SCHOOL OF PUBLIC HEALTH
COLLEGE OF HEALTH SCIENCES
UNIVERSITY OF GHANA

IMPACT OF INDOOR RESIDUAL SPRAYING (IRS) ON MALARIA PARASITAEMIA IN OBUASI METROPOLIS

BY

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THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF A MASTER OF SCIENCE IN CLINICAL TRIALS DEGREE

JULY 2013
DECLARATION

I, Rita Fosuah Adu declare that except for the other people’s investigations which have duly been acknowledged in this dissertation, this work is the result of my own original research carried out for the award of a Master of Science (Clinical Trials) degree. This dissertation has not been presented elsewhere either in whole or in part for another degree.

Signed: .................................................................

Rita Fosuah Adu

Supervisor: .................................................................

Professor Kwadwo Ansah Koram
DEDICATION

This dissertation is dedicated to my mom Mrs. Christiana Adu-Boahene and my brother Eric Adu.
ACKNOWLEDGEMENT

I am very grateful to the Almighty God who has been and continues to be my source of strength, knowledge and wisdom.

My heartfelt gratitude goes to my supervisor Professor Kwadwo A. Koram (Director, Noguchi Memorial Institute for Medical Research) who despite his busy schedule contributed and supported me immensely towards the completion of this work.

I am very grateful to Mr. Clement Narh for the encouragement and assistance throughout this programme and also to the head and staff of the Medicine Department, University of Ghana Medical School.

I finally wish to show my appreciation to the staff and management of the School of Public Health (SPH), University of Ghana; my course mates and to all including family and friends who in diverse ways encouraged and supported me throughout this programme.

God richly bless you all.
ABSTRACT

Background: Malaria remains a significant source of morbidity and mortality in Ghana. The AngloGold Ashanti mining company in Obuasi in the Ashanti Region of Ghana concerned about the threats malaria poses to its operations instituted a comprehensive malaria control programme including Indoor Residual Spraying (IRS) in 2006. This district wide intervention against malaria needs to be evaluated and this report presents such analysis of the effect of the intervention on malaria parasitaemia in school children in the district.

Methods: A cross-sectional survey was conducted prior to the IRS intervention in 2006 and two others after the intervention in 2007 and 2011 with the aim of evaluating the impact of IRS on parasitaemia levels in the Obuasi Municipality. In all, 2173 school aged children (from Kindergarten to JHS 3) were sampled. Data for this analysis was obtained from the pre (2006) and post IRS intervention surveys (2007 and 2011) that had been conducted by the Noguchi Memorial Institute for Medical Research Institution (NMMRI) over the five-year period. Simple proportions were used to determine the age-specific parasitaemia before and after IRS, the percentages of participants, who had fever or anaemia as well as parasitaemia for the different surveys that were conducted. The Logistic regression was also used to model the odds of parasitaemia before and after IRS to determine the association between the prevalence of parasitaemia and the number of spraying.

Results: Of the 2173 school aged children sampled, 710, 828 and 635 children were recruited for the 2006, 2007 and 2011 surveys respectively. Parasite prevalence was
45.5% (323 of 710) of children surveyed prior to the implementation of IRS (May, 2006), 22.66% (182 of 806) screened in the first survey after IRS (June, 2007) and 17.2% (109 of 633) screened in the second survey after IRS (November, 2011). Children in the 0 – 5 years age group had the least parasitaemia levels across all three survey periods. However, the highest parasitaemia levels were recorded among the 11 – 15 years age group before the spraying whereas >15 and 6 – 10 years age groups were found to have the highest parasitaemia levels during the first and second post intervention surveys respectively.

After spraying two and eight times, there was a significant reduction in the malaria parasitaemia levels [0.50 (95% CI: 0.43 – 0.58) and 0.38 (95% CI: 0.31 – 0.46) respectively]. After adjusting for age and sex, a significant reduction again was observed; 0.48 (0.42 – 0.56) after two times of spraying and 0.40 (0.33 – 0.48) after eight more times of spraying.

**Conclusion:** The IRS which was just one aspect of the comprehensive intervention programme instituted by the AngloGold Ashanti company, has proven to be effective in reducing the incidence of malaria in school aged children, since parasitaemia levels were significantly lower after its implementation (p<0.001). It therefore could be used as one of the best ways to control malaria in Ghana.
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ACTs</td>
<td>Artemisinin-based Combination Therapies</td>
</tr>
<tr>
<td>DDT</td>
<td>dichlorodiphenyltrichloroethane</td>
</tr>
<tr>
<td>GHS</td>
<td>Ghana Health Service</td>
</tr>
<tr>
<td>IMCP</td>
<td>Integrated Malaria Control Programme</td>
</tr>
<tr>
<td>IPTPi</td>
<td>Intermittent Preventive Treatment in Infants</td>
</tr>
<tr>
<td>IRS</td>
<td>Indoor Residual Spraying</td>
</tr>
<tr>
<td>ITNs</td>
<td>Insecticide-Treated mosquito Bednets</td>
</tr>
<tr>
<td>MDGs</td>
<td>Millennium Development Goals</td>
</tr>
<tr>
<td>NMCP</td>
<td>National Malaria Control Programme</td>
</tr>
<tr>
<td>NMMIR</td>
<td>Noguchi Memorial Institute for Medical Research</td>
</tr>
<tr>
<td>RBM</td>
<td>Roll Back Malaria</td>
</tr>
<tr>
<td>SP</td>
<td>Sulphadoxine-Pyrimethamine</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

Malaria is a disease caused by *Plasmodium* parasites and is transmitted through the bite of infected female *Anopheles* mosquitoes. According to the World Health Organization (WHO), approximately 80% of annual deaths from malaria occur in young African children out of the estimated one million (WHO, 2008). From approximately three (3) months of age, the immunity these infants acquire from their mothers begins to wane and their susceptibility to malaria increases (WHO, 2008).

Ghana, one of the developing economies in sub-Saharan Africa, has had malaria being a major cause of poverty and low productivity for several decades. It is currently estimated to account for about 32.5% of all out-patient attendances and 48.8% of children under-five (5) years admissions in the country (NMCP Annual Report, 2009).

In the past few years, several measures have been deployed to improve malaria case management including the use of Artemisinin-based Combination Therapies (ACTs) now used as the preferred treatment after chloroquine had been found to be less effective against the parasite in several areas (McIntosh, 1999; WHO, 2006). As a preventive measure, insecticide-treated mosquito bednets (ITNs) have been implemented to aid in the reduction of malaria transmission.
Malaria remained the most significant public health threat for AngloGold Ashanti’s operations in Ghana and its impact significantly affected the functioning of the entire community. Of the 6,000 malaria cases that were recorded per month in 2004, 2,000 were mine staff. At any point in time, an average of about 20% of employees were affected with malaria who took an average time of two to three days off work due to their ailment (AngloGold Ashanti Report, 2004).

The realization that malaria was proving to be a huge economic toll on their operations led the company to institute the comprehensive malaria intervention which they called the Integrated Malaria Control Program in Obuasi. This involved the introduction of several control strategies against malaria, including IRS, ITN use, improved housing, larviciding, early and effective treatment of disease amongst others.

1.2 PROBLEM STATEMENT

Malaria remains a challenge to national and global public health. Increase in malaria incidence is associated with morbidity and mortality rates and if left untreated could have devastating effects on life expectancy, households and healthcare expenditure and the economy as a whole. In a mining community like Obuasi in the Ashanti Region of Ghana, the AngloGold Ashanti mining operations loses productivity through the loss of man hours directly and indirectly especially when parents or guardians have to spend days from work to take care of their children or wards who suffer from malaria.

In order to control this, the company instituted a comprehensive malaria control programme including IRS which was known to be one of the powerful ways to rapidly
reduce malaria transmission, as the main strategy. This initiative was in line with attainment of the Millennium Development Goals (MDGs). Prior to the implementation of the full control programme however, a baseline community prevalence survey was conducted in May, 2006 by the Noguchi Memorial Medical Institute for Research (NMMIR) and this was to be used in assessing the success of local control initiatives.

The aim of this programme was to reduce the number of malaria cases in the community by 50% a year after its implementation and also to reduce the number of working days lost due to malaria among the employees at Obuasi (AngloGold Ashanti Report, 2004). Such programmes needed evaluation and more often than not, this was not done. This report therefore seeks to remedy that by determining the trends in the parasite prevalence in school aged children in the metropolis.

1.3 OBJECTIVES OF THE STUDY

1.3.1 General Objective

1. To assess the impact of IRS on the prevalence of malaria parasitaemia in Obuasi Metropolis.

1.3.2 Specific Objectives

1. To assess the association between the number of spraying and the prevalence of malaria parasites.

2. To determine the age-specific prevalence of malaria parasites among school aged children before and after IRS in the community.
1.4 RATIONALE OF THE STUDY

Malaria remains the leading cause of infant and childhood mortality in endemic countries which mainly consist of sub-Saharan Africa (WHO, 1996). In Ghana, malaria accounts for the majority of health facility attendance and loss of productivity (Binka et al., 1994).

A number of interventions have been introduced in the country over the past decades with the aim of alleviating and eradicating malaria. However, the disease is still prevalent with children under-five and pregnant women being the most vulnerable. The findings which will be obtained from this analysis will contribute to a better understanding of the impact of the IRS intervention which was initiated in the Obuasi municipal as part of AngloGold Ashanti’s Integrated Malaria Control Programme. This would inform policy makers on decisions in developing public health measures in the control of the incidence of malaria in Ghana.
CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Malaria

Malaria is an ancient disease which remains one of the major killers in the world. It is commonly referred to as the disease of the poor since it has very high prevalence rates in poorer countries compared to the richer countries (Worrall et al, 2002). In Africa, the Plasmodium falciparum parasites are the most infectious and can cause life threatening complications than the other three Plasmodium species namely Plasmodium vivax, Plasmodium malariae and Plasmodium ovale. The Anopheles gambiae parasites on the other hand are the most efficient malaria vectors and are widely distributed in Africa.

It is estimated that approximately 40% of the world’s population lives in more than 140 countries at risk of malaria (WHO, 2009). Malaria is endemic in 10 countries in the Western Pacific Region while in Africa, it is endemic in more than 30 countries (WHO, 2009). As the leading cause of morbidity and mortality worldwide, malaria continues to put an increasing number of people at risk. In 2010, an estimated 216 million clinical episodes and 655,000 deaths from malaria were reported (WHO, 2011). Of these deaths, an estimated 91% of malaria deaths occurred in Africa, 6% in South-East Asia and 3% in the Eastern Mediterranean Region. Globally, about 86% of the deaths occurred in children (WHO, 2011).
One of the contributing factors to the prevalence of malaria in Africa is poverty (Teklehaimanot and Mejia, 2008). Malaria which is now a tropical disease of poor countries was present in temperate regions such as Northern Russia and Canada. Its transmission was interrupted in most of these temperate regions between 1958 and 1969 as a result of The World Health Organization (WHO) Global Malaria Eradication Campaign (Teklehaimanot and Mejia, 2008). As a result, there was a decrease in many areas of the world and this was partly attributed to general improvements in housing and nutrition since some studies have shown that inadequate housing and overcrowding can increase one’s risk of being infected with malaria. Poorly constructed housing might have the tendency to attract mosquitoes more easily therefore increasing vector contact than well-constructed ones with screened windows for example. There is also some evidence which suggests that mosquitoes are attracted by the higher concentration of carbon dioxide and other chemicals that are present where there is overcrowding (Linsay, 2003; Alton and Rattanavong, 2004).

Although malaria is not solely a disease of the poor, poverty is known to increase the risk of malaria (Teklehaimanot and Mejia, 2008). Poorer communities have geographical and environmental conditions that accommodate mosquitoes than those inhabited by non-poor communities; therefore these communities might be more likely to suffer from malaria (WHO, 2006).

According to Gwatkin and Guillot in 2000, an estimated 58% of malaria deaths occur among the poorest 20% of the world’s population. A study which was conducted quite recently in the Ashanti Region of Ghana to determine an association or otherwise between socioeconomic situation and malaria parasitaemia demonstrated that the
proportion of children with malaria decreased with increasing socioeconomic status as was classified by a principal component analysis; an association which was significant (Krefis et al, 2010).

Being underweight could result in reduced immunity therefore it is believed to enhance the susceptibility of children contracting malaria and in 2004, Caulfield showed some evidence suggesting that deficiencies in micronutrients such as iron, vitamin A, iodine and zinc in particular contributes to an increase in the burden of malaria morbidity and mortality (Caulfield, 2004).

One key aspect of malaria control is prompt treatment necessary for the prevention of deaths from malaria (McCombie, 2002). At the individual and household level, preventive measures include the use of insecticide-treated nets, insecticides and antimalarial medications. Some studies in Tanzania have shown that poor households living in rural areas spend significantly less on these forms of malaria prevention measures as compared to their richer counterparts (McElroy et al, 2009; Bernard et al, 2009). In a literature review on the relationship between socio-economic status and malaria, Worrall et al, in 2002 also revealed that household expenditure on malaria prevention is more strongly related to one’s income and socioeconomic status than to the expenditure on treatment, and that the cost of getting treatment for malaria infection is likely to be burdensome for the poorer households.

Environmental factors can also predict the transmission of malaria and these include rainfall, altitude and temperature. As the altitude increases, one’s risk of malaria also decreases (Lindsay and Martens, 1998; Curtin, 1989; De Beaudrap et al, 2011). Activities
such as irrigation, deforestation and mining in communities also play a role in predicting the risk of malaria. Ideal mosquito breeding grounds are generated when the excavated areas which are usually abandoned by miners collect stagnant water and waste (Peterson et al, 2009). Heavy rains are also a cause of the dug-out areas which are eventually transformed to stagnant ponds aggravating malaria transmission.

The Obuasi mine personnel are to some extent housed in accommodation provided by the mining company within the Obuasi town. Surface drains have been constructed on the sides of the roads to enable easy flow of liquid waste. Some of the better maintained sections have well constructed concrete drains, and in some instances are covered with concrete slabs. In many areas however, the drains are damaged, creating swampy areas.

The costs of malaria in terms of human capital are huge due to the implications of a wide range of other morbidities and disabilities associated with it such as; anaemia, pregnancy outcomes and cognitive development (McCormick et al, 1992; Holding and Snow, 2001). Estimates from recent studies in Ghana, Mali, Nigeria and Uganda have suggested that malaria hinders economic growth in these countries ranging from 0.067% in Uganda to as much as 3.8% in Nigeria. (Teklehaimanot and Mejia, 2008). The value of days lost because of malaria is estimated at US$8.92 in Uganda and monthly household expenditures on malaria prevention ranged from US$0.32 to US$10.00 in these five countries (Teklehaimanot and Mejia, 2008). Also in Tanzania, malaria is known to have a significant burden, both economically and health wise on society. Generally, individuals allocate about 0.7% on average of their annual income to prevent and treat malaria (Jowett and Miller, 2005; Teklehaimanot and Mejia, 2008).
More than US$12 billion however was spent in managing malaria cases annually (WHO, 2001). Between 2000 and 2010, malaria mortality rates decreased by 25% worldwide and by 33% in the WHO African region although malaria mortality rates remained relatively constant until in 2004 (WHO, 2011). In 2009, an increase from 13 million in 2005 to 75 million people which represented an approximately 10% of the population at risk, were known to be protected from malaria after the implementation of IRS programmes in the sub-Saharan Africa region (WHO, 2010).

The under-five mortality rates have reduced by 35% with each developing region seeing at least a 30% reduction since 1990 (UN Child Mortality Report, 2010). As compared to the developed regions where 1 in 143 children dies before age 5, child mortality is still prevalent in sub-Saharan Africa where 1 in 8 children dies before the age 5 and also in Southern Asia (1 in 15). There has been an increase in disparity between these two regions and the rest of the world although under-five mortality rates have been greatly reduced elsewhere (UN Child Mortality Report, 2010).

Data from the 2003 Ghana Health Service annual report were used to calculate incidence rates for the 5 sub-districts in the Adansi-West district of the Ashanti Region of Ghana. The data show a substantially higher incidence rate of malaria cases in 2003 in Obuasi compared with the previous two years.
Figure 1: Malaria incidence rate by sub-district, Adansi-West, Ghana, 2001 – 2003 (GHS Report, 2003)

Ghana in 2004 still had malaria being the leading cause of outpatient attendance and admissions in all health facilities and contributed to about 44.1% and 24.6% of the causes of outpatient attendance and of all causes of admissions respectively. A total of 25,810 malaria deaths were also reported in health institutions which did not include the Teaching Hospitals, with a mortality rate of 17.1% (Ghana Health Service Report, 2004).

2.2 Impact of Malaria on Children

In high malaria endemic countries like Ghana, infants become very vulnerable approximately three (3) months of age during which immunity acquired from the mothers begin to wane. Pregnant women as well as young children are also vulnerable to malaria morbidity and mortality. Of the 3000 children below the age of 7 who were studied in a rural setting of the Gambia, malaria was found to be the probable cause of 4% of infant deaths and of 25% of deaths in children under five years (Greenwood et al, 1987). Cerebral malaria and anaemia are two of the main causes of these childhood deaths in
Africa (WHO, 2000). It was also reported that all the deaths that resulted from malaria and a high proportion of febrile cases were detected at the end of the rainy season (Greenwood *et al*, 1987).

Although morbidity is most concentrated among pre-school children, school age children also bear a considerable burden which results in absenteeism from school which may also lead to increased failure rates, repetition of school years and drop-out rates. A study in Kenya showed 11% primary school absenteeism and 4.3% secondary school absenteeism per year as a result of malaria (Leighton and Foster, 1993). In another study in Kenya, 13-50% of medically related school absenteeism was attributed to malaria (Brooker *et al*., 2000).

Other studies have associated malaria to cognitive development and learning ability in school aged children despite debates about the direct relationship between malaria and mental functioning (Holding and Snow, 2001). Children with malaria have been found to have poorer nutritional status than non-malarial children which could also lead to impairment in the development of the brain (Rowland *et al*., 1977; Shiff *et al*., 1996 and Lozoff *et al*., 1989).

Cerebral malaria, a severe case of malaria has been shown to affect approximately 575,000 children per year in Africa resulting in 10-40% mortality of patients (Greenwood, *et al*., 1987; Holding and Snow, 2001; Murphy and Bremen, 2001). Managing children with such severe impairment and behaviour difficulties could be very stressful and also put a lot of strain on family relationships. In Uganda, children with severe impairments due to cerebral malaria were examined and the findings were that the
major long-term sequelae were deficits in motor function, behaviour, vision, speech and hearing or epilepsy although some of these deficits such as loss of vision and speech showed little improvement over the follow-up period while others such as behavioural problems developed long after exposure (Idro et al, 2010). In 2004, a study conducted in Malawi, whose population is one of the poorest in Africa and where malaria causes serious health problems, showed that disabling effects of cerebral malaria is as a result of poverty. It also showed that about 33% of all children in the district were estimated to have had malaria (Ingstad et al, 2012).

2.3 Malaria Treatments

Several failed attempts to eradicate malaria have led to the advent of policies and efforts to curb this menace by designing and developing new drugs and candidate vaccines as well as better understanding the biology of the parasite in the last two decades (Guinovart et al, 2006).

Recent trends in parasite resistance to antimalarial drugs and vector resistance to insecticides as well as increases in malaria transmission have led to the introduction of effective interventions such as the insecticide-treated mosquito nets (ITNs), new drug therapies with artemisinin-based combinations and effective vector control measures with indoor residual spraying (IRS). ITNs are known to be effective in killing mosquitoes upon contact and also in reducing mosquito bites on humans. Its use reduces all cause malaria mortality and morbidity between 17 and 43% in children less than five years and provides protection to pregnant women who are most susceptible to malaria (Binka and Akweongo, 2006).
In Ghana, the main control measures against malaria are the use of ITNs, early treatment, education and environmental sanitation. As of 2003, only about 3.5% and 2.2% of children under five and pregnant women respectively slept under bed nets (GHS Report, 2003). Despite the role of ITNs in alleviating disease burden, there is the need to further reduce malaria transmission by assessing alternative control tools such as the IRS. Both the ITNs and IRS are vector control strategies and have a combined effect in the reduction of malaria transmission.

2.4 Indoor Residual Spraying (IRS)

IRS has proven to be efficacious in reducing malaria prevalence for decades. Mosquitoes get killed when they rest on walls sprayed with insecticide. Spraying of houses with dichlorodiphenyltrichloroethane (DDT) also either prevents mosquitoes from entering or promotes their rapid exit from the sprayed houses (Smith and Webley, 1968; Roberts and Andre, 1994). It has been established that most countries which have employed integrated malaria control programmes such as the IRS have experienced an improvement in their economic growth after the intervention was introduced (Mabaso et al, 2004).

Between the 1940s and 1960s, African countries like Benin, Burkina Faso, Cameroon, Liberia, Togo and Kenya amongst others were introduced to several pilot projects with the intention to assist governments to improve techniques towards malaria eradication and also to stop transmission. It was demonstrated through these projects that malaria could be controlled by indoor residual spraying (IRS) with insecticides especially DDT (Mabaso et al, 2004). However, as significant as the reductions in anopheline vectors and
malaria were, transmission could still not be interrupted (Kouznetsov, 1977; Bradley, 1991 and Najera, 2001).

The use of IRS has been adopted since 1950s in most continents and together with DDT and other insecticides it has been one of the effective tools for the elimination of malaria. Some of these areas which benefited from IRS include; Central Asia as well as North and Latin America (WHO, 2008). Recently Ghana was one of the African countries in which IRS was introduced.

Some historical reviews of IRS in Southern and sub-Saharan Africa on the health impacts of IRS interventions have demonstrated substantial epidemiological benefits (Mabaso et al, 2004; Kouznetsov, 1977). Hospital admissions which were due to malarial cases declined from 1177 cases during the 1945-46 transmission season to as low as 61 cases in 1951 in areas of the former Transvaal province of South Africa. Parasite rates in children between the ages of 2 and 5 in the Tzaneen and Lubombo foothills were also reduced from 94% in 1931 to 4.9% between 1956 and 1957 after indoor spraying (Swellengrebel and de Meillon, 1931; Brink, 1958).

Chayajabera et al in 1975 reported a reduction in parasite rates in between 2 and 9 year olds from 43% in 1961-62 to 14% in 1973-74 and from 45% to 13% in Chobe and Ngamiland district respectively, after the introduction of the IRS programme in Botswana.

Residual spraying with DDT was first carried out in 1965 in Namibia but did not achieve full coverage in high malarial districts until in the 1970s. Hansford in 1990 reported of tremendous declinations in Kavango from 1950 to 1979 (83% to 14%) and Ovambo
(65% to 0.1%). A pre-control survey in Caprivi district also showed a declination in overall parasite rate from 32% in 1966 to 2% in 1967. For IRS to be very effective however, it should be carried out as recommended by WHO and also should involve highly skilled and motivated staff.
CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Location

The Obuasi Municipality is located in the Adansi-West district, which is also found in the southern part of the Ashanti Region and 156 km North West of Accra, the capital city of Ghana, West Africa. The municipality has an undulating topography and the climate is of the semi-equatorial type with a double rainfall regime. The mean annual rainfall ranges between 1250 mm and 1750 mm and the mean average annual temperature is 25.5°C. In the wet season, the relative humidity is 75% - 80%.

The vegetation is predominantly a degraded and semi-deciduous forest which consists of limited species of hard wood which are harvested as lumber. The hilly nature of the environment gives the Municipality nice scenery. With the existence of AngloGold Ashanti, mining and its related activities are the mainstay of the Municipal economy and this has contributed greatly to the socio-economic development.
Figure 2: A map of the Ashanti Regional Districts of Ghana showing the Obuasi Municipal (http://en.wikipedia.org)

3.2 Population

The population of the Municipality is estimated at 168,641 using the 2010 Housing and Population Census as a baseline estimate and applying a 4% annual growth rate (2010 Population and Housing Census).

3.3 Study Design

The source of data for this analysis was from cross-sectional surveys conducted in March 2006, July 2007 and November 2011 by researchers from the Epidemiology Department of Noguchi Memorial Institute for Medical Research. The yearly surveys after the baseline survey as planned could not be done due to the lack of funds hence the long delay between 2007 and 2011. A roll list of schools was used to randomly select school
children for the study. The primary data was collected prior to and after the implementation of the comprehensive malaria control programme. The spraying was done twice each year, around May and November (to coincide roughly with the end of the dry season and the wet season).

### 3.4 Eligibility Criteria

Children living and attending school (from kindergarten to JHS 3) in the Obuasi metropolis were eligible to be enrolled into the study. Only children whose parents/guardians had given consent to be included in the surveys were included. The age group included was between 3 years and 17 years.

### 3.5 Sample Size and Sampling Method

A list of all schools, classes and their relative sizes was obtained from the district education office and used as a sampling frame. Schools and classes were randomly selected using a random process in SPSS. The school list was updated before each survey. About 710 school children were recruited for the baseline survey, 828 for the first survey after the implementation of the programme in July, 2007 and 635 for the second post-survey in November, 2011. Therefore, a total number of 2173 school children were recruited for the different surveys.

Table 1 provides the listing of school children in the Obuasi metropolis in 2003/2004, as well as the factors that were taken into account during sampling. It was also estimated that approximately 200 students enrolled in each age group should be enough to perform all comparisons of interest involving age groups.
Table 1: Estimated number of school children recruited based on numbers enrolled

2004/2005

<table>
<thead>
<tr>
<th>Level</th>
<th>Estimated Age</th>
<th>Number on Roll</th>
<th>Estimated Parasite Prevalence</th>
<th>Worst Acceptable Result</th>
<th>Sample Required</th>
<th>Number to be Recruited</th>
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<td>4 - 5 yrs</td>
<td>7,005</td>
<td>70%</td>
<td>60%</td>
<td>80</td>
<td>150</td>
</tr>
<tr>
<td>Primary</td>
<td>6 - 12 yrs</td>
<td>25,074</td>
<td>50%</td>
<td>40%</td>
<td>96</td>
<td>200</td>
</tr>
<tr>
<td>JSS</td>
<td>13 - 15 yrs</td>
<td>8577</td>
<td>30%</td>
<td>20%</td>
<td>80</td>
<td>150</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>500</td>
</tr>
</tbody>
</table>

*The final numbers of children recruited took into account refusal rate, design effect and clustering (given that schools were used as the sampling frame)*

3.6 Data Collection Tools and Techniques

The study team comprised of one physician, one field supervisor, and six field workers. Permission was sought from school authorities, teachers and parents of the school children. The study team visited the schools where they conducted the surveys. Consent forms were given to school children to be given to their parents for signing before the study took place. Parents/Guardians had the opportunity to come to school with their questions which were addressed by the teachers who had been briefed for any explanations needed. Children whose parents/guardians did not sign the consent forms were not included in the surveys.

A questionnaire was employed in collecting both demographic and clinical data. Data extracted from the primary data source for this analysis were date of survey, participant’s school, gender, age, history of fever, axillary temperature (°C), weight (kg), and
gametocyte and parasite counts. Axillary temperature of participants was taken using electronic thermometers and recorded on each participant’s data form.

3.7 Laboratory Methods

A finger prick was performed using a sterile lancet and blood specimens for a thick and thin smears were prepared and then stained with 3% Giemsa solution for 30 minutes, dried and stored for later reading. Haemoglobin concentration was determined using a portable automated Hemocue® photometer (Leo Diagnostics, Sweden). Filter paper blood blots were also done. The specimens were labeled with the individual identification numbers and dated.

A laboratory technician was responsible for estimating the parasite counts by examining 200 fields in the thick films under oil immersion at a power of 100X. The parasite density was scored against 200 wbcs and converted to parasites per µl of blood by assuming a wbc count of 8000/µl. All other slides were stored and read at a later date except for slides from individuals who were symptomatic which were read immediately. The participant data forms were checked by the field supervisors for completeness and thoroughness, and any omissions corrected. The primary data entries were done in Stata™ by data entry clerks.

3.8 Statistical Methods and Analysis

3.8.1 Data Description and Extraction

The data sets were cross-checked for any missing entries, outliers and typographical errors and were described using appropriate basic summary statistics and frequency
distributions. Demographic characteristics such as sex and age groups for all three surveys were presented in tables as frequencies (percentages).

3.8.2 Categorization of Variables

The primary outcome for this analysis was the proportion of malaria parasitaemia before and after the intervention. This outcome which was the presence or absence of parasitaemia was binary. Continuous variables such as age was categorized into <5 years, 6 – 10 years, 11 – 15 years and >15 years, for interpretation of results.

3.8.3 Missing Data Management

Children with missing data were excluded from the analysis of each specific survey.

3.8.4 Statistical Analysis

Simple proportions were used to determine the age-specific parasitaemia before IRS and after IRS by cross-tabulation. Again, simple proportions were used to determine the percentages of participants, who had fever or anaemia as well as parasitaemia for the different surveys that were conducted.

The Logistic regression was used to model the odds of parasitaemia before IRS, one year after IRS and then four years after six monthly spraying to determine the association between the prevalence of parasitaemia and the number of spraying. The crude odds obtained were adjusted for potential confounders such as age and sex. Corresponding p-values of the various odds ratios and 95% confidence intervals were reported. All p-values were two-sided and considered statistically significant if less than 0.05.
The statistical software package that was used to clean the data and to carry out the statistical analyses was Stata version 11.0.

3.9 Ethical Issues

Approval: The original study was reviewed and approved by the Noguchi Memorial Institute for Medical Research Institutional Review Board (IRB). However, ethical approval for this secondary data analysis was sought from the Ghana Health Service Ethical Review Committee of the Research and Development Division of the Ghana Health Service.

Informed Consent Process: Before the study began, the local political and administrative authorities were approached and their consent was sought. Durbars were held where any questions and concerns of the people of the community were addressed. Children who were randomly selected were provided with study briefing documents and consent forms for their parents/guardians. The study documentation included details and reasons for the study, risks and benefits, confidential issues, compensations and the participant’s right to participate as well as withdraw at any point of the study without any penalties. All explanations were done in their own native language (mainly Asante Twi) by locals of the community. Parents and guardians had to provide consent for their children. Children whose parents and guardians agreed for them to participate in the study were therefore enrolled if they met the entry criteria. Participants were clearly made to understand that participation in the study was purely voluntary and they were free to withdraw at any time without penalty.
Appropriate treatments were provided for those participants who were found to be suffering from malaria and other acute febrile illnesses during the survey. Those who were also found to be anaemic were referred for further evaluation and treatment at the hospital.

**Confidentiality:** Each participant had a unique identity code and it was ensured that the participant’s information provided was kept confidential such that data entered into the computer database were protected from unauthorized persons.
CHAPTER FOUR

4.0 RESULTS

4.1 Introduction

This chapter displays the analysis of data and presents the baseline characteristics, the prevalence of fever, anaemia and parasitaemia by age group. It also presents the results of the logistic regression to determine an association between the number of spraying and the prevalence of malaria parasitaemia.

4.2 Demographics of Study Participants

The datasets from the May 2006, June 2007 and November 2011 contained information on a total of 2173 school-aged children mainly between the ages of 3 and 17 years from the Obuasi Municipality. For all the three different data sets, the least numbers were recorded for those in the >15 age group while the highest numbers of participants were recorded among the 6 – 10 age group during the June 2007 and November 2011 surveys; and among the 11 – 15 age group for the March 2006 survey.

The proportions of school-aged children sampled by age group and sex are shown in Table 2. The proportion of males to females in the four age groups varied across the three survey periods. In the 2006 and 2011 surveys the proportion of males were higher than that of the females among the 0 – 5 and >15 age groups, whereas the opposite was observed among the 6 – 10 and 11 – 15 age groups. Generally, higher proportions were recorded for the male participants compared to their female counterparts in all three surveys with 2007 and 2011 surveys recording similar percentages.
Table 2: Demographics of Age groups in March 2006, June 2007 and November 2011

<table>
<thead>
<tr>
<th>Age Group</th>
<th>March 2006 n (M% / F%)</th>
<th>June 2007 n (M% / F%)</th>
<th>November 2011 n (M% / F%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 5</td>
<td>162 (50.6 / 49.4)</td>
<td>130 (47.7 / 52.3)</td>
<td>187 (50.8 / 49.2)</td>
</tr>
<tr>
<td>6 – 10</td>
<td>247 (44.1 / 55.9)</td>
<td>316 (51.9 / 48.1)</td>
<td>204 (42.2 / 57.8)</td>
</tr>
<tr>
<td>11 – 15</td>
<td>266 (48.1 / 51.9)</td>
<td>303 (51.8 / 48.2)</td>
<td>181 (48.1 / 51.9)</td>
</tr>
<tr>
<td>&gt; 15</td>
<td>34 (52.9 / 47.1)</td>
<td>61 (47.5 / 52.5)</td>
<td>26 (57.7 / 42.3)</td>
</tr>
<tr>
<td>Total</td>
<td>709 (48.9% / 51.1%)</td>
<td>810 (49.7% / 50.3%)</td>
<td>598 (49.7% / 50.3%)</td>
</tr>
</tbody>
</table>

*Data presented in frequencies (percentages) to show the proportions of males (M) and females (F) in the respective age groups for the pre- and post- (first and second) surveys.

4.3 Prevalence of Fever by Age Group

From Table 3, it was observed that a higher percentage of participants (92.9% – 98.3%) were found not to have fever (axillary temperature <37.5°C) at the time of the survey across all three time periods. Amongst those who were found to have fever, the June 2007 survey recorded the highest percentage (7.1%) followed by those from March 2006 (4.9%) and then participants from the November 2011 (1.7%). Although the highest proportions of participants who had fever among specific age groups (0 – 5, 6 – 10 and 11 – 15) were recorded during the June 2007, the highest for the >15 age group (5.88) was recorded during the March 2006 survey.
Table 3: Prevalence of Fever by Age Group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>March 2006</th>
<th>June 2007</th>
<th>November 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N</td>
<td>(%)</td>
<td>n/N</td>
</tr>
<tr>
<td>0 – 5</td>
<td>159/162</td>
<td>(98.15)</td>
<td>129/133</td>
</tr>
<tr>
<td>Temp&lt;37.5°C</td>
<td>12/162</td>
<td>(7.42)</td>
<td>3/133</td>
</tr>
<tr>
<td>Temp≥37.5°C</td>
<td>247/270</td>
<td>(91.48)</td>
<td>226/163</td>
</tr>
<tr>
<td>6 – 10</td>
<td>236/248</td>
<td>(95.16)</td>
<td>291/315</td>
</tr>
<tr>
<td>Temp&lt;37.5°C</td>
<td>12/248</td>
<td>(4.84)</td>
<td>24/315</td>
</tr>
<tr>
<td>Temp≥37.5°C</td>
<td>224/230</td>
<td>(92.64)</td>
<td>265/302</td>
</tr>
<tr>
<td>11 – 15</td>
<td>248/266</td>
<td>(93.23)</td>
<td>279/307</td>
</tr>
<tr>
<td>Temp&lt;37.5°C</td>
<td>18/266</td>
<td>(6.77)</td>
<td>28/307</td>
</tr>
<tr>
<td>Temp≥37.5°C</td>
<td>230/248</td>
<td>(90.88)</td>
<td>251/300</td>
</tr>
<tr>
<td>&gt; 15</td>
<td>32/34</td>
<td>(94.12)</td>
<td>60/62</td>
</tr>
<tr>
<td>Temp&lt;37.5°C</td>
<td>2/34</td>
<td>(5.88)</td>
<td>2/62</td>
</tr>
<tr>
<td>Temp≥37.5°C</td>
<td>30/32</td>
<td>(93.75)</td>
<td>58/60</td>
</tr>
</tbody>
</table>

*Table 3 shows the percentages of participants who either had fever or did not have fever. Temperature ≥37.5°C was classified as febrile.

4.4 Prevalence of Anaemia by Age Group

Haemoglobin levels were measured in all participants during the various surveys. Again, the June 2007 survey recorded the highest percentage (26.8%) of anaemia (< 11.0g/dL, < 11.5g/dL, < 12.0g/dL and < 13.0g/dL in the 0 – 5, 6 – 10, 11 – 15 and > 15 respectively) and the least (18.9%) detected during the November 2011 survey. It appears that during the June 2007 survey, a higher proportion of the participants were observed to have
anaemia with respect to all the different age groups. None of the participants in the 6 – 10 and >15 age groups had severe anaemia (< 8g/dL) across all the three time periods. Severe anaemia was recorded in less than 1% of participants in the under five age group during the June 2007 survey and also in 1.06% in the 11 – 15 age group during the November 2011 survey.

There was a general downward trend in anaemia with an increase in age, with children under five recording the highest percentages (27.4% – 38.6%) during each survey. Table 4 shows the prevalence of anaemia by age group and year of survey.
Table 4: Prevalence of Anaemia by Age Group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>March 2006</th>
<th>June 2007</th>
<th>November 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaemia (g/dL)</td>
<td>n/N (%)</td>
<td>n/N (%)</td>
<td>n/N (%)</td>
</tr>
<tr>
<td>0 – 5</td>
<td>N = 162</td>
<td>N = 132</td>
<td>N = 201</td>
</tr>
<tr>
<td>Normal (≥11.0)</td>
<td>108 (66.67)</td>
<td>81 (61.36)</td>
<td>146 (72.64)</td>
</tr>
<tr>
<td>Mild (10.0-10.9)</td>
<td>34 (20.99)</td>
<td>33 (25.00)</td>
<td>35 (17.41)</td>
</tr>
<tr>
<td>Moderate (7.0-9.9)</td>
<td>20 (12.35)</td>
<td>17 (12.88)</td>
<td>20 (9.95)</td>
</tr>
<tr>
<td>Severe (&lt;7)</td>
<td>-</td>
<td>1 (0.76)</td>
<td>-</td>
</tr>
<tr>
<td>6 – 10</td>
<td>N = 248</td>
<td>N = 313</td>
<td>N = 217</td>
</tr>
<tr>
<td>Normal (≥11.5)</td>
<td>193 (77.82)</td>
<td>213 (68.05)</td>
<td>181 (83.41)</td>
</tr>
<tr>
<td>Mild (11.0-11.4)</td>
<td>36 (14.52)</td>
<td>65 (20.77)</td>
<td>22 (10.14)</td>
</tr>
<tr>
<td>Moderate (8.0-10.9)</td>
<td>19 (7.66)</td>
<td>35 (11.18)</td>
<td>14 (6.45)</td>
</tr>
<tr>
<td>Severe (&lt;8)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>11 – 15</td>
<td>N = 266</td>
<td>N = 307</td>
<td>N = 189</td>
</tr>
<tr>
<td>Normal (≥12.0)</td>
<td>215 (80.83)</td>
<td>51 (81.76)</td>
<td>164 (86.77)</td>
</tr>
<tr>
<td>Mild (11.0-11.9)</td>
<td>29 (10.90)</td>
<td>42 (13.68)</td>
<td>20 (10.58)</td>
</tr>
<tr>
<td>Moderate (8.0-10.9)</td>
<td>22 (8.27)</td>
<td>14 (4.56)</td>
<td>3 (1.59)</td>
</tr>
<tr>
<td>Severe (&lt;8)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>&gt;15</td>
<td>N = 34</td>
<td>N = 62</td>
<td>N = 27</td>
</tr>
<tr>
<td>Normal (≥13.0)</td>
<td>33 (97.06)</td>
<td>51 (82.26)</td>
<td>23 (85.19)</td>
</tr>
<tr>
<td>Mild (11.0-12.9)</td>
<td>1 (2.94)</td>
<td>9 (14.52)</td>
<td>1 (3.70)</td>
</tr>
<tr>
<td>Moderate (8.0-10.9)</td>
<td>-</td>
<td>2 (3.23)</td>
<td>3 (11.11)</td>
</tr>
<tr>
<td>Severe (&lt;8)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>N = 710</td>
<td>N = 814</td>
<td>N = 634</td>
</tr>
<tr>
<td>Normal</td>
<td>549 (77.3%)</td>
<td>596 (73.2%)</td>
<td>514 (81.1%)</td>
</tr>
<tr>
<td>Mild</td>
<td>100 (14.1%)</td>
<td>149 (18.3%)</td>
<td>78 (12.3%)</td>
</tr>
<tr>
<td>Moderate</td>
<td>61 (8.6%)</td>
<td>68 (8.4%)</td>
<td>40 (6.3%)</td>
</tr>
<tr>
<td>Severe</td>
<td>-</td>
<td>1 (0.1%)</td>
<td>2 (0.3%)</td>
</tr>
</tbody>
</table>

*Table 4 shows the percentages of participants who were either anaemic or were not anaemic. The ranges for the various age groups are shown in the table above.*
4.5 Prevalence of Parasitaemia by Age Group

Parasitaemia levels were also measured in all age groups across the three time periods. The March 2006, June 2007 and November 2011 surveys recorded 45.5%, 22.6% and 17.2% respectively indicating a downward trend. Parasitaemia levels increased across the various age groups in the June 2007 survey. Prior to the spraying in March 2006, it increased gradually among children in the 0 – 5, 6 – 10 and 11 – 15 age groups, and dropped among the older age group (>15). In the November 2011 survey, parasitaemia levels again increased gradually among children in the 0 – 5 and 6 – 10 age groups and then decreased in the 11 – 15 and > 15 age groups. The prevalence of parasitaemia among the various age groups has been tabulated in Table 5.

Table 5: Prevalence of Parasitaemia by Age group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>March 2006</th>
<th>June 2007</th>
<th>November 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Presence of Parasitaemia</td>
<td>Presence of Parasitaemia</td>
<td>Presence of Parasitaemia</td>
</tr>
<tr>
<td></td>
<td>n/N (%)</td>
<td>n/N (%)</td>
<td>n/N (%)</td>
</tr>
<tr>
<td>0 – 5</td>
<td>61/162 (37.65)</td>
<td>13/133 (9.77)</td>
<td>19/200 (9.50)</td>
</tr>
<tr>
<td>6 – 10</td>
<td>116/248 (46.77)</td>
<td>75/311 (24.12)</td>
<td>47/218 (21.56)</td>
</tr>
<tr>
<td>11 – 15</td>
<td>130/266 (48.87)</td>
<td>76/301 (25.25)</td>
<td>39/188 (20.74)</td>
</tr>
<tr>
<td>&gt; 15</td>
<td>16/34 (47.06)</td>
<td>18/61 (29.51)</td>
<td>4/27 (14.81)</td>
</tr>
<tr>
<td>Total</td>
<td>N = 710</td>
<td>806</td>
<td>633</td>
</tr>
<tr>
<td></td>
<td>323 (45.5%)</td>
<td>182 (22.6%)</td>
<td>109 (17.2%)</td>
</tr>
</tbody>
</table>

*Table 5 shows the percentages of participants in the various age categories with parasitaemia.*
The bar graph in Figure 1 also illustrates the prevalence of parasitaemia after the first (March 2006), second (June 2007) and third (November 2011) in the Obuasi metropolis.

![Bar graph of overall prevalence of Parasitaemia by year.](image)

**Figure 3: Bar graph of overall prevalence of Parasitaemia by year.**

### 4.6 Unadjusted Logistic Regression for the association of Number of Spraying and Prevalence of Parasitaemia

From the unadjusted logistic regression table below, there was a statistical evidence of association observed between the number of spraying and the prevalence of parasitaemia (p < 0.001). After spraying two times and eight times, the odds ratios recorded were 0.50 (95% CI: 0.43 – 0.58) and 0.38 (95% CI: 0.31 – 0.46) respectively. With regards to the age, the presence of parasitaemia in children between the age groups of 6 – 10, 11 – 15, and >15 was about 2 times the presence of parasitaemia in the under fives. A statistical
evidence (p < 0.001) of association between the different age groups and the presence of parasitaemia was observed. However, there was no evidence of association between sex and the presence of parasitaemia (p-value = 0.797).

Table 6: Unadjusted Logistic Regression for the association of Number of Spraying and Prevalence of Parasitaemia

<table>
<thead>
<tr>
<th>Parasitaemia Level</th>
<th>Odds Ratio (95% CI)</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spraying done</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 times</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>2 times</td>
<td>0.50 (0.43 – 0.58)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>8 times</td>
<td>0.38 (0.31 – 0.46)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Age at the time of survey (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 – 5</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>6 – 10</td>
<td>1.63 (1.32 – 2.01)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>11 – 15</td>
<td>1.73 (1.40 – 2.13)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>&gt;15</td>
<td>1.66 (1.20 – 2.29)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Male</td>
<td>1.02 (0.89 – 1.16)</td>
<td>0.797</td>
</tr>
</tbody>
</table>

*Table 6 shows the values representing Odds Ratio with 95% confidence interval for parasitaemia levels with respect to number of times spraying was done, age of participants and gender.

4.7 Adjusted Logistic Regression for the association of Number of Spraying and Prevalence of Parasitaemia

After adjusting for age, there was still a statistical evidence of association between the number of spraying and the prevalence of parasitaemia (p < 0.001). After the second spraying, the odds ratio reduced from 0.50 (95% CI: 0.43 – 0.58) to 0.48 (0.42 – 0.56) whereas there appeared to be an increase from 0.38 (95% CI: 0.31 – 0.46) to 0.40 (0.33 –
0.48) after the eighth spraying. However, sex still remained non-significant with a p-value of 0.633 and a 95% confidence interval which included 1.

Table 7: Adjusted Logistic Regression for the association of Number of Spraying and Prevalence of Parasitaemia

<table>
<thead>
<tr>
<th>Parasitaemia Level</th>
<th>Odds Ratio (95% CI)</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spraying done</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 times</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>2 times</td>
<td>0.48 (0.42 – 0.56)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>8 times</td>
<td>0.40 (0.33 – 0.48)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Age at the time of survey (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 – 5</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>6 – 10</td>
<td>1.61 (1.31 – 1.98)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>11 – 15</td>
<td>1.64 (1.34 – 2.02)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>&gt;15</td>
<td>1.60 (1.17 – 2.20)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Male</td>
<td>1.03 (0.91 – 1.17)</td>
<td>0.633</td>
</tr>
</tbody>
</table>

*Table 7 shows the values representing Odds Ratio with 95% confidence interval for parasitaemia levels with respect to number of times spraying was done, age of participants and gender.*
CHAPTER FIVE

5.0 DISCUSSION

From the study findings it was revealed that the AngloGold Ashanti’s integrated malaria control programme (IRS) had a positive impact on malaria parasitaemia across the five year period as was expected (AngloGold Ashanti Report, 2004). The baseline survey was conducted during the wet season in May, 2006 before the spraying was done, and therefore reported the highest percentage of malaria parasitaemia of about 45.5%. Of the four age groups, a malaria parasitaemia rate of 48.9% which constituted the highest prevalence was observed among the 11 – 15 years age group and the least (37.7%) among the under five group.

The second survey which had the highest number of participants was conducted in June 2007 during the wet season after the indoor residual spraying had been done two times. A 50% reduction in malaria parasitaemia levels was observed after the first post intervention survey with the highest prevalence (29.5%) observed among the >15 age group and the least (9.8%) recorded among the under five group.

In the year 2011, the third survey was conducted in November, 2011 during the dry season but this was after eight more indoor residualsprayings had been done since the IRS malaria control programme was scheduled to be done two times in a year. Again, the under five age group recorded the least prevalence rate of 9.5% while the 6 – 10 age group recorded the highest rate of 21.6%. Between the first and second post intervention surveys which was conducted in June 2007 and November 2011, respectively, a decrease
of about 5% was observed. Although not very much, it still showed a positive impact of the intervention as was expected.

The positive effect of the IRS on malaria parasitaemia that was observed was consistent with findings from several studies carried out in countries like South Africa, Zimbabwe and Swaziland among others (Kouznetov, 1977; Mabaso, 2004). Considering the association between the number of spraying and the prevalence of malaria parasitaemia, a protective effect of the intervention was observed. From both the unadjusted and adjusted regression analysis above, it was clear that the higher the number of spraying, the higher the protection. There was a 50% reduction of malaria parasitaemia level after spraying two times while a further reduction of about 62% was observed after spraying for eight more times. Both effects were highly significant (p<0.001). After adjusting for age and sex however, a significant increase of 52% was achieved after the first two spraying as well as a significant decrease of 60% after spraying for eight more times. This is an indication of a very little effect of age on the presence of parasitaemia after the implementation of the IRS intervention.

Across the three surveys, it was also observed that children under five recorded the least percentages of malaria parasitaemia with a four times reduction (39.7% to 9.8%) during the first post intervention survey (June 2007) and a slight decrease (9.8% to 9.5%) during the second post intervention survey. However, the highest prevalence rates were not consistent among a specific age group since different age groups recorded these percentages across the three time periods.
The reduction in parasite prevalence among the participants below the age of 10, who were grouped into the 0 – 5 and 6 – 10 age groups after the intervention was also consistent with findings from some studies conducted in children between the ages of 2 and 5 years between 1931 and 1958 in the Transvaal province in South Africa (Swellengrebel and de Meillon, 1931; Brink, 1958), and also between the ages of 2 and 9 years in Botswana (Chayajabera et al, 1975). A similar finding of a positive impact of indoor residual spraying was observed in children under six in Tanzania (Curtis, 1998).

Again, it would have been expected that the presence of parasitaemia would increase during the June 2007 survey (Taylor and Mutambu, 1986; Nkuo-Akenji, 2006), but a decrease was observed which could have resulted from the IRS intervention.

Although the overall prevalence of anaemia increased after the first two indoor sprayings, there was a reduction subsequently after spraying eight more times. This reduction was also consistent with that of studies in which there was a marked impact of the effect of Indoor Residual Spraying on anaemia in African children (Korenromp et al, 2004; Skarinski et al, 2012). A study conducted by Ehrhardt et al in 2006 revealed that fever was more common in children under five. However, it was not the same with this study. The under five age group recorded the least percentages of the presence of fever compared to the other age groups, before and after the intervention.

A limitation of this study was the absence of the description and location of the school; a factor which therefore could not be controlled for.
5.1 CONCLUSION

The implementation of AngloGold Ashanti’s malaria control integrated programme resulted in a significant reduction in the presence of parasitaemia after the Indoor Residual Spraying. The relative reduction was highest for the initial spraying between the baseline and the first spray round. The relative reduction between the second survey and third survey may suggest the tailing off of the effectiveness of the IRS programme alone as a control tool.

With respect to the age-specific prevalence of malaria, the 11 – 15 age group had the highest presence of parasitaemia before the intervention while the >15 and 6 – 10 age groups were found to have the highest parasitaemia presence during the first and second post intervention surveys respectively.

The findings from this analysis suggest the protective effectiveness of IRS against malaria morbidity. Since malaria is still endemic in Ghana however, the IRS could be adopted as one of the best ways in controlling the incidence of the disease in the country.
REFERENCES


15. Ghana Health Service Annual Report, 2004


