SCHOOL OF PUBLIC HEALTH
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UNIVERSITY OF GHANA

# MALARIA IN CHILDREN UNDER FIVE YEARS AND ASSOCIATED FACTORS IN ARTISANAL MINING AND NON-MINING DISTRICTS IN THE UPPER EAST REGION, GHANA

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PHILOSOPHY IN APPLIED EPIDEMIOLOGY AND DISEASE CONTROL DEGREE

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# DECLARATION

I hereby declare that except for the references cited to other people's work which has been duly acknowledged, this work is the result of my own research work done under supervision and has neither in part or whole been presented elsewhere for another degree

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# DEDICATION

I dedicate this work to Almighty God, my dear wife Margaret and my two lovely young stars Francis (Jnr) and Franpearl.

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# ABSTRACT

**Background:** Malaria remains a leading public health problem in about 97 nations worldwide. Throughout the world, about 214 million new malaria cases are reported every year and over three billion persons are at risk of malaria. Approximately 90% of all malaria deaths occur in Africa. Africa continues to shoulder heaviest burden of malaria cases. Global demands for natural resources is fueling land use, saddled with unsatisfactory environmental burden in developing countries. We conducted a cross sectional study to determine proportion of malaria in children under five years in artisanal mining and non-mining areas and factors associated with malaria in the districts in the Upper East Region, Ghana**.**

**Methods:** A cross-sectional study was conducted to compare proportion of malaria in children under five and associated factors in artisanal mining and non-mining districts. Data was abstracted from the facility records for children under five. A face to face interview was conducted for caregivers with children under five in the hospital. Categorical variables of the characteristics of the study participants were analysed into frequencies and proportions and presented in tables. The continuous variables such as age were analysed into means and standard deviations.

Two samples proportion test was used to compare whether difference exist between the districts at 95% significant level. Chi square test and Odds ratio were used to examine an association between exposure variables and malaria. Malaria was the dependent variable and demography were independents variables. Univariate analysis was done to determine an association between exposure variables (age, sex, occupation, marital status, income level, educational status, and households' number) and malaria. Logistic regression model was fitted to correctly predict factors that strongly associated with malaria infection in the districts Ethical clearance was obtained from Ethical Review Committee of Ghana Health

Service. Written permission was sought from Regional Health Director of Ghana Health Service, Upper East Region.

Results: Data on 11380 children under five years was extracted from hospital records and 525 caregivers were interviewed. The proportion of malaria was 39.2 % (95%. CI: 38.01%- 40.40%. p< 0.001) in children in the mining district as against 43.8% (95%, CI: 42.41% – 45.19%. p< 0.001) in the non-mining. Proportion of severe malaria was 27.1% (95%, CI: 25.7% - 28.3%) in the mining district compared with 57.47% (95%, CI: 56.0% - 58.8%) in the non-mining district. The child age, district the child resides, educational status of caregiver, occupation of caregiver and bed net (ITN) possession significantly associated with malaria in children under five years in study areas.

**Conclusion:** The findings suggested a relatively low proportion of malaria morbidity and severe malaria in children under five in the artisanal mining as against the non-mining district. Age of child, socioeconomic factors of caregiver and education status were associated with malaria in children in the study areas. Efforts of controlling malaria in these districts have been intensified but could be enhanced with high coverage of ITN possession, health education and vector control activities at wetland and dam sites.

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| | |
|---|---|
| ANC | Antenatal Care |
| ASM | Artisanal and Small Scale Mining |
| CDC | Centres for Disease Control and Prevention |
| CHPS | Community-based Health Planning and Services |
| CWP | Workers Pneumoconiosis |
| DDT | Dichloro-Diphenyl-Trichloroethane |
| DFID | Department for International Development |
| G6PD | Glucose 6 Phosphate Dehydrogenate |
| GDP | Gross Domestic Product |
| GFATM | Global Fund to fight AIDs Tuberculosis and Malaria |
| GHS | Ghana Health Service |
| GSS | Ghana Statistical Service |
| ICMM | International Council on Mining and Metals |
| IPT | Intermittent Preventive Treatment |
| IPTp | Intermittent Preventive Treatment during pregnancy |
| IRS | Indoor Residue Spray |
| ITNs | Insecticide Treated Nets |
| LLINs | Long Lasting Insecticide Nets |
| NMCP | National Malaria Control Programme |
| OPD | Out Patient Department |
| PAHO | Pan Africa Health Organization |
| PMI | President's Malaria Initiative |
| PNG | Paupa New Guinea |
| RBM | Roll Back Malaria |
| RDT | Rapid Diagnose Testing Kit |
| TB | Tuberculosis |
| USAID | United State Agency for International Development |
| W.H.O | World Health Organization |

# CHAPTER ONE

# INTRODUCTION

## 1.0 Background

Malaria is a leading public health concern in over 97 nations and regions in tropical regions worldwide. Throughout the world, about 214 million new malaria cases are reported every year and over three billion persons are at risk of malaria (Dawaki et al., 2016; WHO, 2015). Almost 440,000 people died from malaria in 2015, most of the death were in Africa, where a projected 90% of all malaria deaths happened (WHO, 2015). In 2007, the Millennium Development Goals six to reduce malaria burden 75% by 2015 was set by World Health Assembly (WHO, 2015). Since the tracking of malaria was initiated by WHO, the European regions recorded zero indigenous malaria cases for the first time. The developed countries such as America had also made an important improvement in reducing malaria. However, Africa continues to lead in the burden of malaria cases (WHO, 2015), which is attributable to weak health systems and poor environmental management (Utzinger, Tozan, & Singer, 2001).

Global demands for natural resources is gradually driving local resource extraction and land use. As the world economy is strongly linked together, the demands for these natural resources are increasing the social and environmental problems in the developing nations compared to developed nations. As a result, evolving nations are burdened with unacceptable environmental problems relative to developed states or nations that are importing the unprocessed resources (Swenson, Carter, Domec, & Delgado, 2011).

Although mining has shown to bring about significant improvement in the life of people, their settlement and the economy of mineral endowed nations, it also has resulted in the upsurge of malaria spread in mining communities (Castellanos et al., 2016; Knoblauch et al., 2014).

The technologies that are usually employed inevitably have a undesirable effect on the environment, hence, influencing the upsurge of malaria occurrence in places like northern Mato Grosso, Brazil (Sawyer, 2007; Barbieri, Sawyer, & Soares-Filho, 2005).

In early 1990s, northern Mato Grosso recorded the greatest burden of malaria in Brazil, and this was greater than what was usually reported by known endemic places. In 1993, malaria survey was conducted in the mining communities in North Mato Grosso, average burden of malaria was 33.1% in the mining communities. Additionally, the Amazon sub-region covered with the tropical forest of South America bordered with countries such as Bolivia, Brazil, Colombia, Ecuador, and others. The sub-region extends approximately 7,200,000 square kilometers with about 30 million population (Stefani et al., 2013). This sub-region accounted for about 89% of malaria diseases in all Americans which was recorded by the Pan American Health Organization, 2008 (Stefani et al., 2013) due to land use including small-scale mining, deforestation, water and wetland and among others.

Asian and Africa regions of which Ghana, South Africa, and Papua New Guinea are included, had reported the considerable proportion of malaria diseases from gold mining communities. A survey carried out in Papua New Guinea (PNG) in 2006 in mining communities among 2,264 children indicated that prevalence of malaria was 33.6% (Mitjà et al., 2013).

A household survey conducted between 2006 and 2007 in the Brong Ahafo Region, a forest and mining area of Ghana found the prevalence of malaria among children under five to be 22.8% (Asante et al., 2011). When these results were compared to records from other remotes areas in Ghana, the forest-savanna transition places of Kintampo reported 58% prevalence of malaria in 2004 whereas, 55.5 to 69.3% of the cases were reported in the savanna zone of northern Ghana from 2000 to 2002 (Asante et al., 2011; Malaria & Programme, 2013; Schueler & Kuemmerle, 2011).

### 1.1 Problem Statement

Malaria remains a public health concern in most countries. The parasites and the vectors are found in areas, almost half of the world population reside. Globally, malaria affects more than 300 million individuals per year (Ferreira et al, 2012). It severely affects the Africa regions. In Ghana, over 10 million individuals were affected in 2015 (National Malaria Control, 2015; Ferreira et al., 2012). Despite several interventions to stop malaria in the country as in other endemic nations, success has been very small. It accounts for over 45% of outpatient department visits and at least 20% child deaths (Tay, Badu, Mensah, & Gbedema, 2015). In 2015, nine out of the 10 regions in Ghana reported increase in OPD malaria cases with Central Region recording 44% increase compared to the 2014 (National Malaria Control Programme, 2015).

In mining countries such as Brazil, mining activities have added to increasing number malaria cases of malaria. For instance, 99% cases of malaria are clustered in the Amazon (de Oliveira, 2011) due to unregulated mining activity that has led to intense land use and dramatic environmental change. Ghana is endowed with mineral deposits. These deposits have attracted both large international mining companies and small-scale artisanal miners. The artisanal mining activities that predominate across the country favor the creation of an environment conducive for malaria vector reproduction. Most of the activities result in creating holes which when left uncovered collect water, couples with a small area with high population density (Dery et al., 2015) which favors the production of mosquitoe.

However, most research activities have focused on economic perspective with very few studies examining diseases prevalence at district levels in the country. National Malaria Control Programme (NMCP) in its 2013 final report recommended that malaria prevalence by the districts should be carried out. This would provide vital information such as stratification data in the country for decision making. The essence is that the National Malaria Strategic Plan 2020 to reduced malaria burden by 75% may be defeated since little or no information regarding data on stratified malaria prevalence and associated factors at the districts level is available. This study would focus on children under five years in artisanal mining and non-mining districts because they are mostly at risk of malaria morbidity. According to NMCP, (2013) the prevalence of malaria in children under five years in the Upper East Region was 44%. This figure is relatively high, hence district level data would be appropriate in supporting decision making.

## 1.2 Justification

Almost every Ghanaian is vulnerable to malaria and a sizeable proportion of Ghanaians spend huge sums of income on malaria prevention products such as coils, sprays, and insecticide treated nets, mosquito repellent among others. Nearly, all families pay for malaria treatment in Ghana. The cost of treatment for malaria is equal to the benefits to be derived by the country if malaria is successfully controlled. This study will stratify the proportionate malaria and associated factors at the district level in the artisanal mining and non-mining districts in the Upper East Region. Continuous evaluation or provision of baseline data, would enable the region to successfully plan, implement and appraise malaria control programmes. If malaria control initiatives are to be successful in Upper East Region, there is the need for empirical data on malaria morbidity and the factors influencing the disease in children under five years, therefore this study is timely. More importantly, very little information is available on this subject in the Upper East Region. On basis of testable fact, it has become important to providing people in authority and other stakeholders with important information on the factors influencing the burden of malaria in the Upper East Region for policy formulation and interventions. In addition, the study aims at contributing to knowledge, the proportion of malaria morbidity by stratifying data to mining and non-mining areas.

### 1.3 Hypotheses

The null hypothesis tested in this study was:

1. Proportion of malaria in children under five years in the artisanal mining (Tongo) district is the same in the non-mining (Bongo) district.

### 1.4 Objectives

General objective: To determine the proportion of malaria in children under-five years in artisanal mining and non-mining districts in the Upper East Region.

**Specific objectives**

1. To determine the proportionate malaria morbidity in children under-five years in artisanal mining and non-mining areas in the Upper East region
2. To determine the proportion of under-five severe malaria in the mining and non-mining areas in the Upper East region.
3. To assess factors associated with malaria infection in children under five years in the districts in the Upper East region

### 1.5 Conceptual Framework

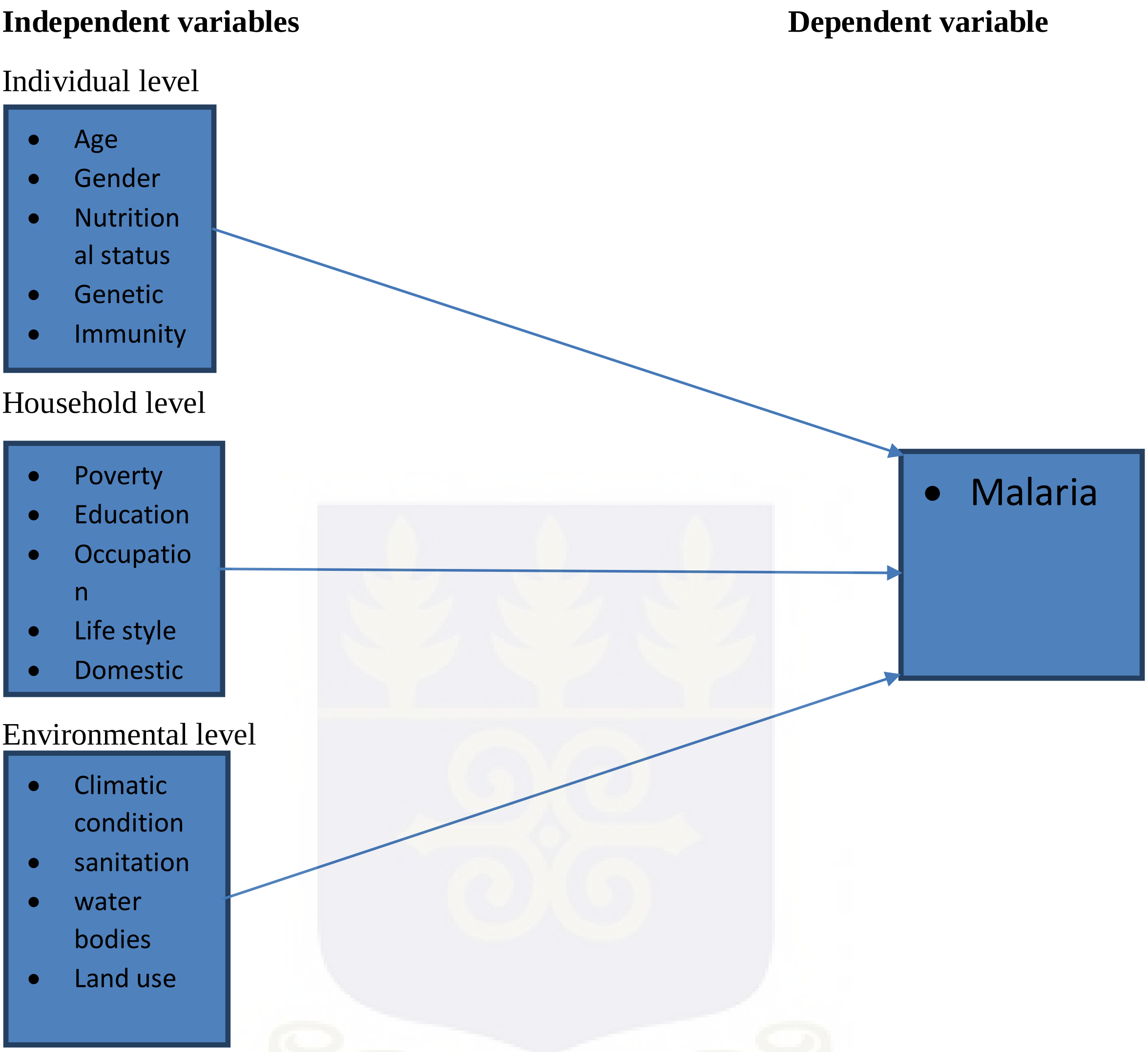


**Figure 1: Conceptual Framework including factors influencing malaria transmission**

### 1.5.1 Determinants of infection

There is evidence that many interrelated factors influence a person susceptibility to diseases of malaria. The factors include individual, households and environmental level risk factors (Bate et al., 2004).

#### 1.5.1.1 Individual level: biological and disease-related factors

Human beings are disposed to disease as results of factors such as biological, hereditary, immunological, and pathophysiological mechanisms. Humans have different levels of susceptibility to malaria infection, severity of the illness and responses to treatment.

An individual immune status is essential in responding to malaria infection. Immunity to clinical malaria is acquired by constant exposure to malaria infection. In places where the spread of malaria is constant, children and babies died frequently because of poor system defense. Places with low spread of malaria, everybody risk infection of malaria (Snow & Marsh, 2002). In high transmission areas of malaria, adults are increasingly infected with malaria but are usually not complicated. The association of human immune system with disease and vice versa has consequences on health policies. In areas with surge in malaria transmission, adults are the main reservoirs because of asymptomatic infections. As such, interventions that target only people presenting with signs and symptoms may reduce deaths resulting from the disease but may not impact on the spread of malaria, specially, if done in isolation from other control interventions (DFID, 2010). Symptoms of malaria is easily presented in malaria immune naïve patients and therefore treatment of such cases mighty impact significantly on malaria transmission.

A group of people with some genetic mutation, have protection to malaria. These group are made up of people with abnormal haemoglobin (alpha and beta thalasaemia, sickle cell) enzyme deficiency (G6PD), and persons of Duffy-negative phenotype blood group. (Weekley & Smith, 2013; Jr & Bordin, 2006). Duffy negative blood group persons were found to be protected from *P. vivax*. However, a new research conducted in Madagascar found that *P. vivax* could cause malaria disease in Duffy-antigen blood group individuals (Chuks J. Mba and Irene K. Aboh, 2006; DFID, 2010).

In stable malaria transmission areas, coupled with normal or overweight, malaria infection in babies and children changes with changed in age. Younger children suffer anaemia and as the children grow older, they are prone to cerebral and severe malaria (DFID, 2010) and the pattern may vary from place to place. In both stable and unstable malaria transmission area, age effect of anaemia is observed. However, complicated malaria is highly pronounced particularly in adults. Adults are of greater odds of renal disease and serious lung disease compared to children. The observed variances are important public health consequences. Working to curtail the spread of malaria and its effect would move the effect of the illness to older and children above five years population. If these population get infected with malaria they would become symptomatic and pursue for remedy.

The risk of malaria infection is low in the initial stage of life. This could be due to the movement of maternal antibodies across the placenta, Haemoglobin-f, breast-feeding and non-exposure to malaria parasites. (Weekley & Smith, 2013).The defensive effect of mother's antibodies would be lowered, if effective malaria control is realized and there is drastic reduction in malaria infection.

In low malaria areas, malaria disease is observed in all age groups, as such work-related problems might become very significant to consider than age. Indeed, this is true when people are infected through the bites of the vectors away from their homes. (P. M. De Silva & Marshall, 2012).

There is lack of enough evidence concerning biological difference of gender and malaria acquisition or infection. The information on gender difference with respect to malaria addresses in pregnancy, occupational risks, and care-seeking behaviors. Occupational and cultural dynamics affect malaria transmission. Access to health service differ considerable from one place to another and across culture and geographical states.

The few reports on gender differences with respect to malaria risk is largely centered in females. But, there are evidences that also suggested that men are more at risk for malaria in some countries because of male dominate life styles. For instance, places where agricultural is male dominated activity and farming activities are extended into the night or even people choose to sleeping in the farms for other reasons could make then more vulnerable for malaria disease (Chuks J. Mba and Irene K. Aboh, 2006; DFID, 2010; P. M. De Silva & Marshall, 2012).

It is a fact that malnutrition compromises the human immunity and therefore increases chance of new malaria diseases. Malnutrition predisposes children to severe malaria and malaria mortality. Chronic malnourished children have 50% more the chances of malaria mortality compared to counterparts who are normal. (Bhan, Bhandari, & Bahl, 2003; DFID, 2010; Kandala et al., 2011). Acute malnourished children are about 50% to 75% at risk of death from malaria infection. The deficiency in Vitamin A supplementary and zinc in the body, play significant role in malaria morbidity and mortality. This is because of importance of these molecules in building the immune system. Children with zinc deficiency have high risk of illness of malaria and death from malaria compared to those with accurate zinc status. However, this evidence need more proofs (Bhan et al., 2003).

### 1.5.2 Household and community levels: social and economic factors

Family and community levels factors have shown a connection between cases of malaria and lack of money. But it may also be strongly contested because of the strength and direction of the association. Many people would accept that relationships exist between malaria and poverty but which influences which one may need more information to conclude. Treatment seeking behavior may be influenced by wealth level. People with inadequate incomes benefits just little from malaria control and prevention interventions compared to rich people. People who cannot afford to pay medical bills only seek health care at very critical time. Malaria disease comes heavy burden on families with financial inadequacy (Baral et al., 2004; Onwujekwe et al., 2009) and as such huge malaria treatment cost would indeed leads to later reporting to the hospital. The malaria prevalence is highly pronounced in poorer households, which in turn imposing substantial cost on people and their families, ensuring that the circle of malaria disease and poverty continues. Poorer families are mostly affected by malaria and could lead to this families selling their properties and food stuffs so as to cater for treatment fees. However, families that are rich could cope with spending more on malaria prevention and treatment.

Indeed, prompt health care seeking behavior ensures good outcomes. However, due to financial inadequacies poor families bear the consequences of malaria such as death, as the ultimate. Poor families would self-treat than to access private or public health providers. Households with lower income are mostly susceptible to malaria during the raining period. During this period the malaria prevalence is highest but cash flows is lower. (DFID, 2010).

Education may influence malaria transmission in either direction. Educated person with vest knowledge in malaria would seek protection against malaria for family members and himself/herself. Also, education would provide him job that in turn earned income with which can provide good home which would be well screened against mosquitoes, and thereby highly protected against malaria. Also educated person have the propensity to easily understand the various preventions, control methods and thereby utilizing them to his benefit. However, non-educated person, would need long time to understand the consequences of malaria and to accept the various preventive and control methods. Also, behavior may be influenced as result of no education and therefore indulging in life style that exposes to mosquitoes. Lack of education may impact on income and though preventive and control methods might be available, affordability becomes major issue.

Occupations such as farming, fishing, animal rearing, mining, stone quarrying, and petty trading, have effect on the spread of malaria illness due to contact with infected mosquito vectors bits. Type of employment of people could also determine the environment and exposure to mosquito bites. If you work late to the night outdoor in mosquito infested environment, the episodes of malaria cases compared to someone whose work is limited to day would be different. Furthermore, work remuneration depends on factors like level of education, job demands, and risk involved. If one works outdoors until late night but not considered essential worker, though exposure to mosquitoes is high, one's remuneration is low and thereby affordability for preventive measure may be compromised.

In addition, life style and domestic activities could affect malaria. People who stay outside or rest late night without protection end up with episodes of malaria. People who are outdoor types or stay outside for purpose of work could end up expose to the exophilic *Plasmodium sp.* People who are involved in house chores that keep them outside longer into the night are exposed to malaria. For instance, women who cook outside late at night are exposed to malaria vector and have increased risk compare to those doing same in closed screened kitchen.

### 1.5.3 Environmental level

Environmental factors largely affect the spread of malaria. It primarily influences the proliferation and existence of the malaria vector, exposure of persons and other animals. The environmental factors that favors the transmission of malaria parasites are the factors that increased proliferation of *Anopheles* mosquito. These conditions may include water which the mosquito lives and breed, temperatures and humidity which enable the vector to live long so that the vector phase of the life cycle of the parasite can be completed. These factors are also affected by climate change, landscape, soil types, soil drainage, vegetation types, land use and water. These are factors differ greatly from place to place because of differences in the weather with respect to different geographical areas and land use. Land use in this case includes water usage, farming, mining, urbanization, and cutting down of trees can significantly influence the spread of malaria.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.0 General Overview of Mining

The mining and metals production companies spans a complex interdependent web which includes a formal and non-formal component. The formal companies are categorized to public-trade and state owned. They engaged over two million people globally and about half the people are engaged by very big companies (ICMM, 2012). The formal mining industry works within the legal and fiscal context linked together by other nationals, regionals and commodity-focused associations devoted to representing the industry, protecting its interests and improving work performance (ICMM, 2012). In contrast, small scale mining and artisanal mining formed the informal component. There is however, no legal frameworks governing the sector, though it is changing from countries to countries (ICMM, 2012; World Bank Group, 2014; World Bank, 2008).

For many people, the term “mining” is related to large-scale processes with sophisticated equipment and technology. However, artisanal or small-scale mining activities (ASM), which use methods that have changed little since ancient times, continues to offer employment to people directly or indirectly for not less than 20 to 30 million and over 100 million people depend on it for livelihood (Hentschel Thomas,; Hruschka Felix, 2003; World Bank, 2008). The World Bank report and Hinton (2005), indicates that about 55 countries of which majority are in poorest countries are engaged in ASM. About 10 – 50 percent of women and between 1-1.5 million children of age less than18 are involved in ASM (World Bank Group, 2014).

**Figure 2: Photograph showing women and children in artisanal mining processing**

Curtesy: World Bank Group, 2014

With the prices for commodities on the world market go high couples with population growth, the demands for mineral resources cum escalating poverty in many nations is increasing number of miners at faster rate (Hinton, 2005).

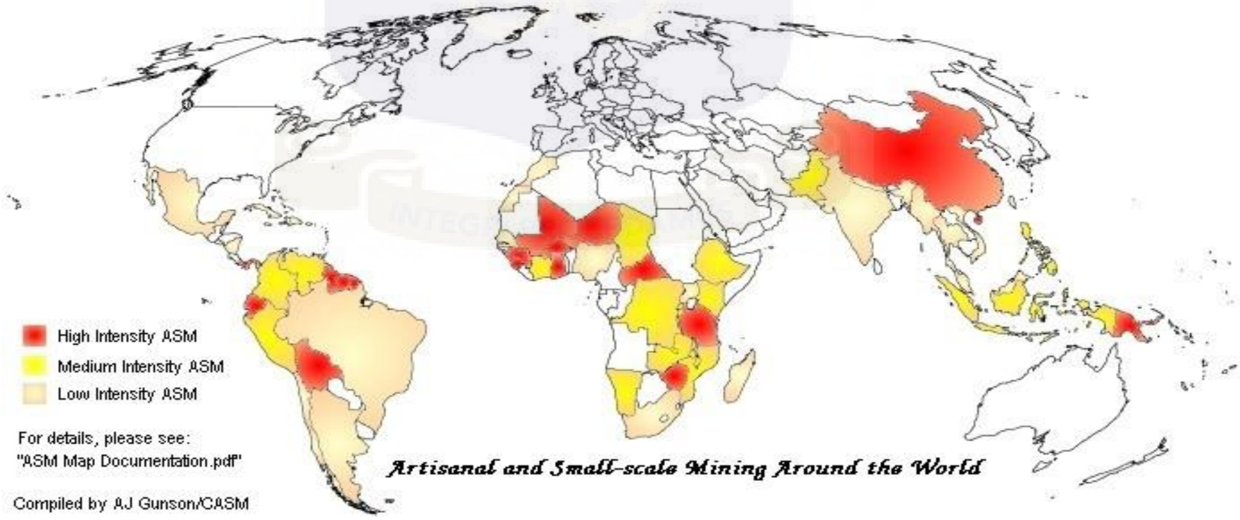


**Figure 3: Distribution of ASM Activities around the World**

Source: www.casmsite.org

Trends in artisanal and small-scale mining employment and decline were observed, with increase in ASM employment through Africa and Asia and declines in Latin America. The ASM activities across the regions of the world is shown in Figure 3.

There is no doubt that ASM has a legitimate and significant role to play in the social and economic development of many countries , particularly in Africa (Collins & Lawson, 2014). The report of Collins and Lawson, further explained the fact that artisanal and small-scale mining (ASM) comes with some benefits, it has also contributed several social menaces, and also has negatively affected the environmental and health of the population through the activities of artisanal and small mining.

## 2.1 Gold Mining Process

### 2.1.1 Placer mining

Placer mining was method that was used first to mine gold from river banks, streams and lakes surrounding the Sierra Nevada Mountains. The technique involves the weight of the gold and gravitational force to separate the gold ores from other alluvial deposits (M. Silva, 1986). In the United States of America, most gold mined were from placer deposits (Butterman, 2005). Though, placer mining can employ simple tools such as gold pans, very sophisticated methods have been developed.

### 2.1.2 Hydraulic mining

After the initial amount of gold found started depleting, prospectors started to look far for golds that were deposited within bedrocks of mountains and gravel. To reach this mineral, the sand beds and rocks must be extracted first. Therefore, miners employed high-powered streams of water to flash out these rocks to reach the gold inside them (Butterman 2005). Though hydraulic mining seems a simple process, it needs various tools and skills to reach the right form of the gold ore. Very large amount of water is usually needed to generate hydraulic power. As such very big projects were embarked on to provide miners with large quantity of that water that were needed to perform hydrological mining (Hill 1999).

### 2.1.3 Lode Mining

When it was later known that gold that were in water bodies were not initially there, miners started looking beyond for the main source of the deposits. Lode gold deposits were as a results of hydrothermal activity below the Earth's surface (Hill, 2006). These types of deposits required deeper mining and digging than hydraulic and placer mines. The deposited golds are concealed in mountains in a several quartz veins. Lobe gold extraction is difficult because of the quartz vein and thus making the process of lode gold extraction difficult. Most of the time, lodes mining required explosion and very deep drilling underground in order to reach the lodes (Butterman, 2005). Shallow lode deposits can be reached to by surface mining. This type of mining method is referred to as open-pit technique which involves the abstraction of the upper layer of bedrock on top of the deposit.

## 2.2 Mining in Ghana

Ghana is found in West African situated on the Gulf of Guinea, it is blessed with many natural resources including gold, diamond bauxite and others. The country has land area of 238,555 square kilometers. Ghana's population is about 26 million, and bordered to Togo, Cote D'Ivoire and Burkina Faso. Ghana was colonized by British, at the time the region was named Gold Coast because of the gold reserves (Yelpaala & Ali, 2005)

### 2.2.1 Artisanal mining methods in Ghana

History has it that artisanal mining has been operating in Ghana as illegal (galamsey) venture and legalized entity. However, it was limited to Birimian and Tarkwaian and the alluvial areas on the boundary through Offin, Pra, Ankobra and Tano rivers and their tributaries. ASM gained worldwide recognitions because it has significantly affected the livelihoods of mineral endowed economies positively. However, it has come with many work-related health hazards which is not limited to those directly engaged in the mining activities, but to the communities they carry out the activities and the surrounding communities. It is projected that Ghana has employed almost one million persons in ASM (Hilson, G & Garforth, 2013) . The types of small and artisanal miners that operate in Ghana including licensed and supervised and those mining and processing without required license and usually on concessions of companies (Nyame, FK & Grant, 2014). In Ghana there is no clear distinction between artisanal and small scale mining in law (Aubynn, 2009). However illegal small-scale gold miners are referred to as galamsey in our local parlance, which means “gather them and sell” (Collins & Lawson, 2014; Hilson, G & Garforth, 2013). Though, many people could not distinguish between legal and illegal small-scale mining when the term galamsey is used. Furthermore, the difference that exist between the groups are not very clear even on the ground, therefore several small scale legalized miners go beyond the concessions allocated to them and often entered on concessions of large-scale mines (Friends of the Nation, 2010; Nyame, FK, Andrew Grant, J & Yakovleva, 2009). A study reported three types of methods of gold mining by artisanal and small scale miners (Aryee, BNA, Ntibery, BK & Atorkui, 2003).

Shallow alluvial mining: this method is used to mine shallow alluvial deposits which are usually found in valleys or low-lying areas. The mineral barring ores are removed and carried to close by waterbodies or river for washing so that the gold can be recovered. Illegal miner mostly employed this type of method.

**Figure 4: wooden sluice box use by illegal gold miners**

Source: Googleimage.org

Deep alluvial exploration method is used to access alluvial that are imbedded on the banks of rivers. This method requires digging deep to reach the gold bearing gravel, which mostly located at 7 to 12 metres deep. Terraces are usually build around the sides of pits to avoid collapse.

Hard rock (lode) mining involves ridges that bear the gold ores, usually located either to the surface or deeper in the reefs. It involves sinking of holes to meet the ridges bearing the gold ore or situations where ridges are too hard, explosives are commonly employed (Aryee, BNA, Ntibery, BK & Atorkui, 2003; Lynas, 2014).

### 2.3 Impact of mining on Environment

Adverse effect of mining operations on the environment have been largely reported by Funoh, (2014) and Lynas, (2014). However, specific attentions have been focused on large and small-scale mining operations in the environment. Though destruction of land as a result of mining is very marked, chemical pollution from the recovering activities have imposed twofold of burden on the environment, the health of mining communities and the people living to close sites (Yelpaala & Ali, 2005). For example, owing to illegal nature of gold mining in certain countries in Africa and Latin America, researchers focus largely on environmental contamination and mercury exposure suffered in the mining and during sluicing of the ores (Hentschel Thomas,; Hruschka Felix, 2003; Hota & Behera, 2015). A study used a pair-wise ranking of problems, to find out natives views on the problems experienced in mining communities, found that the most pronounced problems in mining communities were pollution of water sources from mercury and cyanide, dust, mine pits, cracking and the collapse of buildings (Kitula, 2006). According to Kitula, (2006), since the establishment of Geita Gold Mine in June 2000, near the Geita village, almost 52 cases of housing collapse were as a result of explosion from the mine.

Series of research have shown trends of mercury exposures from gold amalgamation phase (Stephens & Ahern, 2002; Drasch et al., 2001). However, greater number of these works were limited to small sample size, hence were prone to biases. Although small numbers were used, some attempt more rigorous study designs. Study carried out in mining area in Philippines with a sample size of 102 workers 63 other inhabitants who were exposed, 100 persons living downstream of the mine, and 42 inhabitants of serving as controls were recruited into the study. Bio-data and hospital records reviewed for both workers and the inhabitants in the surrounding communities. They reported that 0% of the controls, 38% downstream, 27% from Mt. Diwata non-occupational exposed and 71.6% of the workers were found to be Hg poisoned (Drasch, G., Bose-O'Reilly, S., Beinhoff, C., Roider, G., Maydl, 2001). However, others studies in Tanzania and Ecuador with a like study design reported lower levels of intoxication in adults but high mercury level in children (Stephens & Ahern, 2002). Another study conducted in Venezuela did not find any mercury poison, regardless of occupational and community exposures (Drake et al., 2001)

In Ghana, number of studies conducted in mining area have shown that land destruction, environmental pollution and others were associated with mining processes. A study by Awatey, (2014) reported that land degradation was a major effect of small-scale mining. In that study 70% of residents sampled alluded that small scale mining destroys their lands while 30% said small scale did not destroy their lands. A further retrospective analysis was embarked upon to ascertain the residents in the small-scale mining community's perceptions of actual causes of land degradation, 20 to 30 percent of them attribute it to heavy machinery and toxic materials uses (Awatey, 2014)

The extent of damage caused by small scale mining regards to land degradation is an exhibit in figure 5.

**Figure 5: Impact of ASM on agriculture land**

Source: Awatey, (2014)

Furthermore, large number (60%) of household heads sampled from the small-scale mining communities in the Amansie West District attested to the fact that the small-scale mining activities pollute their water bodies. As high as 70 percent of the above strongly agreed that small-scale mining activities affects their household in terms of water resources. The study revealed that small-scale mining activities have been a major source of both surface and underground water pollution (Awatey, 2014). The degree of pollution of water bodies as a result of ASM in the Amansie West District is shown in figure 6. Another study in Prestea, Ghana revealed that ASM miner resort to water bodies as only means of dumping their toxic waste. They further explained that these toxic chemicals dumped in the water bodies pose a great threat to the safety of drinking water (Adu-Gyamfi, 2016) and the effects are huge to cause damage to the human health, vegetation cover and aquatic lives.

**Figure 6: Effect of ASM on water body in Amansie West District**

Source: Awatey, 2014

## 2.4 Impact of Mining on Human Health

Health is defined as a state of complete physical, mental, and social well-being of an individual, and not merely the absence of diseases (WHO, 2009). Environmental pollution affects human in many ways. Although a clean environment is considered essential for human health and well-being, economic development has resulted in a considerable deterioration in environmental quality across the globe. Air pollution lead to serious public health problems, including acute respiratory illness and chronic bronchitis, and possibly premature death for more vulnerable populations (Zhang et al., 2010). According to WHO, air pollution is considered the world's largest single environmental health risk (WHO, 2014b). Globally, most of premature deaths and morbidity occur because of both ambient and indoor air pollution. A recent study by the WHO (2014) reports that about 7 million people died in 2012 because of air pollution. The populations of developing countries suffer more health problems associated with environmental degradation, compared with residents of developed nations (Hota & Behera, 2015). Environmental hazards, including water pollution by chemicals, air pollution and unhygienic conditions are largely responsible for both diseases and deaths in developing countries. Indoor air pollution is also an important contributor to the global burden of disease. Globally, 4.3 million deaths were attributable to household air pollution in 2012, most of which occurred in developing countries (Hota & Behera, 2015; WHO, 2014b).

Many studies to link pollution and health-related social costs in developed countries have been conducted. However, the shortage of original studies in developing countries, researchers tend to deduce concentration-response functions estimated in the similar of the United States to the levels of pollution in the target country (Ostro, 1994). This approach faced criticism because of the different cultural, behavioral, institutional circumstances, couples with the difficulty of finding places with matching environmental conditions from which predictions can be made for the target country and, therefore, may yield misleading results (Gupta, 2011). Sources of air pollution in mining areas generally include drilling, blasting, overburden loading and unloading (CMRI, 1998). Work related health issues in the mining industry differ from one mineral type to the other, and to the skills employed, category of mines, and the size of the concession. A study by Saha et al, (2011) indicated that high number of particulates suspend in the air at mining areas, and therefore lung diseases are very prevalent in these communities. Another study reported that no difference in health hazards suffered by people living near to underground mining site as compared with those close to opencast mining sites, because of transportation of ores across and related activities (Mishra, 2010). Stephen et al (2002) stated that mechanization of mining operations has resulted in very fine particles in the atmosphere, which has shown to be dangerous to the health of man. Mining residues are one of the important work-related hazards globally, both as short-term hurts and long term human health issues such as cancer and lungs conditions (Stephens and Ahern, 2002). There are evidences to the effect that persons close to coal mining areas were at high risk of heart and lungs diseases, cancer, hypertensions, and kidney disorders. Deaths are higher in residential areas sited close to coal mines and coal fired power stations (Hendryx, M., Ahern, M.M., 2008; Hendryx, M., Donnel, O.H., Kimberley, 2008). Moreover, persons closer to mining communities are most likely to drink water contaminated with chemical and remains from the mining operations. Work-related diseases like silicosis and coal workers pneumoconiosis (CWP) was reported in underground coal miners caused by breathing in dust from the mine (Schatlez, S.J., Stewart, 2012). Another study carried out in Jharsuguda district, Odisha, found that majority of the people suffered from various diseases as a result of air and water contamination. They noticed that most of people had airborne diseases such as respiratory diseases, tuberculosis, pneumonia, gastric disorders, and eye complications (Hota & Behera, 2015).

## 2.5 Malaria Epidemiology

Malaria is caused by protozoa of the genus Plasmodium, transmitted to humans from infected female *Anopheles* mosquitoes. Though, over 120 plasmodium species existed, only four (*P. falciparum*, *P. vivax, P. malariae*, *P. ovale*) were known to cause disease in human until recently when it was discovered that a fifth specie (*P. knowlesi*) also causes disease in human (Weekley & Smith, 2013). Over one million deaths are caused by *P. falciparum* in African where it is found in large number (Sitali et al., 2015). *P. vivax* is largely found in Asia, Latin America, and parts of Africa. This parasite is highly associated with Asia and therefore the most predominant malaria parasite in the world (Feng et al., 2015; Weekley & Smith, 2013). *P. ovale*, have similar morphology as compared with *P. vivax*, widely distributed West Africa, and causes more disease than *P. vivax* in Africa (Kang, Y. and Yang, 2013). The only known species to have longest asexual cycle is the *P. malariae*. It is found globally with 24 hours asexual longer than other species that occur with 48 hours (CDC, 2012b). *P. knowlesi* is found throughout South East Asia and it has recently been discovered to cause human and zoonotic malaria in the region. *P. knowlesi* has 24hours replication cycle and therefore rapidly progress from uncomplicated malaria to severe infection (CDC, 2012b; McCutchan, T.F., Piper, R.C. and Makler, 2008).

All plasmodium species go through similar life cycle and this is complex in nature. It involves two different hosts of an insect vector (mosquito) and human (Figure 7). They exhibit both sexual cycle and asexual cycle. The sexual cycle takes place in the gut and abdominal wall of the female *Anopheles* mosquitoes while the asexual cycle takes place in the liver and red blood cells in human and this causes the symptoms of the disease (Leera S.; Hyacinth C. O. and Victoria D., 2014). During the sexual cycle, the female mosquito picks the microgamete (male gametocyte) during blood meal from infected person to fertilize the macrogamete (female gametocyte) which then form an egg, or oocyst. The oocyst matures into several sporozoites that swim to the mosquito's salivary glands to be injected into another human at the next bite (Morrow, 2007). The malaria parasite mostly alternate sexual cycles with asexual cycles (alternation of generation) in order to continue to exist (Sacci *et al.*, 2006).

Malaria parasites are transmitted by female anopheles mosquitoes in humans (Bousema & Drakeley, 2011). Over 70 species of Anopheles mosquitoes that spread malaria across the globe, but less five than species could found in one region (Malaria Consortium, 2007; Sinka et al., 2012). In sub-Saharan Africa, the species of anopheles mosquitoes that spread diseases include, *A. gambiae* and *A. funestus* (Sinka et al., 2010, 2012). *A. funestus* and two other species of the *A. gambiaesensulato* (s.l.) species complex (i.e., *A. gambiae* and *A. arabiensis*) are primary vectors of P. falciparum malaria in sub-Saharan Africa and *A. stephensi* plays a prominent role in urban malaria transmission in Indo-Pakistan (Fontaine et al., 2012). Furthermore, *A. albimanus* and *A. darlingi* are primary vectors of malaria in Central America and various areas of South America (Fontaine et al., 2012; Lwetoijera et al., 2014)

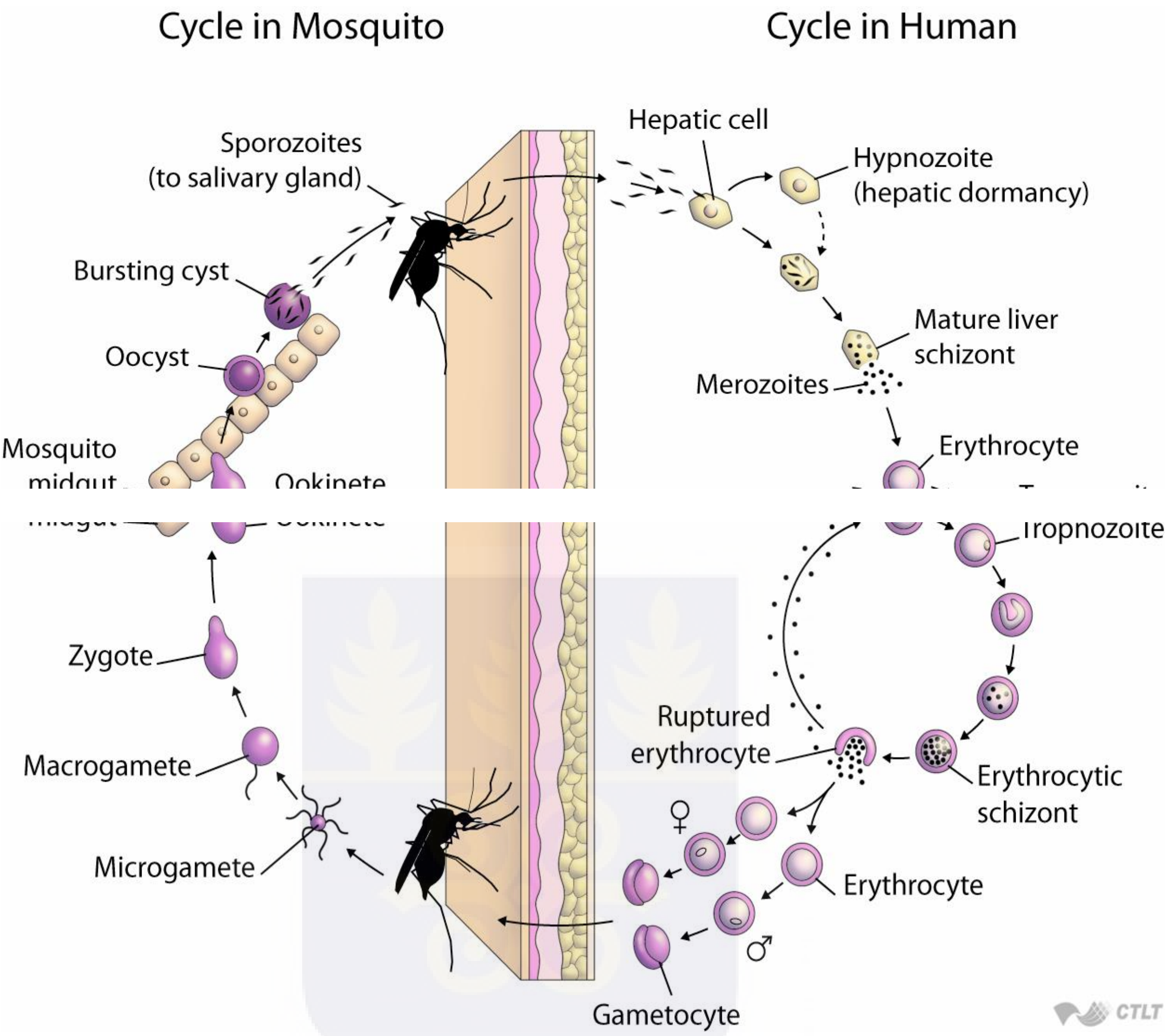


**Figure 7: Life cycle of plasmodium species**
Source: Morrow, 2007

### 2.5.1 Life cycle mosquito species

The *Plasmodium species* are of great health concerns both locally and at the international level. This is because they are found almost every in the globe. (CDC, 2014b). The two most important groups of the vectors are anophelines and culcines. The Anopheles vectors are accountable for spreading malaria disease and the Culex parasites spread diseases including lymphatic filariasis, Japanese encephalitis, and West Nile virus (Webber, 2009; WHO, 2014a). The aedesaegypti vectors infect human with dengue virus, yellow fever, chikungunya and Zika virus. In all the diseases transmitted by *Plasmodium* *sp.* malaria remains a serious public health issues especially in African of which Ghana is included (WHO, 2014a). The Aedesaegypti mosquitoes is more of public health nuisance than risk in Ghana (Opoku & Amoako, 2002).

The life cycle of mosquito has four distinctive phases which include the egg, larvae, pupae, and adult stage (Figure 7). The female Anopheles mosquito lays eggs in clean water usually at night which then hatch after a day to three days. *A. gambiae* is the most active plasmodium vector in Africa, eggs are usually laid in low standing clean water which seldom dries up (Jackman & Olson, 2006). In some regions of Africa, *A. gambiae* larvae were found in foot prints of heavy animals and potholes of water by the roads (Musoke, 2015). In America and Asia, A. darling and *A. stephensi* larvae are found in streams and ponds with clear water and muddy bottoms, with emergent or floating vegetation and man-made cisterns (Williams Jacob; Joao Pinto, 2012). Within two to three days of right temperature and other factors, the eggs developed to larvae which are usually seen swimming on the surface of the water. The larvae of Anopheles rest on top of water because they lack air tubes and this discriminates it from Culex which position at an angle on the water. Mosquito larvae feed on microorganism like bacteria, algae and others, and changes through four larvae instar to become pupae within four to ten days (Jackman & Olson, 2006; Opoku & Amoako, 2002). The pupa transitional stage from larvae which live in water and adult mosquitoes which live on land. Mosquito pupae do not eat, spend most time on water surface and only move if disturbed, hence refer to as tumblers (Jackman & Olson, 2006). The pupae are crescent in nature, comprise of a fused head, thorax and a pair of breathing tubes called trumpet. This phase could remain up to ten days and more, depending on temperature and species of mosquito involved. The pupae avoid trouble by swimming deep the water using the jerky actions. After the pipa stage elapsed the pupa splits out at the anterior end and the adult mosquito comes out.

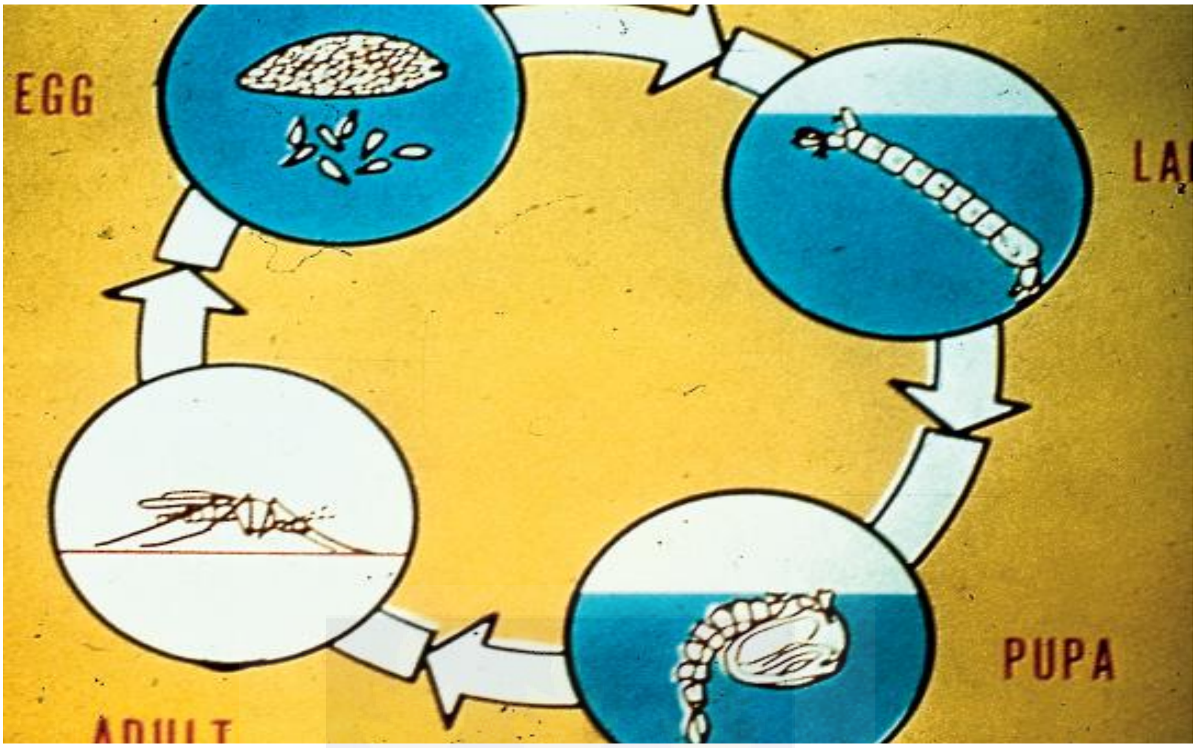


**Figure 8: Life cycle of mosquitoes**

Source: Jackman & Olson, 2006

The adult spends a few hours on top of the water and flies. The head carries the eyes, antennae, proboscis and two sensors (Pitts & Zwiebel, 2006). The antennae have sensors that detect sounds and guide the female anopheles mosquito to the host whereas it feeds through the proboscis (CDC, 2012b). The adult mosquito is the one human beings often come to closure with. When the *Anopheles* mosquitoes are feeding they position to an angle on the surface, and this behavior distinguished them from the *Culex* which stands parallel in the surface (Webber, 2009). Indeed, environmental factors influences distribution and transmission of malaria in large extent. A study in Nigeria indicates that rain provides breeding site for mosquitoes and increased humidity enhances the survival of the vector. It further stated that temperature affects transmission cycle of malaria. At below 22$^{o}$C, determining number of mosquitoes surviving the parasite incubation period of 55 days at 18$^{o}$C and stops at 16$^{o}$C (Akande T.M & Musa I.O, 2005).

Mosquito breeds every time of the year in tropical countries, however, they increased number during the raining season (World Health Organization, 2006). The adult mosquitoes survive maximum of two weeks and this hinges on the conditions such as temperature, humidity and type of species (Beck-johnson et al., 2013; CDC, 2012a). The breeding of mosquitoes is favored if the relative humidity is above 60% and temperature maintains within 16.0 C to 40.0 C (Beck-johnson et al., 2013; Yamana & Eltahir, 2013). The female Anopheles frequently needs blood meals to develop its eggs. It is during this process that plasmodium parasites is deposited to human (Shililu, 2001). Anopheles mosquitoes detects the humans using stimuli to pick respired carbon dioxide and smells. It is these stimuli that lead the mosquitoes to humans for blood meals resulting in the transfer of the plasmodium species to human (Braack et al., 2015; Shililu, 2001). How far Anopheles mosquitoes could go from their habitats depends on the type of species, landscape, the prevailing environmental conditions like temperature and wind speed and among others. Though mosquitoes are usually found approximately to two to three kilometers away from their habitats (Thomas et al., 2013), it was established that wind could move the vectors beyond these limits (Lindsay et al., 1995; Midega et al., 2012). Interventions at small unit levels to reduce the habitants and places of reproduction have positive impacts of reducing the parasites population and the disease (White et al., 2011). In designing a control method, it is important to factor in time and place of mosquito dwellings. Mostly, the female anopheles mosquitoes forage at the evening and at dawn with only small number feeding in the day (Ndoen et al., 2011). Research conducted in Africa, indicated that the female vectors take blood meal during night and inside room (Gatton et al., 2013; Hubo et al., 2013; Killeen et al., 2013; Seyoum et al., 2012). When the female anopheles finished taken blood meal, it rests to help the eggs grow. Though some mosquitoes stay inside rooms after feeding, others rest in places like vegetation (Cottrell et al., 2012; Malaria Consortium, 2007; Warrel & Giles, 2002).

## 2.6 Global Malaria Burden

Malaria can be found in every region of WHO, however, biggest problem is found in African continent. Some countries in West Africa shoulders more than 100 cases of confirmed malaria in 1,000 population (Figure 9). Malaria kills more compared to all other diseases in sub-Saharan Africa. Children below five years are mostly affected (Abdul-Aziz A.R.;, 2012; Cibulskis et al., 2016). The WHO African region 47, including Ghana, Nigeria, Democratic Republic of the Congo, Uganda, Mozambique, Burkina Faso, Mali, Guinea, Niger, Malawi, Côte d'Ivoire, Cameroon, Ethiopia, Kenya, United Republic of Tanzania, Benin, Togo and Sierra Leone mostly affected with malaria. There are 11 South-East Asia, 21 Eastern Mediterranean, 27 Western Pacific, 53 European and 35 America countries formed World Health Organization (WHO, 2015a). Whiles Africa regions accounted for about 82% of all malaria cases, South-East Asia responsible for 15% whist 5% for Eastern Mediterranean region (WHO, 2014c). Recent estimate show that many as 3.3 billion population were risked of malaria, most of these were in poorer Africa countries (Roll Back Malaria, 2008). In 2015, it was estimated 214 million people globally were infected with malaria and 88% of the cases occurred in Africa (Cibulskis et al., 2016). In 2012 Ghana was among top most five countries in Sub-Sahara Africa region to report malaria cases (WHO, 2014c).

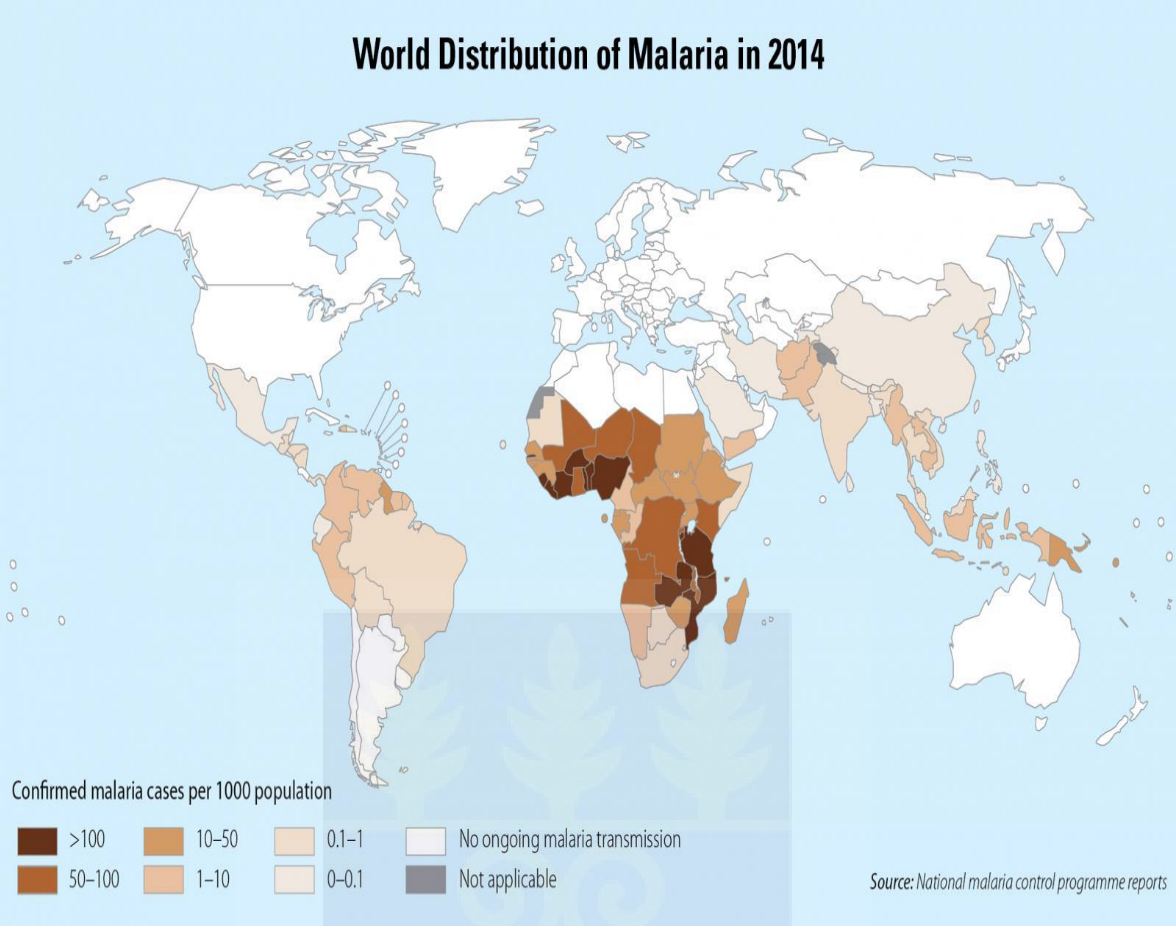


**Figure 9: Global distribution of malaria, 2014**

Curtesy: World malaria report, 2014

Malaria causes serious illness and deaths and it has affected most endemic nations of which Ghana includes. Malaria could cause terminal disabilities including neurological disabilities, and damage to cognitive advancement in children (Sicuri, Vieta, Lindner, Constenla, & Sauboin, 2013). Malaria disease comes with huge economic burden and this is highly shouldered by poor nations (CDC, 2014; Sicuri et al., 2013). Total costs of a malaria incident based on severity of disease, complication and co-morbidities ranged from dollars $8.0 to $229 in Ghana, $5 to $137 in Tanzania, and $11 to $ 288 in Kenya (Sicuri et al., 2013). A study carried out in Ghana showed that, on the average three workdays is lost per fever episode by the patient and two workdays by the caretaker. The value of these days lost to the management and treatment of fever per episode cost approximately $7.0 and this amounted to about 79 % of the cost of seeking treatment (National malaria Control Programme, 2013). Families in rural areas of evolving nations can hardly access malaria prevention interventions like insecticides treated nets. Furthermore, the negative impacts on the economic as a results of malaria in Africa is more than one percent of Gross Domestic Product (VPWA Ghana, 2011; WHO, 2014d). The burden of malaria is not only limited to the individuals but also to the health systems endemic nations, especially among these is sub-Sahara Africa.

### 2.6.1 Malaria burden in Ghana

Malaria found to be the number cause of illness and death in pregnant women and children below the age of five and is responsible for most hospital attendance in the country (GSS/GHS, 2009). Malaria is hyper endemic in Ghana, about all the 26 million population at risk of malaria infection (National malaria Control Programme, 2013). Environmental determinants like land cover of vegetation (savannah, tropical forest, and mangrove), swampy areas, rainfall patterns and average annual temperatures of 26 degree centigrade (26$^{o}$C) all affect risk of disease transmission. The rain fall ranging from 100mm to 2800mm and altitude 0-750m above sea level create conducive environment for the mosquito vectors to breed which significantly increase the malaria risk in Ghana (National malaria Control Programme, 2013)


**Figure 10: Ecological Zones of Ghana**

Source: National malaria control programme, 2013

***P. falciparum*** accounted for about 90% to 98% of malaria morbidity in Ghana, while ***P. malaria*e** and ***P. ovale*** represent 2%-9% and 1% respectively (Afudego, 2011). In 2009, Ghana recorded 3.7 million malaria cases with 26% confirmed (VPWA Ghana, 2011), while in 2012 cases per 1000 population was 300 cases per 1000 population (National malaria Control Programme, 2013; VPWA Ghana, 2011). According to NMCP (2010) report, total OPD cases (approx. 10 million) in the country, 4 million (38.2%) were attributed to malaria. The most affected people were pregnant women and children (NMCP, 2010). Indeed, malaria prevalence in Ghana among children 6-59 months old is shown in figure 11.

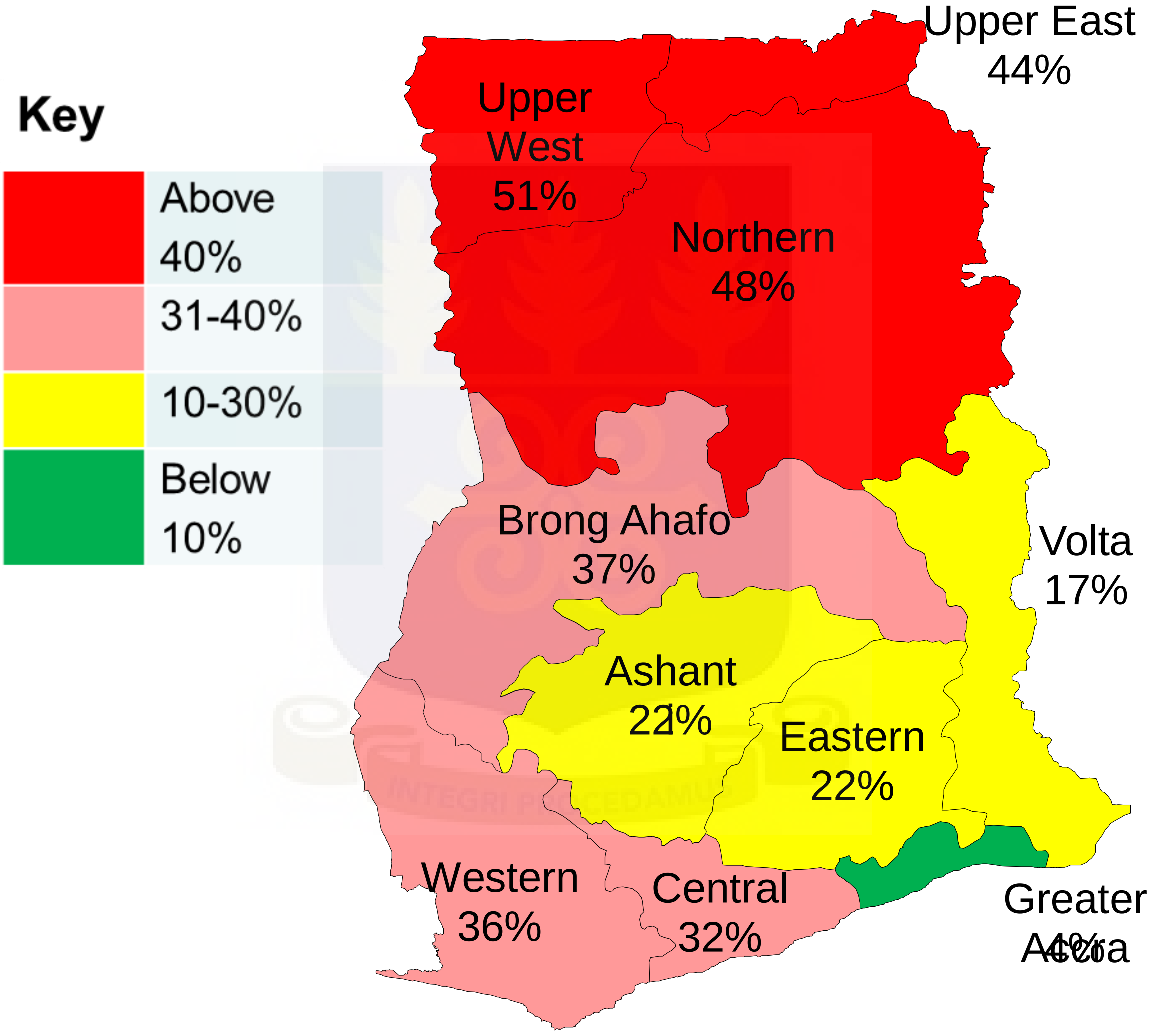


**Figure 11: Distribution malaria prevalence in 6-59 months old children, Ghana**

Source: National Malaria Control Programme, 2013

## 2.7 Mining and Malaria

Mining plays very fundamental role in the livelihoods of human and their settlements. It also affects the national economy positively but at the same time has contributed to the spread of malaria in the mining settlements (Castellanos et al., 2016, Knoblauch et al., 2014).

Gold and diamond are the most exploitable natural resource globally. Approximately, 9 million artisanal miners are actively working in the mining sectors. Though mineral exploration has contributed to the livelihoods of many people, to large extend it leaves a negative effect on the environment, which eventually detrimental to livelihoods (Chupezi, Ingram, & Schure, 2009).

The Amazonian study shows that annual incidence of malaria in Brazil went beyond 10 times since 1970, because of human movement, agricultural and open or surface mining areas in the Amazonian rainforest (da Silva-Nunesa et al., 2012). Approximately 315,000 malaria smear positives confirmed in 2008 of which 99.9% were confirmed in the Amazon Basin. These cases represent over 56.1% of all confirmed malaria diagnosed in Caribbean and Americas in 2008 (da Silva-Nunesea et al., 2012; PAHO, 2009). According to Sibergeld et al, (2002), last decade has seen re-emergent of malaria in South America (Loreto and Peru) where no reported of malaria. According to the study, in 1999, there were 54290 confirmed slide cases of *P. falciparum* malaria reported such that majority of the cases came from mining areas of the Amazon (Silbergeld et al., 2002). The negative influence on the environment due to activities of miners, affect miners, their families, and their communities. The open pits that fill with water during the rainy season may serve as a breeding ground for mosquitoes or other parasites (Smith, Ali, Bo, & Collins, 2016). There are studies that revealed that gold mining contributes to spread of malaria through changes in the ecosystem. There were reasons cited for this happened including immunologically naïve persons come into direct contact of malaria vector, the techniques employed in mining provide conducive environment for malaria vectors to breed, the activities create pools of water which aid the mosquito to propagate and survival. The mining activities increase human contacts with the mosquito vector and miners inhabit in areas that are hard to reach for surveillance activities, diagnosis and treatment. Lastly gold mining involves constant movement from place to place, this creates a mobile reservoir of human to spread the disease locally and across other settlement, both in in and outside the area. (Silbergeld et al., 2002; Smith et al., 2016). A study carryout on abandon pits from granite, quarries and agriculture revealed challenges in total eradication of malaria, because of water bodies that are sheltering numerous species of malaria organisms (Fernando, Jayakody, Wijenayake, & Galappaththy, 2016), which serves as reservoir for recurrent of malaria in places malaria have been eradicated. Another study in the French Guiana among illegal miners indicated high malaria prevalence of which *P. falciparum* accounted for majority of cases. In the same study asymptomatic malaria infections was 48% of the cases (Santi et al., 2016). Lihir Gold Limited (LGL; Newcrest Mining ltd), a mining company in Papua New Guinea, recognizes that malaria was a major issue affecting employee health and surrounding communities conducted study. Overall, 33.3% of the study participants had malaria parasites. Species distribution included *P. vivax* (57.0%), *P. falciparum* (40.4%) and *P. malariae* less common (2.6%) (Mitjà et al., 2013). Ghana recognizing the effects of mining on malaria transmission, conducted a baseline survey prior to start of mining activities of New-mont Ghana Gold limited in 2006/2007. The study was conducted in four districts in Brong Ahafo region. The prevalence of malaria among children below five years was 22.8% (Asante et al., 2011). *P. falciparum* constituted 98.1 % of the cases, *P. malariae* was less common 1.9%, there was no case of *P. vivax, P. ovale* detected and was no mixed infection (Asante et al., 2011). A study by Nartey et al (2012), at Lower Manya Krobo District to assess the effect of quarry mining activities on disease transmission has revealed about 8-folds increased in malaria transmission after inception of the quarry activities. The prevalence of malaria before quarry mining was 5%, but this increased to 40% after work has started in the communities (Nartey, Nanor, & Klake, 2012a). Indeed, mining activities challenge the success of malaria control programmes. However, a study conducted in 47 endemic municipalities including gold mining areas in Colombia, between 2010 to 2013 found that the national prevalence of malaria was 89.3% (Castellanos et al., 2016). Of this, mining areas reported 36% of the malaria cases. This figure might probably be under recorded due to movement of illegal miners. The study further indicated that cases of malaria were low at alluvial (artisanal) mining areas (Castellanos et al., 2016).

### 2.8 Severe Malaria and Inpatients

The National Malaria Control Programme (NMCP) (2013), annual report, shows increasing trend from 2005 to 2012 of children under five inpatient malaria (severe malaria) cases as opposed to the non- malaria inpatients cases in 83 hospitals in Ghana. However, in the 2014 annual report of Ghana Health Service, cases that went on admission which were attributed to malaria had decreased from 38.8% in 2012 to 27.3% in 2014 (Ghana Health Service, 2015). A cross sectional study conducted in Burkina-Faso between July to September, 2012 found that of the 510 participants recruited on admission, 201(39.41%) were severe malaria cases (Zoungrana, Chou, & Pu, 2014). In this study the mean age of severe malaria cases was 19.7 months (SD=11.5). Majority of the severe cases 114(56.7%) were male and about 173(86.1%) lived in rural settlement. Indeed Greenwood et al., (1991) found that about 2% of clinical malaria cases in Africa were severe malaria. In a retrospective cross sectional study conducted for the period 2000 to 2010 in Singapore reported that of the 214 cases malaria recruited 43(20.09%) of the cases were severe malaria (Chung, Guek, Low, & Wijaya, 2014). These findings were however limited in information regarding age and sex distribution.

## 2.9 Malaria Prevention

### 2.9.1 Historical and Global Perspective

An intervention programmes to stop malaria in widespread regions worldwide started in the nineteenth century when the malaria was widespread in most continents (WHO, 2008). In 1955, the Global Programme to eradicate malaria was launched by WHO. This programme used dichloro-diphenyl-trichloroethane (DDT) for Indoor Residual Spray in countries that were heavily infected with the plasmodium vectors (Sadasivaiah & Breman, 2007). Though, application of DDT was seen to be effective against the mosquitoes, the benefits was for only short period (Anto et al., 2009). In 1978, World Health Organisation shifted from eradication to controlling which involved reduction in malaria to lowest bearable which would no long be public health threat. The effort to control malaria went beyond the use of DDT, as such environmental management programmes were instituted as alternative (Walker, 2000). This involved desilting drainages to allow water flows freely, clearing bushes around houses, refilling of dugout or pits and using living organisms to feed on the larvae of the mosquitoes (Musoke, 2015). By the year 1982, as much as 24 countries in Europe were free freom malaria (WHO, 1999; WHO, 2008a). Subsequently, other nations like Maldives, United Arab Emirates, Turkmenistan and America were declared malaria free countries in 1984, 2007, 2010, and 2011 respectively (Meleigy, 2007). Kyrgyzstan was the most current country to be certified malaria free nation by WHO in 2014 (WHO, 2014e). Malaria Control

Programmes are managed by WHO globally (WHO, 2014e). It has among other things responsible for leading the course of malaria control. In addition, the Global Malaria Programme provides guidelines based on established research for malaria control. Before 2000, World Health Organisation rolled out the Roll Back Malaria (RBM) crusade and was prioritized on the international agenda. Indeed, huge sums of money was invested in the programme by many allies United State President's Malaria Initiative as Global Fund United Nations Children's Fund (UNICEF), and among others (Roll Back Malaria, 2014). Most of the money were used to finance interventions projects like Insecticide treated Nets, Indoor Residual Spray and treatment cost for pregnant women and children under five years. (WHO, 2011). There are two main interventions WHO recommends, such as treated bed-nets and indoor residual spraying. Insecticide Treated Nets usage as well as Indoor Residual Spray has been accepted across the world in very recent (WHO, 2014). Certainly, several endemic countries have formulated policies which has ensured these interventions through mass crusade. Though, the crusade on ITNs usage has largely promoted, only 29% of households have adequate ITNs for all households member (WHO, 2014e). Furthermore, less than 4% of the world population that were at risk of malaria infection used IRS in 2013, in spite of WHO recommended 80% of houses coverage (WHO, 2014e). The ITNs and IRS usage is threaten by vectors developing resistance to the insecticides used in treating the nets and spraying (Anto et al., 2009). The alternative method to malaria control would involve good environmental management such refilling of diches, clearing of bushes around houses desilting gutters, proper management of landfilled sites and biological control using larvivorous fish in pond (Mabaso, Sharp, & Lengeler, 2004). Though, ITNs and IRS usage have proven to reduction in malaria in countries like Ghana, Uganda, Mozambique , Zambia and Kenya (Anto et al., 2009; Eisele & Steketee, 2011; Kim, Fedak, & Kramer, 2012). Other researchers have attributed the non-patronage among rural communities to high cost of ITNs (Willey,Paintain, Mangham, Armstrong, & Willey, 2012). However, free insecticide nets were used for finishing in countries such as Zambia, Tanzania, and Rwanda (Ingabire et al., 2015; Mclean et al., 2014).

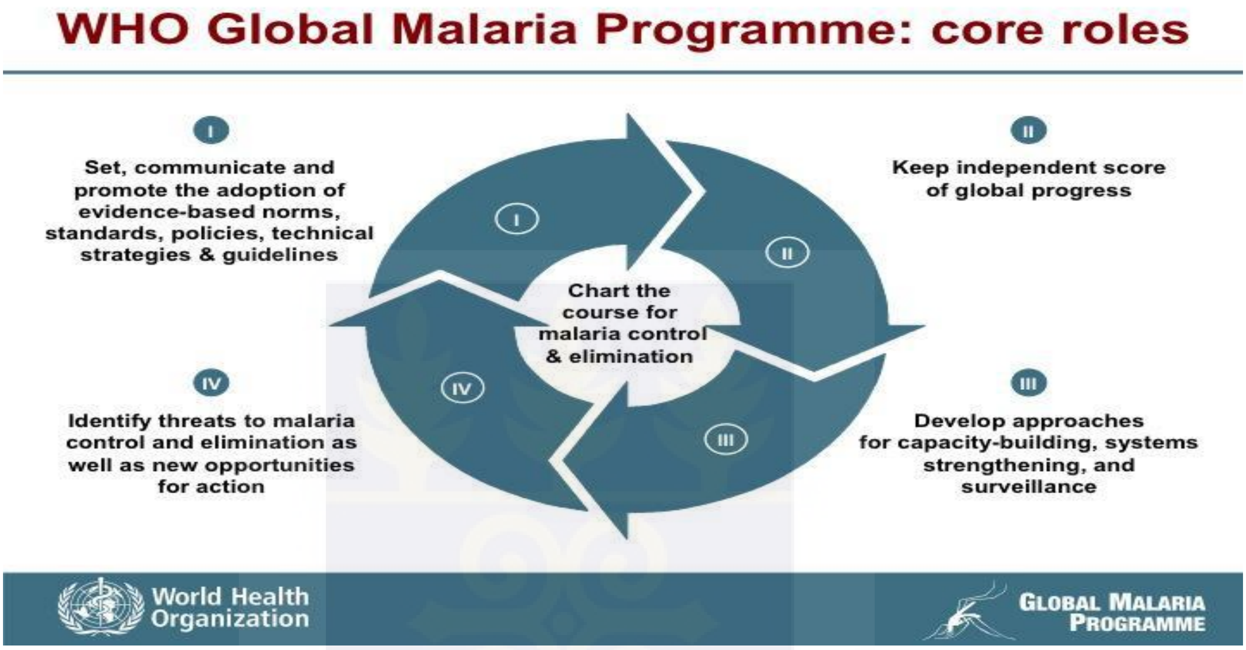


**Figure 12: Roles of global malaria control programme**

Source: http://www.who.int/malaria/about_us/en/ (access 24/07/2016. 00:04)

### 2.9.2 History of Malaria Control in Ghana

The attempt to control malaria in Ghana began in the 1950s with the aim of reducing the malaria disease burden till no longer of public health significance. It was further identified that malaria controlled may fail if handle by the health sector only, therefore multifaceted policies were formulated to include other sectors. In view of this series of interventions were instituted to help in the control of malaria disease. Some of the interventions include residual insecticide application against adult mosquitoes, mass chemoprophylaxis with Pyrimethamine medicated salt and improvement of drainage system (www.**ghanahealthservice**.org/ghs-subcategory.php?cid=4&scid=41,*24/07/2016, 6:47am).* After the WHO had launched the Roll Back Malaria Policies in 1998, Ghana adopted it in 2000 and the same year signed the Abuja Declaration to halve burden of malaria (Cruz et al., 2006; Ghana Statistical Service, 2011) through:

- Distribution of insecticide-treated nets (ITNs) to cover populations at risk (especially children under the age of five and pregnant women)
- Indoor residual spraying (IRS) to reduce transmission
- Prevention of malaria among pregnant women through intermittent preventive treatment during pregnancy (IPTp)
- Prompt diagnosis and treatment with effective medicine

There are two major approaches of preventing malaria in Ghana. The first is integrated vector control which primarily aims at reducing man-vector contact through the use of Insecticide Treated Nets (ITNs), larviciding and Indoor Residual Spraying (IRS).

The second preventive measure is Intermittent Preventive Treatment (IPT) that targets pregnant women (Ghana Statistical Service, 2011; MOH/NMCP, 2010).

### 2.9.3 Malaria Prevention Methods

#### 2.9.3.1 Insecticides Treated Net

The Insecticide Treated Nets use stems from the recommendation of Sir Ronald Ross in 1910 (Passmore, 2010). During the second world war , Russian, German, and US armies treated bed nets and combat fatigues with residual insecticide to protect soldiers against vector-borne diseases (Lengeler, 2009). In the late 1970s, entomologists used synthetic pyrethroids for vector controls. The significantly high insecticidal activity of these chemicals and low human toxicity has made them ideal for this purpose.

Studies conducted 1980s on ITNs and pyrethroids showed that pyrethroids were safe and ITNs had an effects on several measures of mosquito biting (Lengeler, 2009). ITNs distributed free in 97 malaria endemic regions across the globe. Eight five (85) regions, distributed ITNs or Long Lasting Insecticide Nets (LLINs) to all age groups and in 69 countries, ITNs were distributed to all age groups through mass campaigns. In the WHO African Region with high risk of malaria, ITNs mass campaigns were supplemented by distribution of ITNs to pregnant women at antenatal care (ANC) clinics in 37 countries, and to infants through expanded programme on immunization (EPI) clinics in 29 countries (WHO, 2014e). Ghana Health Service (GHS) in 2006 distributed over 20% of ITNs to children under five and pregnant women in Upper East, Upper West and Northern region. The use of ITNs had increased from 3.5 to 21.8 by 2006 (UNICEF, 2007). Studies have shown that use of ITNs could prevent up to 7% of global under five mortality and 48% to 50% episodes of malaria (Cruz et al., 2006). A number of such studies was conducted by Haji et al (2015) who found that household possession of mosquito treated net in Ethiopia was 51%. Among the households that owned ITN, 34.7% had one net, 48.5% two and 17% possessed three or more insecticide treated nets. Of the participants who possessed insecticide treated nets, 58% said they slept under nets each night in the past 15days and 76% slept in insecticide treated nets on the previous night. The proportion of children who slept under nets each night in the past15 days were 62% and 75% reported sleeping under insecticide treated nets the previous night before the study.

### 2.10 Factors Associated with malaria infection in children

There were many studies conducted across the globe which showed that various factors including socio-economic, demographic, environmental and others factors, associated with malaria infection (Roberts & Matthews, 2016). For instance, Roberts & Matthews conducted study in Uganda which involved 4939 children under five, of which 974 (19.7%) tested positive for malaria. There was vast difference in the disease burden of malaria across the regions and health facilities (Haji, Fogarty, & Deressa, 2016a; Roberts & Matthews, 2016). The ratio of male to female prevalence of malaria in children under five was about 1 (19.6%: 19.6 %). This suggested that gender was not significantly associated with malaria infection in children (Roberts & Matthews, 2016). Other studies indicated that age of child in months, parents/caregivers education, and place of residence, housing type and ITNs possession significantly influences child malaria status. A study by Wanzirah et al, (2015), revealed that modern housing was associated with low malaria infection in children. In this study 6816 children were recruited and examine for malaria, 1061 tested positive. Link of housing type and malaria infection varied significantly by site ($p < 0.001$). The likelihood of malaria infection was low in children who live in modern houses compare to those who live in traditional houses (Walukuba) (OR) 0.35, 95%CI 0.13 0.92, p = 0.03), Kihihi (OR = 0.27, 95%CI 0.10–0.71, p = 0.008) and Nagongera (OR 0.59, 95%CI 0.38–0.90, p = 0.01). In the study, after adjusting for age, gender, site and house wealth, the odds of malaria infection have been reduced by 56% in children living in modern houses (OR 0.44, 95%CI 0.30–0.65, p<0.001). A similar study was conducted by (Tusting et al., 2015) found similar result that people who live in modern houses had low chances of malaria compared to those in traditional houses (OR: 0.46, 95 % CI 0.33–0.62, p <0.001). According to Haji et al, (2015), household that possessed ITNs has reduced odds of malaria infection. The adjusted odd ratio (aOR) was found to be 0.69 (95% CI; 0.56-0.85). However, the finding was contrary to work done by Roberts & Matthew (2016) found that use of insecticide treated bed nets or untreated nets, the number of nets possess by household and child sleeping in the net night prior to the study was not significantly associated with malaria in children. This study sampled insecticide treated bed nets from the households. The mean net possessed per household was 2.9 and the median was 3 nets ranges (1 to 7) nets. About 96% of the households possessed a single mosquito treated net, whereas 76% of the study population in selected households slept in long lasting insecticide treated net (LLIN) night prior to the survey. The study of Haji et al (2015) and Roberts and Matthews (2016), further found that odds of malaria infection was high as child grows older (aOR, 2.19, 95% CI: 1.25-3.83) compared to very young children (under two years). However, gender of the study participants, household income level, seeking advice before visiting the current health facility, intervals between onset of disease and treatment, and knowledge of the causes of malaria by the caregivers were not significantly related to malaria infection in the children (Haji et al., 2016a).

Furthermore, effect of mother's level of educational was found to be significantly associated with odds of a child having malaria. For instance, a child whose mother's level of education was Secondary or Higher had lower relationship of malaria compared with the counterparts with Primary education or no formal education (Adebayo, Gayawan, Heumann, & Seiler, 2016). When children of parents with a secondary education were compared with children of mothers who could not indicate their level of education, children of mothers without indication for educational level had at higher chances of malaria (OR 1.97, 95 % CI, 1.35–2.87). Their chances were almost the same compared to the children whose caregivers had no education (OR 1.961, 95 % CI, 1.345–2.858). This indeed, confirmed the thought that caretakers who do not indicate their educational levels mighty be said to have no formal education or dropout of school. In addition, children of caregivers who had only primary education were 59% more the chances of malaria (OR 1.59, 95 % CI, 1.13–2.24). Though, chances of malaria in children of caregivers with a higher education was 0.40 times compared with children of caretakers with a secondary education only, statistically there was on difference between the group (p = 0.2463). Finding further suggested that household wealth, number of sleeping rooms and ethnicity is significantly associated with child malaria. There was high odds of child having malaria if coming from poorer household compared with children from rich households. Another study by Graves et al., (2009) found household possessing of at least a single LLIN [(OR) = 0.66, 95% CI 0.43—0.96, *P* = 0.03], number of LLINs per household [OR = 0.76 (95% CI 0.60 - 0.95) and the asset index (OR = 0.80, 95% CI 0.67- 0.95, *P* = 0.01) to be associated with reduction in malaria.

People who were rich had lower malaria prevalence (OR = 0.44, 95% CI 0.25- 0.77, *P* = 0.004). Although, sleeping in any type of net previous night before survey reduces prevalence of malaria, this association was not statistically significant. Furtherance to the universal analysis was multivariate logistic regression with stepwise elimination showed that increase wealth index significantly reduces malaria prevalence (OR = 0.79, 95% CI 0.66 - 0.94, *p*= 0.009). Thus, children whose parent have high incomes were 31% (95% C.I. = 6% - 54%) less likely of malaria infection than children who were from poor parents.

The number of long lasting insecticide nets in a house was found to be associated with lower malaria prevalence (OR = 0.60, 95% CI 0.40 - 0.89, *p*= 0.012). It also revealed contrary to the univariate analysis, the variable ‘slept under LLIN last night’ was associated with increased chances of malaria after adjusting for other factors, although this was not statistically significant (*p*= 0.070). According to the Ghana Urban Malaria Study, (2012) made vital findings regarding some important determinants of prevalence of malaria in Ghana. For instance, children living in Accra were 86% (96% C.I. = 66% – 94%) less likely to be infected with malaria compared to children in rural settlements of the coastal zone. Children in the Kumasi were 85% (95% C.I. = 66% - 93%) less likely to be infected with malaria as opposed to children in the rural areas of the forest zone. Finally, children in Tamale were 68% (95% C.I. = 37% - 84%) less risk of malaria infection compared to their counterparts in the rural area of savannah zone.

### 2.10.1 Anemia in Children

An estimated burden of anemia in developing countries was 3.2 billion, of which Africa shouldered 64.6% and about 50% and 60% more compared to Europe (16.4%) and North America (3.4%) respectively (Ewusie, Ahiadeke, Beyene, & Hamid, 2014). In West Africa the prevalence of anemia as results of malaria ranges from 17 – 54% (Sowunmi, Gbotosho, Happi, & Fateye, 2010). Plasmodium falciparum (Pf) largely invades red blood cells (RBCs) that cause acute hemolysis and interferes with the development of the RBCs leading to severe anemia (Adebayo et al., 2016).Anemia is defined as children under 5 years of age with hemoglobin level less than11.0 g/dl are considered anemic (WHO. 2008). The cut-off values for the various levels of severity were: < 7 · 0 g/dl for severe anemia, 7·0 g/dl - 9·9 g/dl for moderate anemia and 10·0 g/dl - 10·9 g/dl for mild anemia. Ewusie et al, (2014) in the study of anemia among children under five in Ghana found the prevalence of anemia in children under five to be 78.4% (95% CI; 76.7 – 80.2%), of this 7.8% (95% CI: 6.63-8.91) of the children were diagnosed of severe anemia, 48% (95% CI: 45.9-50.2) moderate and 22·6% (95% CI: 20.8-24.4) had mild anemia. The prevalence of anemia was high among younger (< 2 years) compared to older children that is 85.1% (95% CI: 81.9-88.2) and 70.5% (95% CI: 66.2-74.4) respectively. Similar study conducted in Accra and Kumasi found that anemia prevalence decreases with increasing age. The study found high above 60% of the younger children (6 – 24 months) to be anemic (Klinkenberg et al., 2006). With Ewusie et al, (2014) there was no different in gender regarding anemia in children. However, the prevalence of anemia was lower 81.2% (95% CI: 75.7-86.9) in urban children under five compared to rural children 90.1% (95% CI: 85.5-94.8). Furthermore, the distribution of anemia across the country saw Upper East and Upper West region having the highest prevalence of anemia. It was further reported that 9 children out of 10 children in these two regions were anemic with the estimated prevalence of 88.9% (95% CI: 80.9-94.0) and 88.1% (95% CI: 76.4-94.6), respectively. The lowest anemia prevalence was reported in the Greater Accra region, 62.3% (95% CI: 56.0-68.3). It is interesting to note that Eastern region with only 32% urban area contributed less to anemia prevalence compared to Ashanti region which has 40% urban area. Figure 12, shows the distribution of anemia in Ghana.

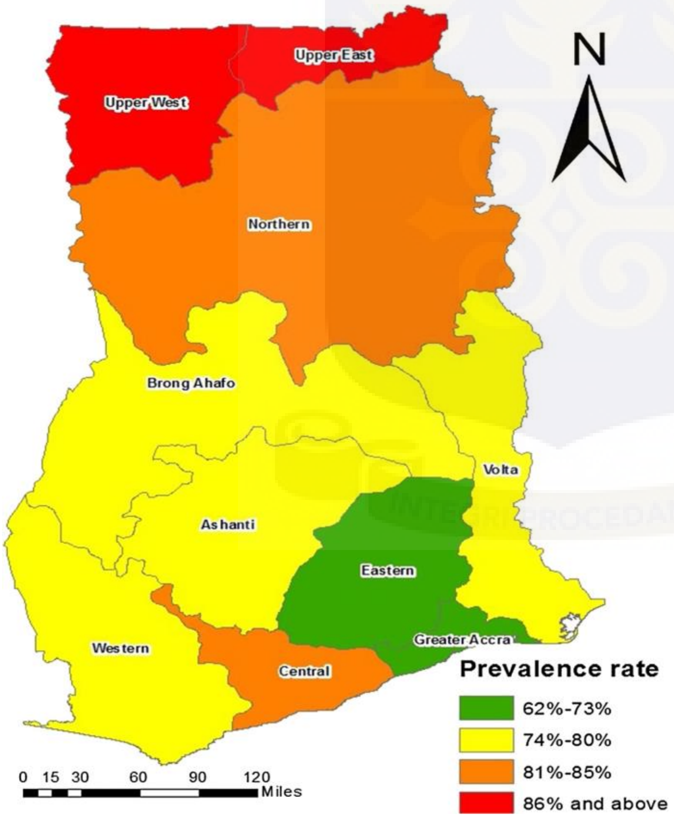


**Figure 13: Concentration of anemia per region in children under five years**

Source: Ewusie et al., 2014.

Another study by (Msangeni et al., 2011) in Bombo regional hospital among severe malaria in-patients found the prevalence of anemia among the patients to be 69.8%. Majority (55.2%) of the cases had mild/moderate anaemia. Severe anaemia was recorded in 14.6%of the patients and the significant percentage (84.7%, p = 0.001) had blood smear positive. The prevalence of severe anaemia was highest in children under five years and decreased with increasing age.

According to Osterbauer et al., (2012) being female, coming from wealthy home and having modern home ware associated with low prevalence of anemia. However, these were not statistically significant.

In the study conducted by (Yeka, Nankabirwa, Mpimbaza, & Kigozi, 2015) on factors contributing to anemia and malaria infection in children from peri-urban and rural regions in Uganda. Generally, hemoglobin level was normal (> 12.0 g/dl) and severe anemia was uncommon at all sites (< 8.0gdl). In the children under five, prevalence of anemia was lower (29.5%) in rural region (Kihihi) compared to Walukuba (peri-urban) (40.7%, p= 0.03). The odds of anemia was high in children under five and decreases with increased age. In the multivariate analysis, age was strongly associated with anemia in children. For children under five years, odds of anemia decreased with increasing age at all sites (0.47 – 0.70) per year increase in age.

### 2.10.2 Parents/Caregivers Knowledge of Malaria

Adequate knowledge on malaria by parents/caregivers for children under five years would promote effective malaria prevention and practices. According to (Thandar, Kyaw, Jimba, & Yasuoka, 2015) in assessing caregivers knowledge of malaria in two villages found that more than 80% of the caregivers recognised chills and rigor as symptom of malaria. Furthermore about 60% of caregivers included sweating as a symptom of malaria, whereas 50% of the participants in the villages recognised that children under five years were at greater risk of malaria infection. Over 90% of the respondents knew that mosquito bite causes malaria. More than 80% of caregivers in the village knew that malaria could be prevented using mosquito nets or Long-Lasting Nets (LLNs). About 90% knew malaria can be treated with anti-malaria drugs. However, there was significant different (p=0.010) about names of the recommended drugs between the villages.

A similar study done by Dhawan et al, (2014) reported that 95.7% of respondents had heard of malaria, but there were differences in awareness across various sectors. All the respondents except one from construction site heard of malaria. In contrast, 17% in the people in the village did not hear of malaria. The respondents who heard of malaria, when stratified into sectors, had variable views regarding knowledge of malaria, symptoms of malaria, transmission of malaria, prevention and control strategies for malaria. When knowledge score assessment was compared, respondents in urban city had higher score (mean=40.2; SD3.6) compared to respondents in slums (mean=36.4; SD, 3.7), villages (mean=36.0; SD, 5.2) and construction sites (mean=34.7; SD, 4.4) at p=0.001. Almost 93% of the respondents knew that malaria is caused by mosquito bite. However, most of the respondents also have wrongful believe that malaria could be contracted through drinking of contaminated water, eating contaminated food and having close contact with malaria patients. Nearly all the respondents knew malaria infected mosquitoes bite in the dusk and night time. Most of the respondents also believed that mosquitoes bite at dawn and day time. More than 95% of the respondents were aware that stagnant water is a breeding places for mosquitoes and such, mosquitoes do not breed in clean arid places. Majority of them recognised that other sources of mosquito breeding include bushes, domestic animal shelters and dark corners. The study further revealed large proportion of respondents identified fever as symptoms of malaria. The respondents to large extend knew there are drugs to treat malaria. Indeed, large percent of respondents identified ITNs usage, IRS and ensuring clean surrounding as mean of malaria prevention.

A study conducted in Ethiopia by Haji et al, (2015) among febrile ill children, found that 87% of the participants related the cause of malaria to mosquito. Whereas 28% incorrectly mentioned hunger. About 19% thought malaria is caused by eating maize stalks. However, 92% recognised fever, 73% headache, 68% feeling cold and 67% thirsty as the symptoms of malaria. Majority of the respondents (89%) knew that sleeping under mosquito treated net prevents malaria infection. Whiles on averagely about 50% of respondents cited draining mosquito breeding sites, keeping surrounding clean and using indoor residual spray as means of preventing malaria.

# CHAPTER THREE

# METHODS

## 3.1 Study Design

The study was hospital based cross-sectional in which children under five years who attended or were admitted to the hospitals during the 13 months period from January 2016 to January 2017 were included. All caregivers of patients who were under five years and agreed to participate in the study were interviewed using a structured questionnaire. The demographic, socio-economic, and household data were collected. Information were also collected regarding knowledge on malaria transmission or infection, prevention, and treatment. We reviewed facility records and obtained demographic and clinical/laboratory data about the children under five years in the artisanal mining district (Tongo) and the non-mining districts (Bongo) in the Upper East Region.

## 3.2 Study area

The study was conducted in two districts in the Upper East Region of Ghana, malaria endemic areas. These comprise of Talensi and Bongo Districts in the Upper East region.

The Talensi District was originally part of the Talensi-Nabdam district in the Upper East region but was created in 2012 with Tongo as the capital (Ghana Statistical Service, 2014c). It is bordered to the north by the Bolgatanga Municipality, to the south by the West and East Mamprusi districts (both in the Northern Region), to the west by Kassena-Nankana District, and to the east by the Bawku West and Nabdam Districts. The district lies between latitude 10$^{o}$ 15' and 10$^{o}$ 60' North of the Equator and longitude 0$^{o}$ 31' and 1$^{o}$ 05' West of the Greenwich meridian. It has a land area of 838.4 km$^{2}$. The district is characterized by rock outcrops and highland slopes with relatively undulating lowlands with gentle slopes ranging from 1$^{0}$ to 5$^{0}$ gradients at the Tongo areas. The main river in the district is the White Volta and its tributaries. The area has about five small dams and few dugouts that get dry up in the dry season. The occupation of the people is mainly peasant farming, small scale mining and petty trading. The district is divided into seven sub-districts with 2016 projected population of 87218. The population of 17444 is made of children age 0-59 months (GHS, 2016). The district has 18 health facilities comprise of a hospital, health centres, clinics and Community-based Health Planning and Services (CHPS) compounds. About eighty-four percent of the population is rural GSS, 2014). The inhabitants in various communities' dependent on subsistent rain-fed agriculture during the wet seasons which stretches from May to October and on livestock rearing. The mean annual rainfall for the district is 95mm and ranges between 88mm-110mm. The areas experience a maximum temperature of 45 degrees Celsius in March, April and a minimum of 12 degrees Celsius in December.

In 2003 gold mining activities started in Talensi District and by 2006 the Mineral Commission started licensing the small-scale miners in the district. The Talensi District has several artisanal mining sites including Tarkwa, Accra, Kejetia, Obuasi and World Bank all in Gbane, Datoko and others in Sergah communities which are likely to affect health and socio-economic indices of the people. These sites are located approximately 1 to 5 kilometers radius in the communities. The miners indulged in artisanal mining which is limited to surface or alluvial mining. The miners employed dig and wash method except for Shaanxi mining service which is mining underground on two concessions. The chiefs and the District Assembly ensure most of the abandoned concessions, the pits were refilled with the top soil or solid waste. The pits that were in use but left during a rainy season, the miners usually add dirty engine oils to the pits.

The Talensi District Assembly has in place vector control interventions such as outdoor spraying championed by Zoom Lion and supported by NMCP and Community Led Total

Sanitation (CLTS), supported NGOs. Dugouts used for road construction and molding of bricks are filled after used. The outdoor spraying is done monthly at public places and in the communities. The environmental department of the district has zoned the district and assigned Field Officers to the zones for monitoring, environmental health education and sanitation in the communities

The Bongo District lies between longitudes 0.45$^o$ W and latitude 10.50$^o$ N to 11.09 and has a total land area of 459.5 square kilometres. The district capital is Bongo and the district is among the most populated in the country with 185 inhabitants per square kilometers. The Bongo District shares boundaries with Burkina Faso to the north, Kassena-Nankana East to the West, Bolgatanga Municipal to the south-west and Nabdam District to south-east. The district lies within the Onchocerciasis-freed zone (Ghana Statistical Service, 2014b). The district has averagely 70 rain days in a year, with rainfall ranging between 600mm and 1400mm.The topography of the district is generally flat or low-lying with ridges of granite and Birimian rocks. Areas occupied by granites are of low, gentle rolling relief 90 to 300 metres above sea level. The district is drained by the Red Volta River and its main tributaries including, Ayedama and Kulumasa Rivers. The area has one large dam at Vea which supply water for Bolgatanga Municipal and Bongo district, nine small dams and five dugouts located in Bongo, Gorogo, Gambrungu, Dua, Balungu, Yidongo, Adaboya, Atampinti and Feo (Ghana Statistical Service, 2014b). Bongo is one of the districts that had enjoyed much supports from Non-Governmental Organization in the Upper East Region. However, it is one that resists reforms or changes just in the name of poverty. The district has communities with wetland areas which are used to cultivate rice with the least rain. Communities such as Gorogo and Vea and Gowire farm during the dry season using dugout or wells to irrigate the crops in the district. Farming in the district is mostly done by women and they usually farm very close to the houses during the rainy season. Bongo District also has in place outdoor spray at target areas in the district. The Community Led Total Sanitation in the district is defunct. The district is divided into 6 sub-districts with about 90818 population. The population of children aged between 0-59 months for 2016 is 18163 (GHS 2016). The district has forty-two (42) health facilities, comprises of a district hospital, clinics, health centres and Community-based Health Planning and Services (CHPS) compounds. The hospital serves the district as well as the neighboring border communities. Map of Upper East Region with the rectangular shape indicating the district capitals of the two districts (Figure 13)

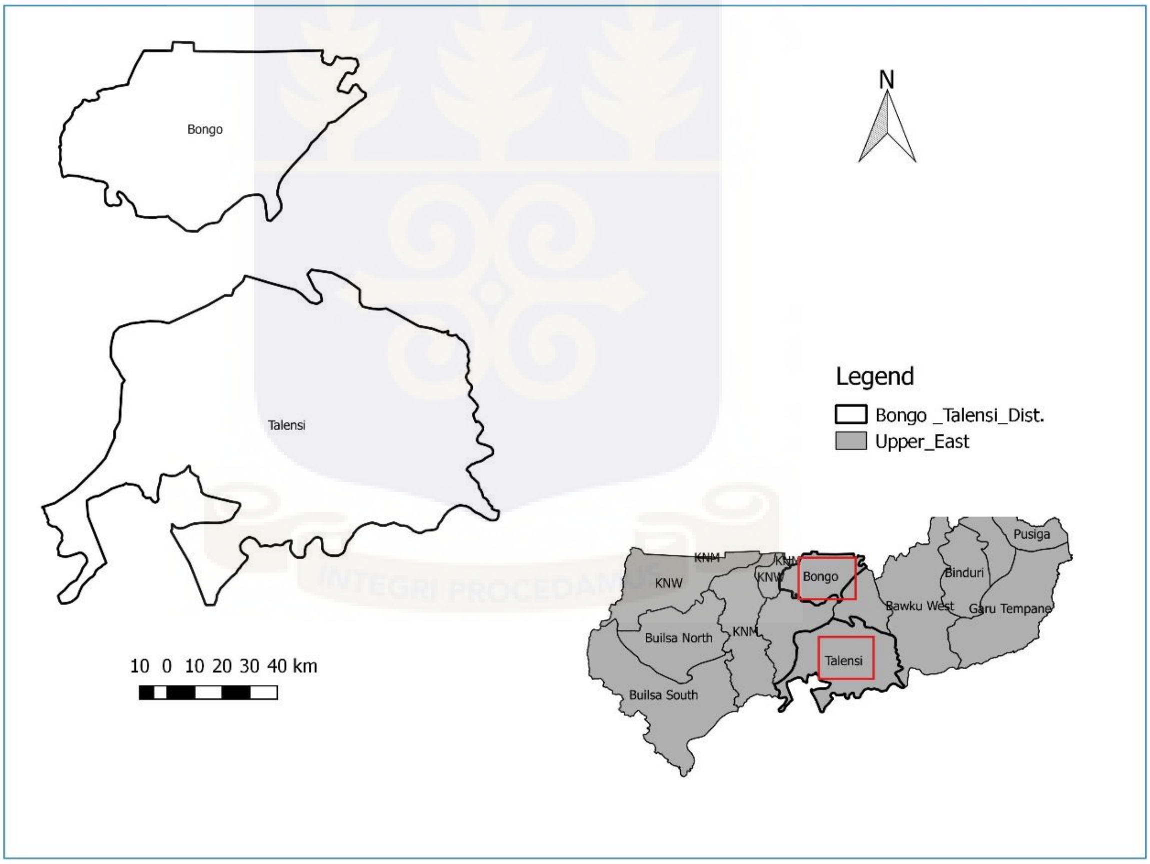


**Figure 14: Map showing study sites in the Upper East Region with the red rectangle pointing to the two study districts in the regional map.**

### 3.3 Facilities Selection and Setting

In each of the district, the district hospital was purposively selected. At the non-mining district, Bongo District Hospital was selected, whereas in the artisanal mining district, Tongo District Hospital in the Talensi District was selected.

The health facilities selection was based on high patient flow and malaria burden in the areas. The facilities are also referral centres for the peripheral health facilities. Each of the hospitals has a bed capacity of about eighty (80) beds of which the pediatric facility capacity was about of sixteen (16) beds. In these hospitals, diagnosis of malaria is based on clinical assessment, microscopic examination of blood films and rapid malaria diagnostic kits (RDT) that guide subsequent treatment using national malaria treatment guidelines (MOH, 2012). The laboratory diagnosis of malaria in these hospitals is based on Gold Standard of laboratory diagnosis of malaria (microscopic examination of blood film) and use of rapid diagnostic test (RDT). The blood films are prepared from finger prick blood samples collected from children clinical suspect of malaria. An experienced Laboratory Scientist prepared the thick and thin blood films on single slides that are well labeled with patient unique identification. The thick and the thin films are air-dried horizontally on slide tray and fixed with methanol for 30 seconds. The slides are then stained with 10% Giemsa stain solution for 20 minutes.

The thick films are used for detecting malaria parasites while the thin films are used for species confirmation. The blood slides are examined and classified qualitatively, as either negative, *P. falciparum* positive, *P. malariae* positive and mixed infection. The blood films are also examined for quantification of the malaria parasites and express as parasites per microliter of blood. According to GHS, (2015) Upper East Regional report, both districts confirmed about 92% of all malaria cases.

Hematological tests (Hemoglobin levels, Full Blood Counts, White Blood Counts) are performed on automated hematology analyzers or semi-automated hematology analyzers and sometimes confirm with microscope examination of blood the films and results are entered into laboratory register.

The health facilities based diagnosis of malaria on the guideline for case management of malaria in Ghana (MOH, 2014). Both districts have instituted the Seasonal Malaria Chemotherapy (SMC) in children under five years.

### 3.4 Study Population

All children under five years who were taken to Bongo and Tongo District hospitals for health care within the period of one year from January 2016 to January 2017 were eligible to participate in the study.

### 3.5 Inclusion and Exclusion Criteria

All children under five years whose records were available at the health facilities were included in the study. Also, children who were seen at the Outpatients Department (OPD) or went on admission at the Inpatients Department (IPD) from 1st-31st January 2017 and their caregivers consented to respond to structured questionnaire were included.

A child was excluded from the study if his/her health record was not available at the health facilities during period under review. Children who were above 59 months and those whose caregivers refused to be part of the study or were not available to consent were also excluded.

### 3.6 Sample Size Determination

All records of patients under five years who received treatment during the period under review (January 2016 to January 2017) were used, therefore no sample size determination was done.

### 3.7 Sampling Methods

A total of 34568 patients visited Bongo District Hospital and 24606 patients visited Tongo District Hospital during the period under review. All the registers were numbered beginning with one. The first register contained records dated from 1st January to the last register which captured information dated up to 31st December 2016. Sampling was done by sequentially reviewing all the records and extracted data on children under five years based on age, as captured by the records. Furthermore, all caregivers of patients under five years who received treatment from 1st to 31st January 2017 and agreed to participate in the study were recruited.

#### 3.7.1 Data Collection Method and Tools

Data collection tools were developed as line listing and structured questionnaire. The line listing form has rows and columns with the columns having the indicators of interest. Each row represented individual information. The structured questionnaire has close ended and open-ended questions. The consulting room and paediatric ward registers captured patient information including age, sex, address, clinical diagnosis, laboratory results, treatments and clinical outcomes of the patients. Whilst the laboratory registers captured data on all laboratory services comprising of malaria, parasitology, hematology and bacteriological information. These registers were reviewed to obtain the principal diagnosis of both inpatients and outpatients cases that were seen from January to

December 2016. Demographic data such as age, sex, address/district and date of visit were obtained using the data abstraction sheet.

Research Assistants stationed at the OPD each day from morning to evening through January 2017, explained the study to caregivers of patients who were under five years both at outpatient and inpatient department. Caregivers who agreed to consent were interviewed using structured questionnaire. Questions administered covered issues on demography (age, sex, place of residence, marital status, occupation, household size, and educational status), knowledge on malaria like signs/symptoms, transmission, infection, treatments, methods of prevention, and insecticides treated nets usage. Data was also collected from children hospital folders.

### 3.7.2 Training of field workers

Field workers were trained a week prior to the start of the work. The training was focused on ensuring that the field workers understood the objectives of the study. They were also trained on the questionnaire and the data abstraction form.

### 3.7.3 Management and Data Analysis

Two data entry clerks independently entered the data into MS Excel version, 2013 and Epidata version 3.1.

The categorical variables( sex, education status, occupation, income level, marital status) of the characteristics of the study participants were analysed into frequencies and proportions and presented in tables. The continuous variables such as age were analysed into means and standard deviations.

Two samples proportion test was used to compare whether difference exist between the districts at 95% significant level. Chi square test and Odds ratio were used to examine an association between exposure variables and malaria. Malaria was the dependent variable and demographic characteristics were independents variables. Univariate analysis was done to determine an association between exposure variables (age, sex, occupation, marital status, income level, educational status, and households' number) and malaria morbidity. Logistic regression model was fitted to correctly predict factors that strongly associated with malaria infection in the districts. This procedure using Stata takes care of interaction and confounders (Norman & Streiner, (2007). A p value of less than 0·05 was considered significant.

### 3.8 Ethical Considerations

Ethical approval was obtained from Ethical Review Committee of the Ghana Health Service. Permission was sought and obtained from Regional Health Directorate and the hospital management team. Caregivers were fully informed about the purpose of the research, procedures, risks and benefits of participating in the study. Those who agreed to participate were made to sign or thumbprint the informed consent form. Participants were assured that their responses would be kept confidential and data collected would be kept for the purpose of this study only.

#### 3.8.1 Participation

Participation in the study was voluntary, nobody was forced or lured to participate in the study. Whether you participated in the study or could not, there was no any form of discrimination in treatments or assistance the hospitals offer.

#### 3.8.2 Risk and Benefits

There was not any risk to participants in this study except time taken to answer the questions. The caregiver interview was short and at a suitable time. The questions were not very sensitive; however, participants were free to decline to questions he/she felt uncomfortable to answer.

During data collection, the facilities were free to decline to provide data they felt they were not comfortable to give out. The facilities reserved the right to reschedule the data collection to the time of the day which they felt would not interfere with their work.

The participants of this study had no immediate or direct benefits. There were not paid or compensated in any form. However, the data and responses that were obtained would be the basis for important information and factors influencing malaria in the districts. This will also affect policy decision concerning malaria control and prevention in the region.

### 3.8.3 Confidentiality

The data that was abstracted from hospital records and information obtained from the parents/caregivers were kept from unauthorized persons. Participants were identified with code and individuals from hospital records were also coded differently from what was in the registers. All the information that were collected would remain solely for the study and would not be shared. The soft copy of the data collected was password on personal computer and the hard copies are under lock and key.

### 3.8.4 Consenting process

A letter of permission to abstract data from hospital records in Tongo and Bongo was obtained from Upper East Regional Director of Health Services office. Permission was also sought from the Health Management Team of the two Hospitals where the study was conducted.

Written informed consent was obtained from caregivers who were interviewed. The purpose of the study was explained to the participant in the language he/she understands.

However, a participant who could not read another person was made to witness the process and both the participant and the witness were made to thumb print or sign the consent and witness form respectively. A copy of the signed form was given to the participant while a copy was kept.

### 3.9 Limitation of study

This study compared malaria in children under five years in artisanal mining (Tongo) and non-mining (Bongo) district in the Upper East region. However, it is not without limitations and therefore should be interpreted in face of the following;

1. Only children under five years who attended the selected health facilities were studied.
2. The study was limited to only two districts in the Upper East region.
3. The data on the children under five years was secondary data and might contain some human errors.

# CHAPTER FOUR

# RESULTS

## 4.1 General Overview

The results are based on data extracted from hospital records of children under five years who were seen in the two district hospitals from January 2016 to January 2017 and data collected from the interview of the caregivers of children under five who were seen in the hospitals in January 2017.

## 4.2 Socio demographic Characteristics of the study participants (children under five years = 11380)

Out of 11380 children under five years, 6228(54.7%) were males. The mean age of the children under five was 23 months (SD ± 14.25 months). However, sex specific mean ages were 23.02 months (SD ± 14.35 months) and 23.04 months (SD ± 14.12 months) for male and female respectively and the difference was not statistically significant (p = 0.93). The mean age for the children in non-mining area (Bongo) was 23.09 months (SD ± 14.15 months) compared to 22.98 months (SD ± 14.32 months) in artisanal mining area (Tongo), with no significant difference (p=0.69).

Most of the children 3039 (26.7%) were between the ages of 10 – 19 months, with males being higher 1714 (27.5%) than the females, which was statistical significant (p = 0.027) as shown in table 1.

**Table 1: Age and sex distribution of children under five years, Tongo and Bongo District, Upper East Region, 2016**

| Age Group (Months) | Sex | | Total |
|---|---|---|---|
| | Male n (%) | Female n (%) | n (%) |
| 0 - 9 | 1131 (18.2) | 947 (18.4) | 2078 (18.3) |
| 10 - 19 | 1714 (27.5) | 1325 (25.7) | 3039 (26.7) |
| 20 - 29 | 1402(22.5) | 1234 (24.0) | 2636 (23.2) |
| 30 - 39 | 1073 (17.2) | 961 (18.7) | 2034 (17.9) |
| 40 - 49 | 900 (14.5) | 678 (13.2) | 1578 (13.9) |
| 50 - 59 | 8 (0.1) | 7 (0.1) | 15 (0.1) |
| **Total** | 6228 (54.7) | 5152 (45.3) | 11380 (100.0) |

Out of 525 caregivers interviewed, majority 479 (91.2%) were females. Most of them 287 (54.67%) were from artisanal mining (Tongo) district. The mean age for caregivers was 27.9 years (SD±7.82) with that in Tongo being significantly higher 29.2 (SD ± 7.50) than mean age in non-mining (Bongo) district 26.3 (SD ± 7.92) and the difference was statistically significant ($p<0.001$). The mean ages for male and female were 30.8 years (SD ± 8.59) and 27.6 years (SD ± 7.70) respectively. The mean age of male was significantly higher than that of female ($p=0.009$). A significant number of caregivers were below 30 years ($p=0.001$) and this is indicated in table 2. The sample population was mainly matrimonial with 87.6% being married, 92.3% of which was in Tongo compared to 81.9% in Bongo ($p<0.001$) district. Majority of the caregivers 349 (66.48%) had no-education or primary education. About 68.5% of caregivers in Bongo as opposed to 64.8% in Tongo had low education. Most of the caregivers 146(27.8%) were traders with about 76 (31.9%) in Bongo as opposed to 70 (26.1%) in Tongo which was statistically significant ($p=0.04$). Out of the 525 caregivers, (91.2%) earned income below three hundred Ghana cedis (Ghc 300) of which significant proportion 97.1% lived in

Bongo as against 86.4% in Tongo. This difference was significant ($p<0.001$). The average household size was 5.7 members (SD ± 2.65). Mean household members in Bongo and Tongo was 6.0 members (SD ± 2.97) and 5.4 members (SD ± 2.32) respectively, the difference was statistical significant ($p=0.01$). Most households 485 (92.4%) slept in Insecticides Treatment Net (ITN) night before visit to hospital. About 94.4% of the households in Tongo as opposed 89.9% in Bongo slept in ITN night before visit to hospital.

The mean members of the households that slept in ITN night before visit to hospital was 4.2 members (SD ± 2.46). The mean members of households that slept in ITN night before visit to hospital in Bongo and Tongo was 3.7 members (SD ± 2.53) and 4.2 (SD ± 2.35) respectively. The difference was statistical significant ($p<0.001$). Majority of the households 318 (60.6%) had more than four members, of Bongo and Tongo had 62.6% and 58.9% respectively of the households with members more than four. However, the difference was not statistical significant ($p=0.39$). About 483 (92.0%) of households with children under five years slept in ITN night prior to visit to hospitals. The range per households with children under years who slept in ITN night before visit to hospital was 0 to 10. The mean children under five years in the households was 1.5 children (SD ± 0.94). There were more households 270 (94.1%) in Tongo with children under five that slept in ITN night prior to visit to hospital as compared to 213 (89.5%) in Bongo.

**Table 2: Socio demographic characteristics of caregivers of children under five years in districts Health Facilities, Upper East Region, 2016 (n = 525)**

| Variables | Districts | | P- value |
|---|---|---|---|
| | Bongo (238) n (%) | Tongo (287) n (%) | |
| **Age** | | | |
| <30 (young adult) | 184 (77.3) | 176 (61.3) | < 0.001* |
| >30 (old adult) | 54 (22.7) | 111 (38.7) | |
| **Sex** | | | |
| Male | 17 (7.1) | 29 (10.1) | 0.23 |
| Female | 221 (92.9) | 258 (91.2) | |
| **Marital status** | | | |
| Single | 37 (15.6) | 14 (4.9) | < 0.001* |
| married | 195 (81.9) | 265 (92.3) | |
| Divorced | 6 (2.5) | 4 (1.4) | |
| Others | 0 (0.0) | 4 (1.4) | |
| **Educational level** | | | |
| Low education | 163 (68.5) | 186 (64.8) | 0.37 |
| High education | 75 (31.5) | 101 (35.2) | |
| **Occupation** | | | |
| Trader | 76 (32) | 70 (27.4) | 0.04* |
| farmer | 66 (27.7) | 75 (26.1) | |
| Civil servant | 14 (5.9) | 20 (7.0) | |
| House wife | 47 (19.8) | 51 (17.8) | |
| Others | 35 (14.7) | 71 (24.7) | |
| **Income level** | | | |
| Low income(<300) | 231 (97.1) | 248 (86.4) | < 0.001* |
| High income(>=300) | 7 (2.9) | 39 (8.8) | |
| **Household Size** | | | |
| Low(<= 4) | 89 (37.4) | 118 (41.1) | 0.39 |
| High(>4) | 149 (62.6) | 169 (58.9) | |
| **Household ITN usage** | | | |
| Slept in ITN | 214 (89.9) | 271 (94.4) | 0.05 |
| Not slept in ITN | 24 (10.1) | 16 (5.6) | |
| **Household with <5 ITN usage** | | | |
| Slept in ITN | 213 (89.5) | 270 (94.1) | 0.05 |
| Not slept in ITN | 25 (10.5) | 17 (5.9) | |

* Significantly difference between Tongo and Bongo District

**4.3 Clinical characteristics of the children under five years, Upper East Region**

Table 3 shows the proportion of various diseases in children under five years in the two districts of the Upper East region. The proportion of malaria in children under five years in both districts was 41.2% (CI: 40.31 – 42.12). However, the proportion of malaria in children non-mining (Bongo) district was 43.8% compared to 39.2% in artisanal mining (Tongo) district. The difference was statistically significant ($p < 0.001$). This shows that there are fewer malaria cases in artisanal district compared with the non-mining district

The overall proportion of anemia in children under five years in the study areas was 1.7% (95%, CI: 1.51 – 1.98) with site specific proportions were 2.7% and 1% in Bongo and Tong districts respectively, and this was statistically significant (< 0.001). Out of 371 children under five years, the mean hemoglobin level was 7.7g/dl (SD ± 1.94) at 95% CI: 7.6 to 8.0 g/dl. The mean hemoglobin level in Bongo was 7.7g/dl (SD ± 2.08) at 95% CI: 7.5 to 8.0 g/dl as opposed 8.0g/dl (SD ± 1.63) at 95% CI: 7.7 to 8.3 g/dl. The difference was not statistically significant (p= 0.26; 95% CI: 0.71 – 0.19).

Proportion of severe malaria in children under five years was 41.1% (95%, CI: 39.7-42.5) with site specific proportion of 57.4% (95%, CI: 56.0 - 58.8) and 27.0% (95%, CI: 25.7 - 28.3) in non-mining (Bongo) and artisanal mining (Tongo) districts respectively. The difference was statistically significant (p< 0.001).

**Table 3: Clinical Characteristics of children under five years in Tongo and Bongo District, Upper East Region, 2016**

| Conditions | Total (11380) n (%) | 95% CI | District | | | | P-value |
|---|---|---|---|---|---|---|---|
| | | | Bongo (4973) n (%) | 95% CI | Tongo (6407) n (%) | 95% CI | |
| Malaria | 4690 (41.1) | 40.31 – 42.12 | 2176 (43.8) | 42.41 – 45.19 | 2514 (39.2) | 38.01 – 40.40 | <0.001* |
| Diarrhea | 1112 (9.8) | 9.23 – 10.33 | 352 (7.1) | 6.40 – 7.85 | 760 (11.9) | 11.12 – 12.71 | |
| Anemia | 197 (1.7) | 1.51 – 1.98 | 134 (2.7) | 2.26 – 3.18 | 63 (1.0) | 0.77 – 1.27 | |
| Malaria / Anemia | 187 (1.6) | 1.43 – 1.89 | 139 (2.8) | 2.35 – 3.29 | 48 (0.8) | 0.60 – 1.05 | |
| Sepsis | 1543 (13.6) | 12.94 – 14.28 | 1063 (21.4) | 20.26 – 22.56 | 488 (7.5) | 6.87 – 8.16 | |
| Bronchitis | 2112 (18.6) | 17.86 – 19.26 | 700(14.1) | 13.14 – 15.09 | 1412 (22.0) | 20.93 – 23.02 | |
| Others | 1726 (15.2) | 14.52 – 15.84 | 548 (11.0) | 10.14 – 11.90 | 1178 (18.4) | 17.46 – 19.36 | |

* Significant difference between Mining and Non-mining district

### 4.3.1 Age distribution of malaria infected children under five years, Tongo and Bongo District, Upper East Region

Figure 4, describes malaria infection in children under five years. Out of 4690 children under five years with malaria infection, most (26.9%) of the malaria infection was in children between ages 20 to 29 months. Less than one percent malaria infection was in adult children (50 to 59) months. The relationship between age and malaria infection was statistically significant (p<0.001).

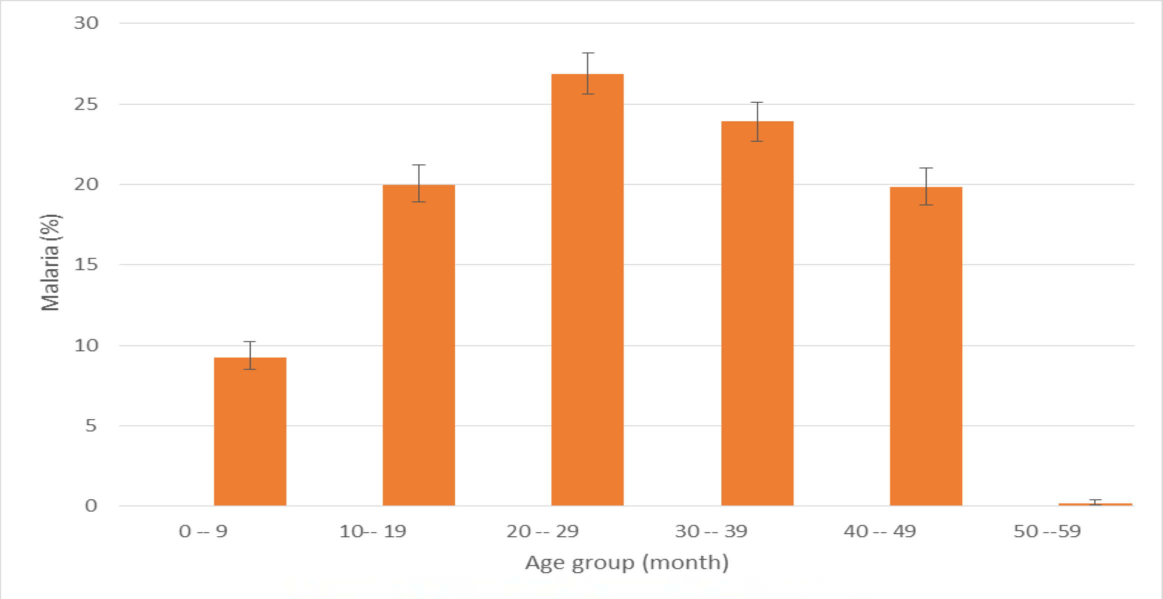


**Figure 15: Children under five malaria infection in different age group (95% CI), in Tongo and Bongo districts, Upper East Region, 2016**

### 4.4 Demographic, socio economic and environmental factors affecting malaria in children under five years in Tongo and Bongo District, Upper East Region.

The analysis revealed that Caregivers occupation (civil servant) (p=0.001), having lived in artisanal mining district (p<0.001), child age (p<0.001), caregiver educational level (p=0.002), income level of caregiver (p=0.03) and ITN possession (p=0.03) were significantly associated with child malaria status. However, sleeping in ITN night before visit to the hospital (p=0.21), household size (p=0.72), marital status of caregiver (p=0.51), building material types (p=0.21) and roof type (p=0.68) were associated with malaria infection but these associations were not statistically significant. To determine the strength of these associations, bivariate analysis was performed. The odds of malaria infection in children who live in Artisanal mining district (Tongo) was 0.83 times compared to counterparts in Non-mining district (Bongo). A unit (month) increase in the age of child increased the odds of malaria. Children between the ages 50 - 59 months were 5.68 times more likely of malaria compared to children between ages 0 – 9 months.

Children of caregivers with high educational level (secondary to tertiary), were 48% less of malaria morbidity. Children of high incomes caregivers were at reduced risk of malaria. Thus, a child of caregiver who is poor was 1.63 more likely for malaria infection. However, this is not statistically significant. Households' possession of INT reduced child malaria by 64% in children under five years. Also, the results show that children of caregivers who are in public service employment have 79% reduction in malaria compared to children of caregivers who are in other employment (Table 4).

**Table 4: Univariate analysis of selected variables for Malaria infection, Children under five in Tongo and Bongo district, Upper East Region, 2016**

| Associated factors | Odds Ratio (OR) | 95% Interval | Confident | P -Value |
|---|---|---|---|---|
| Artisanal mining dist. | 0.83 | 0.77 | 0.89 | <0.001 * |
| **Age (Months)** | | | | |
| 0 - 9 | 1.0 | - | | - |
| 10 - 19 | 1.69 | 1.48 | 1.92 | <0.001 * |
| 20 - 29 | 3.47 | 3.04 | 3.95 | <0.001 * |
| 30 - 39 | 4.66 | 4.06 | 5.35 | <0.001 * |
| 40 - 49 | 5.42 | 4.69 | 6.27 | <0.001 * |
| 50 - 59 | 5.68 | 2.01 | 16.05 | 0.001 * |
| **Caregivers education status** | | | | |
| Low education (No education to JHS) | 1.0 | | | |
| High education(SHS & above) | 0.52 | 0.36 | 0.76 | 0.002 * |
| **Caregivers occupation** | | | | |
| Trading | 1.0 | | | |
| Farming | 1.11 | 0.70 | 1.76 | 0.67 |
| Civil servant | 0.21 | 0.08 | 0.53 | 0.001 * |
| House wife | 1.14 | 0.69 | 1.91 | 0.60 |
| Others | 0.69 | 0.42 | 1.14 | 0.15 |
| **Caregivers income status** | | | | |
| Low income (< Ghc300) | 1.0 | | | |
| High income (> =Ghc300) | 0.61 | 0.33 | 1.14 | 0.12 |
| Households ITN possession | 0.36 | 0.14 | 0.93 | 0.04 * |
| Sleeping in ITN night before visit to hospital | 0.67 | 0.34 | 1.27 | 0.21 |
| Marital status | 0.76 | 0.48 | 1.20 | 0.24 |
| Building material | 0.76 | 0.50 | 1.16 | 0.21 |

* Significant association between variables and malaria

### 4.5 Multiple analysis of factors associate with malaria infection in children under five years in Tongo and Bongo district, Upper East Region

After adjusting for child age, caregiver education status, occupation, monthly income, ITN possessing, the odds of malaria infection in children under five in artisanal mining district was 34% less compared to counterparts in non-mining district. Holding all factors constant, the odds of malaria among age-group 40 to 49 months was 4.27 times compared to 0 to 9 months. And this was statistically significant (95% CI, 2.17- 8.38; p< 0.001). Furthermore, after controlling for child age, artisanal mining district, occupation, monthly income, ITN possessing, odds of malaria infection was 21% reduced in children with caregivers with high education as opposed those with caregivers with low education. Again, the adjusted OR for malaria infection in children under five years, associated with ITN possession was 0.26 times as if they did not. Again, after controlling for all other factors in the model, odds of malaria in children of caregivers who are civil servant was 0.29 times compared to children of caregivers of other occupations.

**Table 5: Multiple Logistic Regression Analysis of factors associated with Malaria in Children under five years in Tongo and Bongo District, Upper East Region, 2016**

| Associated factors | Odds Ratio (OR) | 95%Confident Interval | | P -Value |
|---|---|---|---|---|
| **District** | | | | |
| Non-mining dist.(Bongo) | 1.0 | | | |
| Artisanal mining dist.(Tongo | 0.66 | 0.45 | 0.95 | 0.03 * |
| Age of child (Months) | | | | |
| 0 - 9 | 1.0 | - | - | - |
| 10 - 19 | 1.41 | 0.85 | 2.35 | 0.18 |
| 20 - 29 | 1.61 | 0.92 | 2.83 | 0.09 |
| 30 - 39 | 1.61 | 0.89 | 2.92 | 0.11 |
| 40 – 49 | 4.27 | 2.17 | 8.38 | <0.001* |
| 50 - 59 | 1.76 | 0.21 | 14.63 | 0.60 |
| **Caregivers education** | | | | |
| Low education | 1.0 | | | |
| High education | 0.79 | 0.63 | 0.98 | 0.03 * |
| **Caregivers occupation** | | | | |
| Trading | 1.0 | - | | - |
| Farming | 1.00 | 0.61 | 1.65 | 0.99 |
| Civil servant | 0.29 | 0.10 | 0.80 | 0.01 * |
| House wife | 1.11 | 0.65 | 1.93 | 0.69 |
| Others | 0.74 | 0.44 | 1.26 | 0.27 |
| **Caregivers income** | | | | |
| Low income (< Ghc 300) | 1.0 | | | |
| High income (>=Ghc 300) | 0.94 | 0.79 | 1.11 | 0.47 |
| **HouseholdsITN possession** | | | | |
| No ITN possession | 1.0 | | | |
| ITN possession | 0.26 | 0.11 | 0.79 | 0.02 * |

* Significant association between the variables and malaria

## 4.6 Caregivers knowledge of malaria, treatment and prevention in Tongo and Bongo District, Upper East Region.

Hundred percent of the caregivers in both districts were aware of malaria. The results indicated in table 6 shows that less than 30% of caregivers in each of the two districts stated that malaria was transmissible.

However, more than 90% of caregivers in both district knew that malaria infection was caused by mosquito bites. About 70%, 50%, 80%, 60%, and 20% of the caregivers in each district concluded that headache, body-pains, fever, vomiting and nausea respectively were symptoms of malaria.

**Table 6: Knowledge of Caregivers on malaria infection in Tong and Bongo District, Upper East Region, 2016**

| Variables | Total (525) n (%) | District | | P - value |
|---|---|---|---|---|
| | | Bongo (238) n (%) | Tongo (287) n (%) | |
| Aware of malaria (yes) | 525 (100) | 238 (100) | 287 (100) | |
| Malaria transmissible (yes) | 116 (22.1) | 66 (27.7) | 50 (17.4) | < 0.001* |
| **Causes of malaria** | | | | |
| Mosquitoes (yes) | 521 (99.2) | 235 (98.7) | 286 (99.7) | 0.41 |
| Biting Time-night (yes) | 509 (97.0) | 227 (95.4) | 282 (98.3) | 0.14 |
| **Symptoms of malaria** | | | | |
| Headache (yes) | 393 (74.9) | 170 (71.4) | 223 (77.7) | 0.10 |
| Body pains (yes) | 269 (51.2) | 103 (43.3) | 166 (57.8) | 0.001* |
| Fever (yes) | 422 (80.4) | 188 (79.0) | 234 (81.5) | 0.47 |
| Vomiting (yes) | 316 (60.2) | 156 (65.6) | 160 (55.8) | 0.05* |
| Nausea (yes) | 115 (21.9) | 47 (19.8) | 68 (23.7) | 0.36 |
| Shivering (yes) | 159 (30.3) | 97 (40.8) | 62 (21.6) | < 0.001* |

*Significant difference between Tongo and Bongo

### 4.6.1 Caregivers Knowledge on malaria treatment drugs in Tongo and Bongo, Upper East Region.

All the caregivers (100%) knew that malaria is treatable. Table 7 shows the level of knowledge of caregivers in relation to drugs use for malaria treatment. In each of the districts, about 70%, 50% and 20% of the caregivers identified artesunate amodiaquine (A/A), Quinine and artermether lumefantrine (A/L) respectively as drug of choice for treating malaria.

**Table 7: Proportion of caregivers identified drug for malaria treatment, Upper East Region, 2016**

| Variables | Total (525) n (%) | District | | P - Value |
|---|---|---|---|---|
| | | Bongo (238) n (%) | Tongo (287) n (%) | |
| Artersunate ammodiaquine (yes) | 385 (73.3) | 172 (72.3) | 213 (74.2) | 0.44 |
| Quinine (yes) | 267 (50.9) | 116 (48.7) | 151 (52.6) | 0.06 |
| Artermether Lumefantrine (yes) | 103 (19.6) | 45 (18.9) | 58 (20.2) | 0.83 |

### 4.6.2 Knowledge of caregivers on malaria prevention methods in Tongo and Bongo District, Upper East Region

Table 8, describes proportion of caregivers in both districts who stated or identified various methods for prevention of malaria. More than 90% and about 50%, and 10% of caregivers in both districts concluded that sleeping in ITN, spraying room with insecticides spray, burning coils, switching fan on at night and covering body with clothes respectively were some of the means of preventing malaria.

**Table 8: Caregivers response in relation to malaria prevention method artisanal mining district and non-mining district, Upper East Region, 2016**

| Variables | Total (525) n (%) | District | | P - Value |
|---|---|---|---|---|
| | | Bongo (238) n (%) | Tongo (287) n (%) | |
| Sleeping in ITN | 507 (96.6) | 232 (97.5) | 275 (95.8) | 0.26 |
| Use of mosquito spray | 332 (63.2) | 117 (49.2) | 215 (74.9) | < 0.001* |
| Use of mosquito coil | 316 (60.2) | 103 (43.3) | 213 (74.2) | < 0.001* |
| Switching on fan in night | 75 (14.3) | 28 (11.8) | 47 (16.4) | 0.32 |
| Cover body with clothes | 57 (10.9) | 33 (13.9) | 24 (8.4) | 0.12 |

*Significant difference between Tongo and Bongo

# CHAPTER FIVE

# DISCUSSION

Many environmental factors play important roles in malaria transmission, prominent among these factors is land degradation. Most regions in Ghana are endowed with gold and other mineral resources. Gold production from small scale mining increased from 767,196 ounces to 1576,478 ounces in 2013 (Crawford, Agyeyomah, Botchwey, & Mba, 2015). This shows the huge sums of money being produced and clearly indicates the gains that are made by those involved in the extraction and sale of this resource as well as the benefits derived by the local economy as a whole. (Crawford et al., 2015; Hinton, 2005). However, to harness the benefits of these resources has led to the destruction of the lands and the environment. One major effect of land degradation is increased in malaria transmission and infection with children under five years and pregnant women at greater risk.

This is single hospital-based cross-sectional study that has looked at malaria morbidity in children under five years in artisanal mining (Tongo) and non-mining (Bongo) district in the Upper East region. The study also looked at one complete year and one-month hospital data in individual districts.

We hypothesized that “Proportion of malaria in the artisanal mining (Tongo) district is the same in the non-mining (Bongo) district” was clearly refuted with results shown in Table 3. This shows that, in the artisanal mining district, for every 100 of children under five years 39 of them were diagnosed with malaria, this was however lower compared to the non-mining district. Studies have shown similar results (Kitula, 2006; Mitjà et al., 2013). In the Geita district in the Tanzania, a case study was conducted to identify environmental and socio-economic impacts of mining on local livelihoods of the people had found that fewer number of cases of malaria reported in the impact communities compared to non-impact areas. Mitjà et al., (2013) used similar approach to determine proportion of malaria parasitaemia in mining communities and non-mining community and found that proportion of malaria in the impacts community was low. Similar studies were conducted in Colombia and Ghana reported similar findings. They reported low proportion of malaria in the mining communities compared to the control areas (Asante et al., 2011; Castellanos et al., 2016).

During the environmental search at the artisanal mining area, it was observed that the houses were scattered well apart in the communities. In most of the houses, the bath house was having suck-away or cut pits that were well covered. Even houses that were not with these facilities, the drainages around or behind the houses were dried and cleaned. It was also noticed that drainage systems, in general, were properly kept. The drainages were well desilted, very clean and mostly dried. This is perhaps of the arid nature of the region. It was found that areas that were dug for sand or gravels for molding of brick, block and for the construction of roads were refilled with solid waste. A visit to some of the mining sites revealed that pits that were not functioning were refilled. Those pits that were abandoned during the rainy season, were covered with dirty engine oils. This action inhibits the aquatic lives. An inquiry at the district environmental department revealed that vector control activity such as outdoor spraying programme was implemented in the district with support from National Malaria Control Programme (NMCP). By this, the communities, public places like markets, toilets, refuse dump sites or landfilled areas, schools and health facilities, as well as major drainages in the district, are sprayed every month. The individual houses are also sprayed. It was further observed that other interventions such as Community Led Total Sanitation (CLTS) implemented in the district was well accepted by the communities.  Most of the houses had cut-pits. In addition, the environmental department regularly carries out premises inspection and education in the communities. Indeed, all these interventions mentioned could be the contributing factors that had resulted in what was observed in the mining district compared to the non-mining district. It is important to know that INTs usage in this area was also higher than the non-mining district, although the difference is statistically not significant, it does not mean that it has contributed to the reduction of malaria in the district (Hiwat, Hardjopawiro, Takken, & Villegas, 2012). Again, environmental modifications because of growth and the mining activities may reduce mosquito breeding sites and, therefore, the burden of malaria in the district. However, the finding in this study is contrary to several other studies (Fernando et al., 2016; Mônica et al., 2012b; Santi et al., 2016; Silbergeld et al., 2002; Smith et al., 2016). These studies reported a higher proportion of malaria in mining communities as against the non-mining or non-impacts communities. The challenge is that most of these studies are unable to recruit many participants and therefore had to depend on several years data. But in this study over 11000 participants were recruited within a period of one year.

Although many studies demonstrated that malaria prevalence or proportion is higher at mining areas than the non-mining areas, this study has shown that various interventions that have been put in place in the district are effective and achieving its objectives.

The high proportion of malaria in the non-mining district could be because of many environmental factors in the district. Prominent among these are the several man-made water bodies' couples with farming close to houses during the rainy season (Keiser et al., 2005). These could largely contribute to malaria transmission in these areas and nearby communities. There are some communities in the district where people are engaged in dry season gardens using dugouts water and dams to irrigate the crops. It is obvious that these activities could create breeding grounds for the mosquito that transmits the disease.

However, environmental and or vector control interventions in the district was limited to selected areas including dumping sites, public toilets, and schools. Individual houses and surroundings were only sprayed upon request and payment made to Zoom Lion. The high proportion of malaria morbidity could also be attributed to non-acceptability of reforms by the people in Bongo District. The CLTS activity is defunct in the district, hence only a few houses that have sucker-ways or cut-pits to collected households waste waters. The high percentage of malaria could also be attributed to the fact that Bongo District is one of the districts with high population density and population movements in Ghana. Moreover, Bongo is a border town very close to Guelwongo which is a village under Cominune de Ziou, Nahouri Province in Burkina-Faso. Most of its citizens seek health care in Bongo District, because of closeness, cheaper cost, and fairly good health facilities compared to their place. This could also account for increased number of malaria cases in the district. This, therefore, means that the indigenous cases of malaria in the district would be difficult to establish because of the cross-border movement and preference for health care in Ghana by the Burkinabe nationals. It is important to focus attention on the border area for treatment and control efforts in both Ghana and Burkina side.

The study demonstrated low proportion of severe malaria in the artisanal mining district compared to the non-mining district. Of the malaria cases diagnosed in the mining district 678/2515 (27%) were severe malaria compared to 1249/2178 (57%) cases in the non-mining district. This means that for every 100 children under five years diagnosed with malaria, approximately 27 of the children suffered severe malaria in the artisanal mining district compared to 57 of the children in non-mining district. There are many factors that influence severe malaria, including access to health facility, misdiagnosis, noncompliance to treatment, compromised immunity, geographical location, delaying in accessing health care and others. Most of the children in this study were naïve immunity towards malaria and may probably be building immunity as they are exposed along the line. Therefore, a little delay accessing health care and treatment for the children could be life threatening. This perhaps, the high proportion of severe malaria in the mining district, but lower compared to the non-mining district. Though, few studies have reported low proportion of severe malaria in similar studies (Li et al., 2015; Musset et al., 2014; Narváez et al., 2016), disparities in the results could be attributed to setting in which the studies were conducted as well as sample size in those studies. The high proportion of severe malaria in the non-mining district could be attributed to the fact that most of the cases reported to the hospital late. Parents during the peak malaria season are usually engaged in farming with little attention for the children. In addition, over 90% of the communities lack access to motorable roads hence delay in bring the children to hospital when are sick. Furthermore, most of the parents prefer to treat children with concoction as a way of life or because they do not possess health insurance for the children and could not afford medical expenses. This practice most often results in delay to seek proper health care for the children. This usually leads to the children becoming severely ill before being rushed to hospital.

From the results of this study, factors that were associated with malaria in children were household possession of bed net, child age, a district the child resides, caregiver's income and educational status. The findings suggest that older (40-49 months) children were about 3.3 times more likely for malaria as compared to younger age groups. This implies that a unit increased in the age of a child increases the risk of malaria morbidity. This finding was similar to reports of studies in Tanzania, Rwanda and Ethiopia (Winskill et al., 2011; Haji et al., (2016; Gahutu et al., 2011). In these studies, malaria infections increased with advancement in child age. A study conducted in Uganda showed that the risk of malaria amplified as a child advances in age (OR 1.03, 95 % CI 1.02–1.03)

(Roberts & Matthews, 2016). The study in Rwanda which evaluated malaria prevalence and risk factors in children under five years was consistent with this study. Malaria infection increased with increase in age. Most of the infected children were between the ages of 2 to 4 years.

Household possession of INTs or bed nets significantly reduced child malaria. This suggests that children in households without mosquito treated nets or long-lasting nets are more vulnerable to malaria infection. This result was consistent with those reported by Ayele et al., (2012), Winskill et al., (2011) and Haji et al., (2016). These studies noted that possession of ITN was protective against child malaria status. Children would, therefore, be at risk in families who do not own ITNs. This goes to buttress the fact that mosquito treated nets should be made available to all families. However, sleeping in ITN night before a visit to the hospital was not statistically significant associated with child malaria status. This is in agreement with what was reported by (Okebe et al., 2014), Gahutu et al.,(2011) and Roberts & Matthews, (2016). Lack of association observed could perhaps be that child was already exposed previously to mosquitoes during previous nights when the bed net was not in use or used inappropriately. This means that people should be taught on the appropriate use of bed nets else its purpose would be defeated. Hence, there need to intensify health education on the appropriate use of the insecticide treated nets. Even with the appropriate use of INTs, it is not adequate without other interventions. This again means that ITN alone is not adequate to provide complete protection for any outdoor human activities that take place outside. The study reveals that children of high-income caregivers had some level of reduction in malaria. Though protective (OR=0.61, 95%, CI: 0.33 – 1.14. p= 0.12) it was not statistically significant. Although most studies reported that high-income quintile significantly reduced malaria infection (Liu et al., 2014; Haji et al., 2016; Gahutu et al., 2011; Baragatti et al., 2009), the difference in current study may be due to the fact that caregivers of the children in this study might be in high income status but might not be using the various preventive methods available for malaria appropriately. Again, univariate analysis (OR=0.76, 95%, CI: 0.64 – 177) results from this study revealed that rooms made from mud bricks slightly decrease the chances of child malaria. Despite that there was some effect on child malaria status, this was not significant. According to Ayele et al., (2012), malaria RDT positive was significantly higher among respondents living in rooms made of local building materials. The finding here was similar what was reported Ghana and Tanzania (Winskill et al., 2011; Krefis et al., (2010). Both studies noted that rooms made from local materials or cement blocks were not significantly associated with child malaria status.

Higher education of the caregivers was associated with reduced malaria in children under five years in the study (Table 5). Caregivers with at least secondary or tertiary education level reduced malaria infection in their children by 21%. This is perhaps they understood the mode of infection and prevention methods and therefore ensured the children were protected against the mosquito bites. Adeboyo et al., (2016), reported that mothers of high educational status significantly associated with low odds of malaria in children. For instance, it was reported that child whose mother's level of education was Secondary school or Higher had protective relationship with malaria compared to counterparts with Primary education or no formal education (Adebayo et al., 2016). A study conducted by Roberts & Matthews (2016), to compare children of caregivers with secondary education compared to children of parents without indication for educational level, children of caregivers without specified educational status had higher chances of malaria (OR 1.97, 95 % CI 1.35–2.87). These odds were almost the same compared with caregivers without education (OR 1.96, 95 % CI 1.35–2.86). This shows that most respondents who failed to state their education level were either did not have an education or had low education.

In Table 5, children who live in the artisanal mining district were protected (OR= 0.66, 95% CI: 0.45 – 0.95. p = < 0.001), this shows that children who reside in mining districts had 34% fewer chances of being infected with malaria as though there did not. Though, two studies in Ghana reported that people who live in mining communities were at high risk of malaria compared to those who did not live in the mining areas (Bosson-amedenu, Prah, Adams, Appiah, & Simons, 2016; Reddy, 2005), the challenge is that, one of this studies was conducted in a district which has better health facilities (AGC hospital) compared to nearby districts. So, people travel far and near distances from other districts to receive medical care. This could result in the increased cases of malaria in the district (Reddy, 2005).

### 5.1 Caregivers' knowledge, treatment and prevention of malaria in children under five years Tongo and Bongo District, Upper East Region.

This study discloses very interesting findings regarding knowledge, treatment, and prevention of malaria about caregivers who have children under five years. Knowledge of caregivers regarding the question, whether they were aware of malaria was the same across both districts (Table 6). There was no significant difference between the caregivers' knowledge in identifying symptoms of malaria in the mining area and the non-mining area. Most of the caregivers in both areas could identified at least one symptom of malaria as shown. Though, this compares with several studies that found high caregivers knowledge about malaria and symptoms (Dhawan et al., 2014; Haji, Fogarty, & Deressa, 2016b; Thandar et al., 2015; Yewhalaw et al., 2010; Deressa, Ali, & Enquoselassie, 2003), the findings in other studies in Ghana, India and Brazil were low in caregivers knowledge (Adjei et al., 2008; Matta, Khokhar, & Sachdev, 2004; Ferreira et al., 2011). There was no significant difference between the ability of caregivers in the mining district to state drugs of choice for treating malaria. Table 7, shows the proportion of caregivers who identified the drugs of choice for malaria treatment. About 74.2% as against 72.3% identified artesunate-amodiaquine in the mining district as against the non-mining district respectively. This agrees with the finding in a study conducted in Suriname, which reported 83.5% of the respondents from mining area stated artecom as the drug for treating malaria (Heemskerk & Duijves, 2013). About 96% compared to 98% of the respondents from the mining area and the non-mining area respectively knew that sleeping in ITN was protective against malaria. However, this contradicts what was reported in Suriname, only 18.5% of the respondents slept in a net night before the study (Heemskerk & Duijves, 2013). This could probably be due to the feeling warm in the net.

## 5.2 Characteristic of Study Participants in Tongo and Bongo District, Upper East Region

The study population depicted similar population of gender distribution and location of residence in the Upper East Region (Ghana Statistical Service, 2013). There were 6228 (54.7%) of the children under five years being males and most 479 (91.2%) of the adults (caregivers) were females. Most of the caregivers 87.6% were married. This is, however, contrary to 2010 Population and Housing Census, Regional Analytical Report (2013) which found that 49.2% of the adult population was married. The difference could be explained that only caregivers at the hospital were interviewed and the sample size was relatively small compared to survey sample. The finding is consistent with work done in Nigeria (Eugene-Ezebilo & Ezebilo, 2014). They found that most 93% of the participants were married. A large proportion of the participants (97.4%) reside in the rural settlement. This is similar to Ghana Statistical Service., (2014a) report, which reported that 94% of the population live in a rural settlement. Most of the caregivers 66.5% had no or primary education only. This is similar to study conducted in Uganda which found 70.1% of the caregivers have no or primary education (Roberts & Matthews, 2016). However, it conflicts the findings of (Okebe et al., 2014), in that study 22.8 % of the participants had formal education. About 27.8% of the caregivers in this study were traders. The finding is in agreement with (Ameyaw, Dogbe, & Owusu, 2015) and (Okebe et al., 2014). However, 97.1% of the caregivers earned below 300 Ghana cedis in a month. This is indeed expected as most of the caregivers were petty traders and seasonal peasant farmers. The finding is consistent with that of Adam, Brew-Hammond, & Essandoh, (2013) and Cooke, Hague, & McKay, (2016). In these, studies the average household income was Ghc1217 per year and the rural-urban poverty ratio was about 1: 3.7 with Upper East and Northern Region affected much worse.

The average household size was 5.7 members (SD ± 2.65) and about 92% of the households had children under five years who slept in insecticide treated net (ITN) night before the visited the hospital. The finding in this study is higher compared to work done by Bach, (2014) who found 76% of the sample households had slept in LLN night prior to the survey. The difference could be attributed to small size of the study.

# CHAPTER SIX

# CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Conclusions

The goal of the study was to compare the proportion of malaria in children in two districts including artisanal mining and non-mining district and to determine the proportion of severe malaria in each area. The findings from this study revealed relatively low proportion of malaria morbidity and severe malaria in children under five years in artisanal mining district compared to the non-mining district. In addition, the study has clearly shown that proportion of malaria was high among children between ages 20 to 29 months in both districts. The study confirms that age 40 to 49 months of a child was positively associated with malaria whereas secondary school and above of caregiver education, caregiver employed in public sector, household possession of insecticides treated nets and child living in artisanal mining district were identified as protective factors against malaria. Knowledge of caregivers in malaria, treatment and prevention in children under five years was high.

## 6.2 Recommendations

In the face of present findings, it is recommendation that

- National Malaria Control Programme should institute other outdoor interventions to complement the interventions that are ongoing to prevent malaria in people who stay outside into the night.
- The District Assemblies should institute aggressive vector control interventions at the water bodies and wetlands area.

- The Bongo District Assembly should make outdoor residue spraying free for individual homes.
- The Ministry of Health should ensure that Health Promotion Unit of the Service continues to educate the general population on the appropriate use of insecticide treated nets.

In addition, based on the findings of this study, it is recommended that

- Similar study should be replicated in all the districts across the country, this would ensure accurate data on malaria from district level to national level.

# REFERENCES

Abdul-Aziz A.R., Harris, E., & Munyakazi, L. (2012). Risk Factors in Malaria Mortality among Children in Northern Ghana: A Case Study at The Tamale Teaching Hospital, 35–45.

Adam, F. W., Brew-Hammond, A., & Essandoh, E. O. (2013). Relationships between Energy Use and Income Levels, for Households in Ghana. *European Scientific Journal*, *ESJ*, *9*(16).

Adebayo, S. B., Gayawan, E., Heumann, C., & Seiler, C. (2016a). Spatial and Spatio-temporal Epidemiology Joint modeling of Anaemia and Malaria in children under five in Nigeria, *17*, 105–115. https://doi.org/10.1016/j.sste.2016.04.011

Adjei, G. O., Darkwah, A. K., Goka, B. Q., Alifrangis, M. L., Kurtzhals, L., & Rodrigues, O. P. (2008). Parents' Perceptions, Attitudes and Acceptability of Treatment of Childhood Malaria with Artemisinin Combination Therapies in Ghana Baseline Characteristics, *42*(3).

Afudego, C. E. (2011). Strengthening Institutions to Improve Public Expenditure Accountability Cost Effectiveness Analysis of Insecticide Treated.

Agbodeka, F. (1992). An Economic History of Africa: From the Earliest Times. Ghana University Press, Accra.

Akande, T.M., & Musa, I.O. (2005). Epidemiology of Malaria in Africa.

Ameyaw, E., Dogbe, J., & Owusu, M. (2015). Asian Pacific Journal of Tropical Disease teaching hospital in Ghana. *Asian Pacific Journal of Tropical Disease*, *5*(8), 658–661. https://doi.org/10.1016/S2222-1808 (15)60908-2

Anto, F., Asoala, V., Anyorigiya, T., Oduro, A., Adjuik, M., Owusu-agyei, S., & Hodgson, A. (2009). Insecticide resistance profiles for malaria vectors in the

Kassena-Nankana district of Ghana, *8*, 1–8. https://doi.org/10.1186/1475-2875-8-81

Aryee, B.N.A., Ntibery, B.K., & Atorkui, E. (2003). Trends in the small-scale mining of precious minerals in Ghana: a perspective on its environmental impact. *Journal of Cleaner Production*, *11*(2), 131–40.

Asante, K. P., Zandoh, C., Dery, D. B., Brown, C., Adjei, G., Antwi-dadzie, Y., & Owusu-Agyei, S. (2011). Malaria epidemiology in the Ahafo area of Ghana. *Malaria Journal*, *10*(1), 211. https://doi.org/10.1186/1475-2875-10-211

Aubynn, A. (2009). Sustainable solution or a marriage of inconvenience? The coexistence of large-scale mining and artisanal and small-scale mining on the Abosso Goldfields concession in Western Ghana. *Resources Policy*, *34*(1–2), 64–70.

Awatey, S. (2014). Awareness of Residents in Small-scale Mining Communities on the Perceived Environmental Impact of Small-scale Mining: A Case of Amansie West District in Ashanti Region of Ghana, *4*(10), 161–169.

Bach, J. S. (2014). *Illegal Chinese gold mining in Amansie West, Ghana-an assessement of its impact and implications*. Universitet i Agder/University of Agder. Retrieved from https://brage.bibsys.no/xmlui/handle/11250/222376

Baragatti, M., Fournet, F., Henry, M., Assi, S., Ouedraogo, H., Rogier, C., & Salem, G. (2009). Social and environmental malaria risk factors in urban areas of, *14*. https://doi.org/10.1186/1475-2875-8-13

Barbieri, A. F., Sawyer, Iana, O., & Soares-Filho, B. S. (2005). Population and land use effects on malaria prevalence in the southern Brazilian Amazon. *Human Ecology*, *33*(6), 847–874.

Bates, I., Fenton, C., Gruber, J., Lara, A.M., Squire, S.B., Theobald, S., Thomson, R., & Tolhurst, R. (2004). Vulnerability to malaria, tuberculosis, and HIV/AIDS infection and disease. Part1: determinants operating at individual and household level. *Lancent Infec. Disease*, (4), 267-277

Beck-johnson, L. M., Nelson, W. A., Paaijmans, K. P., Read, A. F., Thomas, M. B., & Bjørnstad, O. N. (2013). The Effect of Temperature on Anopheles Mosquito Population Dynamics and the Potential for Malaria Transmission, *8*(11). https://doi.org/10.1371/journal.pone.0079276

Bhan, M. K., Bhandari, N., & Bahl, R. (2003). Clinical review perspective from developing countries, *326*(January), 146–151.

Bosson-amedenu, S., Prah, K. A., Adams, F. H., Appiah, S. T., & Simons, A. (2016). Modelling of Malaria Risk Factors in the Mpohor District of Ghana using Logistic Regression, *6*(12), 56–66.

Bousema, T., & Drakeley, C. (2011). Epidemiology and Infectivity of Plasmodium falciparum and Plasmodium vivax Gametocytes in Relation to Malaria Control and Elimination, *24*(2), 377–410. https://doi.org/10.1128/CMR.00051-10

Braack, L., Hunt, R., Koekemoer, L. L., Gericke, A., Munhenga, G., Haddow, A. D.,… Coetzee, M. (2015). Biting behaviour of African malaria vectors: where do the main vector species bite on the human body? 1–10. https://doi.org/10.1186/s13071-015-0677-9

Butterman, W. C., & E. B. A. I. (2005). Mineral Commodity Profiles- Gold. *United States Geological Survey*.

Castellanos, A., Chaparro-narváez, P., Morales-plaza, C. D., Alzate, A., Padilla, J., Arévalo, M., & Herrera, S. (2016). Malaria in gold-mining areas in Colombia, *111*(January), 59–66. https://doi.org/10.1590/0074-02760150382

CDC. (2012a). Anopheles mosquitoes.

CDC. (2012b). Malaria Parasites.

CDC. (2014). CDC and Malaria.

Chuks, J. M., & Aboh, I. K. (2006). Prevalence and Management of Malaria in Ghana: A Case Study of Volta Region Chuks J. Mba 1 and Irene K. Aboh 2. *Africa Population Studies*, *22*(1).

Chung, S. J., Guek, J., Low, H., & Wijaya, L. (2014). Malaria in a tertiary hospital in Singapore e Clinical presentatio, treatment and outcome: An eleven year retrospective review. *Travel Medicine and Infectious Disease*, *12*(6), 738–744. https://doi.org/10.1016/j.tmaid.2014.10.016

Chupezi, T. J., Ingram, V., & Schure, J. (2009). Impacts of artisanal gold and diamond mining on livelihoods and the environment in the Sangha Tri-National Park landscape.

Cibulskis, R. E., Alonso, P., Aponte, J., Aregawi, M., Barrette, A., Bergeron, L.,… Williams, R. (2016). Malaria: Global progress 2000 – 2015 and future challenges. *Infectious Diseases of Poverty*, 1–8. https://doi.org/10.1186/s40249-016-0151-8

Collins, N., & Lawson, L. (2014). Investigating Approaches to Working with Artisanal and Small-scale Miners: A Compendium of Strategies and Reports from the Field Summary of Action Research Activity.

Cooke, E., Hague, S., & McKay, A. (2016). *The Ghana Poverty and Inequality Report: Using the 6th Ghana Living Standards Survey*. *Accra: Art Excel Gh.*

Crawford, G., Agyeyomah, C., Botchwey, G., & Mba, A. (2015). International Growth Centre (IGC). Retrieved from https://www.theigc.org/wp-content/uploads/2016/08/Crawford-et-al-2015-Final-Report-1.pdf

Cruz, N. D. La, Crookston, B., Dearden, K., Gray, B., Ivins, N., Alder, S., & Davis, R. (2006). Who sleeps under bednets in Ghana? Analysis of malaria prevention behaviours, *10*, 1–10. https://doi.org/10.1186/1475-2875-5-61

Dawaki, S., Mekhlafi, H. M. Al, Ithoi, I., Ibrahim, J., Atroosh, W. M., Abdulsalam, A. M., & Lau, Y. L. (2016). Is Nigeria winning the battle against malaria? Prevalence, risk factors and KAP assessment among Hausa communities in Kano State. *Malaria Journal*, 1–14. https://doi.org/10.1186/s12936-016-1394-3

Deressa, W., Ali, A., & Enquoselassie, F. (2003). Knowledge, attitude and practice about malaria, the mosquito and antimalarial drugs in a rural community. *Ethiopian Journal of Health Development*, *17*(2), 99–104.

DFID. (2010). Malaria: Burden and Interventions Evidence Overview.

Dhawan, G., Joseph, N., Pekow, P. S., Rogers, C. A., Poudel, K. C., & Bulzacchelli, M. T. (2014). Malaria-related knowledge and prevention practices in four neighbourhoods in and around Mumbai, India: a cross-sectional study, 1–11.

Drake, P. L., Rojas, M., Reh, C.M.,Mueller, C.A., & Jenkins, F. M. (2001). “Occupational exposure to airborne mercury during gold mining operations near El Callao, Venezuela, *74*(3).

Drasch, G., Bose-O’Reilly, S., Beinhoff, C., Roider, G., & Maydl, S. (2001). The Mt. Diwata study on the Philippines 1999- -assessing mercury intoxication of the population by small scale gold mining. *Sci Total Environ*, *267*(1–3), 151–68.

Eisele, T. P., & Steketee, R. W. (2011). African Malaria Control Programs Deliver ITNs and Achieve What the Clinical Trials Predicted, *8*(9), 8–9. https://doi.org/10.1371/journal.pmed.1001091

Eugene-Ezebilo, D. N., & Ezebilo, E. E. (2014). Malaria infection in children in tropical rainforest: assessments by women of Ugbowo Community in Benin City, Nigeria. *Asian Pacific Journal of Tropical Medicine*, *7*, S97–S103. https://doi.org/10.1016/S1995-7645 (14)60212-1

Ewusie, J. E., Ahiadeke, C., Beyene, J., & Hamid, J. S. (2014). Prevalence of anemia among under-5 children in the Ghanaian population: estimates from the Ghana demographic and health survey, 1–9.

Feng, J., Xiao, H., Zhang, L., Yan, H., Feng, X., Fang, W., & Xia, Z. (2015). The Plasmodium vivax in China: decreased in local cases but increased imported cases from Southeast Asia and Africa. 5: *Sci Rep*, *5*, 8847.

Fernando, A. W., Jayakody, S., Wijenayake, H. K., & Galappaththy, G. N. L. (2016). Species composition and population dynamics of malaria vectors in three previously ignored aquatic systems in Sri Lanka. *Malaria Journal*, 1–9. https://doi.org/10.1186/s12936-016-1316-4

Fontaine, A., Fusaï, T., Briolant, S., Buffet, S., Villard, C., Baudelet, E., & Almeras, L. (2012). Anopheles salivary gland proteomes from major malaria vectors.

Friends of the Nation. (2010). End of Project Report: Rights and Voices for Sustainable Small-Scale Mining, Friends of the Nation, Takoradi, Ghana.

Funoh, K. N. (2014). The impacts of artisanal gold mining on local livelihoods and the environment in the forested areas of Cameroon.

Gahutu, J., Steininger, C., Shyirambere, C., Zeile, I., Cwinya-ay, N., Danquah, I., & Mockenhaupt, F. P. (2011). Prevalence and risk factors of malaria among children in southern highland Rwanda, 1–12.

Gatton, M. L., Chitnis, N., Churcher, T., Donnelly, M. J., Ghani, A. C., Charles, H. J., & Lindsay, S. W. (2013). THE IMPORTANCE OF MOSQUITO BEHAVIORAL ADAPTATIONS TO MALARIA CONTROL IN AFRICA, 1218–1230. https://doi.org/10.1111/evo.12063

Ghana Health Service. (2015). Ghana Health Service 2014 Annual Report.

Ghana Statistical Service. (2011). Ghana Multiple Indicator Cluster Survey with an Enhanced Malaria Module and Biomarker, 2011, Final Report. Accra, Ghana.

Ghana Statistical Service. (2013). Regional Analytical Report.

Ghana Statistical Service. (2014a). 2010 Population & Housing Census; District Analytical Report, Bongo District.

Ghana Statistical Service. (2014b). Bongo District.

Ghana Statistical Service. (2014c). Talensi District.

Graves, P. M., Richards, F. O., Ngondi, J., Emerson, P. M., Biru, E., Endeshaw, T., & Gebre, T. (2009). Individual, household and environmental risk factors for malaria infection in Amhara, Oromia and SNNP regions of Ethiopia. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1–10. https://doi.org/10.1016/j.trstmh.2008.11.016

GSS/GHS. (2009). Ghana Demographic and Health Survey.

Gupta, U. (2011). Estimating welfare losses from urban air pollution using Panel Data from household health diaries. In: Haque, A.K.E., Murty, M.N., Shyamsundar, P. (Eds.), Environmental Valuation in South Asia., 36–78.

Haji, Y., Fogarty, A. W., & Deressa, W. (2016a). Acta Tropica Prevalence and associated factors of malaria among febrile children in Ethiopia: A cross-sectional health facility-based study. *Acta Tropica*, *155*, 63–70. https://doi.org/10.1016/j.actatropica.2015.12.009

Heemskerk, M., & Duijves, C. (2013). Study on the knowledge, attitudes and practices of malaria and malaria treatment in the small-scale gold mining sector in Suriname, (November).

Hendryx, M., & Ahern, M.M. (2008). Relations between health indicators and residential proximity to coal mining in West Virginia. *Am. J. Publ. Health*, *98*(4), 669–671.

Hendryx, M., Donnel, O.H., & Kimberley, H. (2008). Lung cancer mortality is elevated in coal mining areas of Appalachia. *Lung Cancer*, *62*, 1–7.

Hentschel, T., Hruschka, F., & Priester, M. (2003). Artisanal and Mining Challenges and Opportunities.

Hill, M. (2006). Geology of the Sierra Nevada. University of California Press: Berkley.

Hilson, G., & Garforth, C. (2013). Everyone now is concentrating on the Mining: Drivers and Implications of Rural Economic Transition in the Eastern Region of Ghana. *Journal of Development Studies*, *49*(3), 348–64.

Hinton, J. J. (2005). Communities and Small Scale Mining: An Integrated Review for Development Planning.

Hiwat, H., Hardjopawiro, L. S., Takken, W., & Villegas, L. (2012). Novel strategies lead to pre-elimination of malaria in previously high-risk areas in Suriname, South America, 1–12.

Hota, P., & Behera, B. (2015). The Extractive Industries and Society Coal mining in Odisha: An analysis of impacts on agricultural production and human health, *2*, 683–693.

ICMM. (2012). *Trends in the mining and metals industry Mining' s contribution to sustainable development*.

Ingabire, C. M., Rulisa, A., Kempen, L. Van, Muvunyi, C., Koenraadt, C. J. M., Vugt, M., & Van Alaii, J. (2015). Factors impeding the acceptability and use of malaria preventive measures: implications for malaria elimination in eastern Rwanda, 1–11. https://doi.org/10.1186/s12936-015-0659-6

Jackman, J. A., & Olson, J. K. (2006). Mosquitoes and the diseases they transmit.

Jr, D.M.L., & Bordin, J.O. (2006). Duffy blood group malaria, 11 (5/6), 389-398

Kandala, N., Madungu, T. P., Emina, J. B. O., Nzita, K. P. D., & Cappuccio, F. P. (2011). Malnutrition among children under the age of five in the Democratic Republic of Congo (DRC): does geographic location matter?

Kang, Y., & Yang, J. (2013). A case of Plasmodium ovale malaria imported from West Africa. *Korean J Parasitol*, *51*(2).

Kim, D., Fedak, K., & Kramer, R. (2012). Reduction of Malaria Prevalence by Indoor Residual Spraying: A Meta-Regression Analysis, *87*(1), 117–124. https://doi.org/10.4269/ajtmh.2012.11-0620

Kitula, A. G. N. (2006). The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study of Geita District, *14*. https://doi.org/10.1016/j.jclepro.2004.01.012

Klinkenberg, E., Mccall, P. J., Wilson, M. D., Akoto, A. O., Amerasinghe, F. P., Bates, I., & Donnelly, M. J. (2006). Urban malaria and anaemia in children: a cross-sectional survey in two cities of Ghana, *11*(5), 578–588. https://doi.org/10.1111/j.1365-3156.2006.01609.x

Leera, S., Hyacinth, C. O., & Victoria, D. (2014). Understanding Human Malaria: Further Review on the Literature, Pathogenesis and Disease Control, *6*(6), 55–63.

Lengeler, C. (2009). Insecticide-treated bed nets and curtains for preventing malaria (Review), (2). https://doi.org/10.1002/14651858.CD000363.pub2.www.cochranelibrary.com

Li, Z., Yang, Y., Xiao, N., Zhou, S., Lin, K., Wang, D., & Zhou, X. (2015). Malaria Imported from Ghana by Returning Gold Miners, China, 2013. *Emerging Infection Diseases*, *21*(5), 2013–2016.

Lwetoijera, D. W., Harris, C., Kiware, S. S., Dongus, S., Devine, G. J., Mccall, P. J., & Majambere, S. (2014). Increasing role of Anopheles funestus and Anopheles arabiensis in malaria transmission in the Kilombero Valley, Tanzania, 1–10.

Lynas, D. (2014). *Investigate the OHS Issues Associated with Small-scale and Artisanal Mining in Ghana Summary of Action Research Activity*.

Mabaso, M. L. H., Sharp, B., & Lengeler, C. (2004). Historical review of malarial control in southern African with emphasis on the use of indoor residual house-spraying, *9*(8), 846–856.

Malaria Consortium. (2007). *Annual Review 2007-08: The challenge of malaria*.

Matta, S., Khokhar, A., & Sachdev, T. R. (2004). Assessment of knowledge about malaria among patients reported with fever: a hospital-based study, (June), 27–31.

McCutchan, T.F., Piper, R.C., & Makler, M. T. (2008). Use of malaria rapid diagnostic test to identify Plasmodium knowlesi infection. *Emerg Infect Dis.*, *14*(11), 1750–1752.

Mclean, K. A., Byanaku, A., Kubikonse, A., Tshowe, V., Katensi, S., & Lehman, A. G. (2014). Fishing with bed nets on Lake Tanganyika: a randomized survey, 1–5.

Mishra, P. (2010). Economic valuation of health impacts in a coal mining region. *Rev. Dev. Change*, *14*(2), 183–200.

Mitjà, O., Paru, R., Selve, B., Betuela, I., Siba, P., Lazzari, E. De, & Bassat, Q. (2013). Malaria epidemiology in Lihir Island, Papua New Guinea, 1–8. https://doi.org/10.1186/1475-2875-12-98

MOH/NMCP. (2010). National Malaria Behaviour Change.

Mônica da Silva-Nunesa, Marta Morenob, Jan E. Connc, Dionicia Gamboad, S. A., & Joseph M. Vinetzb, and M. U. F. (2012). Amazonian malaria: Asymptomatic human reservoirs, diagnostic challenges, environmentally-driven changes in mosquito vector populations, and the mandate for sustainable control strategies, *121*(3), 281–291. https://doi.org/10.1016/j.actatropica.2011.10.001.Amazonian

Morrow, R. (2007). *Epidemilogy and control of malaria*.

Msangeni, H. A., Kamugisha, M. L., Sembuche, S. H., Malecela, E. K., Akida, J. A., Temba, F. F., … Lemnge, M. M. (2011). Prospective study on severe malaria among in-patients at Bombo regional hospital, Tanga, https://doi.org/10.1186/1471-2334-11-256

Musoke, D. (2015). *Integrated approach to malaria prevention in rural communities in Uganda: experiences, perceptions and practices Prof. George Karani – Director of Study*. Cardiff Metropolitan University.

Musset, L., Pelleau, S., Girod, R., Ardillon, V., Carvalho, L., Dusfour, I., & Legrand, E. (2014). Malaria on the Guiana Shield: a review of the situation in French Guiana, *109*(August), 525–533. https://doi.org/10.1590/0074-0276140031

Nartey, V. K., Nanor, J. N., & Klake, R. K. (2012a). Effects of Quarry Activities on Some Selected Communities in the Lower Manya Krobo District of the Eastern Region of Ghana, *2012*(July), 362–372.

Nartey, V. K., Nanor, J. N., & Klake, R. K. (2012b). Effects of Quarry Activities on Some Selected Communities in the Lower Manya Krobo District of the Eastern Region of Ghana, *2012*(July), 362–372.

Narváez, P. E. C., Perez, M. L., Rengifo, L. M., Padilla, J., Herrera, S., & Herrera, M. A. (2016). Clinical and epidemiological aspects of complicated malaria in Colombia, 2007 – 2013. *Malaria Journal*, 1–11. https://doi.org/10.1186/s12936-016-1323-5

National malaria Control Programme. (2013). Ghana Malaria Programme Review of National Malaria.

National Malaria Control Programme. (2010). 2010 Annual Report.

Norman, G.R., & Streiner, D. L. (2007). Biostatistics: the bare essentials. *Pmph USA Ltd.*

Nyame, F.K., & Grant, J. (2014). The political economy of transitory mining in Ghana: Understanding the trajectories, triumphs, and tribulations of artisanal and small-scale operators', The Extractive Industries and Society, *1*(1), 75–85.

Nyame, F.K., Grant, A. J., & Yakovleva, N. (2009). Perspectives on migration patterns in Ghana's mining industry. *Resources Policy*, *34*(1–2), 6–11.

Okebe, J., Mwesigwa, J., Kama, E. L., Ceesay, S. J., Njie, F., Correa, S., & Bojang, K. (2014). A comparative case control study of the determinants of clinical malaria in The Gambia. *Malaria Journal*, *13*(1), 306.

Opoku, A. A., & Amoako, J. (2002). The Occurrences and Habitat Characteristics of Mosquitoes in Accra, Ghana.

Osterbauer, B., Kapisi, J., Bigira, V., Mwangwa, F., Kinara, S., Kamya, M. R., & Dorsey, G. (2012). Factors associated with malaria parasitaemia, malnutrition, and anaemia among HIV-exposed and unexposed Ugandan infants: a cross-sectional survey, 1–6.

Passmore, R. (2010). Exploration of Malaria Prevention Methods in Endemic African Countries.

Reddy, S. G. (2005). A Comparative Analysis Diseases Associated with Mining And Non-Mining Communities: A Case Study of Obusai and Asankrangua.

Roberts, D., & Matthews, G. (2016). Risk factors of malaria in children under the age of five years old in Uganda. *Malaria Journal*, 1–11. https://doi.org/10.1186/s12936-016-1290-x

Roll Back Malaria. (2008). The Global Malaria Action Plan for a malaria free world.

Roll Back Malaria. (2014). Advocacy for Resource Mobilization (ARM) for Malaria Guide.

Sadasivaiah, S., & Breman, J. G. (2007). Dichlorodiphenyltrichloroethane (DDT) for Indoor Residual Spraying in Africa: How can it be used for Malaria Control? *77*(Suppl 6), 249–263.

Samuel Adu-Gyamfi, E. B., & E. A. (2016). Artisanal Mining and Its Ramifications on the People of Prestea Samuel Adu-Gyamfi, Edward Brenya and Ezekiel Abakah Department of History and Political Studies, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, *8*(1), 12–24. https://doi.org/10.19026/crjbs.8.2693

Santi, V. P. De, Girod, R., Mura, M., Dia, A., Briolant, S., Djossou, F., … Pagès, F. (2016). Epidemiological and entomological studies of a malaria outbreak among French armed forces deployed at illegal gold mining sites reveal new aspects of the diseases transmission in French Guiana. *Malaria Journal*, 1–11. https://doi.org/10.1186/s12936-016-1088-x

Sawyer, D. O. (2007). Heterogeneity of malaria prevalence in alluvial gold mining areas in Northern Mato Grosso State, Brazil Heterogeneidade da prevalência de malária em garimpos do norte de Mato Grosso, Brasil, *23*(12), 2878–2886.

Schatlez, S.J., & Stewart, B. W. (2012). A provenance study of mineral matter in coal from Appalachian Basin coal mining regions and implications regarding the respirable health of underground coal workers: A geochemical and isotope investigation. *Int. J. Coal Geo.*, *94*, 123–136.

Schueler, V., & Kuemmerle, T. (2011). Impacts of Surface Gold Mining on Land Use Systems in Western Ghana, 528–539. https://doi.org/10.1007/s13280-011-0141-9

Shililu, J. I. (2001). Malaria Vector Studies in Eritrea.

Sicuri, E., Vieta, A., Lindner, L., Constenla, D., & Sauboin, C. (2013). The economic costs of malaria in children in three sub-Saharan countries: Ghana, Tanzania and Kenya, 1–14.

Silbergeld, E. K., Nash, D., Trevant, C., Strickland, G. T., Souza, J. M. De., & Silva, R. S. U. (2002). Mercury exposure and malaria prevalence among gold miners in Pará, Brazil Exposição a mercúrio e prevalência de malária entre garimpeiros de ouro

Silva, P. M. De, & Marshall, J. M. (2012). Factors Contributing to Urban Malaria Transmission in Sub-Saharan Africa: A Systematic Review, *2012*. https://doi.org/10.1155/2012/819563

Silva, M. (1986). Placer Gold.

Sinka, M. E., Bangs, M. J., Manguin, S., Rubio-palis, Y., Chareonviriyaphap, T., Coetzee, M., … Hay, S. I. (2012). A global map of dominant malaria vectors. *Parasites & Vectors*, *5*(1), 69. https://doi.org/10.1186/1756-3305-5-69

Sinka, M. E., Rubio-palis, Y., Manguin, S., Patil, A. P., Temperley, W. H., Gething, P. W., … Hay, S. I. (2010). The dominant Anopheles vectors of human malaria in the Americas: occurrence data, distribution maps and bionomic précis, 1–26.

Sitali, L., Chipeta, J., Miller, J. M., Moonga, H. B., Kumar, N., Moss, W. J., & Michelo, C. (2015). Patterns of mixed Plasmodium species infections among children six years and under in selected malaria hyper-endemic communities of Zambia: population-based survey observations, 1–6. https://doi.org/10.1186/s12879-015-0935-7

Smith, N. M., Ali, S., Bo, C., & Collins, N. (2016). Human health and safety in artisanal and small-scale mining: an integrated approach to risk mitigation, *129*. https://doi.org/10.1016/j.jclepro.2016.04.124

Snow, R., & Marsh, K. (2002). The consequences of reducing transmission of Plasmodium falciparum in Africa. Advances in Parasitilogy (52) 235-264

Sowunmi, A., Gbotosho, G. O., Happi, C. T., & Fateye, B. A. (2010). *Acta Tropica*, Factors contributing to anaemia after uncomplicated Plasmodium falciparum malaria in children, *113*, 155–161. https://doi.org/10.1016/j.actatropica.2009.10.011

Stefani, A., Dusfour, I., Paula, A., Corrêa, S. A., Cruz, M. C. B., Dessay, N., & Moreno, E. S. (2013). Land cover, land use and malaria in the Amazon: a systematic literature review of studies using remotely sensed data, 1–8.

Stephens, C., & Ahern, M. (2002). Worker and Community Health Impacts Related to Mining Operations Internationally a Rapid Review of the Literature.

Swenson, J. J., Carter, C. E., Domec, J., & Delgado, C. I. (2011). Gold Mining in the Peruvian Amazon: Global Prices, Deforestation, and Mercury Imports, *6*(4). https://doi.org/10.1371/journal.pone.0018875

Thandar, M. M., Kyaw, M. P., Jimba, M., & Yasuoka, J. (2015). Caregivers' treatment-seeking behaviour for children under age five in malaria-endemic areas of rural Myanmar: a cross-sectional study, 1–10.

Tusting, L. S., Ippolito, M. M., Willey, B. A., Kleinschmidt, I., Dorsey, G., Gosling, R. D., & Lindsay, S. W. (2015). The evidence for improving housing to reduce malaria: a systematic review and meta-analysis. https://doi.org/10.1186/s12936-015-0724-1

UNICEF. (2007). Malaria fact sheet.

Utzinger, È., Tozan, Y., & Singer, B. H. (2001). Efficacy and cost-effectiveness of environmental management for malaria control, *6*(9), 677–687.

VPWA Ghana. (2011). Knowledge, Treatment and Prevention of Malaria in Rural GHana: A Case Study of Darmang.

Walker, K. (2000). Cost-comparison of DDT and alternative insecticides for malaria control.

Webber, R. (2009). Communicable disease epidemiology and control: a global perspective. (3rd ed.). CABI.

Weekley, C., & Smith, D. S. (2013). Malaria: the clinical basics Learning Overview (Clinical).

WHO. (2008). Global Malaria Control and Elimination:

WHO. (2009). Basic Documents, (47th ed.) World Health Organization, Geneva, Switzerland.

WHO. (2011). World Malaria Report.

WHO. (2014a). A global brief on vector-borne diseases.

WHO. (2014b). *Burden of Disease from Household Air Pollution for 2012*. World Health Organization, Geneva, Switzerland.

WHO. (2014c). The Africa Regional Health Report.

WHO. (2014d). World Malaia Report, 14–19.

WHO. (2014e). World Malaria Rrport.

WHO. (2015). *World Malaria Report 2015*.

Willey, B. A., Paintain, S., Mangham, L., Armstrong, J., & Willey, B. A. (2012). Systematic Systematic reviews reviews Strategies for delivering insecticide-treated nets at scale for malaria control: a systematic review Systematic reviews, (February), 672–684. https://doi.org/10.2471/BLT.11.094771

Williams, J., & Joao, P. (2012). *Training Manual on Malaria Entomology for Entomology and Vector Control Technicians Training Manual on Malaria Entomology for Entomology and Vector Control Technicians*.

Winskill, P., Rowland, M., Mtove, G., Malima, R. C., & Kirby, M. J. (2011). Malaria risk factors in north-east Tanzania, 1–7.

World Bank. (2008). Communities, Artisanal and Small-Scale Mining (CASM), 1–4.

WORLD BANK GROUP. (2014). Women and Artisanal and Small-Scale Mining (ASM), (4).

World Health Organization. (2006). *MALARIA VECTOR CONTROL Report of a WHO Study Group*.

Yamana, T. K., & Eltahir, E. A. B. (2013). Incorporating the effects of humidity in a mechanistic model of Anopheles gambiae mosquito population dynamics in the Sahel region of Africa. *Parasites & Vectors*, *6*(1), 1. https://doi.org/10.1186/1756-3305-6-235

Yeka, A., Nankabirwa, J., Mpimbaza, A., & Kigozi, R. (2015). Factors Associated with Malaria Parasitemia, Anemia and Serological Responses in a Spectrum of Epidemiological Settings in, 1–19. https://doi.org/10.1371/journal.pone.0118901

Yelpaala, K. (2004). Mining, Sustainable Development, and health in Ghana. The Akwatia Case- Study

Yelpaala, K., & Ali, S. H. (2005). Multiple scales of diamond mining in Akwatia, Ghana: addressing environmental and human development impact, *30*, 145–155. https://doi.org/10.1016/j.resourpol.2005.08.001

Yewhalaw, D., Kassahun, W., Woldemichael, K., Tushune, K., Sudaker, M., Kaba, D., … Speybroeck, N. (2010). The influence of the Gilgel-Gibe hydroelectric dam in

Ethiopia on caregivers' knowledge, perceptions and health-seeking behaviour towards childhood malaria, 1–11.

Zhang, D., Anunan, K., Seip, H.M., Larssen, S., Liu, J., & Zhang, D. (2010). The assessment of health damage caused by air pollution and its implication for policy making in Taiyuan, Shanxi, China. *Energy Policy*, *38*, 491–502.

Zoungrana, A., Chou, Y., & Pu, C. (2014). Socioeconomic and environment determinants as predictors of severe malaria in children under 5 years of age admitted in two hospitals in Koudougou district, Burkina Faso: A cross sectional study. *Acta Tropica*, *139*, 109–114. https://doi.org/10.1016/j.actatropica.2014.07.011

# APPENDICES

## Appendix A: Study materials

**Consent Form**

**Prevalence of malaria and associated factors in artisanal mining and non-mining Districts in the Upper East Region, Ghana**

Principal investigator: Francis Broni

Qualification: M.Phil Applied Epidemiology and Disease Control

Address: School of Public Health

Informed Consent Form -participant

**PART I: Information sheet**

**Introduction**

I am a graduate student of the University of Ghana. As partial fulfilment of the requirements of the University, I am doing a study on **"Prevalence of malaria and associated factors in artisanal mining and non-mining Districts in the Upper East Region, Ghana**". I am going to give you information and invite you to be part of this study. You may choose to talk to anyone you feel comfortable with concerning the research before you decide to participate in the study. There may be some words that you do not understand, please feel comfortable to stop me as we go through the information and I will take time to explain to your understanding. In case you have questions later, do not hesitate to ask me.

**Purpose of the research**

Almost everyone in Ghana is vulnerable to malaria and a sizeable proportion of Ghanaians spend huge sums of money on mosquito control products such as coils, sprays, and insecticide treated nets, mosquito repellent and among others. Nearly every household spend money on the curative treatment of malaria in Ghana. The cost of treatment for malaria is directly proportional to the benefits to be derived by the country for a successful malaria control programme. This study will try to stratify the burden of malaria and associated factors at district level, including artisanal mining and non-mining districts in the Upper East Region. Continuous assessment or provision of baseline data, will enable the region to effectively plan, implement and evaluate malaria control programmes. If malaria control initiatives are to be successful in Upper East Region, empirical information on factors influencing the disease need to be identified and this study is timely to providing such information since much work has not be done in this direction. Indeed, very few researches have been carried out to examining prevalence of malaria and associated factors in artisanal mining and non-mining districts. More importantly, very little information is available on this subject in the Upper East Region. On the basis of available empirical evidence, it is necessary to provide decision makers and other stakeholders with vital information regarding the factors influencing the prevalence of malaria in the region for possible policy interventions. Additionally, the study seeks to contribute to knowledge on the prevalence of malaria by stratifying to mining and non-mining areas.

**Participant selection**

I am reviewing facility records in Bongo District Hospital and Tongo District Hospital and inviting all parents or caregivers of children under five years who seek health care for the children at the Bongo and Tongo District Hospitals.

**Participation**

Your decision to participate in this study is entirely voluntary. Every help the hospital offers you will remain unchanged whether or not you agree to participate in the study.

**Procedure/protocol**

I will ask parents or caregivers of children under five years some questions about themselves and collect some information from the folders of the children. I will also collect information on results of the laboratory test that is done on the children. The records of the facility will be reviewed to abstract data on children under five years.

**Duration**

The study will take place over a period of six months. However, records will be reviewed to cover 12 months and parents or caregivers will be asked some questions only once for 10 minutes for one month. Some information on their children under five including demographics, clinical diagnosis and laboratory diagnosis will be collected from their folders.

**Risks**

There is no risk to participants in this study except your time taken to answer the questions. However, during data collection period, the facility is free to decline to provide data they feel they are not comfortable in giving out. The facility also has the right to reschedule the data collection to the time of the day which they feel will not interfere with their work. The parent/caregiver interview will be short and at a suitable time. The questions are not very sensitive however, whenever you feel uncomfortable to answering any of them you may choose to decline response.

**Benefits**

Taking part in this study will not bring any immediate or direct benefits to you. You will not be paid or compensate for participated participation. However, your responses will provide us vital information that would help us to identify factors influencing prevalence of malaria in the district so that improve malaria control and affect policy.

**Confidentiality**

Every information that will be collected from you and the baby during the study will be kept away from unauthorized persons, except those doing the study. I will not share the information collected from you with anybody, but will keep it and use it only for the study. I will give a different number to every individual who is part of the study so that information collected from them cannot be traced to them. This information will be kept under lock and key.

**Who to contact**

In case of any questions, you may ask them now or later, or even after the study has begun. You may contact the following:

Principal investigator: Francis Broni

Telephone: 0244881069

Supervisor: Dr. Frederick Wurapa

Telephone: 0505639166

Ethical review contact person: Madam Hannah Frimpong

Telephone number: 0507041223

**Part II: Certificate of Consent**

I have read the above information, or it has been read to me. I have had the opportunity to ask questions concerning the study, and all questions I have asked have been answered to my satisfaction. I consent voluntarily to take part in this study.

Name of parent/caregiver of participant……………………………………..

Signature/thumbprint of parent/caregiver of participant……………………………

**Date**……………………………………………………..

I confirm that the participant was given the opportunity to ask questions regarding the study, and all questions asked by the participant were answered correctly and to the best of my ability. I confirm that no participant has been coerced into giving consent, and the consent has been given freely and voluntarily.

**Participant Consent**

I have been adequately informed about the purpose, procedure, potential risks and benefits of this study. I have had the opportunity to ask questions and have been provided answers to my satisfaction. I know that I can refuse to participate in this study without any loss of benefit for which I would be entitled. I understand that even if I agree or as I have agreed, I can withdraw my consent at any time without losing any benefits or services to which I am entitled. I also understand that the information collected will be kept confidential and will be used only for the purpose informed. Finally, findings/results will assist us in policy development as regards malaria control and prevention.

I freely agree to participate in this study.

Right thumbprint

ID of participant……………………………………………………..

Signature ………………………………………………………...

Date…………………………………………………………….

Telephone ………………………………………………………..

If the participant cannot read the form, a witness must sign here below:

WITNESS

I was present while the purpose, risks, procedures and potential benefits of this study were read to and /or interpreted to the understanding of the volunteer. All questions were answered and the volunteer agreed to take part in the research. He/She also agreed to voluntarily release the child folder to the research assistants for records abstraction.

Date……………………………………

Signature…………………………………

I certify that the nature and purpose, potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

………………………………….……

Signature of research assistant

……………………………………………

Date

## Appendix B: Parents/Caregivers Questionnaire

**Interviewer: ________________________________________**

**Date of interview: _____ /_____/__________**

I am a student of University of Ghana, School of Public Health. I and my assistant are here to conduct research into malaria disease in the district. So that we can determine the burden of the disease and factors influencing the disease in the disease. We assure you that information provided will be kept confidential for the purpose of the study.

### Basic Demographic Data of Parent

Q1. Age of parent/Caregiver? _______________

Q2. Sex M ☐ F ☐

Q3. Marital Status? Single ☐ Married ☐ Divorce ☐ Cohabiting ☐

Q4. Residential address/ Location ___________________________________________

Q5.Educational status? None ☐ Primary ☐ Secondary ☐ Tertiary ☐

Q6. Occupation of parent/caregiver? Trader ☐ civil servant ☐ house wife ☐ farmer ☐ others specify________________________________________

Q7. Monthly income of parent or household head? < 100 ☐ 101 - 200 ☐ 201 - 300 ☐ 301 – 400 ☐ > 500 ☐

Q8.Who many are you Household? (Specify)__________________________________________

Q9. Type of housing? Mud brick ☐ block ☐ wooden ☐ others specify____________________

### Awareness of Malaria Spread, Prevention and Treatment

Q10. Are you aware of malaria? Yes ☐ No ☐

Q11. Malaria is transmissible? Yes ☐ No ☐

Q12. What causes malaria? Mosquito bites ☐ fly bites ☐ drinking dirty water ☐ being in the sun ☐ no idea ☐

Q13. Common symptoms of malaria? Fever ☐ headache ☐ body pains ☐ vomiting ☐
Nausea ☐ shivering ☐ no idea ☐ (**multiple choice allowed**)

Q14. Medicine use for treatment of malaria? Artesunate Amodiaquine ☐ Quinine ☐ others ☐ no idea ☐

Q15. What are the common breeding sites for mosquitoes? Standing clean water☐ standing dirty water☐ running clean water☐ running dirty water☐ plant/vegetation ☐ no idea ☐

Q16. What time do mosquitoes bite? Morning ☐ night ☐ noon☐ sunrise/dawn☐ no idea ☐

Q17. How do you prevent mosquito from biting you? Sleep under ITN☐ mosquito spray☐ mosquito coil☐ use fan☐ cover body with clothes☐ no idea ☐ (**multiple choice allowed**)

Q18. How many of your household slept under ITN last night? ______________________________

Q19. How many children below 5 years slept under ITN last night? __________________________

Q20. How many ITNs have the household? ________________________________

Q21. How long have you been using this net? ________________________________

Q22. In the past months have you seen any new holes appearing in the net? Yes☐ No ☐

Q23. During which period of the year is the net used to sleep under? All round ☐ only rainy season ☐only dry season ☐ don't know ☐

**We have finished the discussion.**

**Thank you for your time and cooperation.**

## Appendix C: Work Plan

| Activity | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul |
|---|---|---|---|---|---|---|---|---|---|---|
| Proposal development | ■ | | | | | | | | | |
| Proposal defense | | ■ | | | | | | | | |
| Ethical clearance | | ■ | ■ | ■ | ■ | ■ | | | | |
| **Record review and administration of questionnaire** | | | | | | | ■ | ■ | | |
| Data processing and analysis | | | | | | | | ■ | | |
| Thesis write up | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |
| Submission | | | | | | | | | ■ | |
| Thesis defense | | | | | | | | | | ■ |
| **Correction and final submission** | | | | | | | | | | ■ |

**Appendix D: Data abstraction Form: Date _____/______/______**

| ID | Date of Visit | Age (month) | Sex | Department | Clinical Diagnosis | Laboratory Diagnosis | Type of malaria | Type of Anemia | Hemoglobin (HB) | District |
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**Appendix: E**

Bongo District Hospital
P.O. Box 18
Bongo, UER.
10th February, 2017

The Chairman
Ghana Health Service Ethical Review Committee
Research and Development Division
P.O. Box MB190
Accra, Ghana.

Dear Sir/Madam,

**RE: Prevalence of Malaria and Associated Factors in Artisanal Mining and Non-Mining Districts in the Upper East Region, Ghana.**

Thank you for your useful comments on the above protocol I submitted for review.

The comments of the committee were very helpful and I have made changes to the protocol to take it into account. Please find attached revised protocol with the changes marked bold.

I have also attached all required documents to the protocol.

I detail the main changes below in a point by point response to the committee comments.

**A. Main Protocol**

**I. You requested I correct start of the study and end of study dates on page 2 of Application form.**

**Response:** I have changed date of start of the study to April and date of end of study to July on the **page 2** of the Application form and on the **page 65** of the work plan section of the protocol.

**II. You requested I improve on the ethics section by discussing issues on privacy/confidentiality, potential risk/benefits, voluntary participation, compensation and consenting process**

**Response:** I have improved on the ethics section on **page 63 to 65** of the protocol.

I hope my response clarifies the issues raised.

Thank you.

Yours faithfully,

Francis Broni

(Principal Investigator)

# GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

*In case of reply the number and date of this Letter should be quoted*

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*Email: ghserc@gmail.com*

*My Ref. GHS/RDD/ERC/Admin/App/17/* 331
*Your Ref. No.*

Francis Broni
School of Public Health
University of the Ghana
Legon

The Ghana Health Service Ethics Review Committee has reviewed and given approval for the implementation of your Study Protocol.

| | |
|---|---|
| GHS-ERC Number | **GHS-ERC: 53/12/2016** |
| Project Title | "Prevalence of malaria and associated factors in artisanal mining and non-mining districts in the Upper East Region, Ghana" |
| Approval Date | 14th March, 2017 |
| Expiry Date | 13th March, 2018 |
| GHS-ERC Decision | **Approved** |

**This approval requires the following from the Principal Investigator**

- Submission of yearly progress report of the study to the Ethics Review Committee (ERC)
- Renewal of ethical approval if the study lasts for more than 12 months.
- Reporting of all serious adverse events related to this study to the ERC within three days verbally and seven days in writing.
- Submission of a final report **after completion** of the study
- Informing ERC if study cannot be implemented or is discontinued and reasons why
- Informing the ERC and your sponsor (where applicable) before any publication of the research findings.

Please note that any modification of the study without ERC approval of the amendment is invalid.

The ERC may observe or cause to be observed procedures and records of the study during and after implementation.

Kindly quote the protocol identification number in all future correspondence in relation to this approved protocol

SIGNED.............................................................
DR. CYNTHIA BANNERMAN
(GHS-ERC CHAIRPERSON)

Cc: The Director, Research & Development Division, Ghana Health Service, Accra

C/O Department of Epidemiology and Disease Control

School of Public Health

Legon.

2nd November, 2016

Regional Director of Health Services

Upper East Region

Bolgatanga.

Dear Sir

**PERMISSION TO CONDUCT RESEARCH**

I humbly write to you seeking for approval to conduct a study on the topic "**Prevalence of Malaria and Associated Factors in Artisanal Mining and Non-Mining Districts in the Upper East Region, Ghana"** as part of the requirement to successful completion of my course of the study.

The study will be carryout in two district health facilities, namely Bongo District hospital and Tongo District Hospital which fall directly under your supervision.

The will involve review of facility records over 12 months period for malaria in children under-five years and one month interview of parents of children under-five years.

I am a Biomedical Scientist in Bongo District Hospital and currently resident of M.Phil. Applied Epidemiology and Disease Control Program.

Your usual corporation is highly solicited in this matter.

Thank you

Francis Broni

OUR CORE VALUES
- People-Centered
- Professionalism
- Team work
- Innovation
- Discipline
- Integrity

*Ref :GHS/UE/*
*My Ref. No:*

Regional Health Directorate
Ghana Health Services
Private Mail Bag
Bolgatanga, UER
GHANA.

7th November, 2016

Tel: (03820) 22335
Fax: (03820) 24390
E-mail: ghs-uer@4u.com.gh

FRANCIS BCONI
DEPARTMENT OF EPIDEMIOLOGY
AND DISEASE CONTROL
SCHOOL OF PUBLIC HEALTH
LEGON.

**RE: PERMISSION TO CONDUCT RESEARCH**

I write to inform you that your request to conduct research in Bongo and Tongo District Hospitals on the topic **"Prevalence of Malaria and Associated Factors in Artisanal Mining and Non-Mining District in the Upper East Region Ghana"** has been granted subject to the following conductions:

1. That you submit a full study proposal to the Regional Director of Health Services.
2. That you obtain ethical clearance from the relevant body to carry out the research.

Kindly update the Regional Director of Health Services on the states of these conductions in due cause before the start of the research.

Thank you.

**DR. ABDUL-RAZAK DOKURUGU**
DEPUTY DIRECTOR – CLINICAL CARE
For: REGIONAL DIRECTOR OF HEALTH SERVICES (UER)