SCHOOL OF PUBLIC HEALTH

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COST OF INDOOR RESIDUAL SPRAYINGIN THE OBUASI MUNICIPALITY

BY

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THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF GHANA IN PARTIAL FULFILMENT TO THE REQUIREMENT FOR THE AWARD OF MASTER OF PUBLIC HEALTH DEGREE

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DECLARATION

I, **Tang N. Felix,** declare that except for other peoples investigation which have been fully acknowledged, this work is the result of my own original research and either in part or in whole has not been presented elsewhere for another degree.

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ABSTRACT

Background

World Health Organisation Global malaria programme recommends three primary interventions that must be scaled up in countries to effectively respond to malaria control and management towards achieving the millennium development goals for malaria by 2015 and one of these is Indoor Residual Spraying.

The Indoor Residual Spraying programme was started in the Obuasi Municipality in 2006 by the AngloGold Ashanti Mining Company as a measure to reduce the expenditure incurred in the treatment of malaria among its employees thus reducing the lost days of work to the company due to the disease. Hence, this study seeks to establish the total cost of the intervention and the gains made by it.

Methods

The indoor residual spraying in the Obuasi Municipality was an intervention introduced by the AngloGold Ashanti Mining Company to reduce the prevalence of malaria within its operational area.

The programme covered 53 communities in the municipality consisting 139,000 structures which included dwellings, schools, hospitals and churches.

This study employed the ingredients approach to costing unit costs for both recurrent and capital items used in the IRS programme using detailed retrospective cost data and effectiveness indicators.

Result

The total financial cost of the programme in the Obuasi Municipality was US$ 1,689,090.07 (GH₵ 1,553,962.86) and US$1,703,008.52 (GH₵ 1,566,767.84) was the total economic cost.

The programme covered 35000 structures in the municipality of which 27,000 were human dwellings covering a population 134000. The financial cost per structure was US$ 12.61 (GH₵ 11.70) and US$ 12.71(GH₵ 11.60) for economic cost. The programme reduced the proportion of malaria cases reporting at the health facility by 50% and reduced average costs of malaria medication by US$ 5.48 (GH₵ 5.04) per person protected, saving over 40% on malaria medication.

The main driving forces behind IRS intervention were three fold: the structures, insecticide and personnel emoluments.

Conclusion

The average cost of US$ 12.71 (GH₵ 11.69) per structure sprayed led to 50% reduction in malaria cases and 40% savings on malaria medication. Financial and political commitment to indoor residual spraying programmes would reduce malaria cases and increase productivity in workforce.

DEDICATION

This work is dedicated to the Almighty God for HIS protection and guidance throughout the MPH programme.

Furthermore, I dedicate this to my parents for their continuous prayers and support.

Next, I dedicate this to my siblings for their unflinching love and encouragement.

Finally, I dedicate this to all forward lookers who struggle for a better tomorrow.

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LIST OF ACRONYMS

AGAMCP	-	AngloGold Ashanti Malaria Control Programme
DDT	-	Dichloro Diphyenyl Tricholoroethane
DFID	-	Department for International Development
FTE	-	Full Time Equivalent
IEC	-	Information, Education, Communication
IRS	-	Indoor Residual Spraying
ITN	-	Insecticide Treated Net
LLITN	-	Long Lasting Insecticide Treated Net
LTIFR	-	Lost Time Injury Frequency Rate
MDGs	-	Millennium Development Goals
M&E	-	Monitoring and Evaluation
MLTIFR	-	Malaria Lost Time Injury Frequency Rate
PPE	-	Personal Protective Equipment
STTA	-	Short Term Technical Assistance
UNECE	-	United Nations Economic Commission for Europe
WHO	-	World Health Organisation

OPERATIONAL DEFINITIONS

Term	Definition
Capital cost	The expenditure incurred in the procurement of items with a "lifespan" more than one year.
Cost	The value of a resource used the production of a good or a service
Economic cost	The opportunity cost of all resources used to provide the intervention whether or not a financial expenditure is incurred.
Financial cost	The cost incurred for the delivery of an intervention in terms of cash expenditure.
Indoor Residual Spraying	This is the application of long lasting chemical insecticides on the walls and roofs of all houses and domestic shelters in a given area, in order to kill the adult vector mosquitoes that land rest on these surfaces.
Recurrent cost	any expenditure incurred in the purchase of items or services with "lifespan" <1 year

CHAPTER ONE

1.1 Introduction

World Health Organisation (WHO) Global malaria programme recommends three primary interventions that must be scaled up in countries to effectively respond to malaria control and management towards achieving the millennium development goals (MDGs) for malaria by 2015 and other health targets(WHO, 2006).

These include diagnosis of malaria cases and treatment with effective medicines as well as the distribution of insecticide treated nets (ITNs) to achieve full coverage of populations at risk of malaria and finally, Indoor residual spraying (IRS) as a major means of vector control to reduce and eliminate malaria transmission. Scientific evidence indicates that IRS is effective to control malaria transmission and thus reduce the related burden of morbidity and mortality as long as most premises (houses, animal shelters) (e.g. > 80%) within targeted communities are treated. Scientific evidence of IRS efficacy in reducing or interrupting malaria transmission in different epidemiological settings has been available since the 1940s and 1950s (Russell, 1957; Lividas, 1958). This evidence formed the rationale for introduction of IRS as a primary intervention for malaria control and eradication.

Thus, though a number of research studies have been published on the effectiveness of indoor residual spraying (IRS) (Kouznetsov, 1977; Sharp & le Sueur, 1996; Curtis & Mnzava, 2000; Sharp et al. 2000), studies on the cost effectiveness of IRS are relatively scarce (Guinness, 1997; Goodman et al., 2001; Guyatt et al., 2002). In addition, the number of studies that have been carried out comparing the cost and/or effectiveness of IRS with insecticide treated nets (ITNs) have shown results to being

conclusive. Some studies have shown the cost per person covered per year to be less with IRS (Guinness, 1997; Verlé et al., 1999; Goodman et al., 2001; Guyatt et al., 2002), others suggest that ITN use falls into a lower costs range (Kere & Kere, 1992; Curtis et al., 1998; Konradsen et al., 1999; Goodman et al., 2000).

However, cost analysis has shown both IRS and ITNs to be considered attractive interventions in low and middle income countries (Goodman et al., 2000).The cost-effectiveness of insecticide-treated nets is dependent on whether it is necessary to distribute nets. If so, the cost-effectiveness range in a very-low-income country was $19—85.Whilst that of residual spraying depends on the number of spraying rounds required per year. For one round per year, the cost-effectiveness range in a very-low-income country was US$16—29, and doubled to US$32—58 for two rounds per year, (Goodman, Coleman & Mills, 1999).

Furthermore, studies confirm that IRS is cost-effective, although developments such as insecticide resistance could change the cost-effectiveness. In Africa, the potential threat of resistance to public health insecticides appears to be significant. Resistance to DDT and pyrethroids in major malaria vectors has been found throughout West and Central Africa, in some areas at a high level, as well as in several parts of Eastern and Southern Africa.

Despite the parasite resistance to insecticide, in 2006 the WHO recommended that, where appropriate, IRS with dichlorodiphenyltrichloroethane (DDT) or other insecticides should be a central part of national malaria control strategies. Eight (8) synthetic pyrethroids are safe alternatives to DDT especially in modern housing surfaces and in low and seasonal transmission areas.

The IRS programme was started in the Obuasi Municipality in 2006 by the AngloGold Ashanti Mining Company as a measure to reduce the expenditure incurred in the treatment of malaria among its employees thus reducing the lost days of work to the company due to the disease and secondly, as a cooperate social responsibility to the adjourning communities within the municipality. Hence, this study seeks to establish the total cost of the intervention and the gains made by it.

1.2 Research Question

What is the total financial and economic cost of IRS programme in the Obuasi Municipality?

1.3 Problem Statement

Malaria accounts for 49% of all hospital cases and 22% of all deaths in Obuasi, Ghana. In 2005, the Obuasi Municipal Health Directorate had an estimated average of 11,000 malaria cases per month, with an additional 6,800 of this receiving treatment at Obuasi mines Edwin Cade Memorial Hospital. Of the cases reported at Edwin Cade, 2,400 were employees or contractors and the remaining (4,400) were dependants of the workers of the goldmine. The company after studying the monthly trend of the cost of malaria treatment for employees and dependants (which stood at $55,000/month) in 2005introduced the IRS programme.

From 2005 to 2009, there was a consistent annual decrease in the cases of malaria in Obuasi. The total number of cases reported at the Obuasi Mines Edwin Cade Memorial Hospital (which serves employees and dependents) decreased from 6,800 cases per month in 2005 to 1,150 cases per month in 2009.Following this, an average

monthly medication costs to the company fell from US$ 55,000 in 2005 to US$ 9,800 in 2009. Similarly, average monthly lost days of work due to malaria fell from 6,983 in 2005 to 282 in 2009 (Roll Back Malaria; Progress and Impact Series,2011).

Unfortunately, little is known about the economic cost of IRS programme in Obuasi and gains made regarding productivity losses that may be useful in promoting and scaling-up IRS to other districts and co-operate institutions.

The study aims to document the processes and to estimate the total cost (financial and economic) of the IRS programme in Obuasi and to determine the cost per household sprayed and work output gains due to IRS.

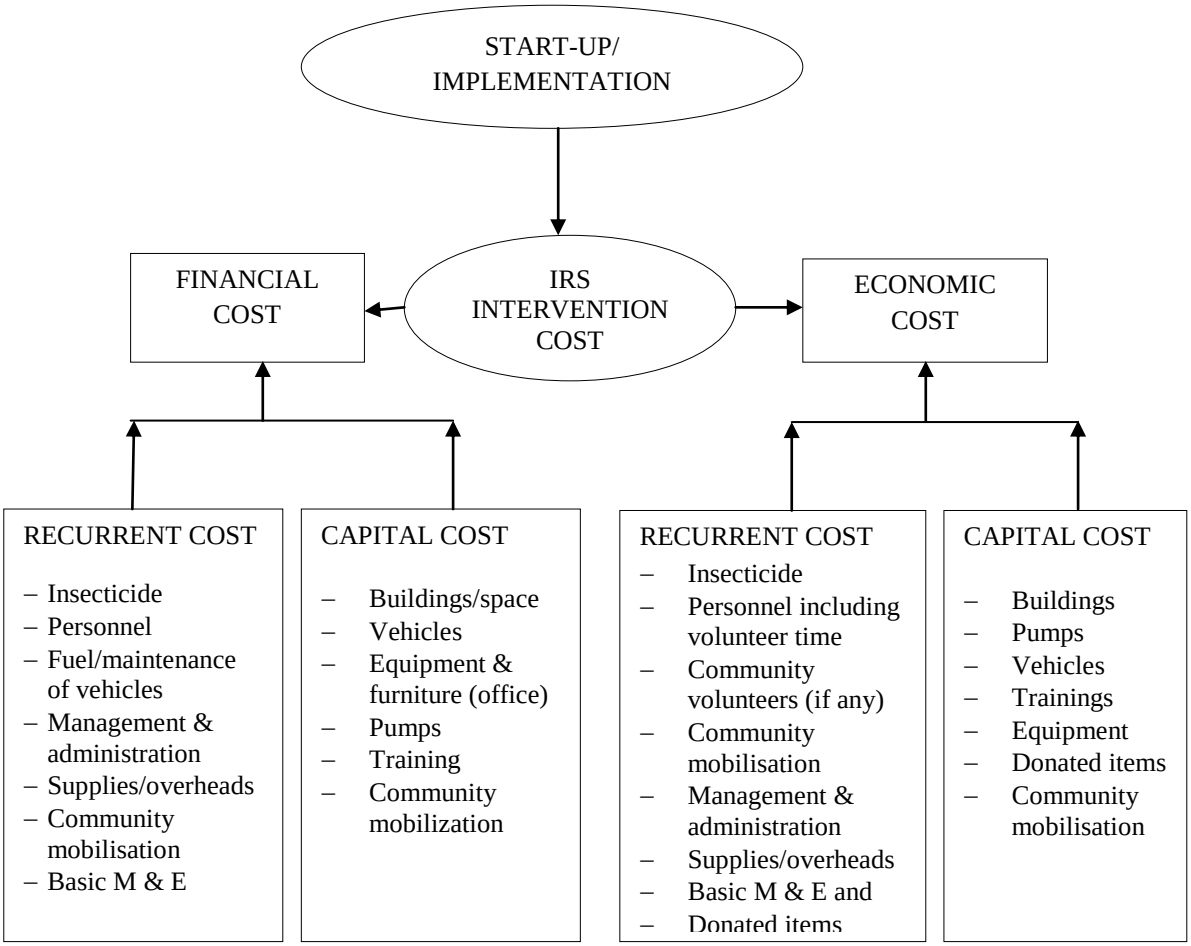
1.4 Conceptual Framework

Estimating the cost of a programme such IRS usually require the estimation of both the financial and economic costs of implementing the programme. Whereas the financial costs is basically the accounting costs of implementing the programme, the economic costs estimates the actual value of the next best use of the resource.

This study seeks to determine the cost of IRS, a malaria control intervention in the Obuasi Municipality. The study intends to do this by estimating the start-up/implementation cost which constitutes financial and economic cost of the IRS programme. The financial and economic costs can be broken into costs incurred at the start of the programme and costs during the programme implementation. Similar costs categories may be captured under economic or financial costs but mode of estimating these cost- categories will vary based on whether there was direct financial outlay on it or not. Economic cost will capture in addition all capital and recurrent costs of items used but which direct expenditure was not made on it. Analysis of the cost of an

intervention such as IRS will entail estimating the start-up cost as well as the implementation cost. These potentially, are subdivided into financial and economic cost, under each the capital and recurrent cost may be determined.

Figure 1: Conceptual Framework for Cost-Analysis Framework of IRS



IRS is labour intensive and therefore, requires inputs such as logistics and supplies to enable the spraying of the prescribed structures within a housing unit. During the pre-implementation phase, personnel recruited for the spraying exercise may be trained as well as the community mobilizations/sensitizations to create the needed awareness on the programme for the beneficiary communities are expected to be carried. If during these activities the participants were paid any form of allowance, it would be estimated under financial cost, but if the participants were not paid, the allowances

they would have received had they spent their time on a similar activity will be costed and is estimated as an economic cost. The extent to which capital and labor are used can critically influence unit costs, (Drummond, et.al., 1997).

The economic and financial cost of IRS can be influenced by the size and spatial distribution in the district as well as the prevailing macroeconomic conditions in the country. Personnel training, building/space that is used to store the insecticide and other equipment as well as for training will yield cost to the programme. These costs for example, the personnel initial training may add up to the start-up costs whereas refresher training will add up to implementation costs. Vehicles that are hired to carry the insecticide and other logistics, for meetings, which all constitute cost to the programme, may be classified as recurrent or capital costs. The fuel and maintenance of these vehicles will be considered recurrent costs if the vehicle was purchased or hired but the costs of the vehicle to the programme will be captured as a capital cost.

Insecticides, personnel emolument (wages), fuel/maintenance of vehicles, management and administration including supplies are considered under recurrent cost due to their variability in nature. However, the economic cost of IRS will be influenced and be different from the financial expenditure used, if the personnel who did the spraying were community volunteers and they were not paid the stipulated wage. Using the recorded amounts paid to volunteers will underestimate the true value of cost of hiring personnel to do training where volunteers are not available. Other factors as the donation of capital goods, such as buildings or office space, vehicles and insecticides which are not captured under the financial cost can greatly affect the cost of the intervention. Thus estimating all cost categories and elements outlined in the conceptual framework will produce costs that can be useful for scaling up IRS in institutions and districts.

1.5 Justification

The company was spending as much as US$ 55,000 per month by 2005 on malaria medication alone which it deemed unsustainable with time. It therefore considered it prudent to refocus on effective and sustainable preventive strategies regarding the problem (malaria), thus the introduction of the intervention (Indoor Residual Spraying.

Tracking of the costs of IRS is also expected to contribute to an understanding of the prospects for sustainability, particularly in the context of achieving host-district self-reliance in managing, planning, implementing, and monitoring IRS programs.

The findings of the study shall also provide an understanding of the intervention structure to any Metropolitan, Municipal and District Assembly (MMDA) with the necessary resources and willing to replicate a similar programme within its catchment area

1.6 Objectives

General Objective

To estimate the cost of indoor residual spraying

Specific Objectives

1. To determine the start-up cost of IRS in the Obuasi Municipality
2. To determine the total cost of IRS in the Municipality
3. To estimate the average cost per household sprayed by the programme.

CHAPTER TWO

LITERATURE REVIEW

2.1 Malaria

Malaria is a mosquito-borne parasitic disease that is common in the world's poorest countries. It is preventable and treatable, yet it still kills some 881,000 people every year, 90% of whom are in Africa and 85% of whom are children under five (WHO, 2006).The direct economic costs of malaria are enormous and weigh particularly heavily on poor countries with fewer resources. Recent research has shown a close correlation at the country level between the rate of economic development and the burden of malaria. Malaria predominantly affects rural and poor populations that have little or no access to current prevention and treatment tools. It is estimated that malaria costs Africa more than US$12 billion every year in lost GDP, due to the heavy toll it inflicts on families in rural areas (Rugimalila et al., 2006).

Malaria imposes a steep economic burden on the poor, not only as direct healthcare expenses but also as lost wages from illness and caring for the sick. The World Health Organization estimates that a poor family in Africa can spend 25% of its income on malaria prevention and treatment (Gallup & Sachs, 2001). The long-term effect of retarded growth translates to a 50% reduction in GNP over the period (Hanson, et al, 2004).

According to the World Health Organization report on malaria in Ghana, US$ 27million and US$38million was spent on malaria in 2008 and 2009 respectively.

In spite of the huge amount of money invested, Ghana still recorded very worrying figures with 3,694,671 cases in 2009 compared to 3,200,147 in 2008. Admission to

hospitals due to malaria also went up from 272,802 in 2008 to 277,047 in 2009. Death due to Malaria from the records of clinics and hospitals stood at 3,378 in 2009 (WHO Malaria Report, 2010).WHO writes in its 2010 report on Ghana, there is no evidence of a reduction in suspected malaria cases between 2000 and 2009, while inpatient cases in all ages increased''.

In recent years, the global malaria community has dramatically increased its efforts to halve the number of malaria cases and deaths and achieve 80% coverage of malaria prevention and treatment by 2010 in line with targets set by the World Health Assembly in 2005 (WHO, 2008). Grassroots organizations and celebrity champions have raised the profile of the disease, and put it on the agenda of global leaders. Between 2003 and 2008, anti-malaria investments grew from roughly US$ 50 million to US$1.1 billion, with substantial new commitments from the US and UK governments; the Global Fund to Fight AIDS, Tuberculosis, and Malaria; the World Bank; and the Bill & Melinda Gates Foundation, among others(World Malaria Report, 2008).

2.2 Control of Malaria

There is a wide range of malaria control interventions whose efficacy and effectiveness have been repeatedly demonstrated over many years, including ITNs, IPT, case-management and indoor residual spraying (IRS) according to Pluess, Tanser, Lengeler, & Sharp, (2010).

In response to calls for widespread control and elimination of malaria and the challenge of meeting the Millennium Development Goals, there has been a rapid scale-up of existing effective anti-malaria interventions, in particular insecticide-

treated mosquito nets (ITNs) including long-lasting insecticidal nets (LLINs), (Flaxman et al., 2008; Yukich et al, 2008), coupled with efforts to improve access to prompt and effective treatment,(Whitty, Chandler, Ansah,Leslie, Staedke,2008; Bosman & Mendis,2007). The costs and cost-effectiveness of these studies have been shown to vary.

2.3 Insecticide Treated Nets (ITNS) Costs and Cost-Effectiveness

The cost per ITN distributed is typically higher than the cost per person protected by a net, as it is usually assumed that nets are shared (e.g. mother and child). However some studies estimate the cost of delivering an ITN to a target group, such as newborn infants, in which case the cost per person protected in the target group may be more than the cost per ITN delivered (e.g. to ensure infants are covered by nets more than one net may need to be distributed per infant, as some nets may be used by other family members, (White, Conteh, Cibulskis, & Ghani, 2011).

The study by White et al., (2011) demonstrates that the median financial cost per ITN distributed (in the first year) was US$7.03 ranging from US$2.97-$19.20 whilst the median economic cost (across the expected lifetime of the net) was US$4.15 ranging from US$2.97-$10.05. The median standardized financial cost for a year's protection with ITNs was US$2.20 ranging from US$0.8 - US$9.54. In the study, a mean proportion of 63% (range 12%-92%) of the cost of distributing a net was attributable to nets and insecticide, 17% (range 2%-67%) was attributable to personnel and training, and 7% (range 1%-17%) to IEC and transport.

2.4 Diagnosis and Treatment with Microscopy

For studies of diagnosis and treatment, White et al., (2011) reported that 27% (range 12%-95%) of the cost was attributable to diagnosis, 41% (range 5%-47%) to treatment, and 17% (range 0%-56%) to personnel and training.

Patients with severe episodes of malaria usually need to be treated as hospital inpatients to ensure effective treatment. According to White et al., (2011) the median financial cost of treating a hospital inpatient was $30.26 (range US$15.64-$137.87) and the economic cost was US$64.50 (range US$26.99 - US$288.79).

Most studies estimated either the financial or economic cost of treating an episode of malaria with a number of drugs including artemisinin combination therapy, sulphadoxine-pyrimethamine and quinine. The median financial cost of treating an episode of uncomplicated malaria (either as hospital outpatients or at health centres) was US$5.84 (range US$2.36-$23.65), and the median economic cost was US$22.48 (range US$9.14-US$37.99) (White et. al., 2011).Hence, this as compared to IRS US$3.91 ranging from US$1.11-$12.87 maiden financial cost and US$3.41 ranging from US$1.14-US$6.23 maiden economic cost is more expensive.

2.5 Larviciding

Larval source management and the use of microbial larvicides offer additional protection against malaria. Microbial are highly effective at killing mosquito larvae, highly specific in action and safe to use. Importantly, the risk that resistance will develop is very low and can be easily managed and reversed. Larval source management may also delay the emergence of resistance to the pyrethroid insecticides used on ITNs. The cost of larviciding is similar to that of ITN and IRS programmes

and may drop if environmental modifications can reduce breeding sites and if larviciding can be targeted in space, time or both (Bulletin of WHO, 2009). The effective operational implementation of these campaigns is difficult, time consuming, and expensive. New evidence however, suggests that adult mosquitoes can be co-opted into disseminating larvicides in a far more targeted and efficient manner than can be achieved using conventional methods (Devine and Kileen, 2010).

Despite its enormous historical successes in Europe and America, mosquito larval source management (LSM) remains a largely forgotten and often dismissed intervention for malaria control in Africa. One of the reasons LSM is not considered for malaria control is that it is perceived as beyond the reach of most resource-deprived communities in sub-Saharan Africa. (Worrall & Fillinger, 2010).

2.6 Indoor Residual Spraying

In Africa, malaria eradication pilot projects were initiated from the 1950s to the 1970s in Benin, Burkina Faso, Burundi, Cameroon, Kenya, Liberia, Madagascar, Nigeria, Rwanda, Senegal, Uganda and the United Republic of Tanzania(World Health Organisation,2006). These projects demonstrated that malaria was highly responsive to control by IRS with significant reduction of anopheline vector mosquitoes and malaria, although in most cases, transmission could not be interrupted (Lividas et al.1958; Garrett-Jones, 1964; De Zuleta et al.1964; Kouznetsov, 1977; Beales et al. 1989).

IRS is effective in rapidly controlling malaria transmission, hence in reducing the local burden of malaria morbidity and mortality, provided most houses and animal shelters (e.g.>80%) in targeted communities are treated (Okiro et al., 2010). IRS was

instrumental in breaking malaria transmission in many parts of the globe including Sri Lanka and South America(WHO, 1969).In Africa, IRS has been focused at selected ecological zones such as those experiencing unstable transmission (Sharp & Le Sueur, 1996), highlands (de Zuleta et al., 1994) and urban areas (Bang et al., 1993). There is also an increasing interest in the use of IRS for containment of epidemics (Mouchet et al., 1997), such as Wajir (north-eastern Kenya) (Brown et al., 1998). The malaria eradication programme (1955-1969) contributed to significantly reducing the global malaria burden, particularly in Asia, Latin America and Southern Africa. The eradication programme was based on IRS against the vector mosquitoes as endorsed by the WHO Kampala conference of 1950.

Numerous studies have shown that IRS has substantially reduced infant and child mortality. This evidence formed the rationale for introduction of IRS as a primary intervention for malaria control and eradication. However, in Africa, the potential threat of resistance to public health insecticides appears to be significant. Resistance to DDT and pyrethroids in major malaria vectors has been found throughout West and Central Africa, in some areas at a high level, as well as in several parts of Eastern and Southern Africa. Resistance to carbamates has been found in countries of West Africa, with a mechanism that also induces cross resistance to organophosphates (WHO, 2006).

There are several issues that may militate against IRS. The first is malaria ecology. Most of the success stories of IRS have been undertaken in areas of low transmission; it is accepted that interruption of transmission is harder to achieve under conditions of intense perennial transmission. However, the evidence from controlled trials of spraying suggests that it could also provide some degree of protection in areas of

higher transmission (Curtis &Mnzara, 2000). The second issue commonly quoted as a hindering factor in the success of IRS is compliance. There have been reports from Namibia of households refusing to allow spray teams into their homes (Hill et al., 1996) and in Zimbabwe 21% of villages refused to have some rooms in their homes sprayed (Vundule & Mharakurwa, 1996).

The role and cost and cost-effectiveness of indoor residual-house spraying (IRS) for malaria control has received far less attention. The cost of one cycle of IRS has been shown to vary from less than US$1-4 per person protected (Faye et al., 1992; Rowland, 1999) to as much as US$2-3 (Curtis et al., 1998; Goodman et al., 2001).

In Africa, IRS has been focused at selective ecological zones such as those experiencing unstable transmission (Sharp & Le Sueur, 1996), highlands (de Zuleta et al., 1964) and urban areas (Bang.et al. 1993). The financial cost per person protected in the first year of operation in Gucha was US$0.86 for one cycle of IRS and US$4.21 for an ITN, indicating that the ITN project was five times more expensive than IRS per person protected according to White et al., (2011), the median financial cost per person protected by IRS was US$3.91 ranging from US$1.11-$12.87 whilst the median economic cost was $3.41 ranging from US$1.14-US$6.23. The median standardized cost of a year's protection with IRS was US$6.70 ranging from US$2.22-US$12.85. A recent comparison of historical trials of IRS in Africa against contemporary evidence of the effects of ITNs highlighted the need to re-visit the comparative advantage of ITNs over IRS under a variety of endemic settings (Curtis & Mnzava 2000). Despite the widespread use and evaluation of ITNs and IRS under the epidemiological conditions of Asia (Verle et al. 1999; Kamolatanakul et al. 2001), there have been only two simultaneous evaluations of ITNs and IRS in Africa.

The economic cost per person protected for ITNs in the first year is estimated at US$2.34 whilst the economic cost for IRS remains similar to the financial cost at US$0.88 per person protected. The only way that ITNs could be cheaper than IRS at a reasonable level of efficiency is if two (2) cycles of IRS were needed. The spraying activities in Gucha in 2000 demonstrated that this activity can reduce the risk of malaria infection by 75%, a higher protective efficacy than ITNs (63%), (Guyatt et al., 2002).

2.7 Cost Estimation

IRS is applicable in many epidemiological settings, provided the operational and resource feasibility are considered in policy and programme decisions. IRS requires specialized spray equipment techniques, and both the equipment and the quality of application must be scrupulously maintained (World Malaria Report, 2011).

The economic cost includes any opportunity costs for existing resources, such as per round. There are several approaches for the estimation of cost of an intervention such as the human capital and the ingredients approach. In human-capital estimations, the value of health improvements is calculated as the decreased consumption of health care and the increased production (Johnesson, 1996). However, it is frequently argued that these valuations overestimate the true cost to society if the individual were to be taken out of workforce, either through illness or to receive health care. For example, for short-term absences, losses in production could be compensated for by the worker on return to work, or by colleagues, (Drummond et al., 2005). The limitations of the human-capital approach were, however, soon realized and the approach was criticized

for not being based on the proper concept of willingness to pay for health improvements, (Johnesson, 1996).

The 'ingredient' approach to costing is about identifying all resources in the process of production.The cost of any input to a production process is the product of the quantity used and the value (or price) of each unit. The ingredients approach is useful for many reasons, the most important are that it allows analysts and policy-makers to validate the assumptions used; judge whether the estimates presented can be applied to their settings; and, if necessary, change some of the parameters to replicate the analysis for their settings, (Baltussen et al., 2002; Walker, 2001; Creese & Parker, 1994).

Summary

Cost-effectiveness depends on various factors specific to each intervention, but certain common influences can be identified. These include the length of the transmission season (through the effect on costs), the price of key commodities (insecticides and spray pumps and so on), behavioural factors (compliance with spray teams and so on), the degree of existing infrastructure, and the degree of drug resistance.

The cost per person protected for IRS is calculated from the cost per sprayed room and the number of people per room in a homestead. The cost per sprayed room from the literature review was calculated from the cost of IRS which included the cost of insurances and freight cost of Icon divided by the number of rooms sprayed (Guyatt et al.2002).

In the economic cost analysis, the cost of all capital items (nets, pumps and vehicles) and the training are distributed over the life expectancy of each resource. The economic cost also includes any opportunity costs for existing resources, such as personnel. However, in the course of literature review the two main cost approaches used are the human capital and the 'ingredients' approach to costing. Therefore, this study shall employ the 'ingredients' approach to costing as it is the preferred approach in most health intervention studies.

CHAPTER THREE
METHODS

3.1 Study Type

This study is a cross-sectional retrospective study. The IRS programme was started in the Obuasi Municipality in 2006 by the AngloGold Ashanti Mining Company as a measure to reduce the expenditure incurred in the treatment of malaria among its employees which is still on-going (AngloGold Ashanti, 2006). The study reviewed financial and programme records of the AngloGold Ashanti Malaria Control Programme for the period January 2006 – December 2006. Data on malaria cases and the costs of treating these cases at the AngloGold hospital were also collected from the provider's perspective.

3.2 Study Location/ Area

The Obuasi Municipality is one of the 27 districts of the Ashanti Region and was carved out of the erstwhile Adansi West District Assembly. The municipality is located at the southern part of Ashanti Region between latitude 5.30N and 5.65N and longitude 6.35N and 6.90N.

It covers a land area of 162.4 square kilometres (Sq. km). There are 53 communities in the municipality which share 30 electoral areas. It is bounded to the east by Adansi South, west by Amansie Central district and to the north by Adansi North, to the south by Upper Denkyira district in the Central Region. It has Obuasi as its administrative capital where the famous and rich Obuasi gold mines now AngloGold Ashanti is located.

The population of the municipality is estimated at 205,000 using the 2000 housing and population census as a base and applying a 4% annual growth rate. The vegetation is predominantly a degraded and semi-deciduous forest. The programme intervention area which covers the complete Obuasi Municipal Assembly area, has 53 communities with 35,000 dwellings, 139,000 structures were sprayed by the programme.

3.3 Study Variables

The dependent variable in this study was the institutional cost of the IRS programme. The independent variables of the study were the recurrent and capital cost items of IRS (Table 1).

Table 1: List of Study Variables, Definition and Indicators

Variables	Definition	Indicators
Recurrent Cost	Value of resources with a life span of one or less than one year.	- Salaries and Allowances, Cost of community sensitization - Cost of materials and supplies - Cost of Maintenance/repairs - Cost of Utilities - Miscellaneous expenses.
Capital cost	Cost of resources with a life span of more than one year.	- Cost of Building and space, - Cost Equipment/implements - Cost of spray equipment - Cost of furniture - Cost of Vehicles

The recurrent cost items included spray operations, management and administration and personnel as presented in Table 2.

Table 2: Recurrent cost variables for IRS Cost Analysis

Cost Category	Items
Spray operations	– Planning and logistic assessment – Training – Information, education and communication (IEC) – Short term labour – Transportation – Medical cost – Post-spray meetings – Monitoring and evaluation (M&E) activities
Spray operations commodities	– Insecticide – Personal protective equipment (PPE)
Personnel	National Staff (Non-expatriates)
Local administration	- Utilities – Services for office support – Management travel and transportation

Capital costs of the IRS programme were made up of costs of all items/activities that had a life span of one year or more (Table 3) and included vehicles, computers, office space, spray equipment and training. The capital items had a lifespan of between 5 years and 40 years for the IRS programme.

Table 3: Capital Costs Variables of the IRS Cost Analysis

Categories	Items	Period
Local administration	– Vehicles – Computers, laptops, and information technology equipment printers and photocopiers, cameras and projectors mobile phones and landline phones, air-conditioners, refrigerators. Tables, chairs, bookshelves, and other furniture	Five (5) Variable
Office space	Office building	Forty (40) years
Spray equipment	Spray pumps	Five (5) years
Laundry services	Washing machine Drying machine	Five (5) years
Training	Training of spray men	

3.4 Study Population

The study population were the dwellings and structures sprayed by the IRS programme in Obuasi Municipality.

3.5 Cost components of the IRS programme

The cost components of the IRS programme comprised the programme start-up, which consisted primarily of capital items was allocated 6.3% and 7.1% of the financial and economic cost respectively. Whilst the implementation cost mainly of recurrent items was allocated 93.7% and 92.9% of the programme cost. This study therefore, assumed the capital cost of the programme to represent the start-up cost since these costs were incurred once in the lifetime of the programme whilst the recurrent cost represented the implementation cost and costs that had a lifespan of a year or under a year.

3.6 Start-up activities

The IRS programme in Obuasi started with the ordering of capital items like vehicles, spray pumps, office furniture, equipment/implements, laundry equipment as well as training of spray men on IRS activities (Table 4). Various quantities of each item were purchased with a useful life years ranging from 5 years to 40 years. The building space for storage and office activities of the IRS programme was donated by the AngloGold mining company.

Table 4: List of start-up capital items

	Item	Quantity	Useful lives
Start-up capital items			
Transportation	Vehicles	10	5
Equipment/implements	Spay pumps	55	5
	Trailers	7	6
	Office building	1	40
	Laptop(dell)	3	5
	Desk top (dell)	7	5
	Hp lesser jet1100 printer	4	5
	Canon 300 photo copier	1	5
	LCD epson projector	1	5
	Tripod projector screen	1	5
	Camera(sony)	1	5
	Television	1	5
	Cell phone	5	7
	Fridge	3	5
Office equipment	Flip chart stand (stationary)	3	6
	White board	10	6
	Notice board	8	6
	Steel filing cabinet with 4 drawers	5	6
	Steel upright stationery cabinet	5	6
	Washing machine	2	5
	Drying machine	2	5
Furniture	Manager's style desk	2	7
	Standard desk with PC attaché	11	7
	Conference table(16 seater)	1	7
	Swivel chairs	15	7
	Visitors chairs	41	7
	Display cabinet	4	7

3.7 Implementation activities

The implementation activities included community sensitisation, refresher training for field staff at the end of every spray round. Two refresher training were organised for five (5) field supervisors and the 100 spray men for the period under review. Other recurrent activities included the purchase of stationery, materials and supplies, costs of local travels, repairs and maintenance and utilities (Table 5)

Table 5: Recurrent implementation activities

Item	Quantity
Personnel	
Management	8
Spray men	100
Office staff	12
Materials/Supplies	
Insecticide	
Printing of IEC materials	
Sheets	100
Overalls	330
Leather boots	125
Respirators	110
Visors	110
Hand gloves	110
Hard helmets	125
Aprons(PVC)	110
Sling bags	110
Shirts	33
Neck protectors	110
Training equipment(buckets)	
Fuel	
Miscellaneous	
PPE for senior staff	
Leather boots	15
Overalls	10
Respirators	5
Hand gloves	10
Hard helmets	10
Community sensitization	7
Repairs and maintenance	
Refresher training	2
Utilities	
Electricity	
Water	
Telephone	

3.8 Sampling and sampling method

The study reviewed all available records on the indoor residual spraying programme retrospectively from January-2006 to December-2006. The study purposively interviewed three (3) of the programme managers (such as the programme Director, the Administrative Officer and the Senior Supervisor In-charge of Operations) to capture data and explanation on the costs variables.

3.9 Data Collection Techniques

The data collection techniques used in this study were key informant interviews and programme records review. In conducting the interview with key informants who were part of the IRS programme, an interview guide was used in the gathering of information regarding personnel, materials/supplies, utilities, vehicles, equipment/implements, office building and furniture that were directly applied to the IRS programme for the period under consideration. The retrospective review of administrative, financial, assets and other relevant programme document records from AngloGold Ashanti Malaria Control Programme (AGAMCP) were used as primary data sources. All costs associated with spray operations, management and administration were identified into the cost categories of spray operations, management and administration, personnel and supplies, building space. This activity was undertaken using a cost data collection form.

3.10 Quality Control

To ensure that the quality of the data was not compromised, the study trained four (4) field assistants who assisted in the collection of data.

This study had a challenge in obtaining data on utilities especially on electricity and water, so the utility department of the AngloGold Mining Company was contacted for assistance in obtaining these figures, on the electricity, a temporal meter was mounted on the four phase that supplies the center and five different readings were taken, one in the morning when all gadgets were supposed to be on and in the evening when only security lights were on and on weekends. The average of the three readings were taken and extrapolated for a month, and then a year applying the prevailing tariffs for 2006.

With regards to the water, a temporal flow meter was affixed on the pipe that supplied the center water. The meter readings were taken for three different periods, in the mornings, afternoons and evenings and the average of the readings taken and extrapolated for a month and applying the necessary tariffs.

In addition, the initial cost of the office building could not be assessed thus the building plan was obtained and presented to a professional valuer who estimated prevailing market price of the structure. All recurrent cost activities were identified and put into their various categories such as salaries/wages, materials/supplies, maintenance/repairs, community sensitization and utilities. Then all capital cost items/activities were grouped and categorised as vehicles, office building, equipment/implements, spray equipment and furniture. The study utilised the ingredients approach to costing.

3.11 Data Processing and Analysis

The data was entered, cleaned and coded in a computer. Analysis was done using Excel Microsoft spread sheet, with results presented in the most appropriate tables and figures.

Costs was assessed from the provider perspective by means of the ingredients approach, where by expenditure of all items under the cost categories such as spray operations, management and administration, and labour were identifies and the costs then aggregated (Johns, Baltussen & Hutubessy, 2003). These were then categorized into capital and recurrent costs. Recurrent costs included primarily salaries/wages of staff since all the staff engaged in this programme were on permanent basis s aside the spray men who were on 6-months contract subject to renewal. The expenditure on consumables such as stationery, detergents for cleaning and laundry were estimated by the quantity bought and used between January 2006 and December 2006. Similarly local travels which included monitoring and supervisory visits and inter-regional travels especially to Accra to hold meetings with staff of Ministry of Health or the Ghana Health Service were identified. The local travels were undertaken using programme vehicles or domestic airlines. The capital costs incurred on vehicles, equipment and office space were estimated based on the quantities and unit costs of these items

Costs of IRS were differentiated by whether they were start-up costs or implementation costs. The economic cost of the intervention, including full opportunity cost (such as donations) were assessed from the provider's perspective.

3.11.1 Assumptions in analysis and estimation of expenditure items

In order to identify cost of in-door residual spraying, price list for IRS procedures at the AngloGold Malaria Control Center for the year 2006 was the reference standard (Tables 3&4) for calculation of recurrent and capital costs and for establishing costs to be captured under financial and economic costs. In addition, this study assumed the prevailing inflation rate of 11.7% (Ghana Statistical Service, 2010) and currency

exchange rates of US $ 1.00 to GH 0.92 (Center For Policy Analysis, 2010) have not been varied over the period under consideration (2006).

3.11.2 Estimating recurrent costs

Recurrent items were calculated at their purchase price multiplied by their quantity consumed as at end of 2006. The recurrent cost calculated as the value of all recurrent resources included items such as salaries/wages, materials/supplies among others.These were regular costs incurred by the programme for the daily running and management of IRS. This was determined by summing the cost of personnel, maintenance and repairs, utilities, materials/supplies, community sensitization, local travels and miscellaneous expenses. The study also identified that the programme expended considerable amount of money on consultancy services which was excluded from the labour cost because it is considered a research activity.

3.11.3 Capital costs

Capital costs of the IRS programme were made up of costs of all items that had a life span of more than one year. For this study the capital costs was calculated using two methods a) straight line depreciation and b) annualization method. The items identified as capital items at the Obuasi AngloGold Malaria Control Center in the Obuasi Municipality were classified into transportation (vehicles), equipment, furniture, and building.

3.11.4 Vehicles

The programme procured a total of ten (10) brand new Toyota hilux four wheel drive (4WD) pick-ups for the period under consideration. The vehicles were used to transport spray men and their equipment to the field, for monitoring and supervision as well as other administrative duties**.**

Vehicle cost was determined by obtaining the current market price thus, the unit price and multiplied by the quantity and divided by the annuity factor using a discount rate of 3%.

3.11.5 Building

The office building of the programme was a donation from the AngloGold Mining Company. The cost of the building was estimated by professional valuer at US $ 130,000.00. The cost was then annualised over its life span of forty (40) years at a 3% discount rate.

3.11.6 Furniture

This study identified the following furniture that were being used by the programme for the period under consideration, executive tables-2,standard office tables-11,a 16 seater conference table-1,swivel chairs-15,visitors chairs-41and display cabinets. Then, their current market prices were annualised over their life spans (Table 3) at a 3% discount rate.

3.11.7 Salaries/wages

The programme had a labour force of 122 employees comprising 8 senior staff, 12 junior staff who were permanently employed by the programme and 100 spray men on contract subject to renewal after every 6 months per the assessment of this study.

This included monthly salaries/wages, medical charges, overtime allowances, end of year bonuses, social security among others.

3.11.8 Utilities

There was no mechanism in place to determine the quantities of the utilities (electricity, water telephone) consumed by the programme especially electricity and water. This was because water and electricity were provided free of charge to the programme by the mining company.

The electrical department of the mining company was then contacted for the estimation and the rate that the Government of Ghana supplies the company electricity to offices and homes was used and total amount of electricity consumed was estimated for period of programme implementation in 2006. The cost per structure was calculated as the total amount expended for the period, divided by the total number of structures captured.

3.11.9 Sensitivity analysis

Sensitivity analysis was undertaken on some of the parameters, variables that were susceptible to change in different settings. These included the insecticide used, personnel cost and the population covered or the structures sprayed as well as the discount rates.

3.12 Limitations

The main challenge for this research study was the difficulty in getting information on activities regarding the start-up as well as items and services which did not incur financial cost.

Also, Institutional bureaucracies presented a challenge such as tight chain of command regarding information dissemination and lack of initial operation data in the center.

3.13 Ethical Considerations

Ghana Health service ethical Approval

The study received ethical clearance from the Ghana Health Services Ethical Review Committee of the Research and Development Division of the Ghana Health Services.

Approval from study area

Approval was sought from the management of the AngloGold Malaria Control Programme in Obuasi, Ashanti Region to ensure relevance of the study to the institution.

Review of financial records went with interview with selected managers of the company who were instrumental in the design of the programme and execution using a voluntary consent. Meanwhile, participants were informed of their liberty to participate and withdrawal at any time they may deem unsuitable to continue with the research work.

Potential risk/benefits

The researcher did not foresee any health risks in the conduct of the study. The researcher acknowledges that there was minimum risk imposed by the study to the

institution as the study was involved in reviewing financial records from the AngloGold Malaria Control Programme.

Privacy/Confidentiality

The privacy/confidentiality of information obtained before, during and after the research work were of prior concern to the study. All records reviewed were kept confidential and only used to respond to the objective of the study.

Data Storage and Usage

Data collected were stored using an external hard disk, which was kept by the principal investigator until a stipulated time agreed upon which it should be discarded. All data collected were kept confidential and used only for the purpose for which it was collected.

Conflict of Interest

There was no conflict of interest related to this study but purely for academic award of degree.

Funding sources

This study was partly sponsored by the Institute of Infectious Diseases for Poverty of the Dodowa Health Research Institute and partly by the principal investigator.

CHAPTER FOUR

RESULTS

4.0 Background

In-door residual spraying is an intervention that requires specific materials and supplies to enable the implementation and spraying of dwellings and structures. Materials and supplies used for the IRS activity in Obuasi, included insecticides ,personnel protective clothing (overalls, leather boots, visors, hand gloves, respirators, aprons and hard helmets) for sprayers and as well as office consumables such as stationary and tonners for printing of reports and other official correspondences.

The programme used deltamethrin, a pyrethriod as the insecticide of choice because deltamethrin has an estimated effective active duration of 3-6 months. Also, in terms of toxicity, the World Health Organisation has classified the insecticide under Class ii, which means that deltamathrin is moderately hazardous and it can be fatal if swallowed or fatal if inhaled or fatal if in contact with skin (dermal) United Nations Economic Commission for Europe (2009).

Considering that IRS is intensive and requires trained labour, to conduct the spraying. This study found that, the IRS programme recruited in all 122 personnel. Of this number, 100 were spray men, 4 senior officers comprising the manager who was responsible for planning, organising, and monitoring, the Administrator (superintendent) was in-charge of the day to day running of the programme, the Senior Supervisor In-Charge of operation was responsible for the field staff operations and the Information officer, was responsible for data management including other media relations. The 18 junior officers were of various positions such

as Community liaison officer who served as an interface between the beneficiary communities and the programme center. There were field supervisors for the supervision of the spray men in the execution of their work and the administrative assistant who provided direct assistance to the Administrator of the programme. However, the 100 spray men were contracted for a period of 6 months subject to renewal, whilst the 22 junior and senior staff was permanent employees of the programme. The 100 spray men received training for two weeks on risk management with regard to hazardous chemicals and First Aid, basic book (records) keeping to enable spray men document the number of structures captured per activity.

The training on community entry profile was to improve spray men understanding of individual values and rights, and a means of enhancing rapport between community members and spray men as well as team work. Cost was incurred on all the personnel and training activities.

Overall, a total of 134,000 (96.4%) structures were sprayed of the 139,000 structures in a population of 205,000 in the municipality. Structures represent houses, churches, schools and hospitals. Of these structures sprayed, approximately 27,000 were human dwellings of the 35,000 estimated human dwellings in the programme area representing 77.1% (AngloGold Ashanti, 2007).

4.1 Total cost of the programme

The cost of IRS was undertaken from the perspective of the programme and thus excluded cost incurred directly by the households. The total financial cost of spraying the 134,000 structures for the programme in 2006 was 1,689,090.07. The total

economic cost (1,703,008.52) was higher than the financial cost due to the donated items (Table 6).

Table 6: Financial and Economic cost

Item Description	Financial cost			Economic cost		
	US$	GH₵	%	US$	GH₵	%
Transportation(vehicles)	67,808.33	62,383.66	4.0	74,037.87	68,114.84	4.4
Building(Donation)		0.00	0.0	5,624.00	5,174.08	0.3
Equipment/Implements	3,471.26	3,193.56	0.2	3,905.05	3,592.65	0.2
Furniture	2,741.83	2,522.48	0.2	3,080.56	2,834.12	0.2
Spray equipment	9,171.74	8,438.00	0.5	9,852.88	9,064.65	0.6
Laundry equipment	516.46	475.14	0.0	1,127.71	1,037.49	0.1
Training	23,500.00	21,620.00	1.4	23,500.00	21,620.00	1.4
Salaries/Wages	768,635.96	707,145.08	45.5	768,635.96	707,145.08	45.1
Insecticides	501,400.00	461,288.00	29.7	501,400.00	461,288.00	29.4
Materials/supplies	259,756.90	238,976.35	15.4	259,756.90	238,976.35	15.3
Repairs and maintenance	1,980.00	1,821.60	0.1	1,980.00	1,821.60	0.1
Community sensitization	14,933.68	13,738.99	0.9	14,933.68	13,738.99	0.9
Local travels	7,200.00	6,624.00	0.4	7,200.00	6,624.00	0.4
Utilities	27,973.91	25,736.00	1.7	27,973.91	25,736.00	1.6
Total	**1,689,090.07**	**1,553,962.86**	**100.0**	**1,703,008.52**	**1,566,767.84**	**100.0**

Of this total salaries and wages US $ 768,635.96 (GH₵ 707,145.08) represented 45.1% of the total financial and US $ 768,635.96 (GH₵ 707,145.08) 45.5% of the total economic cost. Materials and supplies constituted the second huge costs in an IRS programme and represented US $ 761,156.90 (GH₵700, 264.35) (44.7%) of financial costs and US $ 761,156.90 (GH₵ 700,264.35) 45.5% of economic costs.

4.2 Major cost drivers of IRS programme

The study established that the main cost drivers in the IRS programme was the recurrent costs in salaries/wages of personnel and materials/supplies in the form of insecticide, spraying equipment and protective gadgets.

The total amount expended by the programme on salaries and wages was US$ 768,635.96 (GH₵ 707,145.08). This included monthly salaries and wages, medical charges, overtime allowances, end of year bonuses, social security among others. In terms of gross salaries/wages the study established that the average monthly salaries/wages paid by the programme per worker was US$ 4,693.33 (GH₵ 4,317.86) with the maximum being US $6,500.00 (GH₵ 5,980.00) to office staff and about US$ 250.00 (GH₵ 230.00) for the sprayers. Of the items on recurrent cost, insecticide was the key cost driver and cost as much as US$ 501,400.00 (GH₵ 461,288.00). Consumables on the programme cost the lowest US$ 4,000.00 (GH₵ 3,680.00). The costs of vehicle use and wear of 10 brand new Toyota pick-ups purchased that was allocated to the IRS programme was US$ 74,037.87 (GH₵ 68,114.84) for 2006.

4.3 Total Cost of Intervention

The study has shown that, the total cost of the intervention (IRS) in terms of capital and recurrent costs varied. The total economic cost of capital items was the lowest US$ 121,128.07 (GH₵ 111,437.82) (7.1%) expenditure compared to the recurrent costs US$ 1,581,800.45 (GH₵ 1,455,256.41) (92.9%). Similarly, the financial cost of capital items was also US$ 107,209.62 (GH₵ 98,632.85) (6.3%) in comparison to recurrent costs US$ 1,581,880.45 (GH₵1, 455,256.41) (93.7%) (Table 7), IRS programme implementation is thus heavily dependent on recurrent costs.

Table 7: Total Capital and Recurrent IRS programme costs

Items	Financial Cost			Economic Cost		
	US$	Ghana cedi (GH₵)	%	US$	Ghana cedi (GH₵)	%
Capital	107,209.62	9,8632.85	**6.3**	121,128.07	111,437.82	**7.1**
Recurrent	1,581,880.45	1,455,330.01	**93.7**	1,581,880.45	1,455,329.66	**92.9**
Total	**1,689,090.07**	**1,553,962.86**	**100**	**1,703,008.52**	**1,566,767.84**	**100**

4.4 Cost per structure sprayed

The cost of a human dwelling sprayed was US$ 63.07 (GH₵ 58.02) as financial cost and US$ 62.56 (GH₵ 57.56) as the economic cost and for a structure, the average cost was US$ 12.61 (GH₵ 11.60) financial cost and US$ 12.51 (GH.₵11.51) as the economic cost. It also emerged from the study that, the average household size in the municipality was five (5). Thus, the cost per person protected for one year in terms of financial cost was US$ 2.52(GH₵ 2.32) and US$ 2.50 (GH₵2.30) as the economic cost using the cost of spraying a structure.

4.5 Health Care Utilization on Malaria after IRS Implementation

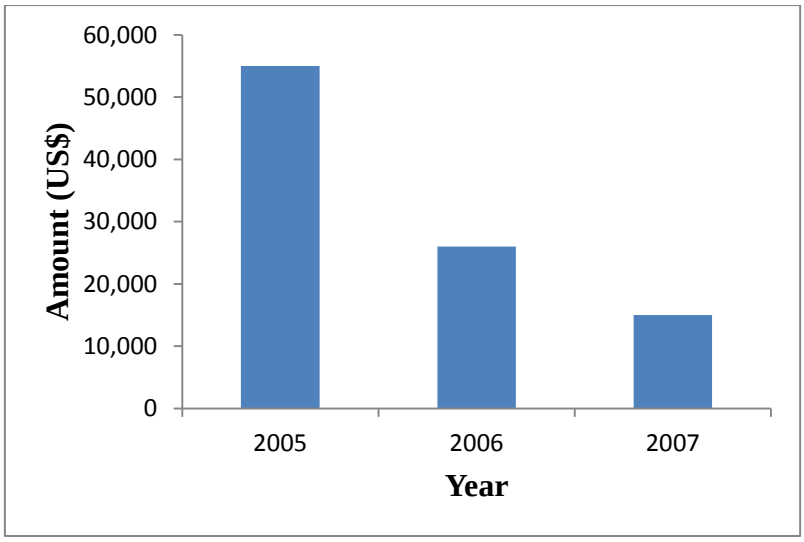
Prior to the introduction of the IRS intervention in 2006 in Obuasi, the Edwin Cade Hospital, the main hospital providing health care services to staff of Anglogold Ashanti Mining Company reported 79,237 malaria cases in 2005.With the implementation of the IRS programme in 2006, the number of malaria cases dropped to 53,070 and to 20,976 malaria cases in 2007 (Table 8).

Table 8: Malaria cases from 2005-2007

Year	Number of cases	Incidence rate
2005	79,237	238
2006	53,070	164
2007	20,976	69

In 2005, an amount of US$55,000.00 (GH₵ 50, 6000.00) per month was expended on the procurement of medication for the treatment of the 79,237 malaria cases, thus the average cost of treatment in terms of medication for an employee or their dependents was US$ 8.09 (GH₵7.44). This however, reduced drastically in the year 2006 when the IRS programme was introduced to US$ 26,000 (GH₵ 23,920) per month. In the second year of implementation of the programme in 2007, the total medication cost per month on malaria was US$ 15,000.00 (GH₵ 13,800.00). This can be seen from Figure 2. This is consistent with the reduction of malaria cases and incidence shown in 2005, 2006 and 2007. This gives a saving of US$ 40,000.00 on malaria medication per month in two years of the IRS intervention.

Figure 2: Expenditure on malaria treatment per month at Edwin Cade Hospital: 2005-2007



4.6 Productivity losses

This study found out through the Country Report Ghana Obuasi (AngloGold Ashanti, 2007) that, the Malaria Lost Time Injury Frequency Rate (MLTIFR) was 1,016.00 in 2005,634.74 in 2006 and 229.83 in 2007-a 77% decrease in three years.

These statistics demonstrate the success of the malaria control programme, which was introduced at Obuasi in January 2006.MLTIFR, expressed as the number of cases (incidents) due to malaria for every million hours worked, allows the rate to be compared with the conventional LTIFR and clearly demonstrates the negative impact malaria has on productivity and health in the workforce. Malaria incidence rates are expressed as a percentage (%) of employees affected by malaria in a given period (Country report Ghana, Obuasi 2007).

4.7 Sensitivity analysis

Table 11 illustrates the findings of this study in certain key parameters such as personnel (salaries), insecticides, discount rates, and coverage (population covered) in terms of structures**.** There was a 9.35% change in the financial cost when 15 spray men were assumed to have been used instead of the 100 initially stated with the economic cost rising by 9.12%. When the unit price of insecticide was changed from US$10.9 (GH₵ 10.03) to US$15 ((GH₵ 13.8), the financial cost appreciated by 9.77% and 9.54% for the economic cost**.**

However, this study established that the discount rate applied did not have any effect on the financial cost of the programme but the economic cost marginally by 0.4% when the discount rate was changed from 3% -5%. The study also found out that the cost per structure was directly proportional to the number of structures captured. Thus

the cost and cost effectiveness of the IRS programme was directly dependent on the coverage of the programme

Table 9: Sensitivity Analysis

Parameter	**Values assumed**	**change in Financial cost**	**change in Economic Cost**
Personnel	150 spray men	9.35 %	9.12%
Insecticide	US $15	9.77 %	9.54%
Discount rate	5%	0	0.4 %
Coverage	140,000 structures	US $12.06	US $12.16

CHAPTER FIVE

DISCUSSION

The objective of this study was to estimate the financial and economic costs of the IRS programme of the AngloGold Ashanti in the Obuasi municipality to inform resource allocation by both government and non-governmental organizations in malaria control programmes and to highlight the unit costs per household protected and work productivity gains due to the implementation of the IRS programme.

In this study the IRS programme costs a total of US$ 1,689,090.07 (GH₵ 1,553,962.86) in financial terms and US$ 1,703,008.52 (GH₵ 1,566,767.48) economic costs for the spraying of 134,000 structures for 2006. The results of this study showed that with a household size of five (5) in the municipality, the cost of person protected for one year using two rounds of spraying in terms of financial cost was US $2.51 (GH₵ 2.31) and US $ 2.54 (GH₵ 2.34) for economic cost. The average costs is US$2.5 per person protected when all structures are sprayed and US$12.5 when only human dwellings are sprayed. These findings are similar to that of White et al, (2011) who found that the median financial cost per person protected by IRS was US$3.91 ranging from US$1.11-US$12.87 whilst the median economic cost was US$3.41 ranging from US$1.14-$6.23. The median standardized cost of a year's protection with IRS was US$6.70 ranging from US$2.22-$12.85.

Furthermore, this study revealed that the main driving forces behind the cost of delivering indoor residual spraying are three folds; the population covered (regarding structures), the personnel and the insecticide used. Salaries and wages accounted for 45.5% of the financial cost and 45.1% of the economic cost whilst the costs attributed to insecticide cost was 65.9% of the entire material and supplies cost. This is in

conformity with results from White et al, (2011) who documented that several different insecticide formulations were used which include DDT and the pyrethroids, deltamethrin and lambdacyhalothrin. The mean proportion of the cost attributable to the cost of insecticide was 49% (range 29%-81%), and the mean proportion attributable to personnel and training was 34% (range 4%-48%), White et al, (2011).

Comparing the unit costs of IRS to ITNs, this study estimated that the cost per person protected for one year using two rounds of spraying in terms of financial cost was US$ 2.51 (GH₵ 2.31) and US$ 2.54 (GH₵ 2.34) for economic cost which was considerable lower than that of ITN as demonstrated in White et al (2011) where the median financial cost per ITN distributed (in the first year) was US$7.03 ranging from US$2.97-$19.20 whilst the median economic cost (across the expected lifetime of the net) was US$4.15 ranging from US$2.97-$10.05. The median standardized financial cost for a year's protection with ITNs was US$2.20 ranging from US$0.88-US$9.54 as compared to and the economic costs (US$2.54) per person protected by IRSs which higher than the results of this study.

Cost of IRS is lower in this study than the cost of ITN distributed. However the average cost (US$12.5) per individual protected when dwellings are sprayed in this study was higher than the average financial unit cost of ITN (US$7.03) in the first year as reported by White et al (2011) but within the range of (US$2.97-$19.20) reported in these same studies.

A number of individual studies have been carried out comparing the cost and/or effectiveness of IRS with ITNs, but the results have been inconclusive (Conteh et al., 2004). Some studies have shown the cost per person covered per year to be less with IRS (Guinness et al., 1997; Verle et al., 1999; Goodman et al., 2001; Guyatt et al,

.2002a). In a study by Kolaczinski & Hanson (2006), they quoted variations in the cost of mosquito nets which ranged from US$ 3.00 in China to US $ 72.00 in rural Cameroun. Also, the cost per net delivered ranged from US$0.58 (GH₵ 0.53) for a public sector programme in northern Vietnam to US$ 6.87 (GH₵ 6.32) for a social marketing programme in four areas in Tanzania making ITNs less preferable to IRS.

Also, in another study by Guyatt et al. (2002) in Kenya, the study demonstrated that IRS is still more cost-effective than ITNs (US$ 3.42) in the financial cost US$ 0.86 per person protected as well as in economic costs were ITN per person protected was US$ 2.34 while the economic cost per person protected was US$ 0.88 for IRS. Similarly, the financial cost per person protected in the first year of operation was US $ 0.86 for one round of IRS and US$ 4.21 for an ITN in Gucha, indicating that the ITN project in Gucha was five times more expensive than IRS per person protected, thus all lending credence to the findings of this study.

IRS also appear cheaper compared to programmes like IPT in children but can be considered a less viable option when it comes to IPTi and IPTp in terms of cost. Again, these are target specific interventions geared at certain groups in society unlike this study which covers every person sleeping in a sprayed room. The median financial cost of protection was US$0.10 (range US$0.08-$0.18) for IPT in infants, $4.03 (range $1.25-$11.80) for IPT in children, and US$2.06 (range US$0.47-$3.36) for IPT in pregnant women whilst the median economic cost of a year's protection was US$0.60 (range US$0.48-US$1.08) for IPTi, US$4.03 (range US$1.25-$11.80) for IPTc, and US$2.06 (range US$0.47-US$3.36) for IPTp. These are more costly than the findings in this study.

In case management of malaria, the median financial cost of treating an episode of uncomplicated malaria (either as hospital outpatients or at health centres) was US$5.84 (range US$2.36-US$23.65), and the median economic cost was US$22.48 (range US$9.14-US$37.99) as being supported by this study which found out that the average cost incurred in terms of medication alone was US$ 8.09 (GH₵ 7.44) at the Edwin Cade Hospital, Obuasi.

Comparing all the malaria control interventions, aside IPTi and IPTp, the indoor residual spraying is still the most economically and practically feasible intervention if the fight against malaria is to succeed.

The effectiveness of most indoor residual spraying activities also depends on community collaboration (Konradsen et al., 1999). An intervention is much more likely to be sustainable if the community identifies with the initiative and feels that it is benefitting from its involvement and seeing results. This was found as a useful strategy to the success of the AngloGold Malaria programme although there were a few noncompliance issues reported. This is not unique to this intervention as long-standing programmes have reported compliance to IRS problems (Newberry & Jansen 1986; Mnzana et al., 1998; Attanayake et al., 2000). Certain programmes in South Africa (with over 50 year's history) have effectively dealt with these through social science surveys and community involvement (Sharp & le Seueur 1996) in which the study found out that the main reasons for noncompliance are plastering of cracks in permanent house structure that needs or requires frequent re-plastering, social events such as weddings and people coming home for leave, the presence and smell of DDT deposit on walls, which may lead to social resistance and the long-term use of DDT leading to resistance in domestic pests such as bedbugs.

The Obuasi malaria control programme aims among other things to reduce the incidence of malaria by 50%; reduce absenteeism due to malaria by 50-60% and reduce deaths due to malaria among its workforce and the population of the municipality by targeting to spray 70,000 structures within the municipality in 2006. This study shows that the programme sprayed 134,000 of the 139,000 structures in the municipality representing 94.4% and far exceeding the 70,000 coverage target (Country Report Ghana, Obuasi, 2007).

The Malaria Lost Time Injury Frequency Rate (MLTIFR) for the company workers was 1,016.00 days in 2005, before the implementation of the IRS. This study shows that implementation in 2006 reduced the MLTIFR to 634.74 in 2006 and 229.83 in 2007, recording a 77% decrease in three years (Country Report Ghana Obuasi 2007). With many work days gained the huge financial expenditure on malaria medication per month would be channelled into other productive areas of the company.

Productivity gains however, did not increase correspondingly due to other micro economic issues such as energy in the form of electricity and the shutting down of some shafts for maintenance during the period of study (Country Report Ghana, Obuasi, 2006).

The decrease in the number of malaria cases reporting at the Edwin Cade Hospital shows IRS effectiveness as reported in other studies such as Guyatt (2002) where the study demonstrated that IRS activities in Gucha in 2000 reduced the risk of malaria infection by 75%, a higher protective efficacy than ITNs (63%).This is corroborated by the AngloGold Malaria Control Programme as it was able to reduce malaria cases in the municipality by 50% from 2005 to 2006 and 73% by 2007,resulting in a savings

of 47.3% of medication costs per month alone at the Edwin Cade Hospital (AngloGold Ashanti, 2006).

However, one of the key drawbacks of cost studies is that they are often not undertaken alongside an evaluation of the clinical and epidemiological effects of the intervention under investigation which was the case in this study where only the costs were calculated irrespective of the transmission season. Implying it will cost the same to spray an area of high transmission as an area of low transmission (White et al 2011).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

This study has shown that the financial cost of IRS programme in Obuasi was US$ 1,689,090.07 (GH₵ 1,553,962.86) and the total estimated economic cost was US$ 1,703,008.52 (GH₵ 1,566,767.84).The average financial cost per structured sprayed was US$ 12.51 (GH₵ 11.69) and average cost per person protected is US$ 2.61 (GH ₵ 2.40).The IRS programme has substantially reduced the proportion of malaria cases reporting at the health facility by 50% and has reduced average costs of malaria medication by US$ 5.48 (GH₵ 5.04) per person protected, which is over 40% savings on only medication. Insecticide for IRS constituted over 65% of the material and supply costs standing as the main costs of an IRS programme.

From these findings, it can be concluded that financial and political commitment to IRS programmes would show substantive reductions in malaria cases seen at health facilities, lead to cost savings and increase productivity in workforce.

6.2 Recommendations

The recommendations made from this study are as follows:

- Central government should consider waiving import duties on insecticide to contribute to the reduction of the cost per structure sprayed. All Metropolitan, Municipal and District assemblies should commit more resources into implementing indoor residual spraying intervention since that would be cheaper but cost-effective intervention geared at attaining the Millennium Development Goals (MDGs) 4 and 6.

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APPENDICES

Appendix 1: Informed Consent

Informed consent for the study entitled Cost of indoor residual spraying in the Obuasi Municipality.

I am a postgraduate student from the school of public health, University of Ghana. Together with my assistants, are carrying out a study in this district to estimate the cost of IRS .We would be very glad if you could kindly read this consent or let someone read it to you so that you can decide taking part in the research study or not.

Your response and cooperation would help formulate an advocacy tool and recommendations to the appropriate authorities to put in more measures to reduce the malaria burden in the country.

The discomfort, if any that you would face by accepting to take part in this study perhaps is your time. If you decide to take part, you are allowed to withdraw whenever you wish like doing so, and you are also permitted to skip answering any of the questions that you are not comfortable with.

However, the information you would provide is going to be identified by a special code number and would be treated as confidential. Apart from the research team and members of the ethics committee of the Ghana Health Service, nobody shall have access to the information since it shall be under lock and key. We assure you that your name shall not appear or be mentioned in any report that might come out from this research work.

In an event of any questions, inquiries or queries, the following persons can be contacted,

a) Tang N Felix, School of Public Health, University of Ghana, Legon. 0247804518 (Student).
b) Dr.Patricia Akweongo, School of Public Health, University of Ghana, Legon.0243138376 (Supervisor).

Participant's Consent

I have read or I have made somebody read or translated all the necessary information that I need to know concerning this study and have fully understood it. I have decided on my own volition without any coercion to take part in this study.

However, by deciding to participate in this study, am not in the least waiving any of my fundamental rights by signing or thumb printing this consent form.

…….

Signature or Left/Right Thumb Print

Appendix 2: Key Informants Interview Guide for Cost of Indoor Residual Spraying Programme in the Obuasi Municipality.

Please you have been selected as a key informant in this study for your contribution in the estimation of the cost of indoor residual spraying programme

Name of key informant	
Designation	
Name of interviewer	
Date	

.

1. Can you tell me the names of all salaried employees who were working in this programme in 2007, their job titles, whether they have been trained in IRS provision and their tasks? (A.1a)
2. Can you tell me the number of planning logistics assessment meetings held, number of participants and their designations? (A.1b)
3. How many community mobilizations were held, and the cost associated with transport and refreshment of the participants? (A.1b)
4. Were community volunteers involved in the spray operations? If yes, how many? (A.1b)
5. Did they receive any money in terms of payment? How much? (A.1c)
6. Could you please tell me if any of the staff listed received free uniforms and other personal protective equipment? (A.1d)
7. What are your supplies stock levels as to the following items (A.2)
8. Can you please furnish me with information regarding media operation on the following? (A.3)
9. Can you tell me what means of transport are available to the programme and their categories and types? (A.4)
10. Did you keep any logbooks for registering their use? (A.4)
11. Do you have any records on equipment/maintenance (recurrent) on the programme? (A.5)
12. Will you be kind enough furnish me with information on utilities? (A.6)
13. Can I please, have information on the following items such as rental buildings, per Diems and miscellaneous? (A.7)
14. Can you please tell me whether programme offices are operating from a self-owned structure (building) or a rented structure? (B.1)

15. Can you tell me what means of transport are available to the programme and their categories and types? (B.2)
16. Can you provide me with the information as to the following capital equipment (B.3)
17. Can you indicate to me whether the following are functioning equipment/furniture in their allocated rooms? (B.4)
18. Can you please indicate to me as to the availability of the following services;
    - ✓ Does this programme provide any laboratory investigations? If yes, indicate the tests done?
    - ✓ Can you please tell me the waste management protocol of the programme?

Appendix 3: Questionnaire

A. 1a: Personnel

Staff No	Personnel name	Job title	How many months did he/she work in 2006	FTE 1=Full time (%)=Part time *	How many hours does he/she usually work each week? (hours)	Trained in IRS 1= Yes 2= No 9= Doesn't know
1. Manager(1)						
2. Manager(2)						
3. Manager(3)						
4. Supervisor(1)						
5. Supervisor(2)						
6. Supervisor(3)						
7. Supervisor(4)						
8. Spray operators						
9. Cleaners						
10. Drivers						
11. Security						
12. Other specify						

A .1b: Personnel Time Allocation

Staff No	**GRADE**	**FTE Full time (%)=Part time.**	**Monthly gross salary**	**Allowance**	**Total**

A .1c: Record Reviewof Programme Start-Up.

Capital cost	**Source of information**	**Quantity /Number**	**Unit Price**	**Total Amount**
Planning and logistic assessment				
Meeting with environmental protection agency.				
Community mobilization meetings (media operating cost)				
Training of personnel				
Recurrent cost				
Flip charts				
Projector				
Refreshment				
Pens				
Note pads				
Files				
Perdiem				

A .1d: Uniform (Personnel Protective Equipment)

Items	**How often does he/she get new ones (times per year)**	**How many do they get each time?**	**How much would she/he pay *if you had to buy one* (Local Currency))**
Protective gloves			
Goggles			
Wellington boots			
Helmets			
Face mask			
Overall, jackets			
Visors			
Others (specify).			

A .2: Recurrent supplies/Implements

No.	**Name of Supply**	**Total amount/qty received**	**Unit price**	**Total amount**	**Source of information**	**Number of months covered**
1.						
2.						
15.						

A.3: Media Operating Cost (Recurrent)

No.	Activity	Source of information	Number	Duration (minutes/hours)	Unit Cost (GH₵)	Total Cost (GH₵)
1						
2						
3						
4						

No	Item	Quantity	Unit of measurement (e.g. Liters, Watts)	Total Expenditure In 2006 (Local Currency)	Number of Months covered
A .4	**Means of transport**				
	Lubricant				
	Maintenance				
	Repairs				
	Insurance				
	Tire spare parts				
	Others (specify)				
A .5	**Equipment/Maintenance (Recurrent)**				
	Maintenance				
	Repairs				
	Other (specify)				
A .6	**Utilities**				
	Electricity bills				
	Telephone				
	Water				
	Gas (for lamps)				
	Kerosene (for lamps)				
	Cleaning				
	Total *(If available)*				
A .7	**Others**				
	Rental buildings				
	Per diem & travel allowances				
	Miscellaneous				
	Total *(If available)*				

B .1a: Capital cost (building)

Request type	**Source of information**	**Quantity/Number**	**Rental Unit price**	**Total**
Ware house/houses				
Programme office				
Training room				
Other (specify				

B .2: Records on Transport

No	**Type of mean of transport**	**Was it functioning?** 1=Yes, 2=No	**What was it used for?**	**Total km Travelled from sept.2006-Apr. 2007.**	**Total fuel Consumed**	**Total fuel costs** (Local
1.	Motorbike		Spray teams supervision			
2.	Four wheel		Transport for insecticides and other logistics			
3.	Bicycle		Administrative			
4.	Truck		Other (specify)			

B.3: Capital equipment

No	**Name of Equipment**	**Source of information**	**Total quantity received**	**Unit price**	**Total**
1	Generator set				
2	Refrigerator				
3	Vehicle				
4	Others(specify)				

B.4: Functioning Equipment and furniture

No	Name of Equipment / furniture	Quantity of functioning items													
		Rooms													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Computers desktop														
2	Computers laptop														
3	Refrigerator														
4.	Printers														
5.	Office cabinets														
6.	Writing deck														
7.	Photocopiers														
8.	Bookshelves														
9.	Projector														
10.	Camera														

C.1: Cost Categories in Programme Cost Sheet

A. RECURRENT COST	
Personnel	Personnel salaries/wages were determined for 8 senior staff, 12 junior staff all permanently employed by the programme as well as 100 contracted spray men. The total amount expended by the programme on salaries/wages was US $ 768,635.96.This includes monthly salaries/wages, medical charges, overtime allowances, end of year bonuses, social security among othersThese
Materials & Supplies	This section included insecticides, stationery, personnel protective equipment (such as overalls, leather boots aprons hand gloves, neck protectors), printing of IEC materials and sheets for covering furniture.
Media operating costs	These were activities that were geared towards creating the necessary public awareness to the programme and included radio advertisements, local jingles, advertisements in the print media (newspapers and journals) radio interviews with programme managers, public and community fora.
Transport operating costs	Activities such as routine servicing of vehicles and other minor repair activities as mending of punctures' constituted this section.These were solely IRS programme vehicles
Maintenance/repairs	Minor works undertaken on the office structure such as changing fluorescent tubes, servicing of air-conditioners and computers for the programme office. The cost was obtained per numbers from the financial records.
Utilities	The programme shared no overhead cost with other programmes and thus, the total amounts of utility items were directly allocated to the programme. Utilities used were electricity, telephone and water.
B. CAPITAL COST	
Building	The programme operated from its own office complex donated by the mining company. Its initial operations were centralized with the workers transported to the field and back to thecenter. Cost of the structure was obtained after it was revalued.
Transport	In terms of vehicles, the programme procured ten (10) brand new Toyota four wheel drive pick-ups for its operations. The cost was obtained by annualizing the current market price over the useful life of five (5) years using a discount rate of 3%.
Equipment and implements	The study considered this as spray pumps, office equipment such as computers, printers, photocopiers among others as well as other implements such as trailers. The respective costs were obtained through annualisation of the prevailing market prices over their various useful lives, using a discount rate of 3%.
Furniture	All the furniture used in the programme were identified by this study and their current market values annualized over a useful live using a discount rate of 3%.

C. 2: Capital items identified

Item description	Quantity	Unit cost $
Toyota Hilux Pick-up	10	33,700.00
Trailers	7	350
Hudson Xpert pump	55	344.95
Hard Helmet	125	4.67
Pump-Lances	20	20.00
Office Building	1	130,000.00
Laptop(dell)	3	750.00
Desk top dell	7	885.42
Hp lesser jet 1100 printer color	2	739.58
Hp lesser jet 1100 printer black &white	2	364.58
Canon 300 photo copier	1	1,171.88
LCD epson projector	1	1,302.08
Tripod projector screen(200cm*200cm)	1	364.58
Camera(Sony)	1	182.29
Television	1	161.41
Cell phone	5	91.15
Fridge	3	218.23
Flip Chart Board(Stand)	3	250.00
White Board (2.4x1.2)	4	78.13
White Board (1.8x1.2)	4	39.06
White Board (1.2x0.9)	2	36.46
Notice Board (1.5x1.0)	2	23.44
Notice Board (1.2x0.9)	4	20.83
Notice Board (0.9x0.6)	2	15.63
Steel Filing Cabinet With 4 Drawers	5	182.29
Steel Upright Stationery Cabinet	5	250.00
Washing Machine	2	1,405.73
Drying Machine	2	1,176.56
Furniture: Manager's style desk	1	1,302.08
Superintendent style desk	1	1,145.83
Standard desks with PC attaché	11	494.79
Conference table(16 seater)	1	1,822.92
Office chairs compatible with desk	15	234.38
Visitors chair	25	130.21
Display cabinet compatible with desk front glass	4	156.25
Chairs for conference table	16	130.21