

**UNIVERSITY OF CAPE COAST**

**IMPACT OF INSECTICIDE TREATED NETS ON MALARIA  
INCIDENCE – THE CASE OF NORTH DAYI DISTRICT**

**BY**

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DISSERTATION SUBMITTED TO THE DEPARTMENT OF  
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**2012**

**DECLARATION**

**Candidate's Declaration**

I hereby declare that this dissertation is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:.....Date:.....

Anselm Dake-Crosby

**Supervisor's Declaration**

I hereby declare that the preparation and presentation of the dissertation were in accordance with the guidelines on supervision of dissertation laid down by the University of Cape Coast

Supervisor's Signature: ..... Date:.....

Mr. Kwaku Kissah-Kosah

## ABSTRACT

One disease that has ravaged the tropical environment for centuries and claimed many lives is malaria. Malaria has been with man since prehistoric times (WHO, 2004). It is the main cause of morbidity and mortality in the North Dayi district of Ghana. The study relied only on existing data on morbidity for malaria from the district health directorate information unit. Data available from the Kpando DHMT had shown that malaria consistently had topped all diseases from 2000 to date.

The study was aimed at assessing the impact of the distribution of ITNs in the North Dayi district. Research objectives were to analyze incidence among children under-five and women in reproductive age. It also aimed to assess the relationship between ITNs and malaria morbidity.

The result from the study indicated that despite the ITN distribution, malaria cases reported at the various facilities increased. This finding did not conform to other studies which suggested that ITNs could reduce the incidence of malaria within the first six months. This is a worrying outcome and could be as a result of the relaxation in education of the other preventive measures that were in place prior to the introduction of the ITNs.

To reverse this worrying situation, it is recommended that sensitization of the other preventive measures should be employed to prevent Anopheles mosquitoes from biting in the night. It was also evident that the quantity of ITNs distributed was not adequate and must be deployed on a mass scale.

## **ACKNOWLEDGEMENTS**

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Finally, I wish to extend my sincerest gratitude to my family who provided me with all the encouragement, support and love. I remain responsible for any errors and omissions.

## **DEDICATION**

To my three children Deladem, Eyram, Kekeli, and my only sweet love Vida.

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## LIST OF ACRONYMS

|      |                                                         |
|------|---------------------------------------------------------|
| ACTs | Artemisinin-based Combination Therapy                   |
| AIDS | Acquired Immune Deficiency Syndrome                     |
| AMDP | Anti- Malaria Drug Policy                               |
| CHPS | Community-based Health Planning and Services initiative |
| CPE  | Community Protective Effect                             |
| DDT  | Dichlorodiphenyl-trichloroethane                        |
| DHMT | District Health Management Team                         |
| GDP  | Gross Domestic Product                                  |
| GMEP | Global Malaria Eradication Programme                    |
| Ho   | Null hypotheses                                         |
| IPT  | Intermittent preventive treatment                       |
| ITBC | Insecticide treated bed net curtain                     |
| IRB  | Internal Review Board                                   |
| IRS  | In-door Residual Spraying                               |
| ITNs | Insecticide treated nets                                |

|        |                                                                       |
|--------|-----------------------------------------------------------------------|
| LLINs  | Long lasting insecticide treated nets                                 |
| MDGs   | Millennium Development Goals                                          |
| MOH    | Ministry of Health                                                    |
| OPD    | Out-Patient Department                                                |
| RBM    | Roll Back Malaria                                                     |
| RDT    | Rapid diagnostic test                                                 |
| RR     | Relative risk                                                         |
| TB     | Tuberculosis                                                          |
| TMMMHF | Training Manual for the Management of malaria<br>at Health Facilities |
| UN     | United Nation                                                         |
| WHO    | World Health Organization                                             |
| WIFA   | Women in fertile age                                                  |
| WWII   | World War 2                                                           |

## CHAPTER ONE

### INTRODUCTION

#### **Background to the Study**

One disease that has ravaged the tropical environment for centuries and claimed many lives is malaria. Malaria is the most devastating tropical disease, remaining widespread throughout the tropics, but also occurring in many temperate regions (WHO, 1997). It exacts a heavy toll of illness and death – especially among children and pregnant women. It also poses major health risk to foreign travellers and immigrants who have no immunity against the disease. Malaria has been with man since prehistoric times (WHO, 2004). The term mal'aria was coined in the sixteenth century by the Italians, who insisted that 'bad air' (mala/aria) from marshy areas was the cause of the disease (Carter & Mendis, 2002).

Treatment and vector control have become more difficult with the spread of drug- resistant strains of parasites and insecticide-resistant strains of mosquito vectors. Health education, better case management, better control tools and concerted actions are needed to limit the burden of the disease (Sweta, 2003).

Malaria has attracted global attention calling for collective effort to deal with it. It is endemic in 105 countries and is responsible for over 300 to 500 million clinical cases and more than one million deaths each year (WHO, 2008). During the 1950,s and 1960s a vigorous campaign to eradicate malaria was waged throughout the world with great success. The disease was in the process of being eliminated in some regions, but over the past two decades (1990 – 2010),

resurgence has been witnessed. The dream of global eradication of malaria is beginning to fade with the growing number of cases, rapid spread of drug resistance in people and increasing insecticide resistance in mosquitoes (WHO, 2011).

In 1955, less than a decade after its establishment, the World Health Organization (WHO) launched the Global Malaria Eradication Programme (GMEP). The goal was to eradicate malaria in endemic regions particularly in the tropics where morbidity and mortality was high. Even though its goal was never attained, the GMEP achieved the elimination of malaria from 37 of the 143 malaria- endemic countries, including 27 in Europe and the Americas. Africa over the years however has experienced a very slow progress (WHO, 2005).

The use of DDT was introduced in Western Africa in 1950,s. This was the World Health Organization' solution to malaria control; although it worked on other continents, the introduction of DDT to Africa did not work (WHO 2005). The development of Plasmodium resistance to chloroquine and anopheline mosquito resistance to the insecticide dichloro-diphenyl-trichloroethane (DDT) resulted in total abandonment of the programme in 1972.

### **The Malaria Parasite: Plasmodium**

Malaria is an infection caused by the protozoal parasite Plasmodium. There are four species of plasmodium that infect man: P.falciparum, P. Malariae, P.ovale, and P. Vivax. Plasmodium falciparum is the most dangerous among the species. It can cause severe malaria, and may lead to death. It is the commonest



specie in virtually all parts of Africa, accounting for 90 - 98% of cases and is associated with significant morbidity and mortality. Other species, *P. Malariae* and *P. Ovale*, form up to 2% - 10% of the cases while *P. Vivax* is rare in Africa (MOH, 2009).

The probability of dying from untreated malaria is more than one in ten persons (Benson, 1990). The vision of eliminating malaria completely from the globe has been the biggest bane of scientists and public health professionals for nearly a century. During the first half of the 20<sup>th</sup> century, the discovery and deployment of efforts to control mosquito vectors and to diagnose and treat malaria infections showed dramatic decline in the malaria burden in many settings. Much of this progress was achieved during World War II (WHO, 2011).

## **Global Transmission Patterns**

### **Early movement towards a global approach to malaria control**

The search for control for the fevers caused by malaria infection has persisted for millennia. The discovery of DDT in 1939 revolutionized the practice of spraying against the malaria parasite. Until then, the role of indoor spraying in malaria control had been minimal due to the non-residual nature of the insecticides and the consequent need to spray very frequently to obtain the desired effect. The DDT, a contact insecticide, required only two or three applications on the indoor surfaces per year, and resulted in greatly reduced transmission of malaria. The success achieved through spraying led to the development of the

modern technique of indoor residual spraying (IRS) (Gallup, Sachs, & Melinger, 1998).

The malaria burden is not evenly distributed. The global pattern of malaria transmission suggests a disease centred in the tropics, but with a reach into subtropical regions in five continents. Attempts to eliminate or at least suppress the disease have been important public health tale through much of the last century. Malaria's furthest successful attempts were made in temperate zones characterized by strong seasonality and cold winters. Beyond any other factors, this reflects the fact that the base case reproduction rate of malaria is considerably lower in temperate regions than in the tropics, so that moderately intensive efforts at vector control and case management can lead to elimination of the disease (Gallup, Sachs, & Melinger, 1998).

Climatic factors such as rainfall and humidity also affect the stability of transmission, seasonal temperature variation a predominant factor in explaining the geographical distribution of the disease. Cold winters facilitated effective elimination of malaria infection from much of the temperate zone, once appropriate interventions become available (Sachs, & Malaney, 2002).

In tropical regions, exposure to mosquitoes may be perennial and frequently includes several contacts with infected vector mosquitoes each night. Such inoculation rates, combined with the long duration of parasite survival in the host, rapidly saturate local human population, resulting in universal prevalence and super infection. This stable pattern of transmission resist amelioration and vector control efforts that succeed in temperate zones but have repeatedly failed to

eradicate the parasite from tropical and subtropical regions, although control is possible (Colluzzi, 1999).

The changing global pattern of malaria transmission from 1946 to 1994 illustrates the success of anti-malaria efforts in the more temperate regions of the world and the increased concentration of the disease burden in the tropics. Today, Africa alone accounts for 90% of the malaria mortality (Macmillan, 2002).

In Africa, only four countries have been certified as free from malaria and even these, the rest two are yet to be certified. The malaria burden could therefore be related to the extreme poverty and perhaps high death rate in the Africa sub-region (Weller, 1958).

### **Future opportunities to eliminate malaria**

Countries that are successful in achieving or nearly achieving malaria-free status have undertaken major strides in attaining their goal. They have benefitted from political and socio-economic stability and national commitment. They have typically invested their own national financial resources into a concerted elimination effort. These countries have confident, passionate leadership and sufficient commitment for the programme. As a result, they have devised a variety of intervention strategies that have evolved with and addressed the changing malaria epidemiology that occurs with reduced disease burden (Barofsky, Chase, Anekwe, and Farzadfar, 2011).

They all use existing tools to break the chain of transmission. They have uniformly established strong health information and surveillance systems aimed at

detecting infection and transmission of foci. It is also to ensure a timely and comprehensive response that quickly contains transmission; it is the same surveillance system that will enable them to know that they have no more malaria transmission (Narasimhan & Attaran, 2003).

### **Malaria in Africa**

It is estimated that about 90% of all malaria deaths in the world occur in Africa south of the Sahara. The remarkably high transmission rates in sub-Saharan Africa also reflect the particular capacity of Africa's main vector mosquitoes, the anopheles gambiae complex of species, with their remarkable tendency towards human biting (Sachs, 2002).

Sub-Saharan Africa's high temperatures and raining season lead to easy mosquito breeding that put people at risk of malaria all year round. In fact, 30 of the 35 countries that account for the vast majority of malaria deaths are in Africa. One condition for successful medical treatment for malaria is affordability. Many African countries do not have the resources to help those infected. One way of easing the means of medical treatment and making it available to people is the introduction of ITNs. A bed net is a simple solution to protect people as they sleep at night, when mosquitoes that spread the disease are out to bite their victims (Sachs, 2002).

Ensuring personal protection of these particularly vulnerable groups is necessary, but there is now much evidence that if an entire community uses treated nets this reduces the population of Plasmodium infected mosquitoes far

more than when only pregnant women and children use them (Maxwell, Msuga & Sudi, 2002).

### **Malaria Situation in Ghana**

Malaria is a common cause of death and illness in Ghana, particularly among pregnant women and children (Ministry of Health, 2009). The three protozoal parasitic Plasmodium responsible for causing malaria in Ghana are *P. falciparum*, *P. malariae* and *P. ovale*. *Plasmodium vivax* have not yet been detected in the country. In 2006, malaria accounted for 38.6% of all outpatients' illnesses and 36.9 of all admissions. Malaria prevalence per thousand populations was 171. There were 2,835 malaria related deaths (all ages). This represented 19% of all deaths.

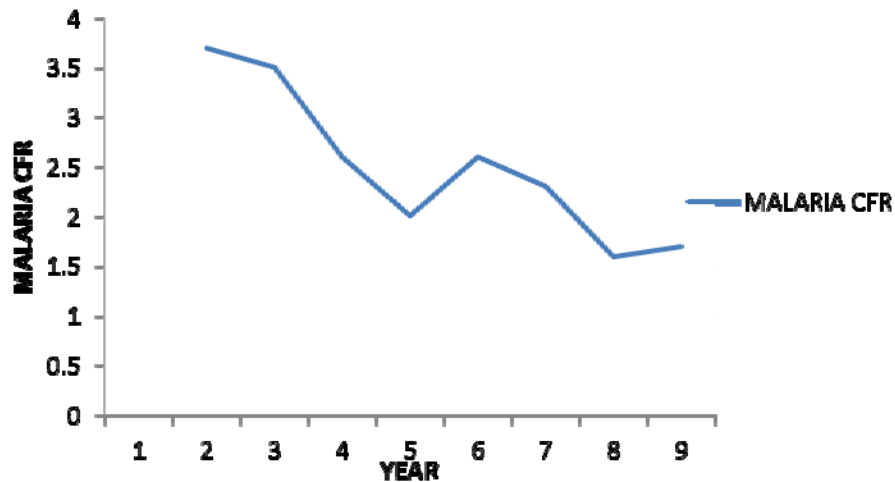
Infection rates are high in children reaching a peak at more than 80% in those aged 5 to 9 years. It falls to lower levels in adults. Malaria infection during pregnancy causes maternal anaemia and placenta parasitemia both of which are responsible for miscarriages and low birth weight. As many as 13.7% of all admissions of pregnant women in 2006 were as a result of malaria, whilst 9.0% died from the disease. Case management has been and continues to be one of the main strategies for the control of malaria in the country (MOH Anti Malaria Drug Policy, 2009).

In 2006, Ghana began child health campaign to provide all children under two years with mosquito insecticide treated nets. This made Ghana one of the 15 focus countries under the U.S President's Malaria Initiatives. The National

Malaria Control Programme announced plans in 2007 to update and revise national malaria strategies which included the mass distribution of treated mosquito nets in the year 2011 (Ministry of Health, 2009).

In 2008, malaria was reported to account for about 33.45% of all outpatient attendance and 30% of all hospital admissions. In 2008, malaria also accounted for 34.6% of deaths in children below the age of five and 5.8% of deaths in pregnant women. In children under five years, malaria is a leading cause of mortality, with an estimated 14,000 children dying from malaria each year. Malaria is also a major cause of severe anaemia, especially in children under five years and in pregnant and lactating mothers (Ministry of Health, 2009).

Figure 2 illustrate malaria case fatalities within an 8 year period. Malaria under- 5 case fatality rate has reduced by more than 50% since 2002 from 3.7% in 2002 to 1.7% in 2009. However, the gradual fall in case fatality stagnated between 2008 (1.6%) and 2009 (1.7%) with the later slightly higher (Ghana Health Service, 2009)



**Figure 1: Malaria case fatality rate for Ghana 2002-2009**

Source: Ghana Health Service (2009)

The proportion of total OPD attributable to malaria continues to increase. With the introduction of the rapid diagnostic tests for malaria, it was expected that the proportion of OPD cases attributable to malaria was going to decrease. Unfortunately, this did not happen, and the 2010 actually recorded an increase (Ghana Health Service, 2010).

There was therefore the need by the Ministry of Health to intensify the fight against the main vector – anopheles mosquito by introducing the new tool – insecticide treated mosquito nets (ITNs), forming the basis of an evolving malaria control strategy (Ghana Health Service, 2009).

The 2009 Kpando Annual Report on malaria makes the geographical study worth pursuing to ascertain the impact treated bed nets have made in efforts to reduce malaria incidence in the North Dayi district.

## **Problem Statement**

Data available from the Kpando District Health Management Team had shown that malaria consistently had topped all diseases from 2000 to date - 2011(Kpando District Assembly, 2006). This could be partly attributed to the topography of the district.

Malaria remains a major public health concern especially for the individual on one hand and government on the other. It is regarded as a leading cause of all hospital admission, mortality and morbidity in particularly among pregnant women and children under-five years. It is a leading cause of miscarriage and low birth weight (Margret Marquart Catholic Hospital, 2005). It is estimated that about 30 to 40% of outpatient cases each year are as a result of malaria (Kpando DHMT 2005). Furthermore, about 61% and 8% of hospital admissions of children below age five and pregnant women, respectively, are related to malaria (Kpando DHMT, 2010).

To strengthen the fight against malaria, North Dayi District in 2004 introduced the ITNs as an additional protective tool. The campaign on the use of ITNs was aimed at reducing malaria and related mortality and morbidity by 25% by the year 2008. These nets are distributed free to pregnant women and mothers with children under five years whilst others were sold at highly subsidized cost. The use of ITN increased successively from 3.5% in 2004 to a peak of 55.3% in 2007. However, the proportion of children under five years sleeping under ITNs declined significantly to 40.5% in 2008 (Kpando DHMT, 2008). Similarly, ITN



use among pregnant women has been encouraging until 2008 where it declined to 30.2% from a peak of 52.5% in the 2007 (Kpando DHMT, 2008).

Even though the district was able to achieve its target for ITN use in 2008 malaria incidence still remains high with a case fatality of 18%. The expectation is that increased use of ITNs should lead to reduced incidence. However, malaria continued to predominate posing a health concern. It is against this background that this study is undertaken to examine the link of ITN use and malaria incidence and prevalence.

## **Research Objectives**

### **General objective**

The main objective of the study is to assess the effect of the distribution of the district-wide insecticide treated nets on the vulnerable groups. Variable of interest is age and sex.

### **Specific objectives**

The specific objectives of the study are to:

- a. analyse the malaria incidence among children under-five and women in fertile age after net distribution;
- b. examine the effect of the distribution of ITNs on malaria incidence; and
- c. assess the relationship between ITN distribution in reducing malaria morbidity and across all ages

## **Hypotheses**

To help achieve the set objectives, the following hypotheses were formulated:

H<sub>0</sub>: There is no significant difference in malaria incidence between women and children under 5 on and the rest of the ages on the other.

H<sub>0</sub>: There is no significant difference in cases of malaria attack between the period before and after the distribution of ITNs.

## **Significance of the study**

Many researchers have delved into the area of ITNs and have come with various finding. The outcome of the study is aimed at adding to existing knowledge. It is therefore expected other researchers would rely on it as a source of information and for further study on the subject and related topics.

Secondly recommendations that will impact on reducing the malaria burden could be adopted and implemented as a national policy. It is envisaged that the study could help identify the weaknesses and strengths in the current strategy to combat malaria. The rationale of the study therefore, was to ascertain if efforts aimed at achieving MDG goals 4 and 5 are on course.

## CHAPTER TWO

### REVIEW OF RELATED LITERATURE

#### Introduction

This chapter deals with review of related literature to the study and summarises materials written by other authors that have some bearing on the research topic under investigation. The researcher introduces the review with the concept of health. Other topics considered include: Health and diseases, Vector Borne Diseases, Malaria transmission & Incubation Period Concept of Effectiveness and Efficacy in ITNs Evidence of the impact of ITNs. It also looked at some conceptual frameworks such as concept of effectiveness and input- output analysis model.

#### Health and Disease

To understand the concept of health or disease, the World Health Organization (1948) defines Health as “a state of complete physical, social and mental well-being, and not merely the absence of disease or infirmity” ([www.pnf.org/Definitions\\_of\\_Health\\_C.pdf](http://www.pnf.org/Definitions_of_Health_C.pdf) 27/5/2012). Thus health is a ‘positive concept emphasising social and personal resources as well as physical capabilities.’ Good health can exist as a relatively passive state of freedom from illness in which the individual is at peace with his environment – a condition of relative homeostasis. Wellness is conceptualized as dynamic – a condition of change in which the individual moves forward, climbing toward a higher potential of functioning (Dunn, 1957).

A healthy person therefore needs to maintain healthy behaviour such as taking regular exercises and adequate rest, adopting a high level of personal hygiene, eating a nutritional balanced diet, abstaining from abuse of alcohol and drugs, taking care of one's mental well-being and developing social skill to interact in a positive manner within society (Chiu, 2003).

### **Vector Borne Diseases**

Vector borne diseases are infectious transmitted to humans principally by insects. In the terminology of epidemiology, vectors are organisms that transmit infections from host to another. The term vector commonly, though not necessarily, is used in contexts where the parasite or pathogen is adapted to be dependent on the vector organism for the completion of its life cycle (Holt, Subramanian, Halpern, Sutton, Charlab, Nusskern, Wincker, Clark, Rebeiro, Wides, 2002).

Most commonly known biological vectors are arthropods but many domestic animals too are important vectors or asymptomatic carriers of parasites and pathogens that attack humans and other animals. Arthropods form a major group of disease vectors with mosquitoes, flies, sandflies, tick, lice, mite and fleas transmitting a huge number of diseases. Many of such vectors are haemotophagous, which feed on blood at some or all stages of their lives. When the insects feed on humans, the parasite enters the blood stream of the host (Semenza & Menne, 2009).

The Anopheles mosquito, a vector for malaria, filariasis and various arthropod-borne-viruses (arboviruses), inserts its delicate proboscis under the skin and feeds on its host's blood. The parasites the mosquito carries are usually located in its salivary glands (used by mosquitoes to anaesthetise the host). Therefore, the parasites are transmitted directly into the host's blood stream (Semenza & Menne, 2009).

### **Malaria transmission and incubation period**

Malaria is usually transmitted through the bite of an infected female Anopheles mosquito. Less commonly, it may occur through contact with infected blood. Malaria is not transmitted from person to person like common cold or the flu. One cannot get it from casual contact with infected people. No other types of mosquitoes are known to transmit this disease. This type of mosquito becomes infected with one of the four Plasmodium parasites that cause malaria in humans, through a previous blood meal from an infected person (malaria-transmission.html 25/5/2012).

When an Anopheles mosquito bites an infected person, a small amount of blood infected with microscopic malaria parasites is taken. The parasite grows and matures in the mosquito's gut for a week or more, then travels to the mosquito's salivary glands. When the mosquito next takes a blood meal, these parasites mixed with saliva, are injected with the bite, and the transmission of malaria is complete.

The malaria transmission cycle continues if a mosquito bites this infected person and ingests the malaria parasite. The period between the infection with the parasites that cause the disease and the beginning of malaria symptoms is called the malaria incubation period. The malaria incubation will vary depending on the type of Plasmodium parasite responsible for the infection. Plasmodium falciparum tends to have a shorter incubation period, while Plasmodium malariae tends to have a longer incubation period. The other kind of malaria, Plasmodium vivax and Plasmodium ovale, can have a much longer malaria incubation period. For these parasites, a proportion of them may begin to grow immediately in the liver and cause symptoms after the normal incubation period. The remaining portion may remain inactive (“dormant”) in the liver for several months (and up to about four years) after a person is bitten by an infected mosquito (malaria-incubation-period.html 25/5/2012).

Once in the blood, the parasites travel to the liver and enter liver cells, to grow and multiply. After a minimum of seven days or as long as several years, the parasites leave the liver cells and enter red blood cells, which normally carry oxygen in the blood to tissues that need it. Once in the red blood cells, the malaria parasites continue to grow and multiply. After they mature, the infected red blood cells rupture, freeing the parasite to attack and enter other red blood cells. Toxins released when the red cells burst are what cause the typical symptoms. The malaria transmission cycle continues if a mosquito bites this infected person and ingests the malaria parasite (malaria-transmission.html 25/5/2012).

## **Concept of effectiveness and efficacy**

Before reviewing the methodology of measuring programme impact, it is important to discuss briefly the concept of effectiveness. It will be shown that community impact can be measured either directly or estimated through its components. Last (1995), defined the terms used below. Interventions have impact at two levels: community and individual.

Community effectiveness is the impact of health programme on the overall death rate in the community. It can be expressed in one of two ways. The ratio of death risk in the intervention group to that in the control group expresses relative risk (RR). With this ratio, the community protective effect ( $CPE=1-RR*100$ ) can be obtained. This expresses the percent reduction in the overall death rate as a result of the intervention -63% and 25% in the two Gambian studies (Alonso, Lindsay, Armstrong, Conteh, Hill, David, Fegan, de Francisco, Hall, and Shenton, 1991). On the other hand, the number of deaths averted as a result of the intervention (attributable risk) is measured by the difference in risk between the two groups. In the Gambian studies, attributable risks were 15.2 and 2.2 deaths per 1000 children, respectively (D' Alessandro, Olaleye, Langerock, Bennett, Cham, Cham, Greenwood 1997).

By contrast, individual effectiveness measures the reduction in disease or death risk that a compliant individual can expect compared to a non-compliant individual. It can be defined only by a risk ratio (relative risk) and hence as a protective effect. Community and individual effectiveness are not equivalent, unless the intervention coverage is 100%. In an Insecticide Treated Bed net

Curtain (ITBC), programme coverage refers to the number of target children with access to ITBC. For an ITBC intervention: Community Effectiveness is equal to Individual Effectiveness multiplied by Coverage. This model provides a useful framework, since directly measuring community effectiveness may not be easy. Coverage can be measured either from data that are routinely obtained or from limited cross-sectional surveys (Alonso et al, 1991).

### **Time frame of effectiveness measurement**

There is need to assess the impact of ITBC programmes over a period longer than 1-2 years for two reasons. First, the Gambian phase IV trial assessed impact on mortality while the programme was relatively new and the morale and enthusiasm of providers and recipients were likely to be highest. Short-term evaluations are therefore unlikely to reflect sustained impact. Secondly, there is the impact on the functional anti-disease immunity of reducing human-vector contacts over long periods. Comparative studies of high- and low- transmission areas in East Africa show similar rates of severe, life-threatening disease below the age of 5 years, although the peak age of severe disease is younger in areas of high transmission (Snow, de Azevedo, Lowe, Kabiru, Nevill & Mwankusye, 1994).

This fact has been used to explain the apparent similarities in malaria-specific mortality across a wide range of transmission intensities (Snow & Marsh, 1995). The study suggest that under natural conditions in Africa, a > 90% reduction in infection rates could alter only the age at which severe disease and



death occur, without a net cohort gain by the fifth birthday. Current trials of 1-2 years are unlikely to detect this because they are conducted with a large proportion of children who have some immunity due to high transmission conditions (Snow & Marsh, 1995).

The most important group, young, immunologically “naive” children, will be initially protected by the intervention, but the trial will have been completed when they enter the period of deferred risk. Although evidence pointing to this phenomenon is scanty, it is critical for a recommendation on ITBC programmes in Africa. Only through long-term programmes (with phase IV assessment) can such questions eventually be answered, since randomized controlled trials are unsustainable over long periods (Snow et al, 1994).

### **Measuring Community Effectiveness directly**

Mortality changes are the most unambiguous, objective, and tangible indicators of programme success. Overall mortality should be preferred to malaria-specific mortality as an outcome measure, since it is difficult to assess the latter in areas where acute respiratory tract infections and gastroenteritis compete with malaria as causes of childhood death. Two investigations of verbal autopsy in Africa (Snow, Peshu, Forster, Mwenesi, Marsh, 1992) confirm that it lacks sensitivity and specificity.

## **Evidence of the impact of insecticide treated mosquito nets**

Malaria is an important cause of illness and death in many parts of the world, especially in Africa, south of the Sahara. There has been a renewed emphasis on preventive measures, both at community and at individual level. Insecticide treated mosquito nets are a promising preventive measure (Sexton, 1994).

To evaluate the potential of ITNs, efficacy trials (using permethrin – the chemical used in treating the nets) were carried out in countries with a wide range of transmission intensities in Africa, Asia, Latin America and the Western Pacific. The majority of these trials were randomized-controlled trials, comparing ITN use with no net use and less commonly, comparing ITN use with use of untreated nets. The impacts measured have included all-cause child mortality (age 1-59 months), incidence of severe malaria, incidence of uncomplicated malaria episodes, and prevalence of parasitaemia, mean haemoglobin level, splenomegaly, and nutritional status (Winch, Makemba, & Kamazima, 1997).

A Cochrane review concluded that ITNs reduce overall mortality by about 20% in Africa (range 14% - 29%) and that, for every 1,000 children aged 1 – 59 months protected by ITNs about six lives are saved each year. The review also concluded that ITNs reduce clinical episodes of uncomplicated malaria caused by *Plasmodium falciparum* and *Plasmodium vivax* infections by 50%, as well as reducing parasitaemia (Lengeler, 1998).

Studies carried out in Africa, south of the Sahara show that insecticide treated bed nets reduce morbidity and mortality in pregnant women. Eritrea had a

population of 3.8 million in 2001 and reported a total of 126,000 malaria cases in that year. Approximately, 818,000 nets were distributed from 2001 to 2006, with long lasting insecticide net distribution starting in 2005. By 2001, the number of reported cases had reduced to half the number reported in 1998 (255,000) (Nyarango, Gebremeskel, Mebrahtu, Mufunda, Ghebrat, Abdulmumini, and Okbaldet, 2005).

Philips-Howard, Nahlen, Wannemuehler, Kokzak, Kuile and Gimning (2003) reported that women in their first to third pregnancies who had slept in insecticide treated bed net were significantly less likely to (a) to develop malaria parasitaemia compared to those living in control villages, and (b) to become anaemic. The incidence of low birth weight and low birth weight combined with stillbirths, abortions and intra-uterine growth retardation were significantly reduced by 28% and 25% respectively in parities 1- 4.

The classic bed nets that had been used previously were a personal protection method. The net gives the person sleeping under the net protection but had little impact on malaria transmission overall. The protection of the insecticide treated net boosted this technology to an entirely new level: the ITNs not only protected the person sleeping under the net, but also kill the mosquitoes that landed on it. Large-scale study trials in intense transmission areas proved that if many people religiously used ITNs, they could greatly reduce overall malaria incidence, and contribute to saving lives in a very cost-effective way (Wiseman, Hawley, ter Kuile, Philips, Vulule, & Nahlen, 2003).

Despite the massive impact of ITNs and later, long lasting insecticide-treated nets (LLINs), on malaria control, their role today in malaria elimination has been limited as they have been more widely deployed in high-transmission settings. However there is strong evidence that when deployed on a mass scale, ITNs do result in a large-scale impact on transmission (Lindblade, Eisele, Gimnig, Alaii, Odhiambo, Kuile, Hawley, Wannemuehler, Philip-Howard, Rosen, Nahlen, Terlouw, Adasu & Vulule, 2004).

Evidence also suggest that while the greatest protection is obtained by sleeping under an ITN, sleeping in a house where an ITN is deployed, or even in a house without an ITN that is close to a house with one, provides some degree of protection. One challenge for elimination is that the less malaria there is; the lower the personal motivation may be to sleep under a bed net (Hawley, Philips-Howard, ter Kuile, Terlouw, Vulule, Ombok, Nahlem, Gimnig, Kariuki, Kokzak, & Hightower, 2003).

### **Use of insecticide treated nets in Ghana**

A Study carried out by Browne, Maude, & Binka, (2001), on “The impact of insectide-treated bed nets on malaria and anaemia in pregnancy in Kassena-Nankana district Ghana: a randomized controlled trial” failed to achieve the desired result. It focused on pregnant women in primigravidae and multigravidae. The characteristics of women in intervention and control groups were comparable. The results showed that the odd ratios with 95% of confidence interval for different study end points were, for Plasmodium falciparum

parasitaemia - 0.89 (0.73, 1.08), for anaemia – 0.88 (0.70, 1.09), for low birth weight (LBW) – 0.87 (0.63, 1.19).

The report revealed that there was no benefit for treated bed net use. It also further indicated that effective net use by parity varied from 42% in primigravidae to 63% in multigravidae, inspite of free nets and insecticide impregnation. The study concluded that the main reasons for not using a bed net were warm weather and perceived absence of mosquito biting.

Wednesday January 13 2013 edition of the Daily Graphic reported that the use of the Insecticide Treated Nets in some communities in the Western and Central regions has helped reduce the incidence of malaria among pregnant women and children under five years in those communities. It stated that the over 120,377 pregnant women and 630,177 children under five have benefitted from the bed net. The report testified that malaria cases in the community had reduced from 3133 in 2010, 488 in 2011 and 443 in 2012. The report further stated that for the past two years no maternal mortality or children under- five deaths from malaria had been recorded in the community and cases of acute malaria had been eliminated, especially among children (Quaicoe-Duho, 2013).

## **Input –Output Analysis**

Input-output analysis is a basic method of quantitative economics that portrays macro-economic activity as a system of interrelated goods and services. The technique in particular observes various economic sectors a series of inputs of source material (services) and outputs of finished or semi-finished goods (services). The field is credited to the work of Leontief (1906-1999), who was awarded the 1973 Nobel Prize in Economics for his pioneering work in that area. Leontief once explained input-output analysis with this analogy: ‘when you make bread you need eggs, flour, and milk.’ Juxtaposing this to the study, preventing malaria using ITNs, one need mosquito nets and to further expand its impact to a larger population, more mosquito nets are needed (Alonso et al, 1991).

To a limited extent, because input- output analysis deals with aggregate categories, it falls within the purview of macro-economics. Yet, because it is applied within the realm of observable and measured phenomena, input-output analysis is considered a branch of econometrics. Its application incorporated major traditional areas of economic analysis such as short-term forecasting, dynamic input-output modelling, income and employment multipliers, regional and interregional analysis, environmental impacts, social demography, international trade and underdeveloped economics.

### **Leontief’s development of input-output analysis**

Leontief’s 1944 early extensions of input-output analysis were intended to demonstrate that: (1) production coefficients, expressing relationships among the

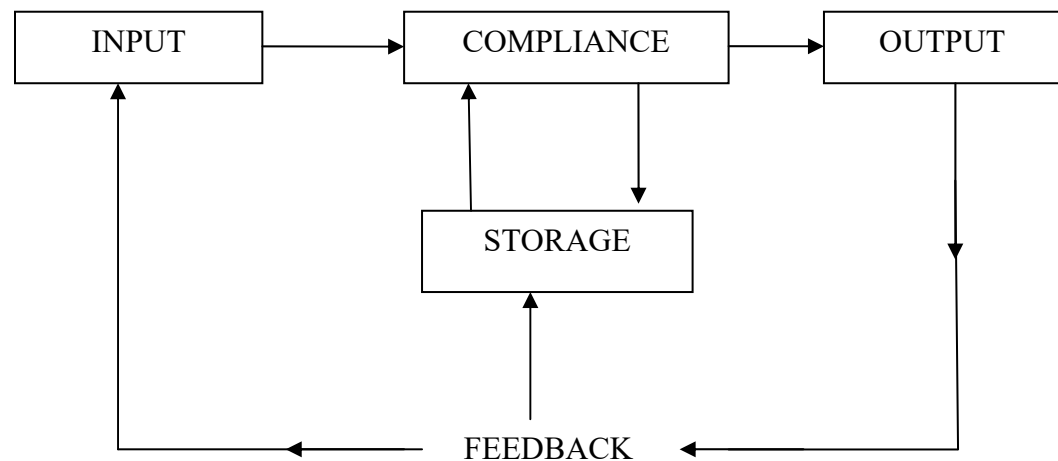
industrial sectors of an economy, lent themselves to statistical estimation; (2) that the estimated coefficients were sufficiently stable to be used in comparable static analysis, i.e. different equilibrium states; and given the above two points (3) that on a quantitative level, the merits of different economic policies could be evaluated by taking into consideration both their direct and indirect feedback effects (or multiplier impact) on inter-industry flows.

In more recent years, input-output analysis has been applied to the issues of worldwide economic growth, its environmental consequences, its impact on the world reserve of natural resources, and the political economic ramifications for relations between the economies of developed and less developed countries (Leontief, 1986). Under a project funded by the United Nations, Leontief managed a study on the growth of the world economy until year 2000. The multi-regional input-output model extended across 15 regions consisting of 45 sectors each with balanced trading accounts.

### **Theoretical implication of concept**

Linking the concept into the study, the introduction of the ITNs is considered as the “input”. The compliance here referred to the effective usage of the treated bed nets. These include storage and proper handling of the product to ensure its effectiveness. “Output in this case refers to the expected outcome. Previous research outcomes suggest that ITNs were capable of reducing the malaria incidence compared to those who do not use it. The premise is that if the community experiences increase in malaria parasitaemia, then a conclusion could

be drawn that the nets distributed were not sufficient in reducing the malaria incidence. Therefore the amount of bed nets distributed (input) is important to determine the expected outcome (output). The “feedback” is the total response from clinicians on the malaria incidence. Has the ITNs reduced the malaria incidence?



**Figure 2: Input –Output Analysis Framework**

Source: Federal Planning Bureau, (2002)

### **Limitations**

- a. Only part of the information is available for this production coefficient while the remainder had to be arduously gleaned from other sources. In other words, reducing malaria incidence is not only being affected by bed nets, but there are other interventions such as in-door residual spraying, keeping a clean environment and the use of repellents.
- b. Secondly, underlying Leontiefs input-output method was of the assumption that production coefficients remained largely constant for



extended periods. This proposition was hard to reconcile with the dominant neoclassical theory of production; that factors of production were readily substituted for one another as their relative prices changed. Prices in this case refers to the benefits that people derive from using any of the roll back malaria messages and its convenience will make people to either stick to one or shift to the use of the other.

- c. Focuses on households without considering the effects of structural and other sleeping arrangements.
- d. Does not account for social norms and public policy (e.g. affordable decent housing) which have effect on behaviour change.

The research therefore aims to evaluate the effort in terms of input and its impact (output) on malaria incidence in the North Dayi District. The underpinning framework is the Input-Output Model.

## **CHAPTER THREE**

### **METHODOLOGY**

#### **Introduction**

This chapter outlines the various methods and materials that were used to achieve the study objectives. Secondary data was the main source of information from the District Health Directorate, Kpando. The chapter discussed the following: study area, target population, study design, source of data, research instrument, methods of data collection, data processing and analysis, and ethical considerations.

#### **Study Area**

North Dayi district with the district capital sited in Kpando is one of the eighteen administrative districts of the Volta Region. It shares administrative boundaries with Jasikan District at the north, South Dayi District at the south, east with Hohoe District, and West with the Lake and the Afram Plains in Eastern Regions. The most conspicuous physical features in the district are the Volta Lake and the Akwapim-Togo ranges. Scattered over the district are hills and ridges giving the topography an undulating nature.

The population structure of the district bears resemblance to the demographic characteristics of developing country. Thirty-eight percent of the population is made up of young people aged between 0-14 which is lower than the regional average of 41.1%. The aged population made up of 60 years and above

accounted for 9.8%, while the economically active population of 15 to 59 years accounted for 52%. Data from the 2010 population and housing census indicates that the total population of the district represented only 4.4% of the total Volta Region with a growth rate of 0.8%.

Majority of the inhabitants (65%) are engaged in small scale farming and trading activities. Communities along the Volta Lake are also involved in fishing activities with the main fishing landing site located at Kpando Torkor. Other satellite fishing sites located at Wusuta Tornu, Tsorxor, Awate Tornu, Sovie, and Agbenorxoe serve as conducive breeding site of mosquitoes. A small proportion of the inhabitants (2%) are into poultry and the carving industry.

There is also a deposit of white clay in commercial quantities which is currently being mined by the indigenes of the Anfoega Traditional area. The dug-out mines serves as breeding grounds for mosquitoes. The estimated district population of 77,295 was projected from the 2000 census with an annual growth rate of 1.8%. Households that benefited from the district wide ITN distribution were 2,321. On the whole, 5,559 bed nets were distributed. Malaria continued to rank first among all reported cases. Most cause of admission of pregnant women and children under-five were as a result of malaria morbidity.

The district is has four established government approved Senior High Schools, one Senior Technical School and a Vocational institution established by the Catholic Church. The district has three hospitals, one private and two owned by the Catholic Church located at Anfoega and Kpando with the later serving as the district hospital. The district has ten functioning clinics spotted in ten towns

with an additional three (3) CHPS zones located at Gbefi, Bume and Yordan-Nu. There is also a Lake Team that runs an outreach clinic providing both curative and preventive services based on availability of logistics (Kpando DHMT, 2010). Apart from the over-bank services on the lake, geographical accessibility to health care is good.

The target population is made up of all people (male and female of all ages) who attended a health care facility in the district within the period July 2010 through to May, 2012. The population of interest were clients diagnosed of malaria. The health directorate has divided the district into five sub-districts to ensure effective administration of the catchment area. The breakdown of the population is as follows:

**Table 2: Distribution of North Dayi Sub-District Population for 2011**

| Sub-District | Projected<br>Pop.<br>(1.8%) | 0-<br>11mths<br>(4%) | Expected<br>pregnancy<br>(4%) | WIFA<br>(23%) | CHN<br>0-59<br>(20%) |
|--------------|-----------------------------|----------------------|-------------------------------|---------------|----------------------|
| Kpando       | 23,295                      | 932                  | 932                           | 5,358         | 4,659                |
| Agbenorxoe   | 9,318                       | 373                  | 373                           | 2,143         | 1,864                |
| Anfoega      | 19,832                      | 793                  | 793                           | 456           | 3,966                |
| Vakpo        | 15,532                      | 621                  | 621                           | 3,572         | 3,106                |
| Island       | 9,318                       | 373                  | 373                           | 2,143         | 1,864                |
| Total        | 77,295                      | 3,092                | 3,092                         | 13,672        | 15,459               |

Source: Kpando DHMT, 2011

## **Study Design**

Discussion of study design in epidemiology normally follows cause and effect paradigms. The cause-effect relationship can be deterministic or probabilistic. Statements of “fact” can be made in a deterministic relationship about an event being studied. On the other hand, probabilistic relationship indicates that a relationship could exist between the cause and the effect. Causal knowledge can help predict the outcome of an intervention and help treat disease.

Quantitative technique was used in the study exploring an interventional Quasi Experimental design. Quasi-experimental involves indirect manipulation of the subjects. In quasi-experiment, participants or objects of study are not randomized. It is often described as a natural experiment. Quasi-experimental studies are normally applied in evaluating health programmes after a distal factor has been introduced in a population (Friis & Seller, 2004). On the other hand, prevention trials usually take many years to conduct and require tens of thousands of participants because they often focus on reducing the incidence of diseases that typically occur at a yearly cumulative incidence of 1% or less (Prentice, 1995).

Positivist philosophy – quantitative approach was used in analyzing district wide data on malaria with the general focus of assessing the impact and effectiveness of ITNs in reducing the malaria incidence as an integral part of the fight against the malaria disease.

## **Data and sources**

The main source of data was the Kpando District Health Directorate. Data quality was assessed by cross-checking the figures from the various health facilities. There is also in-built software that synchronizes the quality of data. Five main sub-districts constitute the population of interest comprising; Kpando, Agbenorxoe, Anfoega, Vakpo and Island communities. These communities seek health care in facilities within the period under investigation in the district. The target population was made up of all persons (all age groups, males and females) who visit health facilities and were diagnosed of malaria. This could either be clinically or laboratory confirmed cases and was duly recorded by a clinician as malaria.

In addition, target groups included persons from adjacent districts with close proximity to the district. These communities included Have, Nyangbo, Tafi, Alavanyo, all in the Hohoe district; Abutuase and Nkonya in the Biakoye district; and Kpeve in the South Dayi district. These populations served as limitations to the quality of data by adding up to estimated population of the district. The nature of the data did not make it possible to screen and eliminate clients who come from places outside the district. This was a major limitation because it failed to assess true population of the district.

## **Determination of Sample Size**

The study did not make use of any mathematical calculations in determining the sample size. It instead a total count of all malaria cases within the

period was investigation. Therefore the desired sample size in this case was total facility OPD attendance diagnosed for malaria the entire district within the two periods. Before the introduction of the intervention, reported total malaria cases obtained was 20,283 and after the intervention were 20341. The study examines only new cases and excluded the re-attendances or reviews of patients' visits. The observed population at risk was studied for a one year period for both the exposed and controlled periods. The observed population at risk refers to all clients/patients diagnosed of malaria. A total of 242 cases were observed for the exposed (before the intervention) and another 242 cases for the controlled (after the intervention) bringing the total observed cases to 484.

### **Data collection techniques**

The study relied on morbidity on malaria using existing data from the district health directorate information unit. Data was obtained primarily from the consulting room register books which specified patient diagnosis. This was collated by the health information units in the various facilities at the end of every month and submitted to the district directorate.

### **Data analysis and presentation**

Paired t-Test was used to compare means of the two variables with the assistance of the Statistical Package for Service Solution (SPSS.17) software. This computes the difference between the two variables for each case, and test to see if the average difference is significantly different from zero. The main assumption

was that both variables should be normally distributed. 95% confidence interval for mean change in malaria incidence was used; where  $SEM = S/\sqrt{n}$

A partial correlation analysis was used to assess if the use of ITNs showed any significant difference in malaria incidence.

### **Ethical considerations**

Ethical approval was obtained from the University of Cape Coast IRB noting that the study does not pose any personal harm to individuals since their identity is not linked to the research. Institutional approval was also obtained from the District Health Directorate, Kpando for approval facilitating access to information.

The study also acknowledged all other sources of information used in reviewing literature thereby making it worth reading and source of information for future studies.



## **CHAPTER FOUR**

### **RESULTS AND DISCUSSIONS**

#### **Introduction**

The chapter deals with analyses of data obtained from field investigation at the district health directorate, Kpando. Data has been organized in two parts. The first part deals with the sex classifications. Malaria incidence has been grouped into males and females. The second part analyzed malaria differences in the various age groups. Efforts were also made to calculate the mean difference between the two periods. Finally, paired sample t-test was used in assessing the relationship between ITNs and malaria morbidity across all ages.

#### **Socio-demographic characteristics of cases**

This section examines the sex and age classification of the cases. A case in this content refers to each episode of reported and confirmed malaria by a clinician. The data did not capture other demographic characteristics such as education and occupation. This limitation was due to the fact that the data source was secondary and did not capture other demographic characteristics. Information collected was therefore restricted to only age and sex.

#### **Sex**

The study was interested in sex of cases reported. Cases were identified and classified by gender (male and female) separately for the period before and after. It emerged from the study that 58% of all cases were represented by females

and the other 42% being males. It was therefore evident that the malaria burden afflicted females than males. This outcome might be due to the fact that females report onset of ill health at health facilities than male counterpart.

## **Age**

Age is a demographic characteristic used to differentiate individuals into child, youth, adolescence adult and old age. The study was interested in analysing age categories of ‘cases’ and did not consider using ‘respondents’ because there was no personal contact with individuals. Result of analyses of age is presented in tables and figures. Appendix contains the main survey data. Age was classified into eleven unequal age groups based on the Ghana Health Service standard. The lowest age group category was children less than one year and the upper group being ages above seventy.

Age classifications were specially done to easily identify children under five, young children, early adolescence, mid-adolescence, late adolescence, reproductive years in the case of females up to age 49. Menopausal ages fell within 50s to 60s and 70s and above representing the aged.

## **Descriptive characteristics of field data**

One way of assessing the malaria transmission and morbidity was to categorise the cases into two groups – before and after. The variables were transformed to make them dichotomous. For metric variable (before and after cases), their mean values were used. “Before” cases were coded 1 and those

“after” coded 2. The data was grouped into months beginning from July 2010 to June 2011 representing the exposed period and July 2011 to May 2012 denoting the controlled period. On the whole, 484 grouped cases of out-patient cases were reviewed.

**Table 3: Characteristics of field malaria data of North Dayi, 2010-2012**

|        | N   | Mean   | SD     | Std. Error | Skewness Statistic | Minimum | Maximum |
|--------|-----|--------|--------|------------|--------------------|---------|---------|
| Before | 242 | 201.67 | 82.690 | 0.156      | 1.226              | 85      | 600     |
| After  | 242 | 204.86 | 97.559 | 0.156      | 1.424              | 13      | 762     |
| Total  | 484 | 203.26 | 89.358 |            |                    | 13      | 762     |

Source: Field Survey, 2012

In table 5, the minimum case value observed for a particular period was 13 whilst the maximum was 762. On the whole, an average of 203 cases was reviewed for all age categories and the confidence interval was set at 95%.

### **Before intervention**

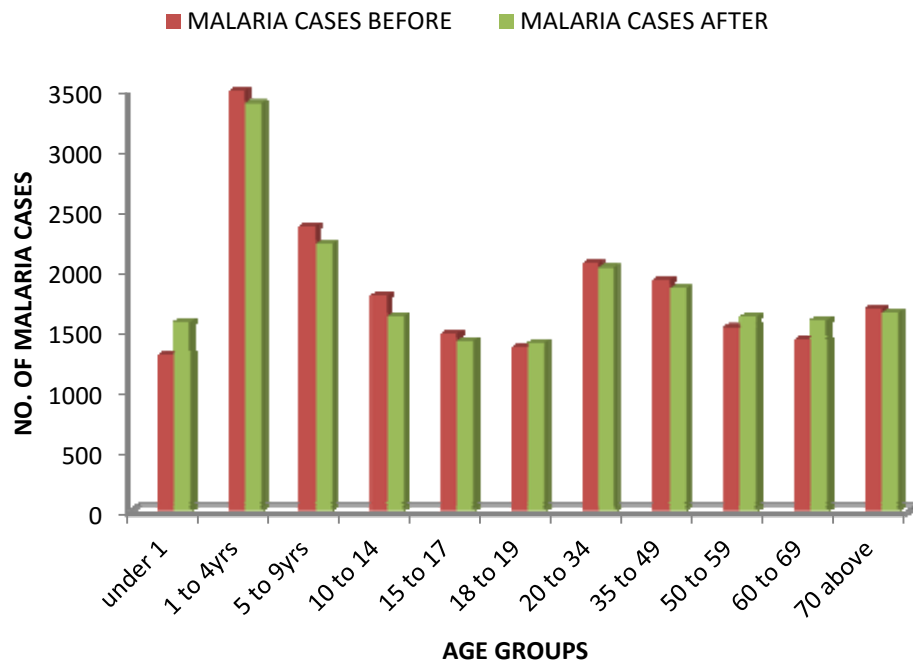
The least malaria cases recorded was 85 for males in the month of May, 2011 for ages 18 to 19 years and the maximum of 600 cases for females was recorded in the month of June 2011 for ages 20 to 34 years. The mean value calculated was approximately 202 implying that on the average, 202 cases was seen on monthly bases. The confidence interval was set at 95%.

### **After intervention**

Minimum value of 13 was recorded for the 'after' intervention for males in the month of May and a maximum of 762 recorded for females in the month of March. The mean value of approximately 205 after the intervention was an indication that more cases were recorded for the period than 'before' intervention but this was marginal. Again since the value for the lower and upper limits of the confidence interval do not overlap or encountered zero, we conclude that there is significant difference between the 'after' and 'before' intervention.

### **Malaria incidence affecting males**

The study in assessed the impact of the disease on the sexes and its possible effect on livelihood. Malaria transmission had been prevalent in the North Dayi district all year round. This could be due to the fact that the district experiences two maxima of rainfall and also the district is bounded to the west by the River Volta and the west by the River Dayi which facilitated the breeding of the mosquitoes. Figure 4 illustrates the burden of malaria incidence on the male population. On the average, incidence reduced among seven out of the eleven age groups. Under 1 year of age incidence of malaria was recorded to be highest among the male group after the intervention. It recorded a percentage increase of 21.



**Figure 3: Male malaria cases, North Dayi, 2010-2012**

Source: Field Survey, 2012

Age grouping was based on the Ghana Health Service standard classification for disease morbidity. For both periods, the malaria disease tends to place more burdens on ages below 10 years and 20 to 49 age groups. Under 1 year male incidence of malaria both periods showed a relatively lower case episode. This could be due to the fact that it was the group with the least interval. That notwithstanding, under 1 year reported malaria cases represented 42% of that population. Again, under 5 years reported malaria cases was the most affected constituting 24% of all male malaria incidences before the intervention.

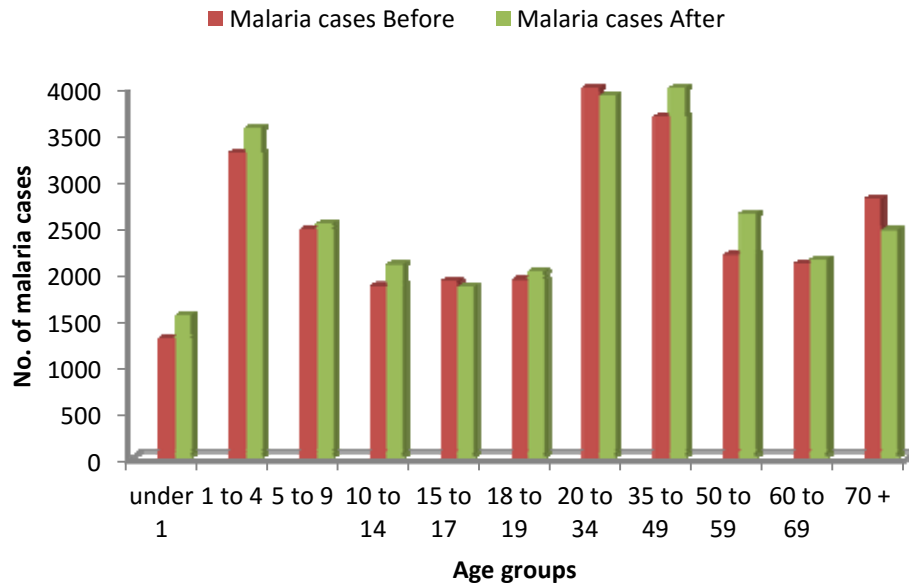
Further analysis of the data indicates that people within the 5-9 years age group were most vulnerable to the disease. Another group mostly affected by the

disease was observed within the 20 to 34 and 35 to 49 age groups. These age groups (20 to 34 and 35 to 49) are adults either in collage or in the labour industry. The implication could be that, man hours could therefore be lost leading to huge revenue lost to both the individual and the national economy.

Within the control group, under 5 malaria incidences constitute 25% of all male cases. This was an indication that children under 5 were more likely to be at risk of the disease malaria. Male incidence of malaria after the intervention depicted an increase of 0.3% within the eleven months period of investigation. On the whole, age groups mostly affected by malaria were the under 5, 5 to 9 and 20 to 49 age groups all together representing 54.4%. High incidences of the disease were noted in the raining season notably in the months of May, June, July, August and September.

### **Malaria incidence affecting females**

The study was interested in establishing the impact of the disease on females and its effect on the various age groups categories. From the study, it was established that females were in the majority of the sex groups constituting 51%. The major activity of women (as reviewed in the literature) in the district was trading and therefore spent most of their daily activities outdoors thereby becoming victims to the mosquito vector. The month of June had shown high incidence among all age groups before the intervention emphasizing the vectors prevalence during the period. Figure 5 illustrates the spread of the disease among the age groups with children 1 to 4, 20 to 34 and 35 to 49 recording high number.



**Figure 4: Female malaria cases in North Dayi, 2010-2012**

Source: Field Survey, 2012

The Female groups identified to be most at risk to the malaria disease before the intervention was the 20 to 34 and 35 to 49 years. These groups' falls within the reproductive ages and the disease could have serious implications for their children and the work they do for a living. Expectant mothers who suffer from malaria could experience incomplete or spontaneous abortion resulting in days of hospitalization. This situation could increase a woman's parity especially where a woman had never had a living child. High incidence was also noticed among the 1 to 4 years group. Incidence rate during the controlled and exposed period was 0.50 and 0.41 respectively. Incidence was relatively high within the

under 1 year group representing 50% of the total target population of that age group and about 17% of the total female reported malaria cases.

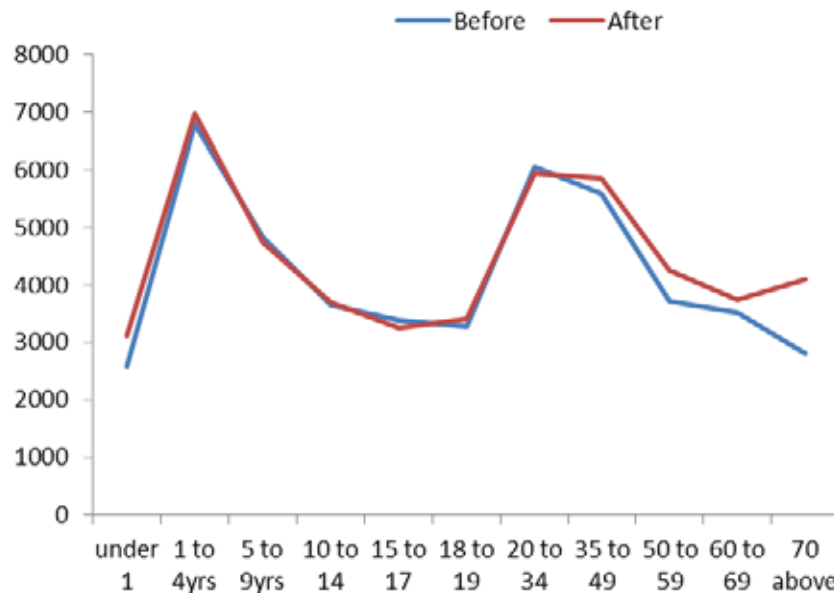
As noted earlier, the trend for females after the intervention had shown that women within the age groups 20 to 34, 35 to 49 and children 1 to 4 were the most affected. These collectively represented 40% of the vulnerable groups after the introduction of the bed net. Compared with females before intervention, the percentage increase after the intervention was 3%. Again, the disease has shown its debilitating effect on children and especially women in the reproductive age groups (Sachs, 2002). Compared to the target population, the study had shown that female children aged 0 to 5 years affected by malaria was 33%, a 3 percent increase over the before intervention. The under five female cases compared to the total female cases was about 18% showing a 1% increase over the before intervention.

### **Incidence of malaria among all age groups**

Figure 6 is aimed at combining the sexes in order to illustrate a single trend for the two periods. The objective was to identify which age group category was most affected by the disease. In other words Figure 6 represents a summary of both groups of patients who reported and were diagnosed with malaria within the two periods. Separating the sexes had demonstrated that both males and females were at risk of being affected by the disease. The study had shown that younger children 1 to 4 who were most likely to have low immunity were affected most. There was a gradual drop up to age 18 to19 peaking again at 20 to 34 and



35 to 49 with women mostly at risk. A possible explanation to this could be that women of those age groups spend most of their time outdoors. They are either attending to house chores or engaged in other economic activities in the evening thereby exposed to the vector.



**Figure 5: Malaria incidence among age groups in North Dayi 2010-2012**

Source: Field Survey, 2012

Malaria incidence ‘before’ the intervention had been noted to be lower than ‘after’ intervention throughout the period under investigation except for ages 5-9 and 20-34 year groups. Peak periods of incidence were observed within the ages 1 to 4 and 20 to 49 years. However, considering the population of children under one (3,092) it showed that 51% of children in that group were affected by the disease. This could be explained by the fact that the district received clients from the neighbouring districts notably Biakoye and the South Dayi and also the

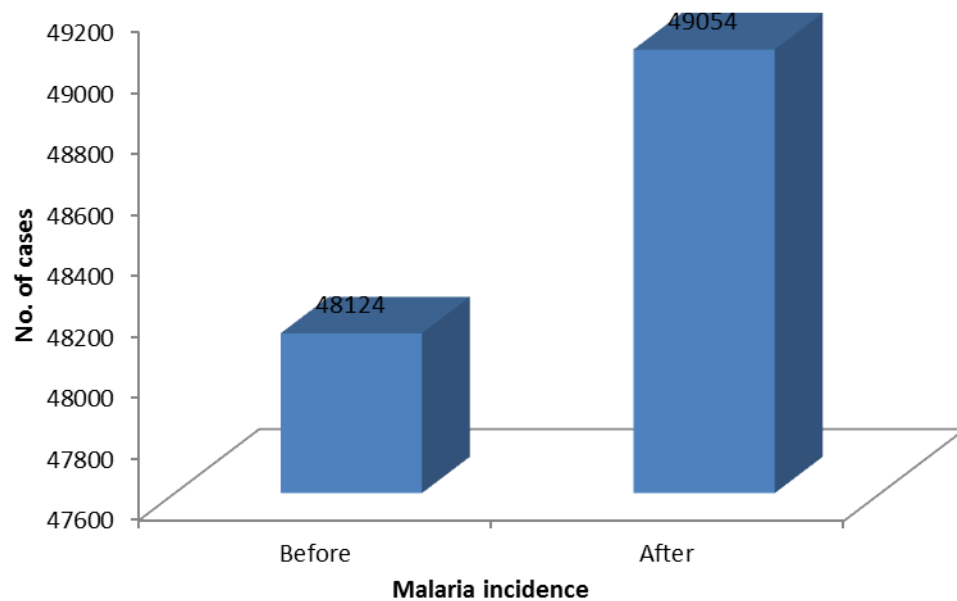
fact that it was the only district privileged with three hospitals. From age five, incidence reduces as one ages through to age nineteen an indication that children begin building their immunity against the disease from age five through adolescence. Soon after, immunity begins to fall until completion of the reproductive years in the case of women. The trend showed that the introduction of insecticide treated nets did not make any significant impact in reducing the malaria incidence.

With the population of children under- five estimated at 15,459, it meant that 61% of children reported with malaria before intervention. After the intervention, malaria incidence increased to 65%. With the population of women in fertile age also estimated at 13, 672, eighty-four percent of cases before the intervention were diagnosed with malaria whilst the corresponding figure after the intervention had increased to 86% an indication that incidence had increased by 2% over the period under review. A possible reason could be that some women might not be sleeping in the net. Critical analyses of the trend revealed that females within the ages of 15 to 17 and 20 to 34 might not be sleeping the treated nets.

### **Total incidence of malaria**

Figure 7 was to demonstrate how introduction of the district-wide Insecticide Treated Bed Nets had impacted on malaria incidence. The expectation of distributing the bed net was to reduce the malaria burden on the people of the district. The ITNs was first of all to prevent people who sleep in it from the bites

of the mosquitoes. Secondly, mosquitoes are killed shortly after getting into contact with the net. This way, it was expected that the mosquito population would be reduced in the environment where the nets are used. The study revealed that incidence of malaria remained high despite the introduction of the ITNs.



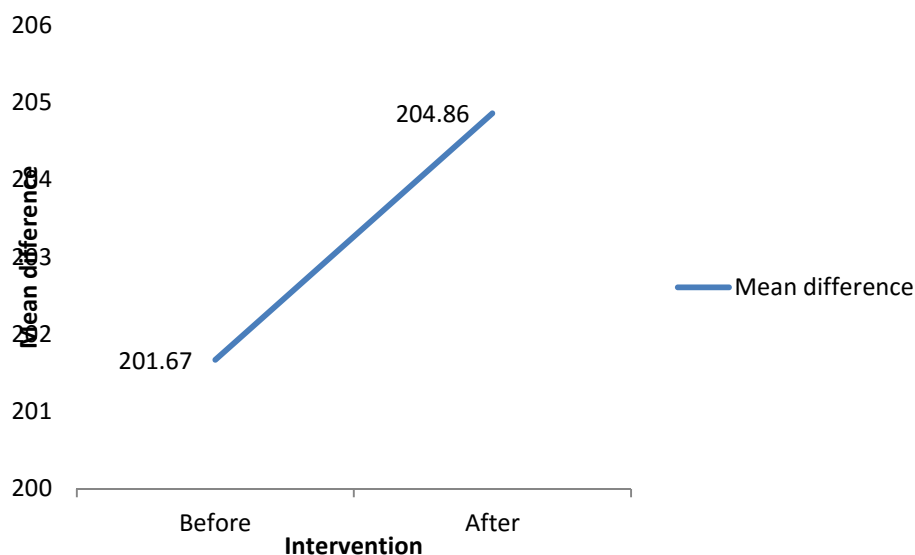
**Figure 6: Total malaria incidence in North Dayi, 2010-2012**

Source: Field Survey, 2012

The period under review witnessed a 1.9% increase of the malaria disease over the period before the intervention. This finding was contrary to the Cochrane’s review conclusion that ITN’s reduced clinical episodes of uncomplicated malaria caused by Plasmodium falciparum and Plasmodium vivax infections by 50% (Lengeler, 1998).

### Mean difference of malaria before and after intervention

Mean difference was used when comparing the two groups of, before and after in Figure 8. The sample mean difference between the two groups was 3.19. The increase rate of incidence was perhaps an indication that ITNs use alone could not have been the panacea to the malaria transmission.



**Figure 7: Means difference of ITN use in North Dayi, 2010-2012**

Source: Field Survey, 2012

There was not much difference between the before and after the intervention implying that the introduction of the Insecticide Treated Nets had had little influence in reducing the incidence of malaria for the period under investigation. It was therefore concluded that there was significant difference in malaria incidence between the period “before” and “after” the distribution of ITNs. In reference to the concept of effectiveness, the treated bed net could not

reduce the malaria disease or death risk that a compliant individual could expect compared to the period of non-compliance. The household structure could be part of the challenges to the problem. On the other hand it could also be as a result of the quantity of bed nets distributed. Earlier evidence suggesting the effectiveness of treated bed nets was done on a large scale and had both personal and community-wide effect. It meant that further investigations needs to be conducted. A possible area for research could be in the area of individual/communities usage and health education.

#### **Paired samples test analysis for malaria incidence**

Paired sample test analysis is a statistical tool used to run a before and after phenomena. It was used to compare the mean of the two variables. It computed the differences between the two variables for each case, and tested to see if the average difference was significantly different from zero. The assumption was that the two variables should be normally distributed. Table 6 had shown a negative lower limit value of -14.505 and a positive upper limit value of 8.125. This was an indication of the fact that the intervention had no positive effect on the unit of measurement.

**Table 3: Paired samples test analysis for malaria incidence in North Dayi, 2010-2012**

|                        | Paired Difference |           |            |                 |       | t    | df  | Sig(2-tailed) |
|------------------------|-------------------|-----------|------------|-----------------|-------|------|-----|---------------|
|                        | mean              | Std. Dev. | Std. Error | 95% conf. Inter |       |      |     |               |
|                        |                   |           |            | Lower           | Upper |      |     |               |
| Pair1 Before-<br>After | -3.190            | 89.358    | 5.744      | -14.505         | 8.125 | -555 | 241 | 0.579         |

Source: Field Survey, 2012

Assessing the relationship between ITN distribution and malaria morbidity across all ages, the significant value calculated using the paired sample test was 0.579. Referring to the earlier hypothesis set, Ho: there is no significant difference in cases of malaria attack between the period before and after the distribution of the ITNs – the study concluded that since the alpha value was greater than 0.005, the study fail to reject Ho and concluded that the intervention had no effect on reducing malaria cases in the district. This was also testified by the overlap of the lower and upper limit values of -14.505 and 8.125 respectively. In other words, the intervention did not help reduce malaria incidence in the district.

One possible reason that could be assigned to this set back could be attributed to the inadequate number of bed nets distributed. Out of a district population of 77,295, bed nets distributed were 5,559. Statistically, this amounts to 7.2 % of the population. In reference to the input-output analysis framework,

the study concluded that distributed bed nets (input) was inadequate to generate the expected result (output).

### **Paired correlations of age of malaria incidence**

Comparing the associated of the partial correlation of the age groups on the influence of ITNs on malaria incidence before and after, the correlation was 0.0519. It implied that there was weak positive correlation between age and period of intervention.

**Table 5: Paired correlations of age of malaria incidence, 2010-2012.**

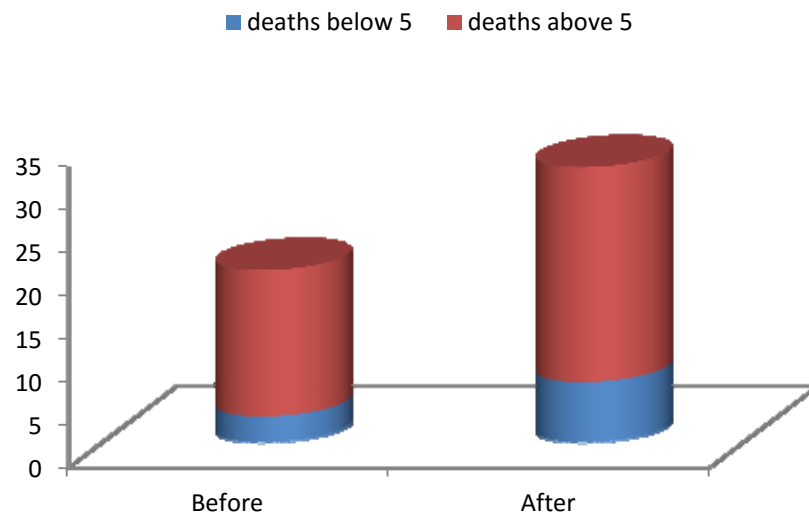
| Control variable |                         | Before | After | Age group |
|------------------|-------------------------|--------|-------|-----------|
| Before           | Correlation             | 1.000  | 0.519 | 0.054     |
|                  | Significance (2-tailed) |        | 0.000 | 0.401     |
|                  | df                      |        | 240   | 240       |
| After            | Correlation             | 0.519  | 1.000 | 0.000     |
|                  | Significance (2-tailed) | 0.000  |       | 0.996     |
|                  | df                      | 240    | 0     |           |

Source: Field Survey, 2012

Since the alpha value was less than 0.005, the study failed to reject the null hypothesis and concluded that the intervention had little effect on the reduction of malaria cases among the age groups in the district. In other words, the intervention did not result in any improvement among the age groups.

### Malaria related mortality

Malaria related mortality refers to all deaths clinically confirmed by the physician as being caused by the plasmodium parasite. It is important to note that deaths related to malaria were in some cases not exclusive but as a result of other complications. Mortalities recorded were therefore either principal or additional diagnosis of the cause of death. Figure 9 illustrates mortalities recorded in the district for the two periods under review. Using the indicators for deaths below 5 and above 5 years, increased fatalities were observed after the introduction of the insecticide treated net. In other words, mortality due to malaria before the intervention was observed to be lower than after the intervention was introduced.



**Figure 8: Malaria related mortality in North Dayi 2010-2012**

Source: Field Survey, 2012

Among children under five, there was an 85% increase in the mortality rate. Similarly, deaths among patients above the ages of five, witnessed a 78%



increase after the intervention using the ITNs. Between the two periods, mortality rate increased by approximately 81% after the intervention was introduced. As observed earlier, it could be that public health education on early home based management of malaria had not been adhered to resulting in cases arriving in facilities in a bad state. Also, case management at the first point of contact in facilities could also be examined especially on their emergency preparedness on severe malaria conditions. In reference to the concept of effectiveness, the intervention could not avert the risk of dying between the two groups. In effect the impact of the programme seemed not to be beneficial to the community.

**CHAPTER FIVE**  
**SUMMARY OF FINDINGS, POLICY IMPLICATIONS, CONCLUSIONS**  
**AND RECOMMENDATIONS**

**Introduction**

Some studies had shown that, where malaria prospers most, human societies have prospered least. The study had shown some evidence that malaria incidence continued to rise despite the use of insecticide treated bed nets in the North Dayi district. Malaria incidence was noted to be highest in the months of June, July, August and September which is the peak of the raining season. It is therefore recommended that multiple measures of intervention be intensified such as out-door spraying, use of DDT at potential breeding site and use of repellants to reduce the mosquito population. It was also evident that male children under 5 recorded high incidence of Malaria compared to their female counterparts for the same period. The reverse was seen among females within the reproductive ages (15-49). Females of these ages have shown higher risk to the malaria disease.

The average case recorded a month had also been low (198) before the intervention and a high of (234) after the intervention. On the whole figure.7 had shown that malaria incidence is rather on the ascendancy defeating the purpose of introducing the treated bed net.

It is also worth noting that, only 7.2% of the population was reached in the distribution process covering 2,321 households. It therefore implied that more than half of the populations (92.8%) were without the insecticide treated bed nets.

The finding that malaria incidence was rather increasing should be a worrying outcome to the Ghana Health Service and the North Dayi district in particular. This could result in mistrust and negatively affect the subsequent use of the treated nets. In another dimension, it could influence the activities of the Ghana Health Service in combating malaria thereby winding the clock backwards.

### **Summary of Findings**

The main objective of the study as noted earlier was to assess if district-wide distribution of ITNs helped reduced incidence of malaria first of all among children under-five and women in fertile age after the intervention. The rationale of the study therefore, was to ascertain if efforts aimed at achieving MDG goals 4 and 5 are on course. In all, 484 OPD malaria cases were reviewed comprising 242 individual cases before the intervention and 242 cases after the introduction of the insecticide treated bed nets. Results of the study are summarised as follows:

1. The study had shown that in both cases that is the period before or after, children and women were the most affected groups by malaria. Females recorded 37% more cases of malaria than their male counterparts before the intervention. Even though children under five had shown some vulnerability, the male child under five was more affected by the disease by 4.1% cases than the girl child. Male under five malaria represented 24% of all male malaria incidence after the intervention. Before the

intervention, it was 23%. In relation to the first objective ITNs did not help in reducing the malaria incidence among children under five.

2. After the intervention, female malaria cases were 41% more than their male counterparts. Contrary to the 'before' data for children under 5, the girl child under 5 recorded approximately 2.8% increase in incidence. Before the intervention, female under five malaria incidences constituted 16.5% of all female cases and 17.8% after the intervention. This had shown an increase of 1.3% in that age group.
3. The study also revealed that higher incidences were recorded in the peak periods of the raining seasons – June, July, August, and October (Appendix I & II) with its short term effect exhibiting in November and December. In the case of females after the intervention, malaria incidence was all time high with the exception of May, 2011. But this was explained as a result of the fact that at the time of collating the data, most facilities were yet to validate their final data to the district health directorate. As a result the data for May was incomplete.
4. The findings revealed that high incidences were recognized among females 0-9 and 20-49 years age groups representing 54%. Females within the reproductive age groups were the most affected by the disease before and after intervention recording 48.03% and 48.3% of malaria cases respectively. An indication that the percentage difference (increase) was marginal. Insecticide treated bed nets therefore did not seem to be beneficial to women in the reproductive age groups.

5. Incidence after intervention among age groups had been noted to be generally high of 1.9% increase over the 'before' figure. It also indicated that children under one incidence exceeded 100% in reference to the target population of the district. Three reasons could be assigned to this;
  - i. that people from the adjacent districts took advantage of health facilities in the district,
  - ii. that the data included other visits other than new registered malaria cases and,
  - iii. that the estimated working population of the district could not have been correct,

The trend of reported cases reduced after age five through to the end of adolescence. It again picked up within the ages 20 through to age 49. Two percent increase in malaria incidence was observed among women in fertile age after the intervention.

6. Total malaria incidence as discussed earlier was 1.9% increase over the data before. This was evident by the marginal mean difference of 201.67 to 204.86 before and after intervention respectively. The study therefore failed to reject the hypothesis that the intervention had no effect on reducing malaria cases in both sex and age in the district. The impact of ITNs on sex was minimal in reducing malaria incidence within eleven months of study in the North Dayi district.

## **Policy Implications**

The objective of the Ministry of Health and for that matter Ghana Health Service is to reduce the disease burden of the citizenry. It is therefore a cause to worry about if efforts in terms of finance and technical expertise will not generate the expected result. Reducing the malaria burden is key in achieving the Millennium Development Goal (MDG) 6 by 2015. The current trend if it continued meant that Ghana may not be able to improve the already gains made in halving malaria by 2015 let alone reverse the incidence of malaria and other major disease.

In addition, malaria places a heavy economic burden on many affected countries, contributing to the visual cycle of poverty and limiting economic development. The disease is estimated to cost Africa about \$12 billion per year in lost gross domestic product (GDP), slowing GDP growth by as much as 1.3 percent a year (Gallup & Sach, 2001). Ghana will lose so much in terms had currency in trying to import drugs to treat people and lose man- hours leading to lose of revenue to the government and impoverishing the individual as a result of their incapacitation.

Motivation in ITN use becomes peculiarly important. ITNs may be misused by people who value them mainly as a measure for providing relief from pest mosquitoes and its continuous use may not be sustained. The essence to protect prior to bed in the evening may also be misunderstood. The study provides an objective overview of the opportunities and obstacles to the ITN-based anti-malaria strategies including intensive education in Ghana.

Degree of ITN coverage constituted a particularly crucial element in this strategy of only 7.2% of the population. The use of depleted insecticide nets would divert rather than kill vector mosquitoes. Relatively, non-immune people would occasionally be exposed to infection while an increasing portion of the vector population would focus their bites on people, perhaps children and pregnant mothers who slept unprotected.

### **Conclusion**

The main purpose for the study was to assess the impact of the ITNs in reducing the malaria burden on the population. Using the concept of effectiveness, it was evident that the concept of effectiveness had failed. This was because the main objective of reducing malaria among the vulnerable groups that is children under 5 and women in reproductive age had not been achieved. As noted by Last (1995), interventions should be able to reduce impact at both individual and community levels. In other words, the ratio of incidence or death risk in the intervention group to that of the control group had shown no percentage reduction. Similarly, individual effectiveness which measures reduction in the disease or death risk could be as a result of non-compliance of individuals to the effective use of the ITNs or other extraneous factors.

These extraneous factors could be public health education. The fact that Anopheles mosquito bites early in the evening and not only at late night when one is asleep is also important. It is therefore important to intensify public health education on environmental cleanliness, the design of local buildings to prevent

mosquitoes from first of all entering our rooms and being conscious of the fact that it is only mosquitoes that give malaria.

The study was therefore not consistent with other studies (Sexton, 1994) which saw Insecticide treated mosquito nets as a promising preventive measure. Again, an 85% increase in the mortality rate among children under five and 78% death rate among patients above the age of five was contrary to a Cochrane's review which concluded that ITNs reduced overall mortality in Africa by about 20%.

Across all ages, the distribution of the insecticide treated nets did not reduce malaria morbidity. The relationship therefore between ITNs distribution and malaria morbidity was negative. In other words it did not yield the expected result of reducing the incidence of malaria.

### **Recommendations**

The study showed that children under 5 (particularly the male child) and females in the reproductive age groups were the most vulnerable to the malaria disease. There is the need to promote collaboration with research institutions to critically examine the type of mosquitoes to determine whether the mosquitoes had built some immunity against the perthedine. This is because evidence had shown that the malaria epidemiology is changing in areas where ITNs were used with reduced burden (Barofsky, Chase, Anekwe, & Farzadfar, 2011). There is however the need for future studies to ascertain the efficient and effective use of the net. Other campaign strategies such as environmental cleanliness and use of



chemical to kill and reduce the mosquito larvae must also be strengthened to win the fight against malaria.

It is also important for the Government of Ghana to abide by the ‘The Abuja Declaration on Roll Back Malaria (RBM) to remove or reduce taxation on such measures that are expected to increase the utilization of the ITNS.

It was evident from the study that the quantity of ITNs that was distributed district-wide was inadequate. Strong evidence suggest that it is only when ITNs are deployed on a mass scale that do ITNs result in a large scale impact on transmission (Lindblade, Eisele, Gimnig, Alaii, Odhiambo, Kuile, Hawley, Wannemuehler, Philip-Howard, Rosen, Nahlen, Terlouw, Adasu & Vulule, 2004). Efforts should be made by the Ministry of Health (MOH) in collaboration with other donor agencies to increase the number to cover majority of the population.

The study showed that the district was prone to the malaria disease all year round as a result of its proximity to the Lake Volta and other small rivers in the catchment area. It is therefore recommended that public health education on the use of the treated mosquito nets should be intensified and continuous. This way, people would be awake to the task of using the net all the time.

It is important to identify areas prone with mosquitoes and occasionally spray or apply chemicals at their breeding sites. This way, the population of mosquitoes will be reduced. It is also important to consider the housing structure of people in the area. This is because most households were not protected with wire or nylon mesh, households were already exposed to mosquitoes before bed time. To avert this challenge, it is important to economically empower the citizens

to be able to acquire affordable housing. On the other hand, the government in collaboration with other development partners could put in place affordable housing schemes fixed with mesh to prevent mosquitoes.

Another way to prevent the mosquitoes from being active could be by making perthedine – the chemical used in treating the nets – available to households. The chemical could then be used to apply window and door blinds in households where meshes were non-existent. It is expected that when mosquito lands on the treated door and window blinds, it will kill the mosquito or make it too weak to fly.

Postnatal education on the use of the insecticide treated bed nets by nursing mothers should be intensified at all antenatal clinics days. Malaria children under 5 should be especially protected from mosquito bites since the study revealed that male children under 5 were the most affected constituting 25% of all male malaria cases.

The percentage increase of 3% among females after the intervention was an indication that the bed nets were not being used effectively. The district health directorate should conduct a survey in establishing reasons why mothers fail to use the treated nets despite its perceived advantages. The public health unit of the MOH/Ghana Health Service (GHS) should intensify their information, education and communication on the ITN in all available media. These channels should include radio, television, the print, door-to-door campaigns involving community members and the routine outreach activities of the community health nurses. The district should also strengthen the surveillance systems aimed at detecting

infection and transmission foci. This would enable the GHS to review their strategy in combating the malaria disease or identifying households that actually need the bed net.

Finally, the district should continue to adopt multi prevention strategies in fighting malaria. These strategies include intermittent preventive treatment (IPT), indoor residual spraying (IRS), and spraying of water bodies and its surroundings with chemicals especially during the raining season. Stagnant waters should also be treated with appropriate chemicals at least quarterly supervised by the environmental health unit in the district.

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## APPENDIX

## APPENDIX

### Field Data 2010 - 2012

|                            | under 1     | 1 to<br>4yrs | 5 to<br>9yrs | 10 to 14    | 15 to 17    | 18 to 19    | 20 to 34    | 35 to 49    | 50 to 59    | 60 to 69    | 70<br>above |
|----------------------------|-------------|--------------|--------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| MALE                       |             |              |              |             |             |             |             |             |             |             |             |
| July                       | 112         | 291          | 191          | 156         | 134         | 142         | 229         | 171         | 126         | 119         | 149         |
| August                     | 122         | 356          | 259          | 203         | 122         | 117         | 171         | 190         | 138         | 140         | 181         |
| September                  | 105         | 295          | 203          | 171         | 115         | 117         | 161         | 141         | 142         | 139         | 151         |
| October                    | 144         | 415          | 245          | 165         | 158         | 148         | 177         | 201         | 158         | 167         | 203         |
| November                   | 134         | 378          | 250          | 176         | 174         | 151         | 182         | 142         | 142         | 110         | 138         |
| January                    | 116         | 312          | 207          | 122         | 134         | 106         | 139         | 151         | 124         | 97          | 121         |
| February                   | 103         | 277          | 160          | 131         | 119         | 103         | 184         | 194         | 160         | 139         | 176         |
| March                      | 104         | 327          | 177          | 114         | 123         | 122         | 209         | 176         | 128         | 122         | 154         |
| April                      | 98          | 202          | 164          | 133         | 87          | 103         | 132         | 125         | 125         | 90          | 109         |
| May                        | 131         | 268          | 175          | 183         | 103         | 85          | 206         | 189         | 125         | 153         | 127         |
| June                       | 126         | 374          | 339          | 231         | 202         | 162         | 268         | 238         | 161         | 145         | 176         |
| <b>TOTAL</b>               | <b>1295</b> | <b>3495</b>  | <b>2370</b>  | <b>1785</b> | <b>1471</b> | <b>1356</b> | <b>2058</b> | <b>1918</b> | <b>1529</b> | <b>1421</b> | <b>1685</b> |
| After introduction of ITNs |             |              |              |             |             |             |             |             |             |             |             |
| July                       | 141         | 408          | 308          | 188         | 170         | 153         | 231         | 171         | 162         | 170         | 193         |
| August                     | 135         | 374          | 276          | 200         | 159         | 136         | 218         | 190         | 181         | 161         | 168         |
| September                  | 146         | 312          | 228          | 153         | 164         | 156         | 203         | 202         | 150         | 179         | 158         |
| October                    | 142         | 284          | 181          | 160         | 141         | 170         | 194         | 228         | 187         | 187         | 175         |
| November                   | 185         | 336          | 249          | 185         | 151         | 139         | 214         | 196         | 194         | 163         | 202         |
| December                   | 150         | 283          | 167          | 137         | 105         | 109         | 175         | 158         | 134         | 117         | 151         |
| January                    | 137         | 262          | 164          | 137         | 94          | 110         | 172         | 143         | 115         | 135         | 127         |
| February                   | 134         | 289          | 159          | 114         | 111         | 118         | 135         | 132         | 114         | 124         | 151         |
| March                      | 194         | 346          | 178          | 148         | 132         | 154         | 185         | 196         | 173         | 170         | 162         |
| April                      | 146         | 284          | 212          | 163         | 161         | 140         | 234         | 183         | 164         | 155         | 132         |
| May                        | 62          | 216          | 101          | 36          | 26          | 13          | 61          | 50          | 38          | 27          | 29          |
| <b>TOTAL</b>               | <b>1572</b> | <b>3394</b>  | <b>2223</b>  | <b>1621</b> | <b>1414</b> | <b>1398</b> | <b>2022</b> | <b>1849</b> | <b>1612</b> | <b>1588</b> | <b>1648</b> |

**APPENDIX**  
**Field Data 2010 - 2012**

| Before<br>introduction of<br>ITNs | under 1     | 1 to 4      | 5 to 9      | 10 to 14    | 15 to 17    | 18 to 19    | 20 to 34    | 35 to 49    | 50 to 59    | 60 to 69    | 70 +        |
|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                   | FEMALE      |             |             |             |             |             |             |             |             |             |             |
| July                              | 93          | 327         | 219         | 172         | 189         | 182         | 380         | 287         | 216         | 189         | 214         |
| August                            | 131         | 342         | 244         | 181         | 159         | 160         | 321         | 297         | 232         | 196         | 309         |
| September                         | 97          | 270         | 207         | 169         | 157         | 123         | 238         | 313         | 229         | 191         | 278         |
| October                           | 144         | 364         | 263         | 219         | 195         | 213         | 398         | 332         | 252         | 213         | 309         |
| November                          | 134         | 361         | 234         | 187         | 201         | 172         | 414         | 349         | 223         | 200         | 239         |
| January                           | 117         | 283         | 212         | 160         | 152         | 155         | 361         | 319         | 226         | 198         | 240         |
| February                          | 119         | 259         | 173         | 128         | 160         | 143         | 287         | 339         | 209         | 190         | 250         |
| March                             | 127         | 268         | 177         | 136         | 140         | 155         | 364         | 361         | 229         | 166         | 268         |
| April                             | 91          | 213         | 195         | 109         | 111         | 108         | 278         | 234         | 173         | 147         | 227         |
| May                               | 109         | 267         | 173         | 152         | 196         | 190         | 359         | 351         | 224         | 183         | 221         |
| June                              | 131         | 352         | 373         | 245         | 252         | 320         | 600         | 500         | 278         | 227         | 244         |
| <b>TOTAL</b>                      | <b>1293</b> | <b>3306</b> | <b>2470</b> | <b>1858</b> | <b>1912</b> | <b>1921</b> | <b>4000</b> | <b>3682</b> | <b>2491</b> | <b>2100</b> | <b>2799</b> |
| After introduction of ITNs        |             |             |             |             |             |             |             |             |             |             |             |
| July                              | 169         | 470         | 326         | 241         | 184         | 219         | 528         | 441         | 270         | 217         | 265         |
| August                            | 157         | 473         | 339         | 284         | 246         | 222         | 493         | 498         | 307         | 293         | 316         |
| September                         | 118         | 294         | 251         | 271         | 246         | 250         | 417         | 395         | 275         | 210         | 236         |
| October                           | 151         | 282         | 235         | 195         | 221         | 258         | 486         | 368         | 299         | 225         | 273         |
| November                          | 146         | 350         | 246         | 237         | 210         | 204         | 358         | 341         | 259         | 249         | 251         |
| December                          | 154         | 280         | 173         | 142         | 123         | 198         | 270         | 281         | 243         | 159         | 193         |
| January                           | 135         | 334         | 244         | 183         | 149         | 160         | 285         | 253         | 211         | 180         | 210         |
| February                          | 133         | 272         | 161         | 132         | 125         | 112         | 259         | 267         | 217         | 160         | 220         |
| March                             | 182         | 364         | 271         | 177         | 133         | 179         | 344         | 762         | 202         | 219         | 231         |
| April                             | 149         | 295         | 169         | 152         | 162         | 190         | 321         | 258         | 275         | 186         | 195         |
| May                               | 42          | 155         | 112         | 73          | 45          | 21          | 156         | 134         | 83          | 46          | 69          |
| <b>TOTAL</b>                      | <b>1536</b> | <b>3569</b> | <b>2527</b> | <b>2087</b> | <b>1844</b> | <b>2013</b> | <b>3917</b> | <b>3998</b> | <b>2641</b> | <b>2144</b> | <b>2459</b> |

