59	21.16	3.141
Age of child in months	250	10.51	74.51	34.28	15.498
Malaria parasite Load	250	0.00	10970.00	113.31	873.801
Haemoglobin levels	250	5.30	16.60	10.67	1.233

This section depicts the descriptive statistics of nutritional indices and laboratory test on their children. The statistics considered in this section were the mean, standard deviations, and minimum and maximum values as displayed on table 4.1.7. Z-scores were generated from anthropometric measures of 242 children out of the 250 children. *Z*-scores could not be generated for eight children using the WHO Anthro. Software because they were five years and some months old, and the software is used for only children under five years. Although the WHO AnthroPlus could generate W/A and H/A *Z*-scores for children more than five years, it does not however generate W/H *Z*-scores. Hence the eight children were left out to create a balance. Overall, the mean Z-scores were -0.73, -1.15 and -1.13 for weight-for-height, height-for-age and weight-for-age respectively. This shows that, overall the children were mildly stunted and underweight but not wasted. The minimum and maximum Z-scores, as well as the standard deviations for each nutritional indicator are also indicated on the table.

The table also displays the descriptive statistics of mothers BMI. The mothers BMI had a mean of 21.166 with a standard deviation of 3.141 and ranged from 12.96 to 38.59. Age in months of the child had a mean of 34.285 with a standard deviation of 15.499 and ranged from 10.57 to 74.51, parasite load of child had a mean of 113.316 with a standard deviation

of 873.802 and ranged from 0.00 to 10970 and lastly Haemoglobin (Hb) concentration of child had a mean of 10.672 with a standard deviation of 1.233 and ranged from 5.30 to 16.60.

4.2 Inferential Statistics

This section presents inferential statistics on the prevalence and distribution of nutritional status, asymptomatic malaria parasitaemia and anaemia of the children. The association between these factors and other related factors were tested using Pearson chi-square test of significance and Pearson correlation.

Table 4.2.1: Prevalence of Undernutrition

Acute undernutrition		
❖ Weight-for-Height z-score	Frequency	Percentage (%)
Normal (Z-score > -1)	155	64.0
Mild wasting (-2 < Z-score < -1)	58	24.0
Moderate wasting (-3 < Z-score < -2)	20	8.3
Severe wasting (Z-score < -3)	9	3.7
Prevalence of wasting (Z-score < -2)	29	12.0
Chronic undernutrition		
❖ Height -for- Age z-score	Frequency	Percentage (%)
Normal (Z-score > -1)	102	42.1
Mild stunting (-2 < Z-score < -1)	93	38.4
Moderate stunting(-3 < Z-score < -2)	36	14.9
Severe stunting (Z-score < -3)	11	4.5
Prevalence of stunting (Z-score < -2)	46	19.4
Acute and chronic undernutrition		
❖ Weight-for-Age z-score	Frequency	Percentage (%)
Normal (Z-score > -1)	109	45.0
Mild underweight (-2 < Z-score < -1)	93	38.4
Moderate underweight(-3 < Z-score < -2)	29	12.0
Severe underweight(Z-score < -3)	11	4.5
Prevalence of underweight (Z-score < -2)	40	16.5

Table 4.2.1 on page 43 above represents the nutritional status of the children according to anthropometric indexes defined by Z-scores. As shown, Z-scores > -1, -2 < Z-score < -1, -3 < Z-score < -2 and < -3 represent normal anthropometric indexes, mild, moderate and severe undernutrition respectively. Overall, 12.0% of children were wasted, 19.4% were stunted and 16.5% were underweight. This means that, 12.0% and 19.4% of the children were suffering from acute and chronic undernutrition respectively whilst 16.5% were suffering from both acute and chronic undernutrition; since underweight is a measure of both acute and chronic undernutrition.

Table 4.2.2: 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)

Background Characteristic	WASTING			STUNTING			UNDERWEIGHT		
	W/H	W/H	W/H	H/A	H/A	H/A	W/A	W/A	W/A
	% 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									
Vea	4(6.5%)	1(1.6%)	-0.57	10(16.1%)	3(4.8%)	-1.13	4(6.5%)	2(3.2%)	-1.01
Tangapore	4(6.9%)	3(5.2%)	-0.95	10(17.2%)	0(0.0%)	-1.21	10(17.2%)	2(3.4%)	-1.31
Gowrie	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

Table 4.2.2 is the distribution of nutritional status of the children categorized by gender, age, community of residence, household income level and malaria status. Overall, 8.3% and 3.7% were moderately and severely wasted respectively. 14.9% were moderately stunted whilst 4.5% were severely stunted, and 12.0% and 4.5% were moderately and severely underweight respectively. Also, more males compared to females were severely wasted, whilst more females (1.1%) were relatively severely stunted and underweight. More males were moderately stunted and underweight compared to females (i.e.15.3% males compared to 14.4% females and 10.5% males compared to 5.1% females were moderately stunted and underweight respectively) whereas more females were moderately wasted.

Relatively, high numbers of children with moderate wasting, moderate stunting and moderate underweight were recorded in children within the 2-2.9, 1-1.9 and 5-5.9 age groups respectively. Comparatively, more children in the 5-5.9, 2-2.9 and 3-3.9 age groups had severe wasting, stunting and underweight respectively.

Gowrie community witnessed the greatest proportion of wasted children and Vea community recorded the least. There were higher percentages of stunting and underweight in Nyariga compared to the other communities. Furthermore, children from households with smaller incomes seem to experience more undernutrition compared to those from relatively affluent

households. Except for wasting, a relatively higher prevalence of malaria parasitaemia was recorded among stunted and underweight children.

Table 4.2.3: Distribution of Underweight and Statistical Test of Significance and Correlations

Characteristic		Normal	Underweight		Total Number	Statistical test	
			Moderate	severe		P - value	Pearson Correlation. (R)
		Num. (%)	Num. (%)	Num. (%)			
Gender:	Male	106(85.5)	13(10.5)	5(4.0)	124	0.593	0.082
	Female	96(81.3)	16(13.6)	6(5.1)	118		
Community	Vea	56(90.3)	4(6.5)	2(3.2)	62	0.183	0.076
	Tangapore	46(79.4)	10(17.2)	2(3.4)	58		
	Gowrie	53(88.3)	4(6.7)	3(5.0)	60		
	Nyariga	47(75.8)	11(17.7)	4(6.5)	62		
Age	1-1.9	64(80.5)	12(15.6)	3(3.9)	77	0.328	0.001
	2-2.9	53(79.1)	11(16.4)	3(4.5)	67		
	3-3.9	54(88.1)	3(5.1)	4(6.8)	59		
	4-4.9	26(92.8)	1(3.6)	1(3.6)	28		
	5-5.9	9(81.8)	2(18.2)	0(0.0)	11		
Hb:	Anaemic	118(81.3)	22(15.2)	5(3.4)	145	0.235	-0.038
	Non anaemic	84(86.6)	7(7.2)	6(6.2)	97		
Malaria parasite seen in blood film:	Yes	28(81.0)	5(14.3)	2(5.7)	35	0.921	-0.020
	No	174(84.1)	24(11.6)	9(4.3)	207		
Mother's occupation:	Artisan	111(82.2)	17(12.6)	7(5.2)	135	0.0968	-0.044
	Professional	6(85.8)	1(14.3)	0(0.0)	7		
	Trading	26(81.2)	4(12.5)	2(6.2)	32		
	Unemployed	32(86.5)	4(10.8)	1(2.7)	37		
	Farmer	27(87.1)	3(9.7)	1(3.2)	31		
Mother's education:	primary	49(77.8)	8(12.7)	6(9.5)	63	0.432	-0.023
	JHS	29(90.6)	3(9.4)	0(0.0)	32		
	SHS	35(87.5)	5(12.5)	0(0.0)	40		
	Post secondary	8(72.8)	3(27.2)	0(0.0)	11		
	Tertiary	2(6.7)	1(33.3)	0(0.0)	3		

	None	79(85.0)	9(9.7)	5(5.4)	93		
Number in Household:	1-4	41(89.2)	3(6.5)	2(4.3)	46	0.640	-0.004
	5-9	128(81.0)	23(14.6)	7(4.4)	158		
	10-14	28(87.5)	3(9.4)	1(3.1)	32		
	15-20	5(83.3)	0(0.0)	1(16.7)	6		
Where child gets treatment	Hospital	202(83.8)	29(12.0)	10(4.2)	241	0.005	0.173
	Herbalist	0(0.0)	0(0.0)	1(100)	1		
Child has appetite:	Yes	59(78.7)	12(16.0)	4(5.3)	75	0.317	-0.021
	No	143(85.6)	17(10.2)	7(4.2)	167		
Household income:	<100	116(84.7)	14(10.2)	7(5.1)	137	0.188	-0.013
	100-300	64(81.0)	13(16.5)	2(2.5)	79		
	400-600	11(78.6)	1(7.1)	2(14.3)	14		
	700-900	10(100)	0(0.0)	0(0.0)	10		
	1000-2000	1(50)	0(0.0)	1(50)	2		
Num. of times Child eat/day:	Once	5(71.4)	1(14.3)	1(14.3)	7	0.799	-0.018
	Twice	22(88.0)	3(12.0)	0(0.0)	25		
	Thrice	99(82.5)	14(11.7)	7(5.8)	120		
	Four times	52(82.6)	8(12.7)	3(4.8)	63		
	Five times	12(85.7)	2(14.3)	0(0.0)	14		
	Six times	0(0.0)	1(100)	0(0.0)	0		
	Breast milk only	11(91.7)	1(8.3)	0(0.0)	12		
Have all year round access to food:	Yes	65(86.7)	7(9.3)	3(4.0)	75	0.756	-0.018
	No	137(82.0)	22(13.2)	8(4.8)	167		
On medications:	Yes	63(78.8)	12(15.0)	5(6.2)	80	0.503	-0.097
	No	139(85.8)	17(10.5)	6(3.7)	162		
On vitamin/mineral supplements:	Yes	110(84.6)	13(10.0)	7(5.4)	130	0.656	0.028
	No	92(82.2)	16(14.2)	4(3.6)	112		
Complete vitamin A supplementation for age:	Yes	117(83.0)	17(12.0)	7(5.0)	141	0.742	0.029
	No	73(83.9)	10(11.5)	4(4.6)	87		
	No idea	12(85.7)	2(14.3)	0(0.0)	14		
Taken anti-malaria for the pass 2 weeks:	Yes	46(80.7)	8(14.0)	3(5.3)	57	0.921	-0.043
	No	156(84.3)	21(11.4)	8(4.3)	185		

Disease child suffered in the pass 2 weeks:	Diarrhoea	32(84.2)	5(13.2)	1(2.6)	38	0.145	-0.057
	Malaria	25(80.6)	5(16.1)	1(3.2)	31		
	Fever	26(84.3)	9(25.7)	0(0.0)	35		
	Abdominal pains	7(77.8)	1(11.1)	1(11.1)	9		
	Others(e.g. rashes)	9(90)	0(0.0)	1(10.0)	10		
	None	103(86.6)	9(7.6)	7(5.8)	119		
BMI of Mother:	Underweight	28(77.7)	6(16.7)	2(5.6)	36	0.320	-0.112
	Normal	155(83.4)	22(11.8)	9(4.8)	186		
	Overweight	16(100)	0(0.0)	0(0.0)	16		
	Obese	3(75)	1(25)	0(0.0)	4		
p-values < 0.05 means significant association							

Table 4.2.3 is the distribution of underweight and its association with socio-demographic characteristics, haemoglobin (Hb) concentration and malaria status of participants. The results indicate that 85.5% of males had normal weight-for-age, whilst 10.5% and 4.0% of males were moderately and severely underweight respectively. Also, 81.3% of females had normal weight-for-age whilst 13.6% and 5.1% of females were moderately and severely underweight respectively and there was a positive but weak correlation between gender and underweight (R = 0.082). Also, it was statistically not significance (p = 0.593); suggesting that, no association exist between gender and underweight.

Overall, there was no significant correlation between underweight and characteristics such as age, gender, child's community of residence, mother's occupation and level of education, number of people in household and household income, Haemoglobin level, malaria parasitaemia, the number of times the child eats in a day, whether the child was on medications or vitamin/mineral supplements or had completed vitamin A supplementation for his/her age, mothers Body Mass Index (BMI), among others. The only significant association was recorded between underweight and where (i.e. hospital or herbalist) a child got treatment when sick (p = 0.0001). This was used to assess the level of care for children; since care is an

underlying cause of undernutrition. This finding therefore confirms the fact that, adequate care for children would enhance their nutritional status.

Finally, although a greater percentage (i.e. 84.1% compared to 81.0%) of the children who had normal weight-for-age, had no malaria parasitaemia, it is worth noting that, majority of the children who had malaria parasitaemia were underweight compared to those who did not have malaria parasitaemia. For example, 14.3% had malaria parasites and were moderately underweight compared to 11.6% who had no malaria parasites and were also moderately underweight. Also, 5.7% had malaria parasites and were severely underweight compared to 4.3% who had no malaria parasites and were also severely underweight. Though the association between underweight and malaria parasitaemia at the asymptomatic state was not significant ($p = 0.921$), the trend suggest that, malaria parasites even at the asymptomatic, could possibly contribute to underweight.

Table 4.2.4: Distribution of Asymptomatic Malaria Parasitaemia and Statistical Test of Significance and Correlations

Characteristic		Asymptomatic Malaria Parasitaemia Test		Total	Statistical Test	
		Positive (+)	Negative (-)		P - value	Pearson correlation (R)
		Num. (%)	Num. (%)			
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	1-1.9	9(11.7)	68(88.3)	77		
	2-2.9	15(22.4)	52(77.6)	67		
	3-3.9	6(10.2)	53(89.8)	59	0.316	-0.001
	4-4.9	4(13.8)	25(86.2)	29		
	5-5.9	3(16.7)	15(83.3)	18		
Community:	Vea	8(12.9)	54(87.1)	62		
	Vea- Tangapore	6(9.7)	56(90.3)	62	0.443	-0.081
	Gowrie	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 take 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

Table 4.2.4 presents the prevalence of asymptomatic malaria parasitaemia, as well as its distribution and association with gender, Hb, intake of anti-malaria medications and herbals, vitamin A and other vitamins/mineral supplementation among others.

Overall, the prevalence of ASMP was 14.8%, representing 37 children who tested positive for malaria parasites in peripheral thick blood smears, meanwhile did not have any malaria related symptoms, and had axillary temperature < 37.5°C, as at that moment. Also, more females (15.7%) than males (14.0%) had ASMP. There was however, no significant association between gender and ASMP (p = 0.697).

Furthermore, ASMP was more prevalent among the 2-2.9 year group; of the 67 children in this age group, 15 of them tested positive for malaria, representing (22.4%). The least was recorded among the 3-3.9 year group; 6 children were positives out of 59 children in that particular age group, representing 10.2%. Also, there was more ASMP in Nyariga (18.8%) community, followed by Gowrie (17.7%), Vea (12.9%) and Vea-tangapore (9.7%) communities. In addition, more ASMP was recorded in children with anaemia (17.0%) compared to those without anaemia (11.7%). However, there was no significant association between anaemia and ASMP (p = 0.240). ASMP is however a predictor of anaemia (p = 0.040; OR = 2.419; 95% CI: 1.041-5.622) using binomial logistic regression model as indicated on page 57. Also, children who had completed vitamin A supplementation for their age had lower (12.5%) ASMP compared to those who had not completed their vitamin A supplementation (16.5%) or had no idea of their immunization status (26.7%). Although a lesser percentage (12.5%) of children who had ASMP had completed vitamin A supplementation for age was recorded, no significant association between ASMP and complete vitamin A supplementation was established (p = 0.289). Furthermore, children who took on regular basis, anti-malaria herbal medications or were on vitamin or/and mineral supplements, had higher prevalence of ASMP of 18.2% and 15.0% respectively compared to

14.5% each, of the children who neither took anti-malaria herbal medications nor were on vitamin or/and mineral supplements. These associations were however not significant as depicted by the p-values in table 4.2.4.

Table 4.2.5 Distribution of anaemia and statistical test of significance and correlations

Variable		Haemoglobin concentration (Hb) Test			Statistical Test	
		Anaemic	Non anaemic	Total	P - value	Pearson correlation (R)
		Num. (%)	Num. (%)	Num. (%)		
Overall:		147(58.8%)	103(41.2%)	250(100%)	–	–
Gender:	Male	78(60.5)	51(39.5)	129		
	Female	69(57.0)	52 (43.0)	121	0.581	0.035
Community:	Vea	44(71.0)	18(29.0)	62		
	Tangapore	40(64.5)	22(35.5)	62	0.004	0.132
	Gowrie	25(40.3)	37(59.7)	62		
	Nyariga	38(59.4)	26(40.6)	64		
Age (years):	1-1.9	58(75.3)	19(24.7)	77		
	2-2.9	43(64.2)	24(35.8)	67		
	3-3.9	29(49.2)	30(50.8)	59	0.0001	0.306
	4-4.9	13(44.8)	16(55.2)	29		
	5-5.9	4(22.2)	14(77.8)	18		
Took anti-malaria medication 2 or less weeks ago:	Yes	38(64.4)	21(35.6)	59	0.317	0.063
	No	109(57.1)	82(42.9)	191		
Regular take of anti-malaria herbal medications:	Yes	14(63.6)	8 (36.4)	22	0.629	0.031
	No	133(58.3)	95(41.7)	228		
Completed vitamin A supplementation for age:	Yes	80(60.2)	55(38.2)	144	0.420	0.082
	No	15(56.0)	40(44.0)	91		
	No idea	7(46.7)	8(53.3)	15		
On vitamin or/and mineral supplementation:	Yes	80(60.2)	53(39.8)	133	0.644	0.029
	No	67(57.3)	50(42.7)	117		
Dewormed:	Yes	96(60.4)	63(39.6)	159		
	No	42(63.6)	24(36.4)	66	0.046	0.100
	No idea	9(36.0)	16(64.0)	25		

Source of drinking water:	River/dam Pipe Bore hole Others	1(33.3) 17(60.7) 124(58.8) 5(62.5)	2(66.7) 11(39.3) 87(41.2) 3(37.5)	3 28 211 8	0.828	-0.025
Disease child suffered in the pass 2 weeks:	Diarrhoea Malaria Fever Abdominal pains Others(e.g. rashes) None	22(57.9) 23(67.6) 25(69.4) 7(77.8) 4(40.0) 66(53.7)	16(42.1) 11(32.4) 11(30.6) 2(22.2) 6(60.0) 57(46.3)	38 34 36 9 10 123	0.223	0.063
p-values < 0.05 means significant association						

Table 4.2.5 presents the prevalence and distribution of anaemia. The statistical test of significance and correlation and its associate factors are also indicated on the table. Overall, a prevalence of 58.8% of anaemia defined as haemoglobin concentration less than 11.0 g/dl was recorded. Of the 250 children involved, 58.8% were anaemic and 41.2% were non anaemic. More males (60.5%) than females (41.2%) were anaemic. However, there was no significant association between gender and anaemia; indication that, it is not a risk factor for anaemia in children under five years.

Anaemia was very prevalent in Vea communities (71.0%), followed by Vea-tangapore (64.1%), Nyariga (59.4%) and Gowrie (40.3%). The association between anaemia and community was significant (p = 0.004). Also, children within the 1-1.9 year group recorded the highest prevalence of anaemia (75.3%). The prevalence of anaemia seemed to decrease with increasing age as shown on the table above and the association between anaemia and age was significant (p = 0.0001).

Furthermore, children who took anti-malaria medication in a few weeks ago and those who took regular anti-malaria herbal medications were relatively more anaemic; recording 64.4% and 63.6% of anaemia respectively, compared to children who did not take any of these medications. Also, children who had completed vitamin A supplementation for their age or

were on other vitamins/mineral supplements were relatively more anaemic; recording 60.2% anaemia each, of the number of children involved. These associations were however not statistically significant as indicated by the p-values in table 4.2.5. It's also worth noting that, children who were not dewormed for three or more months, showed a higher anaemia prevalence of 63.6%, compared to 60.4% who were not dewormed. The association between deworming and anaemia was significant (p = 0.04); suggesting that, deworming may be an effective way of controlling anaemia in young children.

Diseases children suffered in the past two weeks was not associated with anaemia (p = 0.223) and the correlation between these two was also weak (R = 0.063). However, it was observed that, children who suffered abdominal pains recorded the highest percentage of anaemia (77.8%) compared to those who suffered other diseases or had not been sick in the past two weeks.

Table 4.2.6 Correlation between nutritional status and asymptomatic malaria

Nutritional Status Indicator		Asymptomatic Malaria Test			Statistical Test	
		Positive (+)	Negative (-)			
		Number (%)	Number (%)	Total	P - value	Pearson correlation (R)
WHZ:	Normal	32(15.1)	181(84.9)	213	0.341	0.060
	Moderate wasting	1(5.0)	19(95.0)	20		
	Severe wasting	2(22.2)	7(77.8)	9		
WAZ:	Normal	28(13.8)	174(86.2)	202	0.921	-0.020
	Moderate underweight	5(17.2)	24(82.8)	29		
	Severe underweight	5(18.2)	9(81.8)	11		
HAZ:	Normal	25(12.8)	170(87.2)	195	0.030	-0.116
	Moderate stunting	5(13.9)	31(86.1)	36		
	Severe stunting	5(45.5)	6(54.5)	11		
p-values < 0.05 means significant correlation						

Table 4.2.6 shows the distribution and association of asymptomatic malaria according to nutritional status, defined by weight-for-height z-scores (WHZ), weight-for-age z-scores (WAZ) and height-for-age z-scores (HAZ). In the table, the percentages of children in each category are in brackets. For example 15.1% with normal nutritional status had malaria parasitaemia at the asymptomatic state compared to 84.9% that did not. Although undernutrition was relatively higher among children who had no malaria parasitaemia, there was relatively higher malaria parasitaemia among severely undernourished children for all nutritional indicators compared to children with moderate or normal nutritional status. The exception was that wasting, stunting and underweight in children with asymptomatic malaria seemed to worsen with deteriorating HAZ and WHA Z-scores. The association between wasting and underweight were not statistically significant with p-values of 0.341 and 0.921 respectively. The correlation between wasting and asymptomatic malaria was positive but weak (R = 0.06). Underweight also recorded a weak negative correlation (R = -0.02) signifying that, decreasing low WAZ (underweight) was associated with increasing asymptomatic malaria in young children. On the other hand, stunting was significantly associated with asymptomatic malaria (p = 0.03). Also, the correlation between stunting and ASMP was negative (R = -0.116) suggesting that, improving on chronic undernutrition (stunting) may be associated with decreasing asymptomatic malaria in young children or the vice versa.

Table: 4.2.7 Binomial Logistic Regression analysis to predict association between nutritional status indicators to 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: 4.2.7 presents results on binomial logistic regression that was employed to estimate the contribution of nutritional indicators (i.e. predictor or independent variables) to the likelihood of a child having malaria at the asymptomatic state. The predictor or independent variables were entered simultaneously into the model. The model explained only 3.0% of the variance in asymptomatic malaria parasitaemia; implying that, an insignificant amount of the variations in asymptomatic malaria parasitaemia could be explained by the nutritional indicators. The model was however a good predictor of outcomes as it classified 85.5% of cases. The results indicate that, low weight-for-height is associated with higher chances of having malaria at the asymptomatic state (OR = 1.234), low height-for-age z-scores is associated with lower odds of ASPM (OR = 0.651) and weight-for-age z-scores have about a neural effect on ASMP (OR = 1.094). These associations were however not statistically significant as indicated by the significance values on the table. The results also suggest that, when the nutritional indicators are kept constant, the odds or probability of asymptomatic malaria occurring is 8.436 times (p = 0.001). This implies that, asymptomatic malaria is better predicted by factors other than nutritional status.

Table: 4.2.8 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
Age group (years)	1 - 1.9	reference	0.0001	-	-	-
	2 - 2.9	0.533	0.147	1.704	0.830	3.499
	3 - 3.9	1.150	0.002	3.158	1.526	6.535
	4 - 4.9	1.324	0.004	3.757	1.533	9.210
	5 - 5.9	2.369	0.0001	10.684	3.135	36.409
Asymptomatic malaria		0.883	0.040	2.419	1.041	5.622
Gender (male/female)		0.181	0.526	1.198	0.685	2.098
Community	Vea	reference	0.003	-	-	-
	Tangapoore	0.148	0.725	1.159	0.509	2.639
	Gowrie	1.392	0.001	4.024	1.772	9.140
	Nyariga	0.484	0.233	1.622	0.733	3.589
Dewormed	Yes	reference	0.050	-	-	-
	No	0.350	0.312	1.419	0.720	2.796
	Know idea	1.236	0.017	3.441	1.245	9.508

a. Variable(s) entered: Step 1; WHZ, HAZ and WAZ. Step 2; Age groups. Step 3; Asymptomatic malaria, Gender, Community, and Deworming

* P-values < 0.05 mean significant

Table: 4.2.8 presents results of logistic regression that was used to estimate the effect of anthropometric measurements and other variables such as age, asymptomatic malaria parasitaemia, gender, child's community and deworming on the likelihood of a child being anaemic. The anthropometric measurements and age groups were entered separately from the

others variables into the model. For the anthropometric measurements, the model explained 5.0% of the variance in anaemia and correctly classified 60.3% of cases. For the others, 22.0% of the variance in anaemia were explained by the model and 71.2% of cases correctly classified. The results for the anthropometric measurements indicate that, height-for-age z-scores significantly predicted anaemia (p = 0.003) and low height-for-age z-scores were associated with lower odds of anaemia (OR = 0.484); suggesting that, stunting has a significant protective effect on anaemia. The variable coefficient for height-for-age z-scores also indicates that, a unit increase in stunting was associated with 0.726 (72.6%) reduction in anaemia. Although low weight-for-height z-scores and weight-for-age z-scores were respectively associated with lower and higher chances of anaemia; OR (WHZ) = 0.681; OR (WAZ) = 1.763, the associations were however not statistically significant as indicated by the p – values.

Age also had a significant association with anaemia (p = 0.0001). When ages were categorized and unilaterally compared with Hb levels using binomial regression, it was observed that children had increased chances of anaemia starting from two years (OR = 1.704) but it was not statistically significant (p = 0.147). However ages three through to five years were associated with significantly higher chances of being anaemic; 3-3.9 (p = 0.002; OR = 3.158); 4-4.9 (p = 0.004; OR = 3.757) and 5-5-9 (p = 0.0001; OR = 10.684). This implies that, children from the 3-3.9 age group were about three times more likely to be anaemic and those from the 5-5-9 age group were about ten times more likely to be anaemic compared to those in the 1-1.9 age group.

In addition, asymptomatic malaria was a significant predictor of anaemia (p = 0.04; OR = 2.419; 95% CI: 1.041-5.622). This implies that, children who had malaria at the asymptomatic state, were about 2.4 times more likely to be anaemic compared to children who had no malaria. Also, children from Gowrie community were about four times more

likely to be anaemic compared to those from Vea community (p = 0.001; OR = 4.024; 95% CI: 1.772- 9.140) and children whose deworming status was not known were about three times more likely to be anaemic compared to those who were dewormed (p = 0.017; OR = 3.441; 95% CI: 1.245- 9.508). Gender however, was not a significant predictor of anaemia (p = 0.526; OR = 1.198; 95% CI: 0.685-2.098).

CHAPTER FIVE

DISCUSSION

This study recorded a prevalence of 14.8% of asymptomatic malaria parasitaemia, in children aged 1-5 years, from four (4) rural communities of the Upper East region of Ghana. However, Crookston *et al.*, (2010) recorded an asymptomatic malaria prevalence of 31.8% in southern Ghana. 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 and Johnston *et al.*, 2006). However, Wagner et al., (1998) recorded 13.6% of asymptomatic malaria parasitaemia in newborns in southern Ghana using the PCR malaria detection technique. 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.

A significant association was observed between regular intake of anti-malaria medications and asymptomatic malaria using Pearson chi-square test ($p = 0.016$). Further analysis using logistic regression model showed that, every unit intake of anti-malaria medication resulted in about 1.4 times reduction in asymptomatic malaria episodes ($p = 0.025$). On the contrary, there were no significant associations between asymptomatic malaria and a child's gender, age, child's community, vitamin A supplementation status and overall vitamin and/or mineral supplementation in this study. However, there were some important trend associations observed. For instance, relatively higher proportion of the children (17.0%) who had asymptomatic malaria had anaemia, compared to 11.7% who were non-anaemic but also had asymptomatic malaria parasitaemia. Although the association between completed vitamin A

supplementation for age and ASMP was not statistically significant, vitamin A supplementation appeared to provide some immunity against asymptomatic malaria as children who had completed vitamin A supplementation for their age, had the least cases of asymptomatic malaria. Assuming that, completing vitamin A supplementation meant that a child had an adequate vitamin A status, then this observation agrees with that of Mwanga-Amumpaire *et al.,* (2012) who found in a trial that, children in a vitamin A supplementation group had lower incidence of malaria compared to placebo, although the association was not statistically significant. However, Nankabirwa *et al.,* (2011) and Shankar *et al.,* (1999) found a protective effect of Vitamin A supplementation on malaria in their clinical trials. Also, Nussenblalt and Semba (2002) reported that, vitamin A and other anti-oxidant micronutrients may reduce malaria morbidity. On the contrary, Villamor *et al.,* (2003) and Binka *et al.,* (1994) found no effects of Vitamin A supplementation on malaria in their respective cohort study and clinical trial.

Regarding nutritional status, 19.4%, 16.5% and 12.0% were moderately and severely stunted, underweight and wasted respectively. This means that, 19.4% and 12.0% of the children were suffering from chronic and acute undernutrition respectively whilst 16.5% were suffering from acute and/or chronic undernutrition; since underweight is a composite measure of both acute and chronic undernutrition. These findings are not significantly different from the national prevalence of moderate and severe stunting (22.8%) and underweight (13.4%) reported in the multiple indicator cluster survey (Ghana Statistical Service, 2011). Wasting recorded in this study is however about double of the national prevalence (6.2%). These are also not so varied from the prevalence of moderate and severe stunting, underweight and wasting in the Upper Region of Ghana which are 31.5%, 20.0% and 7.2% respectively (Ghana Statistical Service, 2011). Weight-for-age z-scores were compared with factors that may influence anthropometric measurements of the children, to ascertain the effect of these

factors on their nutritional status. Although there were no statistically significant association between underweight and factors such as age, gender, child's community, mother's level of education or occupation, number of people in household or household income, there were important trend associations worth noting. For instance, more females compared to males were relatively moderate and severe underweight. Contrary to this finding, McDonald *et al.*, (2012) observed that, the male gender was a predictor of underweight, wasting and stunting. Also, Medhin *et al.,* (2010) found that males were at an increase risk of underweight and stunting at the first year of life. In addition, children who were on non malaria medications or had taken anti-malaria medications for the past two weeks were relatively moderately and severely underweight compared to those who were not on any medication. Also, children from mothers who had low BMI, were relatively more underweight compared to children from mothers with suitable BMIs. Furthermore, this research established no statistically significant association between undernutrition and malaria at the asymptomatic state, in children. Although Pearson's chi-square test suggested a significant association ($p = 0.03$) between stunting and asymptomatic malaria, further logistic regression analysis however showed no significant association between stunting (chronic undernutrition) and asymptomatic malaria ($P = 0.169$; OR = 0.651; 95% CI: 0.353- 1.200). Also, wasting; an indicator for acute undernutrition and underweight; a composite measure of both acute and chronic undernutrition were not associated with asymptomatic malaria in this study. It is however worth noting that, there were increased odds of asymptomatic malaria associated with weight-for-age 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. The lack of statistical significance may be due to the relatively low prevalence (14.8%) of asymptomatic malaria recorded in this study. The low prevalence could be attributable to the fact that the

research was conducted in the dry season which is usually not a malaria peak season. Crookston *et al.,* (2010), the only published research on this subject area, also found no association between chronic undernutrition (stunting) and asymptomatic malaria. This research however did not consider wasting and underweight as included in this research. There are however related research works on nutritional status and clinical or symptomatic malaria. For instance, Ong'echa *et al.,* (2006) and Deribew *et al.,* (2010) found no association between undernutrition (stunting, wasting and underweight) and clinical malaria. This finding is to an extent similar to the findings obtained in this research. In addition, Ehrhardt *et al.,* (2006) established no association between malaria and stunting as well as wasting, but with only underweight. On the contrary, Friedman *et al.,* (2005) found significant association between malaria and stunting and wasting. Also, Olney et al., (2009) and Fillol [a] *et al.,* (2009) established significant associations between malaria and stunting. However, Olney et al., (2009) did not consider wasting and malaria but Fillol [a] *et al.,* (2009) found significant association between wasting and malaria. Longitudinal/cohort studies which are relatively better designs compared to the cross sectional studies cited above, have not also reached an agreement as far as the association between undernutrition and malaria is concern. For instance, Fillol [b] *et al.,* (2009) found no effect of malaria on stunting and underweight in children but concluded that, wasted children were at a reduced risk of contracting malaria. Arinaitwe *et al.,* (2012) confirmed a part of Fillol [b] *et al.,* (2009) finding that, malaria was not associated with underweight. However, he established that, stunting was associated with an increase incidence of malaria. In addition, Genton *et al.,* (1998) confirmed Arinaitwe *et al.,* (2012) finding that stunting and malaria were associated but contradicted that of Fillol [b] *et al.,* (2009), because wasting was not associated with malaria in his study.

Regarding 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 maximum and

minimum 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) (Chessbrough, 2005). The prevalence of anaemia recorded in this study was about the same as that reported in the Ghana multiple indicators cluster survey which was 57.0% for children aged 6-59 months old (Ghana Statistical Service, 2011). It is however less than the 77.5% of anaemia prevalence in the Upper East region of Ghana; suggesting that anaemia in the region might have decreased over the years. This research discovered that anaemia was significantly associated with asymptomatic malaria. Using binomial logistic regression analysis, asymptomatic malaria was a significant predictor of anaemia. This finding confirms that of Crookston *et al.,* (2010) that asymptomatic malaria parasitaemia may be a risk factors for anaemia in children, and it's the only published research work on this subject area. Other related researches considered anaemia and symptomatic malaria. For instance Tine *et al.,* (2012), Manning *et al.,* (2012), Magalha'es *et al.,* (2011); Verhoef *et al.,* (2002) and Biemba *et al.,* (2000) all established that malaria was a risk factor for anaemia. The finding of this research is therefore agrees literature. However, other related researches on iron status (a predictor of iron deficiency anaemia) and malaria had varied findings. For example, Jonker *et al.,* (2012) and Nyakeriga *et al.,* (2004) found that iron deficiency had a protective effect against malaria. However Snow *et al.,* (1991) found no correlation between iron deficiency and malaria. Furthermore, this research discovered being stunted was protective against anaemia. This means that, children suffering from chronic nutritional deficits or are shorter for their age may be less predisposed to anaemia. This finding is not in line with most literature. For instance, Verhoef *et al.,* (2002) and Tine *et al.,* (2012) established that stunted children suffer more from anaemia. These findings seem to agree with Osazuwa *et al.,* (2010) and George *et al.,* (2000), that undernutrition is the primary cause of anaemia. However, this research did not find an association between anaemia and all indicators of undernutrition,

except for stunting. Other researchers such as Sumbele *et al.,* (2013) however found wasting as a risk factor for anaemia and Biemba *et al.,* (2000) established a correlation between underweight and anaemia.

In addition, this research also established significant association between anaemia and age of the children. When ages were categorized and unilaterally compared with Hb levels using binomial regression, it was observed that every year increase in age may be associated with increase in the chances of anaemia, from age two to five years. This is consistent with the findings of Tine *et al.,* (2012) who found that anaemia was associated with age from two to four years and even above five years. Osterbauer *et al.,* (2012) also found that older infant age was a risk factor for anaemia. Although males appeared to be at an increase risk of anaemia, a child's gender was not a significant predictor of anaemia in this research ($p = 0.526$; OR = 1.198; 95% CI: 0.685 – 2.098). This is consistent with the findings of Tine *et al.,* (2012). However, other researchers such Egbi *et al.,* (2014) and George *et al.,* (2000) reported that the female children were relatively more susceptible to anaemia compared to males.

In conclusion, asymptomatic malaria parasitaemia persist in young children during the dry season but malaria at the 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. Furthermore, intake of anti-malaria medications was associated with significant reduction in ASMP. Conversely, a child's gender, community of residence, complete vitamin A supplementation for age, vitamin/mineral supplementation status and use of mosquito net had weak correlations or no significant associations with ASMP. For anaemia, a child's community of residence and age were significantly associated with anaemia. On the contrary, a child's gender, intake of anti-malaria medications, source of

drinking water, recent history of disease, complete vitamin A supplementation for age and vitamin/mineral supplementation status had weak correlations or no significant associations with anaemia.

CHAPTER SIX

6.1 CONCLUSION

There was no significant association between asymptomatic malaria parasitaemia and chronic and/or acute undernutrition as defined by stunting, wasting and underweight of children in this study. This implies that, 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 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.

6.2 LIMITATIONS AND RECOMMENDATIONS

Resource limitation was the main constraint of this research. This informed the use of microscopy (Giemsa-stained blood films) instead of the Polymerase Chain Reaction (PCR) as a technique for the diagnosis of Asymptomatic Malaria Parasitaemia (ASMP). Also causation effects could not be established between associated factors since a cross-sectional study design was employed. It is therefore recommended that, a national survey on asymptomatic malaria parasitaemia using the PCR technique be conducted, to provide a national database on the prevalence and distributions of asymptomatic malaria parasitaemia, especially for children and pregnant women. Also, asymptomatic malaria screening should be included in routine child growth assessment programmes at the community levels.

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APPENDIX

APPENDIX I: FIELD WORK PLAN

Stage1: Subject recruitment and baseline assessment

Check for symptom of clinical malaria (fever, chills and headache), medical screening and date of birth.

⇩

Stage2: Filling of consent Form

Explain the research methodology and procedures to Participants (parents and children) and those who agree to the protocol should fill a consent form and proceed with the study.

⇩

Stage 3: Filling of a questionnaire

On demographic characteristics, Dietary assessment, Child health and care giving practices, risk factors to malaria. Parents would also complete their questionnaire.

⇩

Stage 4: Anthropometry

Take the weight, height or length and Mid-Upper Arm Circumference (MUAC) of enrolled children. Also measure the weight and height mothers of participating children.

⇩

Stage 5: Blood Samples

Only qualified laboratory technicians or biomedical scientist should take blood samples. Samples would be transferred in a cold box to the laboratories for MPs and FBC tests.

⇩

Stage 6: Snacks

Fresh fruit juice or soft drinks and biscuits were given to participants as appreciation for their participation

APPENDIX II: PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

This leaflet was given to all prospective participants to educate them about the research before they decide to or not to participate

Title of Research:

Assessing the association between nutritional status and Asymptomatic Malaria Parasitaemia (ASMP) in children

Name(s) and affiliation(s) of researcher(s):

This study is being conducted by Daniel Ayine Nyaaba; a student of Human Nutrition and Dietetics (MPhil.) program at the department of biochemistry and biotechnology, KNUST, Kumasi. He is being supervised by Dr. Patricia Brown (PhD) and Dr. Jacob Agbenorhevi (PhD).

Background

This is a community-based cross-sectional study that seeks to determine the prevalence of Asymptomatic Malaria Parasitaemia (ASMP) and its relationship with undernutrition (stunting, wasting, underweight and anaemia) in children from one to five years in the Upper East region of Ghana.

Purpose(s) of research:

The findings of this research would contribute to the planning and implementation of malaria control strategies and nutrition interventions in a bid to reduce or eliminate malaria transmission and enhance the nutritional status of children in the study region and Ghana at large.

Procedure of the research, what shall be required of each participant and approximate total number of participants that would be involved in the research:

The study involves children from the ages of one to five years. Only children from the specified communities, who agree with their parents to the approach or methodology of the study, would be recruited for the study. You as a parent would decide with your child whether he/she would be involved in the study after I have explained the procedures of the research to you. If you both agree, I would then take/record your approval (verbal and written

consent or thumb prints) before allowing you to participate. You may be engaged for a period of 30 minutes.

Anthropometric measures of your child such as weight, height or length and Mid-Upper Arm Circumference (MUAC) would be taken. Your child would also be physically examined and have their vital signs such as temperature taken. Also, about 3-5ml of your child's venous blood would be taken for Malaria Parasites (MPs) and Full Blood Count (FBC) tests. You the parent would be required to complete a simple questionnaire regarding socio-demographic characteristics, food intake and health care of your child. If your child is tested positive for malaria, I would referred him/her to the nearest clinic for treatment or treat him/her at my cost with standard malaria treatment, prescribed by a medical Doctor where a clinic is not available. If your child is found with other medical or nutritional complications upon screening, I would also refer him/her to the nearest health facility for further treatment.

Risk(s):

Your child may develop a slight skin discomfort in the course of taking the blood samples. He/she may also have a slight skin swelling at the site where blood is drawn. These are however temporary and would naturally resolve within a short time. To minimize these, only fully qualified personnel will be employed to undertake the collection of blood specimens. The site where blood sample would be taken would properly be cleaned before taking blood and covered for a few minutes with sterile cotton.

Benefit(s):

1. If your child is tested positive for malaria at the start of the study or during the study he/she would be treated by a qualified medical officer with the standard malaria treatment at a clinic nearby or at my cost where there is no clinic around.

2. I would also explain to you the outcomes of your child's nutritional assessment and laboratory tests so that you may know the state of health and growth of your child.

Confidentiality:

All information collected in this study will be given code numbers. Your names would not be recorded. Therefore, data collected cannot be linked to you in anyway. No name or identifier will be used in any publication or reports from this study. However, as part of our responsibility to conduct this research properly, I may allow officials from the ethics

committee to have access to your records. You may also choose not to answer any question you find uncomfortable or private

Voluntariness:

Participation in this research is optional. You are by no means obliged to participate or allow your child to participate in this study and you are allowed to opt out of the study at any stage.

Alternatives to participation:

If you or your child does not participate in this study, you lose nothing and cannot be denied treatment in any hospital or clinic when you fall sick.

Withdrawal from the research:

At any point in time, you may decide not to continue with the study or withdraw from it. However, information already obtained prior to withdrawal notice may be used by the researchers and withdrawal does not necessitate deletion of this information.

Consequence of Withdrawal:

You will not be punishment or loss any benefits or denied health care if you choose to withdraw from the study. Please note however, that some of the information that may have been obtained from you without identifiers (e.g.name etc), before you chose to withdraw, may have been modified or used in analysis reports and publications. These cannot be removed anymore. However, I pledge to comply strictly with all safety and ethical measures of the research.

Costs/Compensation:

For your time, I will compensate you with snacks such as fruits or fruit juices, sweets e.t.c.to show our appreciation for your participation. This is not to bribe you to participate in the research.

Contacts:

Please contact Daniel A. Nyaaba on the following address on all enquiries concerning the research. If you have any concerns on the legality of this study, please do not hesitate to contact the Committee on Human Research and Publications Ethics, Kumasi on the contacts below.

All correspondence should be directed to the address below

Daniel Ayine Nyaaba

C/o Department of Biochemistry and Biotechnology

Kwame Nkrumah University of Science and Technology

Kumasi.

Mobile: +233 247260072 or +233 209190493

Email: ndanielayine@yahoo.com

Further, if you have any concern about the conduct of this study, your welfare or your rights as a research participant, you may contact:

The Office of the Chairman
Committee on Human Research and Publication Ethics
Kumasi
Tel: 03220 63248 or 020 5453785

CONSENT FORM

Statement of person obtaining informed consent:

I have fully explained this research to _____ and have given sufficient information about the study, including that on procedures, risks and benefits, to enable the prospective participant make an informed decision to or not to participate.

DATE: _____ NAME: _____

Statement of person giving consent:

I have read the information on this study/research or have had it translated into a language I understand. I have also talked it over with the interviewer to my satisfaction.

I understand that my participation is voluntary (not compulsory).

I know enough about the purpose, methods, risks and benefits of the research study to decide that I want to take part in it.

I understand that I may freely stop being part of this study at any time without having to explain myself.

I have received a copy of this information leaflet and consent form to keep for myself.
NAME: _____

DATE: _____ SIGNATURE/THUMB PRINT: _____

Statement of person witnessing consent (Process for Non-Literate Participants):

I _____ (Name of Witness) certify that information given to _____ (Name of Participant), in the local language, is a true reflection of what l have read from the study Participant Information Leaflet, attached.

WITNESS' SIGNATURE (maintain if participant is non-literate): _____

MOTHER'S SIGNATURE (maintain if participant is under 18 years): _____

MOTHER'S NAME: _____

FATHER'S SIGNATURE (maintain if participant is under 18 years): _____

FATHER'S NAME: _____

APPENDIX III: MEDICAL ASSESSMENT FORMS

1. DIESEASE SCREENING

Child ID [……]. Code of Child [……..……]. Sex: [M, F]. Age […...…]
Community [……..…..] Name Research Assistant […….]

Axillary Temperature [……. ºc] Pulse [……bpm]

A. Symptoms presented by caregiver	Yes	No	Duration (Days)
1. Fever			
2. vomiting			
3. Diarrhoea			
4. Refusal of food (appetite lose)			
5. Chills			
6. Headache			
7. Abdominal pain			
8. General weakness			
9. Cough			
10. Runny nose			
11. Fast breathing/difficulty in breathing/noisy breathing			
12. Pallor			
13. Convulsion			
14. Jaundice			
15. Dark urine			
16. Others (Specify)……..			

B. Ask These Questions	Yes	No
1. Does the child vomit after eating?		
2. Is your child able to drink or breastfeed?		
3. Has the child had a convulsion with this illness?		
4. Does the child have bloody diarrhoea?		

C. Check for these signs	Yes	No
1. Severe palmer pallor		
2. Sunken eyes/reduced skin elasticity		
3. Lethargy/Unconsciousness		
4. Fast breathing/difficulty in breathing/noisy breathing		
5. Neck stiffness		
6. Ear discharge		

*If any item in **B** or **C** is ticked **yes,** refer immediately to the nearest health facility.

2. PHYSICAL EXAMINATION

[For each trait specify: 0. = normal, (a). = mild (+), (b). = moderate (++) (c). = severe (+++)**]**

a. Odema ☐
b. Paleness (lips, tongue, palms, mouth, skin) ☐
c. Dry, dull hair ☐
d. Glossitis (the tongue is swollen and changes colour) ☐

ADDITIONAL INFORMATION AND NOTES

……
……
……

APPENDIX IV: QUESTIONNAIRE

A QUESTIONNAIRE TO ASSESS THE ASSOCIATION BETWEEN NUTRITIONAL STATUS AND ASYMPTOMATIC MALARIA PARASITAEMIA (ASMP) IN CHILDREN IN THE UPPER EAST REGION OF GHANA

[Please note that the information to be provided will be treated confidentially]

Statement of person giving consent:

I have read the information on this study/research or have had it translated into a language I understand. I have also discussed it with the interviewer to my satisfaction.
I understand that my participation is voluntary (not compulsory).
I have received a copy of this information leaflet and consent form.
I and my child have voluntarily agreed to participate.

CHILD I.D: _____

DATE: _____ SIGNATURE/THUMB PRINT: _____

Please tick (√) and/or fill in where appropriate.

PART 1: SOCIO-DEMOGRAPHIC CHARACTERISTICS

1. Child ID (code)……...
2. Date of interview ……. /……../……
3. Interviewer ID……..
4. Sex of Child: (a) Male (b)Female
5. Date of birth of child …… /……. /…….
6. Age of child (in years) (a) 1-1.9 (b) 2-2.9 (c) 3-3.9 (d) 4-4.9 (e) 5-5.9
7. Class of child (a) Crèche (b) Kindergarten (c) P.1 (d) P.2 (e) Doesn't school (f) Others [Specify] …….
8. What is the birth position of the child? (a)1st (b) 2nd (c) 3rd (d) 4th and above
9. Ethnicity: (a) Frafra (b) Dagaaba (c) Dagomba (d) Akan (d) Others [Specify] ……..
10. Religion: (a) Christianity (b) Islam (c) ATR (d) Others [Specify]……..
11. Parent's Contact number: [Telephone number] ……..
12. Residential Address (state community name, house number e.t.c)

……

……

PART 2: DIETARY ASSESSMENT

1. How many times does your child eat in a day?

(a)Once (b) Twice (c)Thrice (d) Four times (e) Five times (f) Others (specify) ……..

2. Has your child lost appetite for the pass days or weeks? (Relative to your child's usual intake) (a) No (b) Yes

3. Has your household ever slept hungry because you did not have food? (a) No (b) Yes

4. Did your child take breast milk after birth? (a) Yes (b) No.

[If no, why? (optional) ……..]

5. When did your child start breastfeeding? (a) Immediately after birth (b) Days after birth (c) Weeks after birth (d) Months after birth

6. What did you do to the first breast milk immediately after birth?

(a) Discarded it (b) my child took it

7. How many times does your child breastfeed in a day? (a) Once (b) Twice (c) Thrice (d) Four times (e) Five times (f) Others (specify) ……

8. For how long did you breastfeed your child? (a) 6-11 months (b) 1-1.9years (c) 2-2.9 years (d) 3-3.9 years (e) Still breastfeeding

9. Does your child take any other food apart from breast milk? (a) Yes (b) No.

[If yes, complete FFQ and 24 Hour dietary recall]

10. Does the child consume food sold outside the home? (a) Yes (b) No (c) Sometimes

PART 3: FACTORS THAT INFLUENCE NUTRITIONAL STATUS

1. Is your child on any medication right now? (a) Yes (b) No

(If yes state medicines……)

2. Does your child take vitamin or mineral supplements now? (a) Yes (b) No

(If yes state medicines……)

3. Has your child completed vitamin A supplementation for his/her aged?

[**Please check immunization card for details**] (a) Yes (b) No

4. Resent malaria episodes [Last time child had symptoms of malaria]

(e.g. **chills, headache, and fever** e.t.c).

(a) 1-6 days (b) 1 week ago (c) 2 weeks ago (d) 1 month ago (e) more than a month (f) none

5. What malaria treatment was given and where?

(a) Malaria drug given at the hospital upon testing

(b) Malaria drug given at the hospital without testing

(c) malaria medication bought from pharmacy

(d) herbal preparations

(e) None

6. Has your child taken regular anti-malaria medication in the pass 1 or 2 weeks?

(a)Yes (b) No

7. Does your child take regular anti-malaria herbal medications? (a) Yes (b) No

8. Has your child been ill with any disease apart from malaria? (a) Yes (b) No

(If yes please state the disease……)

9. What disease(s) affected the child in the past 2 weeks? (a) Diarrhoea (b) Malaria

(c) Fever (d) Abdominal pain (e) Others [Specify]……

10. Have you observed any of these sign(s)/symptoms(s) in child? (a) Pale looks

(b) body weakness (c) tiredness (d) none (e) others [Specify] ……

11. Has your child ever been dewormed? (a) Yes (b) No (c) No idea

12. If yes, when was the last time he/she was dewormed? (a) 1 month ago (b) 2 months ago

(c) 3 months ago (d) Others [Specify] ……

13. Where was the deworming done? (a) School (b) Home (c) Hospital (d) Others [Specify]……

14. Any signs/symptoms of these intestinal parasitic infections in child? (a) Painful abdomen

(b) diarrhoea (c) vomiting (d) Others [Specify]……

15. Where do you fetch water for drinking? (a) River/dam (b) Pipe (c) Bore hole

(d) Others [Specify] ……

16. Where does the child seek medical attention when he/she is sick? (a) Hospital (b) Drug store (c) Herbalist (d) Self-medication (e) Religious leader (f) Others [Specify] …….

17. Where do you seek medical attention when you are sick? (a) Hospital (b) Drug store (c) Herbalist (d) Self-medication (e) Religious leader (f) Others [Specify] …….

18. Who cares for the child in your absence? (a) House help (b) Rivals (c) Husband (d) Child's Siblings (e) Myself

PART 4: MALARIA TRANSMISSION

1. Do you have a mosquito net in your home? (a) Yes (b) No

2. Does your child sleep under a mosquito net? (a) Yes (b) No

3. How often do you use mosquito repellents (a) Not at all (b) daily (c) weekly (d) Others (specify) ……

4. Has there been a mass mosquito spraying exercise in this community? (a) Yes (b) No

5. If yes, when (a) …days ago (b) … weeks ago (c) …months ago (d) ….years ago

5. Are there stagnant waters/bushes closer to your house? (a) Yes (b) No

6. Does the mother/father or siblings of the child have symptoms of malaria or has been diagnosed of malaria in recent times? (a) Yes (b) No (c) No idea

7. Do you take any other precaution to prevent your child from getting malaria (a) Yes (b) No

(If yes, please state the precaution

……

……

……

8. Any other observation(s) made on environmental sanitation?

……

……

PART 5: PARENT INFORMATION

PERSONAL DATA CODE

1. Nickname of father…….
2. Nickname of mother……
3. Respondents relationship to child ……..
4. Marital status: a. Single b. Married c. Divorced
5. Marital status of mother: (a) Married (b) Single (c) Divorced (d) Separated
6. Ethnic grouping – (please state)……..
7. Head of household (a). Father (b). Mother (c). Others (specify)
8. Highest educational level of father or male guardian (a). Primary/elementary (b). Secondary (c). Post secondary (d). Tertiary (e). None (f). Other (specify) ……
9. Highest educational level of mother or female guardian (a). Primary/elementary (b). Secondary (c). Post secondary (d). Tertiary (e). None (f) others (specify) ……..
10. Occupation of father or male guardian (a) Artisan (carpenter, hairdresser, seamstress e.t.c) (b) Professionals (Teachers, Lawyers, Accountants e.t.c) (c) Office work (secretary, civil servants e.t.c) (d) Trading (e) Unemployed (f) Others (specify)……..
11. Occupation of mother or female guardian (a) Artisan (carpenter, hairdresser, seamstress e.t.c) (b) Professionals (Teachers, Lawyers, Accountants e.t.c) (c) Office work (secretary, civil servants e.t.c) (d) Trading (e) Unemployed (f) Others (specify)……..
12. Age (years) of mother. (a) 15-19 (b) 20-29 (c) 30-39 (d) 40-49 (e) 50+
13. Residential status (a). Own house (b). Family house (c). Rented house (d) Government house (e). Caretakers (f). Others (specify)…….
14. How many people are in the household? (Eat from the same kitchen) (a)1-4 (b)5-9 (c)10-14 (d)15-20
15. How many children do you have? (a) 1 (b) 2 (c) 3(d) 4 (e) 5 (f) others (specify) …….
16. On the average, how much income comes into the household per month in GH¢? (a). < Gh¢ 100 (b) Gh¢ 100-300 (c) Gh¢400-600 (d) Gh¢ 700-900 (e) Gh¢ 1000-2000 (f) Gh¢ 3000-4000 (f) Gh¢5000 and above

PART 5: ANTHROPOMETRIC MEASURES AND LABORATARY TESTS

Key	**ANTHROPOMETRY AND LABORATRY TESTS**	
A	**Anthropometric measurement**	**Value**
w	Weight of child (kg) Weight of mother (kg)	
h	Height of child (m) (a) Standing:…… or (b) Recumbent:…… Height of mother (m)	
m	Mid Upper Arm Circumference (cm)	
B	**Malaria Test (For child)** (a) Positive (b) Negative (**Skip C when malaria test is negative**)	
C	**Type of Malaria Parasite**	**Load of Malaria Parasite (Parasite density)**
f	*Plasmodium falciparum*	
o	*Plasmodium Ovale*	
m	*Plasmodium malarie*	
v	*Plasmodium vivax*	
D	**Full Blood Count (FBC)**	**Value**
	HGB (g/dl) WBC HCT RDW MCHC MCV Others (specify) ……..	
	Clinical Signs/Symptoms Temperature **(**^{o}C**)** Pulse (bpm)	**Value**

APPENDIX V: RESEARCH REFERRAL FROM

Name of child .....

Age (year)..... 1. Referral Weight (Kg)..... 2.Weight (Kg) after treatment.....

1. Hb (g/dl) on referral..... 2. Hb (g/dl) after treatment.....

Mobile number of a parent/guardian (+223) .....

Reason for referral

.....

.....

Diagnosis

.....

.....

Treatment given

.....

.....

[Please keep this form at the clinic. The research team would contact you later for it]

Name of child .....

Age (year)..... 1. Referral Weight (Kg)..... 2.Weight (Kg) after treatment.....

1. Hb (g/dl) on referral..... 2. Hb (g/dl) after treatment.....

Mobile number of a parent/guardian (+223) .....

Reason for referral

.....

.....

Diagnosis

.....

.....

Treatment given

.....

[Please keep this form at the clinic. The research team would contact you later for it]

APPENDIX VI: ASMP and Anaemia Test results and Z-scores of Anthropometric measures

CHILD I.D	MPs	HB (g/dl)	WHZ	HAZ	WAZ
➢ **Vea Central 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
➢ **Vea Tangapore 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
	➢ **Gowrie 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
➢ **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