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DEVS8SSH1: DEVELOPMENT STUDIES

MASTERS COURSEWORK DISSERTATION

Estimates of the financial costs of Goodbye Malaria's (GBM) indoor residual spraying (IRS) operations to reduce the malaria incidence in the districts of Boane, Magude, Marracuene and Xinavane in Mozambique from 2013 – 2016

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Declaration

I, Liezl Knoll, declare that this dissertation is my original work and that all information borrowed from other authors and sources is duly acknowledged. This is for the purpose of fulfilling the requirements of the degree, Master of Development Studies, in the School of the Built Environment and Development, located within the College of Humanities, University of KwaZulu-Natal, Howard College.

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Abstract

This Study seeks to identify and analyse the financial unit costs related to two Indoor Residual Spraying (IRS) programmes run in Mozambique, one in a peri-urban area and the other in a rural area. By undertaking a detailed analysis of the financial costs of both programmes, this Study demonstrates the direct influence of the context in which an intervention is delivered on its costs, as well as the role and impact of donors and subsidised or sponsored inputs on a programme's costing and sustainability. It aims to provide decision-makers with insight into the potential costs of an IRS investment, particularly when resources are limited, and decisions need to be made around whether to initiate a new programme.

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List of Acronyms

CBA	Cost-benefit Analysis
CE	Cost Effectiveness
CEA	Cost-effectiveness Analysis
GDP	Gross Domestic Product
IEC	Information, Education and Communication
IRS	Indoor Residual Spraying
ITN	Insecticide-treated Net
LLIN	Long-lasting Insecticidal Net
LSDI	Lubombo Spatial Development Initiative
NMCP	National Malaria Control Program
PMI	Presidents Malaria Initiative
TB	Tuberculosis
WEF	World Economic Forum
WHO	World Health Organisation

Chapter 1: Introduction

1.1 Background

Referred to as the 'King of Diseases' in the Vedic scriptures of India, ancient writings dating as far back as 4000 BC give testament to malaria's long reign (Kakkilaya, 2015). No disease throughout human history has had as profound an impact on human development as malaria, with hundreds of millions of people having died from the disease over the millennia (Arrow et al, 2004). Malaria, endemic to 91 countries globally, remains a life-threatening disease despite being both preventable and treatable (WHO, 2018). Although fifty percent of the world faces the threat of contracting malaria, Africa carries the heaviest burden of the disease (Rees, 2018).

In 2017, the World Health Organisation (WHO) reported a staggering 92% of the 219 million malaria cases diagnosed worldwide, and 93% of the 435 000 malaria related deaths, had occurred in Africa (WHO, 2018). In 2018, Sub-Saharan Africa (SSA) was home to almost 80% of malaria cases globally, across just 17 countries in the region (WHO, 2018). Global health initiatives, including Roll Back Malaria and The Global Fund to fight AIDS, Tuberculosis and Malaria, have been pivotal in raising much-needed funds to fight the disease, particularly in Africa, by partnering with governments on malaria control programmes (Rees, 2018).

The result of these efforts has been a substantial decrease in the malaria mortality rate in Africa, with the number of deaths almost halving since 2000 (WHO, 2018 & Rees, 2018). However, despite an increase in funds to US$3.1 billion per year to fight malaria globally, it is less than half of what is required to maintain advances made against preventing and eliminating the disease in recent years (WHO, 2018 & Rees, 2018). Compounding the challenge of sustained funding, is the issue of malaria control being exceptionally fragile. A reappearance of malaria can arise during a single infectious season if control measures and activities are abandoned (Schermbrucker, 2020 & Rees, 2018). Given the recent plateau in financial support by development partners for health-related programmes such as malaria prevention and elimination, due to funds being channelled toward other global imperatives, African governments find themselves having to play a more significant and creative role in raising the funds required to safeguard ongoing malaria control programmes (Shretta et al, 2017 & Rees, 2018). In order to eradicate malaria in Africa, a deeper understanding of the costs, coupled with innovative financing and technology, is required in order to lend already overstretched African governments the capacity needed to combat malaria on the continent.

What is Malaria?

Malaria in Africa, is spread through the female Anopheles mosquito (commonly called the “night-biting" mosquito as it feeds between sunset and sunrise) which is infected with one of numerous plasmodium parasites (Goodbye Malaria, 2019). The transmission of malaria is dependent on climatic conditions, with tropical areas being an ideal environment for the Anopheles mosquito, particularly after seasonal rains (Centres for Disease Control and Prevention, n.d.). Symptoms of infection include severe fever, chills and a headache. Malaria can rapidly become deadly when blood supply to vital organs is impaired (Centres for Disease Control and Prevention, n.d.)

How is malaria controlled and eliminated?

Currently there are two types of effective malaria vector control recommended and promoted by the WHO which reduce and prevent malaria transmission. These include Insecticide-Treated mosquito Nets (ITNs) and Indoor Residual Spraying (IRS) of insecticides. Insecticide resistance has to be closely monitored by national malaria control efforts; however, areas with high levels of ITNs and IRS are recognised as providing an important measure of protection against malaria (WHO, 2018).

Long-lasting Insecticidal Nets (LLINs) are used as protection from mosquitos while a person sleeps. They are typically provided by public health programmes and are provided, typically at no cost, to all people at risk in malaria areas (WHO, 2019). IRS is a more complex and labour-intensive process of malaria control as it comprises spraying the interior walls of inhabited structures, by a trained spray person, with a WHO approved insecticide (Africa Airs, n.d.). While it is a potent method of effectively and rapidly decreasing the spread of malaria, a minimum of 80% of houses within a specific area must be treated for it to yield a positive outcome. Furthermore, the wall treatment only lasts between three to six months, subject to the type of insecticide utilised, and the nature of wall covering that is sprayed (WHO, 2006). Often more than one spray round is required to protect a community for the entire malaria season (WHO, 2006).

Ultimately, the eradication of malaria requires the continuous implementation of control measures to prevent the transmission cycle from recurring. According to the WHO, “malaria eradication is the permanent reduction to zero of the worldwide incidence of malaria infection caused by human malaria parasites as a result of deliberate activities” (WHO, 2019). Only once eradication has been achieved, interventions can be discontinued.

The impact of malaria from an economic perspective

Malaria has serious implications for the economic growth and development of countries, particularly in Africa where high infection rates affect the poor the most, and the cycle of poverty is perpetuated (UNICEF, 2019). It is estimated that in Africa monthly household expenditure on malaria treatment is between $2 and $25, and prevention between $15 and $20 (Oluyole et al, 2011).

Research undertaken to explore the burden of malaria on households in Mozambique found direct household expenditure averaged $6.50, with 32-34% of households incurring disastrous costs for malaria incidences (Castillo-Riquelme et al, 2008). Considering that 95% of the 828 households surveyed survived on less than $1 a day at the time, this represents a significant drain on already low-income levels, diverting household funds from going towards other basic necessities, such as food and education.

Furthermore, socio-economic costs are compounded by low productivity, as a person suffering from the disease is usually unable to work for several weeks, resulting in further loss of income (Onwujekwe et al, 2013). This also has implications for companies operating in malaria prevalent environments in terms of employee absenteeism and decreases in business productivity. According to the World Economic Forum, malaria comes at a cost of $12 billion per year to Africa’s economy, with the Gross Domestic Product of malaria affected developing countries reduced by between five to six percent because of the disease (Gallup et al, 2001 & World Economic Forum, 2006). It has been argued “a net present value of benefits over costs of US$208.6 billion” could be realised by 2035 through adequate investment into worldwide malaria control initiatives (Purdy et al, 2013).

The benefits of malaria prevention therefore include:

A) Returns in economic development, productivity and growth

In economic terms, the prevention of malaria has a positive impact on several areas of an economy, including foreign direct investment, travel and tourism and agricultural production (Malaria Free Future, n.d.) The dire knock-on effect of malaria is evident when it comes to agricultural production, particularly in low-income countries and communities where the poor are the most vulnerable. Small-scale farmers afflicted with malaria cannot work their fields regularly, leading to a decrease in productivity, which negatively affects the harvesting cycle and ultimately leads to poor nutrition and an increase in food insecurity (Swiss Malaria Group, 2018). Furthermore, malaria has been found to negatively impact on the output of women who are responsible for 70% - 80% of food crop production in Africa (Kuecken et al, 2015). A study of 516 rural farmers in Zambia, who were given insecticide treated bed nets to use and were monitored over the period of one year, increased the value of their harvest by 14.7% (Fink & Masiye, 2015).

Malaria prevention and elimination is therefore fundamental in increasing human capital and the productivity of factors of production such as land, specifically in improving the income of small-scale farmers and food security, while reducing malnutrition and the vulnerability of the rural poor (particularly women) in low-income, high burden countries (Swiss Malaria Group, 2018). Companies benefit from malaria prevention and elimination through reductions in workforce absenteeism and increased productivity from employees, as well as consumers who have the disposable income to purchase their products and services, as they do not need to spend money on medication and treatment instead (Purdy et al, 2013). More than 20% of the 8 000 business leaders from over100 countries surveyed by the World Economic Forum in a 2006 report entitled 'Business and Malaria: A Neglected Threat?' stated that malaria 'harms their business' (Bloom, 2006). A significant 72% of respondents from Sub-Saharan Africa shared this view, while 40% stated that malaria posed 'serious detriments' to their business (Bloom, 2006). Development of markets, entrepreneurship and much needed investment to spur economic growth in poor countries with a high malaria burden can only be achieved through eradication of the disease (Purdy et al, 2013).

According to the WHO (2019), a study analysing the impact of malaria on GDP from 180 countries between 2000 and 2017 found that for every 10% reduction in the incidence of the disease, the result was a 0.3% increase in GDP per capita (on average), as well as an increase in GDP growth (WHO, 2019). It was also noted that low-income, high malaria burden countries experienced 'higher than average gains' as a 10% reduction in malaria incidence resulted in almost 2% increase in GDP per capita (WHO, 2019). There is no doubt of the significant macroeconomic, microeconomic and productivity gains that can be achieved through malaria elimination and eradication in both the short and long term (Arrow et al, 2004).

B) Returns in equity, women's empowerment and household wealth

Families in low-income areas often divert their spending towards healthcare expenditure, at the expense of meeting other fundamental needs (Purdy et al, 2013). It is estimated that in Africa, as much as 25% of household income goes towards malaria related expenditures (Creamer, 2018). Not only do reductions in malaria incidence provide these families with the opportunity to improve their level of disposable income and consumption, but it also reduces their prospect of becoming financially impoverished by seeking treatment, which is a significant drain on family resources (Snowden, 2016).

Impoverished women and children from rural areas are at highest risk for malaria related illness, death or disability. In endemic regions, it is estimated the disease is responsible for as much as 50% of absenteeism from schools, while impairing 60% of school children's capacity to learn (Malaria Free Future, n.d.). A 2015 study of Roll Back Malaria control programmes across 14 countries in Africa found that programmes implemented to reduce malaria burden resulted in a rise how many years of schooling were finished by primary school children, as well as an improvement in their educational achievement and cognitive performance (Kuecken et al, 2015).

C) Returns for health security and systems

Malaria places an enormous strain on public health systems, in both the treatment of the disease and the prevention of it (Purdy et al, 2013). In terms of prevention, IRS and insecticide treated bed nets are considered a public good in malaria-affected areas, given the overall health benefit accrued to communities through the prevalence of fewer mosquitoes (Purdy et al, 2013 and Apouey et al, 2018). The public healthcare sector incurs costs on several fronts in the treatment of those infected with malaria, consuming a significant proportion of the capacity of healthcare systems (Purdy et al, 2013). This includes time and money spent on and by health practitioners (doctors and nurses); medication, equipment for diagnoses, and the use of facilities by patients such as clinics and hospitals (Centre for Disease Control, n.d.). Reducing the malaria burden therefore assists in better functioning public health systems, allowing for resources to be spent on other critical health challenges (Purdy et al, 2013).

Image 1: Map of Mozambique (Global City Map, n.d.)

1.2 Malaria in Mozambique

Mozambique, situated on the southeast coast of Africa, is a low-income country and home to around 29 million people. Malaria, as a primary cause of death, is responsible for 71.51 deaths per 100 000 people in Mozambique (Human Development Report, n.d.). According to the WHO, Mozambique shared 5% of the global burden of malaria in 2018, ranking third for the highest number of malaria cases globally (WHO, 2018). The entire country is at risk of malaria, with highest risk of infection throughout the rainy season, which lasts from December to April. According to the country's Public Health Department, there were 7.1 million malaria cases, and 740 subsequent fatalities, in 2018 (Frey, 2019).

Based on the most recent data, government health expenditure in Mozambique stood at just US$19,21 per capita in 2016, which is the lowest in the region (World Bank, 2019). As a result, Mozambique is reliant on external funders for its public health interventions (Frey, 2018). This includes the United States Government and the Global Fund, which are the principal donors financing HIV, TB and malaria programmes. Public healthcare is further constrained by limited human resources and poor infrastructure. Only half the population have access to healthcare, and only 36% reside within half an hour of a medical clinic (Macuácua et al, 2019). Mozambique currently has 1.74 health workers per 1,000 (with only 3,500 community-based health workers) which is much lower than the minimum of 2.5 per 1,000 recommended by the WHO (The Global Fund, 2017). Despite these constraints, there have been advancements in decreasing the malaria mortality rate, through partnerships with external development agencies and the private sector. Malaria related deaths were reduced by 74%, and cases declined by 37%, between 2000 and 2014. However, malaria incidence in Mozambique remains high at 307.8 per 1000 people (Human Development Report, 2019).

1.3 Tackling Malaria Through an IRS Public-Private Partnership

The key objectives of this Study included:

- To identify the resources utilised in the provision of two indoor residual spraying programmes in Mozambique, one in a peri-urban area and the other in a rural area.
- To estimate the financial costs of each programme.
- To contrast and compare the estimated financial costs of service provision between the peri-urban and rural programmes in this Study with similar indoor residual spraying programmes run in other African countries.
- To compare the estimated financial costs of service provision between the peri-urban and rural programmes, and in doing so, identify the different cost drivers for each programme within their respective context.

The key questions explored by this Study included:

1. What are the financial costs of indoor residual spraying interventions in Mozambique?
2. What are the differences in the financial costs of an indoor residual spraying programme implemented in a peri-urban area, compared to an indoor residual spraying programme implemented in a rural area?
3. What are the key contextual and environmental factors that directly impact on the financial costs of implementing an indoor residual spraying programme?
4. What are the cost drivers and key challenges of running an indoor residual spraying programme in Mozambique?

As outlined above, in the key research objectives and questions explored in this Study, the intention was to contrast the financial costs and identify the cost drivers of two operationally similar IRS programmes, funded through a public-private partnership, run in two different areas in Mozambique in 2017. Both programmes worked in conjunction with the National Malaria Control Programme (NMCP) of Mozambique, the Global Fund, and an international private sector partner, in a unique public-private partnership (WEF, 2006). The main malaria intervention of both programmes was IRS. Sprayers were recruited locally in order to create much-needed employment in both areas, as well as improve programme efficiencies, as they were familiar with both the local community and the terrain.

The insecticide was supplied to the Mozambican government by the Global Fund at no cost, while labour, equipment, gear, management and training for both programmes was funded by the private sector organisation. The financial costs of both programmes were recorded by the private sector organisation. One programme was implemented in a peri-urban area and the other in a rural area. Key variables for each area are summarised in Table 1.

Table 1: Key variables statistics for the peri-urban and rural programme 2017

	Peri-urban area	**Rural area**
Population (2017)	178 032	44 371
Area (square km)	815 km	7 010 km
No. houses	59 617	17 248
People per household	4,14	4,87
No. spray operators	80	104

As Table 1 indicates, while the peri-urban area is significantly smaller in terms of geographic size than the rural area, it has a significantly higher population, which translated into a large number of houses and structures to be sprayed. IRS activities for both programmes were undertaken by spray teams organised and supervised by both the private sector organisation involved and district health personnel representing the Mozambican Department of Health. The rural programme employed more spray operators than the peri-urban programme, given the larger area to cover and the greater distance between houses.

Both programmes completed two spray rounds within the year, with community Information, Education and Communication (IEC) and training activities taking place during the off-season. It is important to note that the peri-urban programme was advantaged in terms of access to resources due to existing capacity and resources from an IRS programme run in the area previously. Specific details on this will be covered in the Analysis Chapter. It was the first time an IRS programme was run in the rural area.

1.4 Summary

In this Chapter, a brief overview of the history and epidemiology of malaria was provided, including prevention measures for the spread of the disease, and IRS, which forms the basis of this Study. The impact of malaria and subsequent consequences of its transmission, and benefits of its prevention, were highlighted. The prevalence of malaria in Mozambique was discussed, while the IRS intervention to be analysed by this Study was introduced.

Image 2: IRS spray tank and visor
(Source: Author's own)

Chapter 2: Literature Review

2.1 Introduction

In this Chapter, the difference between financial and economic cost analyses, followed by an exploration of the factors and drivers of the expenses related to the implementation of IRS programmes is explored through the review of similar programmes run in various African countries.

Malaria affected countries across Africa have been implementing Indoor Residual Spraying programmes for more than 50 years, either as annual campaigns before the start of the malaria season, or in response to an outbreak of the disease (Pindolia & Dolenz, 2017). The rollout of such programmes is both resource intensive and costly for any country, however, in the African context several factors such as the remote location of affected communities being difficult to reach, budget and human resource constraints, and type of housing to be sprayed, add to the costs incurred (Pindolia & Dolenz, 2017). Meticulous and effective budgeting and planning are required to ensure the implementation of a programme achieves maximum efficiencies, coverage and impact, with the funding available (Pindolia & Dolenz, 2017).

Inputs required to support health interventions, such as malaria prevention programmes, are called resources (LeFevre, 2017). In measuring the value of the resources needed to implement and run a health intervention, their financial and/or economic cost should be considered in order to demonstrate value for money (Ranson, 2018). This is particularly critical for African governments attempting to find a balance between the limited budget available and competing demands (Ranson, 2018).

Financial costs consider only the explicit monetary value of the resources required for an intervention, examples include operational costs such as payroll and rent, as well as capital costs such as vehicles and machinery (LeFevre, 2017). Financial costs are easily measured and calculated, with a financial evaluation of a programme indicating its affordability and sustainability (LeFevre, 2017).

Economic costs include both the financial (explicit) costs described above, and the value of indirect (implicit) costs, such as the costs of products and services that were donated or volunteered free of charge to an intervention (LeFevre, 2017). Economic costs may also include indirect costs such as the travel costs incurred by patients seeking medical treatment from an intervention, and productivity losses businesses incur as a result of employees' illness (LeFevre, 2017). The evaluation of the economic costs of an intervention indicates the costs and benefits of a programme, representing its overall net present value, as well as the opportunity costs if the resources were to be used for another purpose (LeFevre, 2017). The appraisal of economic and financial costs of an intervention provides decision-makers with evidence to review its worth as it moves through its various stages, including conceptualisation, trial, scale-up, assimilation and ultimately, sustainability (LeFevre, 2017).

It is also important to differentiate between variable and fixed costs. Fixed costs remain constant in the short term, and include capital inputs such as vehicles and equipment, which have a lifespan longer than one year, or are leased on a long-term basis thereby incurring a regular expense over time (Larson et al, 2016). Variable costs include inputs that are easy to adjust over time, such as contract labour or commodity costs such as insecticide (Larson et al, 2016).

Numerous studies have been undertaken to explore the direct costs, indirect costs and cost effectiveness of IRS programmes implemented around the world. There are several important factors to consider when reviewing such studies, particularly when comparing them. Not only do these studies consider different countries, each having their own unique set of social, political and economic variables that affect the design, delivery and outcomes of IRS interventions, they also consider different measures and criteria, with specific costs being included and others excluded (Conteh et al, 2004). The inclusion and exclusion of certain costs in a study are based on its objectives, as importantly, the availability of cost data – not all information is easily or readily accessible (Conteh et al, 2004). The variations in the costs implementing an intervention not only reflect the varying contexts of where it was delivered, but also the different costing methodologies used (WHO, 2019).

Larson et al (2016) note there is often little detail provided in peer-reviewed studies on the processes adopted when undertaking a cost analysis for a malaria programme. The 'costing' section typically offers a concise summary of the generic methods used or the costing methodology is summarised in the appendices with few examples (Larson et al, 2016). Such lack of detail not only makes it challenging for academics, researchers and malaria control programme staff to make use of similar methods for their own studies, but also limits the opportunity for them to understand and explore trends around why and how, outcomes vary across different locations and periods of time (Larson et al, 2016).

Sine et al (2011) and Abbott et al (2014) discuss how cost analyses of IRS expenditures across different countries and programmes can vary widely due to individual programmatic and country specific conditions. Some variations between countries, which impact directly on programme costs, are due to factors unrelated to the structure and implementation of an IRS intervention. These factors are considered cost drivers, as they change the overhead costs of an activity – in this case the overhead costs of an IRS intervention (Bragg, 2019). Key IRS cost drivers are summarised in Table 2 below, with a detailed description of each provided under the table.

Table 2: IRS intervention cost drivers summary

	Cost-driver	**Definition**
A)	Structures to be sprayed	Type and average size of structure to be sprayed as well as accessibility to and distance between structures
B)	Size of household	Household size impacts the cost per person protected of an intervention
C)	Insecticide	The type of insecticide used, which can be influenced by resistance to certain insecticides, and the number of rounds IRS is undertaken per year.
D)	Programme stage	Stage at which the programme is being costed
E)	Programme inputs	Cost and quality of programme inputs, as well as subsidies
F)	Location of the central country office	Location of the central country office in relation to the programme being implement
G)	Data and mapping tools	Availability and accuracy of data and mapping tools

A. Type and average size of structures sprayed

The type of materials from which structures to be sprayed are made determines which kind of chemicals will be required for IRS programmes (WHO, 2015). In the African context, structures may be made using mud, thatch, wood or brick, each requiring a specific formulation when selecting and mixing the insecticide to be used; while also affecting the 'residual efficacy' or duration that the insecticide will be active once sprayed on the walls (WHO, 2015). The efficacy of insecticide sprayed onto the walls of traditional housing made from mud, thatch and wood is shorter than that of brick, and would require more than one spray round annually in areas with longer transmission seasons (WHO, 2015). This implies a higher insecticide cost to maintain malaria prevention initiatives in areas where traditional housing is prevalent, and transmission seasons are long. Furthermore, the average size of the structures in an area will also have an impact on insecticide costs, as the larger the average house size, the more insecticide the programme will require, and the higher the overall insecticide cost (WHO, 2015).

The average distance between structures and their accessibility also directly impacts on the costs of a programme. The greater the distance between structures, the more time it takes for spray teams to move between them, which increases labour costs, as spray teams are typically paid daily (Sine et al, 2011). In cases where structures are widely dispersed and it is not feasible for spray teams to walk from one to the next with their heavy equipment, transport will be required which incurs transportation costs in either the purchasing or hiring of vehicles (WHO, 2015). Areas home to nomadic populations may lead to temporary structures not being accessible for spraying when spray teams visit, requiring spray operators to return at a later stage to perform follow-up or 'mop-up' spraying that increases labour costs for additional days' worked (WHO, 2015).

B. Size of household

The average number of people living within a structure can increase or decrease the cost of an intervention as the impact of IRS programmes is measured by the cost per person protected (Sine et al, 2011) For example, the greater the number of inhabitants per structure, the lower the cost per person.

C. The type of insecticide used and the number of rounds IRS is undertaken annually.

Subject to the duration of the transmission season, some programmes undertake two rounds of spraying per year, while others undertake only one (Sine et al, 2011). Implementing an intervention requiring two rounds would substantially increase the overall costs of the programme in terms of labour, insecticide and other running costs (WHO, 2015). Furthermore, there are several different kinds of insecticides that can be used for an IRS programme, including dichloro-diphenyl-trichloroethane (DDT), pyrethroids and organophosphates, each at a different price point (Chanda et al, 2015). Mosquito resistance to a specific insecticide requires the programme to procure an alternative, which can lead to a dramatic increase in costs should the alternative be more expensive, and in some cases, lead to a programme becoming financially unsustainable (Chanda et al, 2015).

D. Stage at which the programme is being costed

The stage at which the programme is being costed is important. If a programme is in the start-up phase capital expenditure will be high as high cost items, such as vehicles and spray equipment, will need to be purchased but will be used over several spray seasons (Sine et al, 2011). Not only will already established programmes have fewer high cost items to purchase, but having previous experience typically implies lower training costs for staff involved in the programme (Sine et al, 2011).

E. Cost and quality of programme inputs and subsidies

The market prices and quality of local inputs such as labour and insecticide can lead to variations in unit costs, which do not reflect the efficiency or cost effectiveness of an IRS programme (Sine et al, 2011). For example, the cost of labour in some countries, like Ethiopia, is significantly cheaper than in others – such as Angola, as will be demonstrated in the upcoming review and comparison of several IRS programmes implemented in Africa in recent years. Furthermore, the procurement of poor quality equipment, such as spray pumps, can increase operational costs when they need to be repaired or replaced (Chanda et al, 2015). Furthermore, the nature and quantity of inputs subsidised or paid for by stakeholders contributing to a programme, such as the Global Fund, which in some cases provides insecticide, will affect its costing (Sine et al, 2011).

F. **Location of the central country office in relation to the area the programme is being implemented**

The distance between the central country office managing and implementing the programme from the targeted region or area will also affect the cost – the further away the office is from the target area, the higher the transport and supply chain costs to move insecticide and other programme resources to the site of delivery (Sine et al, 2011).

G. **Accuracy and availability of data and mapping tools**

African countries often rely on local knowledge and estimates of which areas to spray, rather than mapping tools and precise data, which can result in shortages or over-estimates when ordering insecticide, as well as inefficient operations in the field (Pindolia & Dolenz, 2017). Furthermore, an overreliance on based data collection can delay analyses during the rollout phase of an intervention, limiting the ability of programme co-ordinators and managers to make quick decisions and improve operational efficiencies (Pindolia & Dolenz, 2017).

Ultimately, while a lack of heterogeneity in IRS programmes across countries and regions makes the comparison of different studies challenging, if the cost drivers and different conditions between interventions are understood, trends can be identified; particularly when considering whether economies of scale can be achieved over time (Sine et al, 2011). Importantly, the question of which factors might mitigate cost savings and which factors might lead to cost savings, can be identified (Sine et al, 2011). Understanding the structure and nature of IRS programme costs is important for:

Assessing performance

Once a project is underway, cost estimates are useful in mapping out how an intervention has been implemented, as well as assessing its performance (Vassall et al, 2017). This is particularly true for policy and decision-makers when assessing and improving the performance of an intervention within a health system, as well as offering guidance when allocating resources for existing and prospective programmes (Sine et al, 2011 & Johns et al, 2003).

Understanding variability

When planning a new programme, some basic costs can be assumed, however, an intervention will be designed and implemented around the local context of where it will run (Sine et al, 2010). Its structure and scale will be determined by the size of the population to be covered, the geography and topography of the area, and the cost of local goods and settlement patterns, among other factors (Sine et al, 2010). Having sound knowledge, an understanding of the variability of interventions and how this will affect costs, assists intervention designers and managers in the planning phase, and provides the opportunity to benchmark interventions against one another in terms of their resource efficiencies and overall effectiveness (Sine et al, 2010).

Programme sustainability

It is critical for countries hosting international organisations responsible for running health-related interventions to have an accurate record of how much an intervention costs, so that if there is a handover of the programme to local authorities at some point, the government has full clarity on what it will cost to continue to run the intervention successfully (Sine et al, 2010).

Achieving maximum impact

The relative impact and requirements of each kind of intervention available for the prevention of malaria needs to be understood, so that the option offering the maximum impact with the resources available, in that particular context, may be implemented (Sine et al, 2010).

Current and future investment

Cost information is important to decision-makers when making health intervention investments, particularly when resources are limited and decisions need to be made around whether to expand current programmes or initiate new programmes (Sine et al, 2011).

Image 3: Members of the local rural community in Mozambique walking home. (Source: Author's own)

2.2 Review of Similar IRS Studies

The various IRS related studies considered in this Literature Review were run in different developing countries and contexts, and did not follow the exact same financial costing framework as this Study. They were selected based on the fact that each undertook a financial costs analysis rather than an economic cost analysis in various African countries, to ensure comparability with this Study. By outlining the approach of each study selected, this Literature Review will explore the various approaches when undertaking an IRS costing, and how these different approaches impact the findings. It is important to highlight that:

1) The studies discussed in the Literature Review did not provide a comprehensive breakdown of the financial costs incurred in each cost category compared to this Study, which does provide a detailed breakdown of each cost category.
2) There were limited similar financial costings of IRS programmes in African countries available from which to compare this Study.
3) In order to support comparability between the studies, costs for the Studies discussed in the Literature Review are also expressed in 2019 prices so as to account for inflation.

Study 1, "*The cost and cost-effectiveness of malaria vector control by residual insecticide house-spraying in southern Mozambique: a rural and urban analysis*", by Conteh, et al (2004), aimed to compare the financial costs of two IRS programmes in southern Mozambique, which ran in 2000. One programme was run in a rural area with a population of 71 047, and the other in a peri-urban area with a significantly larger population of 180 871. The programmes were separately funded – the rural programme was funded by an organisation called Business Trust, and the peri-urban programme by Mozal – a BHP Billiton smelter operating in Mozambique. While the programmes were not funded or run by the same organisation, they operated in a similar way (Conteh et al, 2004).

Using historical cost data from both the Medical Research Council in Durban, South Africa, and Lubombo Spatial Development Initiative (LSDI) budgets managed in Mozambique, the costing was undertaken using an ingredients approach. According to the WHO (2019), an "ingredients" based approach, also known as a "bottom up" approach, sees all resources required for an intervention identified and valued. The researchers opted to take a provider perspective when considering costs, as household costs towards the implementation of the programme were considered to be minimal (Conteh et al, 2004). Resources linked to research activities were excluded from the costing. The following cost items were identified and included in the costing:

1. Personnel;
2. Vehicles and equipment;
3. Training;
4. Insecticide;
5. Supplies;
6. Buildings;
7. Project management; and
8. Monitoring and surveillance.

The Study was limited in that it did not provide a detailed breakdown or discussion of the costs making up each category identified. Programme costs for each category, expressed as a percentage of the overall cost of the programme, are outlined in Table 3 below. The author added in an additional column expressing the cost per category in US dollars 2019, to provide comparability with the financial costing of this Study.

Table 3: Cost profiles for the rural area and peri-urban programmes (USD 2000 and 2019)

	Rural area			Peri-urban area		
	Cost in 2000	**Cost in 2019**	**% cost**	**Cost in 2000**	**Cost in 2019**	**% cost**
Personnel	$76 644	$113 790	17%	$88 200	$130 946	14%
Vehicles and equipment	$59 225	$87 929	13%	$55 314	$82 122	9%
Training	$11 936	$17 721	3%	$15 601	$23 162	3%
Insecticide	$129 928	$129 928	29%	$264 363	$392 487	45%
Supplies	$9 802	$14 553	2%	$4 329	$6 427	1%
Equipment	$21 760	$32 306	5%	$7 192	$10 678	1%
Buildings	$10 375	$15 403	2%	$7 596	$11 277	1%

Project management	$94 640	$140 507	21%	$95 458	$141 722	16%
Monitoring & surveillance	$40 392	$59 968	9%	$45 357	$67 339	9%
Total	**$454 703**	**$675 076**	**100%**	**$583 410**	**$866 161**	**100%**
Cost per person	**$5,25**	**$7,79**		**$3,13**	**$4,65**	

(Source: Conteh et al, 2004)

The Study found that the total costs of the IRS programme were $4 54 703 in 2000, which totalled $675 076 in 2019 when accounting for inflation, in the rural area. In the peri-urban area total costs came to $5 83 410 in 2000, and $866 161 in 2019. The financial cost per person covered was $7,79 in the rural area, and $4,65 in the peri-urban area, in 2019. The variance between them was attributed to:

i. The population size in the peri-urban area was 2,5 times greater than the rural area
ii. The insecticide used in the peri-urban area was more expensive, accounting for 45% of the total programme costs, as opposed to the insecticide used in the rural area, which accounted for 29% of the overall programme costs.

It is worth noting that vehicle costs were lower in the peri-urban area as fewer vehicles were required given that the houses targeted for spraying were more easily accessible to the spray team by foot (Conteh et al, 2004). It was concluded that the population covered and the type of insecticide used were the two key factors driving the costs of the IRS programmes (Conteh et al, 2004).

Study 2, A 2010 USAID publication *"Analysis of 2008 Expenditures in Five IRS T01 Countries"* by Sine et al, compared and contrasted the costs of IRS programmes run by the America's 'President's Malaria Initiative' (PMI) in Benin, Ethiopia, Ghana, Mali and Mozambique in 2008. Like Study 1, retrospective cost information for the IRS interventions running in each of the five countries was used. This was obtained from Research Triangle Institute (RTI), which implemented the interventions, and the local National Malaria Control

Program (NMCP) (Sine et al, 2010). Study 2 offers a more detailed breakdown of the costs included than Study 1, by identifying cost categories and detailing the specific cost items included in each category. These included:

- **Spray operations**: assessment of the planning and logistics; training; environmental compliance; IEC; warehouses; contract employees (sprayers, IEC mobilisers, supervisors and data capturers); transport; medical expenses; mop-up activities; meetings; and monitoring and evaluation.

- **Spray operations commodities**: spray equipment; insecticide; protective gear and shipping.

- **Local labour**: local staff and labour employed by the programme intervention.

- **Local in country administration**: leases and utilities; furniture and equipment; office related services; and management transport/travel costs.

- **Short-term technical assistance**: US and Nairobi based labour expenses.

While Sine et al (2010) noted that there was a contribution from the Ministry of Health and NMCP in terms of labour, transportation and warehouse space across all five countries; this was not included in the costing. In addition, RTI did not pay for insecticide in Ethiopia and Mozambique, as it was funded by other stakeholders. The costs for insecticide in these two countries was determined and included so that cross-country comparisons could be undertaken (Sine et al, 2010). Limitations to the costing were highlighted as:

A. Given that 2008 was the first year an IRS programme was run by the PMI in Benin, Ghana, Mail and Ethiopia, staffing requirements were supplemented and strengthened by USA and Nairobi based RTI employees during the period of recruitment and training of locals in each of the four countries. As such, external labour and travel costs were expected to decrease in subsequent years (Sine et al, 2010)

B. The full costs for several capital investments, such as soak pits and spray equipment, were included in the 2008 costing. While these resources would be used over several years, they were not amortised due to the way in which they were captured, making it difficult to differentiate these expenses from other associated spray costs (Sine et al, 2010).

Based on the above, the total costs for each country programme in 2008 were calculated as:

Table 4: Programme costs for five PMI countries in 2008 and 2019 (USD)

Country	Population covered	Total intervention cost in 2008 and 2019 (millions)	Cost per structure in 2008 & 2019	Cost per person in 2008 & 2019
Ethiopia	1 000 526	$3,26 | $3,87	$10,62 | $12,61	$3,30 | $3,92
Ghana	601 973	$2,94 | $3,49	$11,55 | $13,71	$4,90 | $5,82
Mozambique	1 457 142	$5,94 | $7,05	$14,38 | $17,08	$4,10 | $4,87
Benin	521 738	$2,44 | $2,90	$17,07 | $20,27	$4,70 | $5,58
Mali	420 580	$2,98 | $3,54	$27,67 | $32,86	$7,10 | $8,43

(Source: Sine et al, 2010)

Table 5 on the following page summarises the expenditures of the IRS operations in each of the five countries. The Study was limited by the fact that the total for each cost category was given, with no detailed breakdown of each category provided.

Table 5: IRS Programme Expenditures, 2008 (USD millions)

Cost category	Ethiopia			Ghana			Mozambique			Benin			Mali		
	Cost 2000	Cost 2019	% cost	Cost 2000	Cost 2019	% cost	Cost 2000	Cost 2019	% cost	Cost 2000	Cost 2019	% cost	Cost 2000	Cost 2019	% cost
Spray operations	$1,61	$1,91	49,4%	$1,20	$1,42	40,8%	$3,10	$3,68	52,2%	$0,88	$1,04	36,1%	$0,93	$1,10	31,2%
Insecticide	$0,29	$0,34	8,9%	$0,36	$0,43	12,2%	$0,86	$1,02	14,5%	$0,42	$0,50	17,2%	$0,30	$0,36	10,1%
Spray gear/equipment	$0,56	$0,66	17,1%	$0,30	$0,36	10,2%	$0,23	$0,27	3,9%	$0,11	$0,13	4,5%	$0,14	$0,17	4,7%
PPE	$0,22	$0,26	6,7%	$0,14	$0,17	4,8%	$0,08	$0,09	1,3%	$0,12	$0,14	4,9%	$0,08	$0,09	2,7%
Shipping	$0,20	$0,24	6,1%	$0,07	$0,08	2,4%	$0,08	$0,09	1,3%	$0,13	$0,15	5,3%	$0,14	$0,17	4,7%
Local labour	$0,06	$0,07	1,8%	$0,20	$0,24	6,8%	$0,32	$0,38	5,4%	$0,13	$0,15	5,3%	$0,27	$0,32	9,1%
Administration	$0,07	$0,08	2,1%	$0,31	$0,37	10,5%	$0,65	$0,77	10,9%	$0,34	$0,40	13,9%	$0,65	$0,77	21,8%
STTA & US costs	$0,19	$0,23	5,8%	$0,13	$0,15	4,4%	$0,27	$0,32	4,5%	$0,09	$0,11	3,7%	$0,09	$0,11	3%
US/Nairobi labour	$0,18	$0,21	5,5%	$0,16	$0,19	5,4%	$0,35	$0,42	5,9%	$0,21	$0,25	8,6%	$0,38	$0.45	12,7%
Total	**$3,26**	**$3,87**	**100%**	**$2,94**	**$3,49**	**100%**	**$5,94**	**$7,05**	**100%**	**$2,44**	**$2,90**	**100%**	**$2,98**	**$3,54**	**100%**

(Source: Sine et al, 2010)

Unlike Study 1, Study 2 divided the overall cost of the programme by how many structures were sprayed in each country, to arrive at a figure for the ‘cost per structure sprayed’. Study 2 then divided the total cost of the interventions by the population to calculate the cost per person protected (Sine et al, 2010). The distribution of costs across the different categories was then considered when comparing intervention expenditures between the five countries. Noteworthy findings included:

A. Spray operations were the biggest cost across all five countries, unlike Study 1, which found insecticide to be the highest cost contributor to the intervention at 29% in the rural area under review and 45% in the peri-urban area. Insecticide costs in Study 2 were 9% of the total costs of the intervention in Ethiopia, 12% in Ghana, 14% in Mozambique, 17% in Benin and 10% in Mali (Sine et al, 2010). The reason for the difference between the two studies is due to the population sizes covered in Study 2 being significantly higher than Study 1, implying economies of scale can be achieved when purchasing insecticide – the larger the intervention the more cost efficient the insecticide.

B. The most significant range in costs across the five countries was for the category of local administration. While local administration cost just 2% of all spending in Ethiopia, it was ten times more in Mali at 22% (Sine et al, 2010). This was attributed to the high cost of office leases and utilities, and local travel and transportation. The low cost of administration in Ethiopia was due to the sharing of offices by intervention staff with host country counterparts (Sine et al, 2010). In Ghana and Mozambique local administration accounted for 11% of the total intervention costs, and in Benin 14%.

C. When considering the costs per structure sprayed, expenditures in Ethiopia and Ghana were the lowest, while Mali was the highest. This was partly attributed to efficiencies in countries with ongoing programmes having previous IRS implementation experience, which led to lower start-up costs (Sine et al, 2010 and Conteh et al, 2004). Benin and Mali had no recent experience in running an IRS intervention, which provides some explanation as to why their cost per structure is higher than the other three countries.

While Study 2 did not include contributions from the Ministry of Health and NMCP in terms of labour, transportation and warehouse space in each country, those countries with previous IRS experience are likely to have contributed to the intervention (Sine et al, 2004). Likewise, those countries with greater resources and better infrastructure would have benefited from lower input requirements (Sine et al, 2004). Furthermore, Sine et al (2004) noted that private sector support in Ghana, from AngloGoldAshanti, may have assisted in lowering the intervention costs.

The average structure size in each country is also important to consider, as this determines the time taken to spray the structure, the amount of insecticide required and ultimately, how many people are protected. For instance, in Benin the average structure is small (32 square metres) compared to Mozambique (142 square metres), Ethiopia (82 square metres), Ghana (60 square metres) and Mali (59 square metres). Furthermore, in Benin, more labour and transport time was used moving between structures in sparsely populated areas than actual time spent spraying each structure (Sine et al, 2004). The high cost per structure in Mali was largely attributed to greater administration and labour costs when compared to the other four countries (Sine et al, 2004).

The Study concluded by noting that intervention costs across all five countries should decline over time as local capacity and resources are mobilised, and the reliance on external service providers and suppliers – which are typically more costly – is reduced (Sine et al, 2010).

Study 3 published in 2011, also written by Sine et al for USAID, entitled "*An economic analysis of the costs of indoor residual spraying in 12 PMI countries, 2008–2010*" looked at the costs of IRS interventions in 12 African countries over a period of time. Nine of the countries were analysed over a period of three years, two over two years and one over one year. The countries under review varied in terms of the scale of their respective interventions. Seven countries ran large programmes - those that sprayed more than 150 000 structures in 2010 - and five ran smaller programmes - those that sprayed less than 150 000 structures in 2010 (Sine et al, 2011). Countries included in this comparative cost study, the number of people protected, the time period analysed and size of the IRS programme (as defined above) were:

Table 6: PMI IRS analysis of 12 countries and population covered, by year

Country	Population covered	Period of analysis	Programme size
Angola	1 821 724	2008 – 2010	Small
Benin	2 294 581	2008 – 2010	Large
Burkina Faso	118 691	2010	Small
Ethiopia	4 604 078	2008 – 2010	Large
Ghana	2 159 696	2008 – 2010	Large
Liberia	583 686	2009 – 2010	Small
Madagascar	5 489 557	2008 – 2010	Large
Mali	1 358 517	2008 – 2010	Small
Malawi	406 194	2008 – 2009	Small
Mozambique	6 666 272	2008 – 2010	Large
Rwanda	4 728 080	2008 – 2010	Large
Senegal	2 380 431	2008 – 2010	Large

(Source: Sine et al, 2011)

Using retrospective financial records provided by RTI, which implemented the interventions, and the respective NMCP in each country, Study 3 applied the same cost categories as Study 2: Spray related activities, Spray gear, Labour, Local country administration and Short-term technical assistance (Sine et al, 2011). The costs and change in costs, over a three-year period (2008, 2009 and 2010) were considered. Unlike Study 2, Study 3 identified and amortised the cost of capital goods. All costs were also adjusted using price deflators to make them in 2010, US Dollar terms (Sine et al, 2011). See tables 7 and 8 below for all programme costs, and tables 9 and 10 for the cost per person protected for the large and small programmes over the three-year period.

Table 7: IRS Programme Expenditures for Large Programme Countries (2008 – 2010)

Cost Category	**Expenditures (US$ millions)**																				
	Ethiopia			**Mozambique**			**Madagascar**			**Ghana**			**Rwanda**			**Senegal**			**Benin**		
	‘08	**‘09**	**‘10**	**‘08**	**‘09**	**‘10**	**‘08**	**‘09**	**‘10**	**‘08**	**‘09**	**‘10**	**‘08**	**‘09**	**‘10**	**‘08**	**‘09**	**‘10**	**‘08**	**‘09**	**‘10**
Spray operational costs	1,61	1,66	2,25	3,10	2,09	4,03	1,15	1,43	2,27	1,2	1,05	1,89	3,50	4,46	3,72	1,09	1,16	1,75	0,96	0,87	1,53
Insecticide	0,29	0,35	0,92	0,86	1,57	1,57	0,32	0,25	1,58	0,35	0,26	0,28	0,52	1,70	0,7	0,27	0,30	0,30	0,25	0,28	0,75
Spray gear/equipment	0,56	0,26	0,56	0,23	0	0,18	0,09	0,02	0,31	0,3	0,04	0,06	0,11	0,1	0,08	0,01	0,07	0,09	0,11	0	0,06
Personal protective gear	0,22	0,06	0,10	0,08	0,2	0,15	0,18	0	0,46	0,14	0,03	0,10	0,23	0,07	0,21	0,09	0,07	0,13	0,12	0	0,04
Shipping	0,2	0,03	0,15	0,08	0	0	0,11	0,09	0,24	0,07	0,09	0	0,31	0,03	0,03	0,13	0,07	0	0,13	0,03	0,02
Resident labour	0,06	0,14	0,19	0,32	0,19	0,53	0,27	0,27	0,23	0,2	0,22	0,56	0,38	0,39	0,32	0,31	0,35	0,44	0,13	0,15	0,23
Administration	0,07	0,1	0,27	0,65	0,48	0,66	0,45	0,37	0,79	0,31	0,38	0,89	0,42	0,38	0,26	0,23	0,28	0,38	0,34	0,13	0,16
STTA & U.S. expenses	0,19	0,35	0,07	0,27	0,17	0,19	0,03	0,18	0,13	0,13	0,09	0,08	0,1	0,49	0,13	0,08	0,06	0,1	0,09	0,08	0,12
Nairobi & US labour	0,18	0,16	0,22	0,35	0,93	0,79	0,1	0,11	0,26	0,16	0,08	0,20	0,31	0,58	0,6	0,09	0,13	0,23	0,21	0,33	0,81
TOTAL	**3,38**	**3,12**	**4,72**	**5,94**	**5,63**	**8,11**	**2,71**	**2,72**	**6,26**	**2,86**	**2,25**	**4,06**	**5,88**	**8,21**	**6,05**	**2,33**	**2,49**	**3,42**	**2,36**	**1,87**	**3,72**
Structures sprayed (‘000)	317	459	647	413	571	618	217	216	576	254	285	343	190	295	304	154	176	255	143	156	167
People protected (‘000)	1,000	1,539	2,064	1,457	2,263	2,945	1,320	1,275	2,895	602	708	850	886	1,329	1,366	645	662	960	522	512	636

(Source: Sine et al, 2011)

Table 8: IRS Program Expenditures for Small Programme Countries (2008 – 2010)

Cost Category	Expenditures (US$ millions)														
	Angola			Mali			Malawi			Liberia			Burkina Faso		
	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10
Spray operational costs	1,15	2,72	2,08	1,02	1,36	1,28	0,27	0,79			0,27	0,9			0,28
Insecticide	0,32	2,72	0,3	0,16	0,14	0,14	0,07	0,17			0,05	0,15			0,18
Spray gear	0,09	2,72	0,04	0,14	0,01	0,09	0	0,04			0,04	0,05			0,04
Personal Protective Equipment	0,18	2,72	0,04	0,08	0,03	0,12	0	0,03			0,03	0,09			0,04
Shipping	0,11	2,72	0	0,13	0,04	0	0,02	0,03			0,04	0,08			0,07
Resident labour	0,27	2,72	0,54	0,27	0,19	0,24	0,04	0,07			0,05	0,13			0,1
Local administration	0,45	2,72	0,31	0,65	0,41	0,53	0,13	0,22			0,11	0,17			0,12
STTA & U.S. expenses	0,03	2,72	0,28	0,09	0,09	0,06	0,05	0,12			0,09	0,06			0,08
Nairobi & US labour	0,1	2,72	0,92	0,38	0,33	0,46	0,1	0,31			0,21	0,44			0,46
TOTAL	**2,71**	**2,72**	**4,51**	**2,93**	**2,58**	**2,92**	**0,68**	**1,79**			**0,90**	**2,06**			**1,38**
Structures sprayed ('000)	136	103	136	108	127	127	25	75			20	48			34
People protected ('000)	686	486	650	420	457	441	106	300			163	421			119

(Source: Sine et al, 2011)

Table 9: Cost per Person Protected for Large Programmes (2008 – 2010)

Year	Ethiopia		Mozambique		Madagascar		Ghana		Rwanda		Senegal		Benin	
2008 / 2019	$ 3,32	$3.94	$ 4,42	$5,25	$ 2,26	$2,68	$ 3,36	$3,99	$ 7,14	$8,48	$ 3,60	$4,27	$ 4,41	$5,24
2009 / 2019	$ 2,27	$2,71	$ 2,92	$3,48	$ 2,66	$3,17	$ 3,79	$4,52	$ 7,32	$8,72	$ 4,39	$5,23	$ 4,47	$5,33
2010 / 2019	$ 2,15	$2,52	$ 2,77	$3,25	$ 2,05	$2,40	$ 4,74	$5,56	$ 4,43	$5,19	$ 3,48	$4,08	$ 5,79	$6,79

(Source: Sine et al, 2011)

Table 10: Cost per Person Protected for Small Programmes (2008 – 2010)

Year	Angola		Mali		Malawi		Liberia		Burkina Faso	
2008 / 2019	$ 4,20	$4,99	$ 6.92	$8,22	$ 7,19	$8,54	n/a	n/a	n/a	n/a
2009 / 2019	$ 7,07	$8,43	$ 7,04	$8,39	$ 6,85	$8,16	$5,90	$7,03	n/a	n/a
2010 / 2019	$ 7,04	$8,25	$ 6,53	$7,66	n/a	n/a	$4,71	$5,52	$11,11	$13,03

(Source: Sine et al, 2011)

Table 11 outlines the cumulative change in resource usage, across the different cost categories for both small and large programmes, over the three-year period under review.

Table 11: Contrast of Average of the Spend on each Cost Category for Small and Large Programmes between 2008 and 2010 (Percent)

Cost category	Large programmes %			Small programmes %		
	'08	**'09**	**'10**	**'08**	**'09**	**'10**
Spray operational costs	52	50	49	42	51	43
Insecticide	13	16	18	10	7	7
Spray gear	2	2	2	1	1	1
Personal protective equipment	3	2	3	2	3	3
Shipping	4	1	2	5	2	1
Resident labour	7	7	7	10	8	9
Administration	10	9	9	20	14	11
STTA & US expenses	4	5	2	2	5	4
Nairobi & US labour	6	8	7	9	10	20
Total (%)	100	100	100	100	100	100

(Source: Sine et al, 2011)

Programme costs were compared on both an intra-country basis and across countries. By considering intra-country costs the study aimed to identify trends over the three-year period between 2008 and 2010 in terms of cost per person protected, as well as per structure sprayed. This provides insight into whether cost efficiencies were realised, and by investigating variations in how costs were distributed across the various categories, it was possible to determine if and where efficiencies were accrued (Sine et al, 2011). When undertaking a cross-country comparison, the study aimed to pinpoint trends across countries in relation to the consistency of intra-country changes, as well as assess if economies of scale are in fact related to programme costs (Sine et al, 2011). This was achieved by categorising the 12 countries according to intervention size based on the number of structures sprayed (Sine et al, 2011).

One round of spraying was undertaken in all countries in 2008. In 2009 one round of spraying was undertaken, except for in Rwanda and Senegal where some structures were sprayed twice, and in 2010 one round was completed in each country, excluding Benin and Rwanda where some structures were sprayed twice (Sine et al, 2011). The difference in number of spray rounds undertaken in 2008 and 2009 does limit the comparability of programme costs when performing in both intra-country and across countries analyses (Sine et al, 2011). Costs that were not considered in the Study included:

i. Government contributions to programmes within their country, such as warehouse space to store IRS related inputs and labour provided by NMCP and Ministry of Health employees.
ii. RTI did not carry the cost of insecticide in Ethiopia and Mozambique. In order to improve cost comparisons between countries, information on these costs was acquired and included.

Key findings of the costing analyses between the large and small country programmes included:

- Programme size has a significant influence on programme cost (Sine et al, 2011). The cost of smaller programmes (spraying fewer than 150 000 structures) was found to be higher than that of larger programmes (spraying over 150 000 structures). The cost per structure for small programmes averaged more than $20 compared to less than $15 per structure for large programmes (Sine et al, 2011). The two exceptions were Rwanda, which averaged almost $35 for all three years, and Benin, which reached almost $25 in 2010. Costs were higher in these two countries due to additional spray rounds having been undertaken annually (Sine et al, 2011).

- Measuring the mean cost per structure sprayed reveals that IRS programme costs decrease over time for large programmes. The change in the mean cost per structure sprayed declined by 17% across all the countries under study between 2008 and 2010, with the decline greatest among the larger programmes, at 23%. The small programme country grouping saw a 28% increase in the mean cost for each structure sprayed, between 2008 and 2010 (Sine et al, 2011).

- The average size of structure sprayed impacts significantly on costs of the programme – specifically the cost of insecticide – the larger the structure the more insecticide and spray operator time required to spray each structure (Sine et al, 2011).

- A similar trend was found when cost per person protected was calculated, with the larger programmes incurring a lower per person cost than the smaller programmes; and the mean cost per person decreasing by 27% for the larger programmes while increasing by 22% for the smaller programmes (Sine et al, 2011).

- When comparing costs from the first year of operation, in 2008, to the end of the study in 2010, it was found that costs per structure sprayed had decreased from 2008 to 2010 in six out of the seven countries running large programmes (Sine et al, 2011).

- The need for external support and the associated costs with such support, decreased between 2008 and 2010 for large programmes, while it increased for the smaller programmes (Sine et al, 2011).

- The distribution of IRS cost expenditures was consistent over time across programmes (Sine et al, 2011). Spray operational costs for larger programmes, as a proportion of total annual programme costs, decreases gradually over time. The distribution of costs for the smaller programmes was less consistent over time. This was attributed to increases in the costs of local administration and external assistance provided (Sine et al, 2011).

- Demonstrating the extent to which local context and conditions impact on costs Sine et al, (2011) note the difference in total programme costs in 2010 for Ethiopia and Mozambique. These two countries sprayed a similar number of structures that year; however, total programme costs for Ethiopia were $4.4 million ($5.16 million in 2019 terms), compared to $8.15 million ($9.56 million in 2019 terms) in Mozambique. The enormous difference between the two programmes is largely attributed to:

i. Local administration and labour costs are higher in Mozambique; and
ii. Spray operational costs in Mozambique were 40% higher than in Ethiopia because the average structure size in Mozambique is double that of Ethiopia, substantially increasing both insecticide and labour costs (Sine et al, 2011).

When considering the costs of each programme under study Sine et al (2011) went a step further by comparing and analysing whether technical and administrative efficiencies were achieved over the period under review. In order to assess whether economies of scale can be achieved the changes in spray operational costs (technical efficiency) and the cost of local administration (administrative efficiency) with changes in programme size were compared between 2008 and 2010 (Sine et al, 2011). The authors concluded that technical efficiency was achieved in five of the seven large programmes, as the percentage variation in spray operational expenses was lower than the percentage change in programme size. These countries were Mozambique, Madagascar, Ethiopia, Rwanda and Ghana. The difference in percentage changes in Senegal were almost the same, while they were higher in Benin. This was attributed to additional spray rounds undertaken in Benin as compared to the other countries (Sine et al, 2011).

Small country programmes were found to be less efficient than their large programme counterparts as growing spray operation costs surpassed the growth in programme size (Sine et al, 2011). For instance, in Angola the cost of spray operations ballooned by 50% from 2008 to 2010, while the size of the programme remained the same.

In terms of administrative efficiency, the results were mixed. Large programmes in Mozambique, Madagascar, Rwanda and Benin saw programme size increasing at a faster pace than the costs of local administration, therefore demonstrating improvement in administrative efficiency (Sine et al, 2011). In Ghana and Ethiopia costs increased faster than programme size and in Senegal they were evenly matched. In contrast, the smaller programmes showed greater administrative efficiency overall as the costs of local administration decreased (or increased at a slower rate) relative to programme growth (Sine et al, 2011). The authors noted that further investigation was required to determine precisely why smaller programmes are more efficient in their administration than large programmes.

2.3 Summary

In this Chapter, the difference between financial and economic cost analyses, followed by an exploration of the factors and drivers of the costs related to the execution of IRS programmes, through reviewing similar programmes run in various African countries was explored.

Chapter 3: Theoretical Framework

3.1 Introduction

This Chapter will consider the theory of financial and economic costings, and cost estimations. It is important to understand the different frameworks used for estimating costs, as well as cost types and what the implications are when taking different costing approaches. According to the WHO (2006), a "costing can be defined as a process of identifying the resources required to produce something or undertake an action, and then valuing these in monetary terms." Essentially, a cost estimation uses various methods to forecast the quantity, cost and prices of the resources required to undertake a process or project in a particular context (location) over a specific time period (Vassall et al, 2017). Larson et al, (2016) state that the cost of implementing any kind of health intervention is borne out of the transformation of "programme inputs into health outcomes". The total cost to implement an intervention is therefore the sum of all inputs required and used to implement a programme (Larson et al, 2016).

3.2 Cost types and costing methodologies

In order to estimate the costs of a programme there are several approaches available to researchers, as well as guidelines and frameworks, and the assumptions made. The time horizon of a costing, in conjunction with its scale and scope, will impact on the findings in terms of total and individual costs (Levin, n.d.). Ultimately, it is up to the researcher to interpret the direction they will take for the costing, based upon their experience and the context within which the costing will be undertaken (Vassall et al, 2017).

There are various cost types that may be measured in a healthcare intervention. When undertaking a costing it is imperative to be clear on what kind of costs will be considered in the scope of the costing – are they financial or economic costs? Financial costs denote the explicit or direct costs of the programme. These are resources which are paid for. As such, financial costs have a monetary value and are easily identified and calculated (Stenberg & Rajan, 2016).

Direct health-care costs include costs related to treatment or preventative care such as hospital, medication, tests and procedures, and equipment costs (Levin, n.d.). **Direct non-health care costs**

refer to costs for patients and their families. These are costs incurred by a patient and their family when seeking treatment. For example, transportation costs when travelling to and from healthcare facilities.

A Cost-benefit Analysis (CBA) is a costing framework which relies on financial costs to assess the economic impact of an investment by determining whether the benefits of a programme (measured in financial terms) exceed its financial, direct costs. Simply put, the direct costs of an intervention are added together and then subtracted from the monetary benefits. If a net gain is achieved as opposed to a net loss, the intervention is considered a worthwhile investment (Edejer et al, 2003 & Monette et al, 2010). A CBA may be performed prior to the implementation of an intervention (ex ante analysis) or after an intervention has been implemented (ex post analysis). The difference between the two is when undertaking a CBA prior to the implementation of an intervention it will be based largely on estimates and assumptions, while a CBA performed after an intervention has run will rely on actual costs, therefore making the findings more accurate and reliable (Monette et al, 2010).

One of the challenges of a CBA is the reliability of the purported benefits that the analysis monetises. If an intervention's benefits are easily related to an economic outcome, then it is relatively simple to attach a monetary value to the benefits (Monette et al, 2010). When an intervention's benefits are related to non-economic activities it becomes more difficult to monetise the benefits and researchers will make subjective evaluations and assumptions which are usually controversial (Monette, 2010). For instance, it is challenging to place a financial value on the benefit of improved mental health compared to measuring the benefit of subsidised day care, where the costs of day care are known and can be subtracted from a parent's salary, as they are able to work while their child is being cared for (Monette et al, 2010).

According to Bergmo (2015), costings, which include only direct financial costs, are considered partial economic evaluations. While these may be useful for understanding the costs associated with an intervention, they cannot be used to make conclusions about the cost effectiveness of an intervention (Bergmo, 2015). Decision-makers should also consider economic, social, technical and feasibility factors when making a final decision as to whether to proceed with an intervention or not (Cameron et al, 2011).

By considering the opportunity cost (the value of the next best alternate course of action which was not selected), an economic costing attempts to uncover the true cost and value of an intervention to a community by including externalities that do not have a financial cost (Edejer et al, 2003). This can be achieved by following the framework of a *cost-effectiveness analysis* (CEA) which evaluates the advances made in a specific health-related area, in relation to the costs incurred, by various health programmes (Jamison et al, 2006). The financial cost of an intervention is divided by the gains in health that are expected to be achieved through the intervention, for example how many lives were saved (Jamison et al, 2006). A CEA therefore studies the outputs/effects of an intervention that are not measured in financial or monetary terms. The result is therefore represented as a ratio of costs to effectiveness (WHO, 2019).

Cost Effectiveness ratio: CE = C1/E1

This equation expresses the cost per unit of effectiveness, in other words, the amount of money spent per life saved. C1 is the financial cost of option one (measured in Rands/Dollars for example), while E1 is the effectiveness of option one and is measured in physical components, for example, the number of lives saved. The lower the CE ratio, the more cost effective an intervention is (WHO, 2019). The effectiveness per unit of cost, or the lives saved per Rand/Dollar paid, is represented by the EC ratio = E1/C1. In this case interventions are ranked from highest to lowest EC ratios (WHO, 2019).

When undertaking a CEA, analysis researchers must characterise the health intervention in detail, such as the level at which the intervention will be delivered, the processes and supplies required, and the kinds of healthcare workers involved (Jamison et al, 2006). How wide or narrow the scope of costs included in the analysis are has implications for how low or high the cost per unit of health gain will ultimately be – the wider the scope of costs, the higher the cost per unit will be, making the intervention seem less cost effective (Jamison et al, 2006). When undertaking a CBA or a CEA it is imperative to include as many costs and benefits as possible, particularly the indirect and long-term effects of an intervention, so that the analysis is comprehensive and the interests of all stakeholders to be impacted by the intervention's implementation are represented (WHO, 2019).

In the context of costing and evaluating the financial performance and efficiencies of malaria interventions, Larson et al (2016) highlight the many approaches that can be taken, each with their own assumptions and modelling strategies. These may include, for example, randomised trials, costs inferred from information provided by the government health department staff or the estimating of costs by modelling studies using data from various sources such as the WHO (Larson et al, 2016). Larson et al (2016) note that while the concepts and basic principles that should be applied when estimating the costs of an intervention are well documented, in reality such frameworks are relatively vague when it comes to specifying how to apply costing methods to a particular intervention.

3.3 Summary

This Chapter considered the theory of financial and economic costings, and cost estimations as it is important to understand the different frameworks used for estimating costs, as well as cost types and what the implications are when taking different costing approaches. There are several different types of costs which can be considered in a healthcare intervention. When undertaking a costing it is imperative to be clear on what kind of costs will be considered in the scope of the costing – economic or financial costs. The differences between the two, as well as fixed and variable costs were discussed.

Image 4: A spray operator spraying the interior walls of a home in a rural area in Mozambique (Source: Author's own)

Chapter 4: Methodology

4.1 Data and methodological approach

In this Chapter, the objectives and approach taken for this Study will be discussed, with reference to methodology for data collection and the limitations of the Study.

The aim of this Study was to estimate the financial costs and cost drivers of the operations of various IRS programmes in Mozambique, over a period of time, from a budgetary perspective. Financial costs denote the explicit or direct costs of the intervention. These are resources, which are paid for, have a monetary value and are easily identified and calculated (WHO, 2016). This Study followed a 'mixed methods approach', relying on both quantitative, numerical data, which was supplemented by qualitative data. Quantitative research seeks to establish facts, establish relationships between variables and calculate outcomes, through the classification, counting and analysis of numerical data (Van der Merwe, 1996 & Neill, 2007). It is designed to guarantee reliability, impartiality, generalisability and consistency (Weinreich, 2009). Qualitative research on the other hand, comprises the collection and analysis of non-numerical data in order to understand concepts and opinions, as well as experiences (Bhattacherjee, 2012). Not only is qualitative research useful in gathering deep insights into a problem, but it can also be valuable in creating new research concepts (Bhattacherjee, 2012).

A mixed methods approach allows for the integration and "mixing" of both quantitative and qualitative data within an individual study (Wisdom & Creswell, 2013). This approach is useful as it is flexible, allowing quantitative and qualitative data to be compared, and offers the opportunity for contradictions between quantitative and qualitative results to be identified and understood (Wisdom & Creswell, 2013). By integrating the two research approaches it also provides the opportunity for a 'complete picture' of a study to be obtained, as focusing on only one approach (for example, only a quantitative approach) may not reflect the nature of the Study in the context in which it is being observed (Wisdom & Creswell, 2013). This is particularly relevant to this Study, as the environmental context in which the two IRS programmes were implemented had a direct impact on the financial cost of each intervention.

The financial costings for both programmes were based on the annual budgets reported by the private sector organisation funding the initiative during the period under study and were in US Dollars. The budgets were reported in US Dollars given that multiple stakeholders were involved, including the

Global Fund, the private sector organisation and the Mozambican government. It also made the costing easier to manage over time given the volatile nature of the Mozambican currency, the metical.

An activity based costing approach was followed, which "measures the cost and performance of activities, resources, and cost objects, specifically, resources are assigned to activities, then activities are assigned to cost objects based on their use" (Cardos & Pete, 2011). The Study included a budgetary analysis and cost identification exercise, with allocations based on the nature of costs (e.g. fixed versus variable costs, financial versus economic costs).

As Turner et al (2019) note, for health-related economic costings it is usually necessary to factor in inflation when calculating costs over different periods of time. As such, all costs reported in the 2017 budget were adjusted for inflation to 2019 prices. To capture changes in the value of the US Dollar over time the online inflation adjustment tool, US Inflation Calculator, was used ("US Inflation Calculator," n.d.). The cost analysis was then conducted using Microsoft's spreadsheet programme, Excel.

Supplementary data was collected using a blend of face-to-face interviews with those involved in the intervention, as well as a visit to the areas where the programme was being implemented in Mozambique. Interviews were undertaken with selected individuals on the team involved in the intervention from the private sector organisation, as well as individuals managing the programme on the ground, including district health officials, programme managers and spray operators.

In terms of the interviewee selection criteria, a non-probability approach of 'expert sampling', which sees respondents selected in a non-random fashion based on their expertise in the particular area under study, was followed (Bhattacherjee, 2012). Respondents included:

- The programme financial manager from the private sector organisation, who was selected due to his responsibility for maintaining and recording the financial budgets for the programme.
- An operations manager from the private sector organisation, who was selected due to his responsibility for the rollout of the programme and managing the use of resources at the site of implementation on a daily basis.
- A spray operator employed by the private sector organisation, who was selected due to his experience in utilising and working with the programme's resources (such as equipment and insecticide).

While the author was in Mozambique for a few days to observe the programme being implemented, the opportunity to interview a manager for the Mozambican Department of Health, responsible for managing the relationship between the Department of Health and the private sector organisation and managing government funded resources, presented itself.

All interviews were semi-structured, employing a mix of closed and open-ended questions, which allowed for additional ‘why’ or ‘how’ questions to be posed to interviewees (Adams, 2015). The objective of the interviews was to secure more granular detail around the implementation and rollout of the programme, and identify resources utilised that had potentially been under or over recorded, or omitted, from the budget. External secondary data research was undertaken by identifying existing information related to malaria prevention and financial costings from different organisations, such as the World Bank and Global Fund. In order to gain insights and knowledge into the nature, implementation and costing of IRS programmes, journal articles, case studies and articles focusing on IRS campaigns were analysed and used to supplement the discussion and findings in this paper, as well as for comparative purposes. This literature was selected based on the criteria that it analysed the financial costs of an IRS intervention, in an African country, between 2000 and 2019. Only African countries were considered given their unique socio-economic environment, in conjunction with the high burden of malaria on the continent, which provided for more relevant comparisons to the IRS campaign under study in this paper. The period selected - 2000 to 2019 - was based on the limited number of financial costing case studies on IRS programmes available in Africa. The majority of case studies available are cost benefit analyses and offer very little detail on the financial costing of programmes. As Larson et al (2016) note, the ‘costing’ section typically offers a concise summary of the generic methods used, or the costing methodology is summarised in the appendices with few examples.

4.2 Limitations of this Study

The first limitation of this Study was once it was underway, the author was not provided with access to the full costing data for all districts initially identified to be part of the Study. As such, it was possible to cost only two of the districts. Furthermore, costing data for these two districts was only made available to the author for 2017.

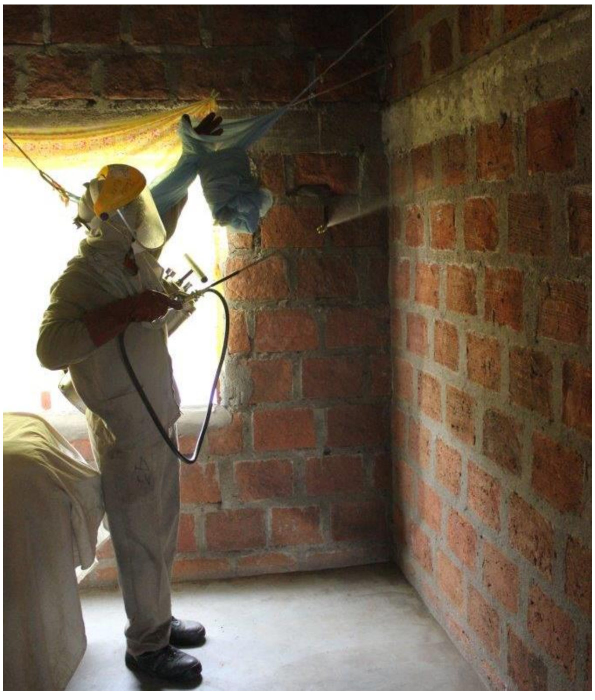
Further limitations included:

- Inaccurate budgets and costings provided by the private sector organisation funding the programmes due to resources utilised during the intervention being omitted, under or over recorded.
- Given that only direct financial costs are considered in this Study, it is a partial economic evaluation of both programmes. While this is useful for understanding the costs related to the programmes, it cannot be used to make conclusions about their cost effectiveness.
- The author spent limited time on the ground in Mozambique to observe the rollout of the programmes, therefore she did not experience its full implementation or have the opportunity to witness or record the practical use of all programme resources over the course of the programme rollout.

4.3 Summary

In this Chapter, the objectives and approach taken for this Study were discussed, with reference to the methodology for data collection. Several limitations to the Study were outlined and explained.

Image 5: A spray operator spraying insecticide in a house in a peri-urban area in Mozambique (Source: Author's own).



Chapter 5: Data Analysis

5.1 Introduction

In this Chapter, the financial costs of the programme are presented and analysed. Comparisons will be made against the IRS programmes discussed in the Literature Review, providing clarification as to whether each cost category consists of fixed or variable costs, and how this relates to the programme either achieving economies of scale, or reductions in the financial cost per person protected.

Costs were grouped into specific categories, namely:

- ‘Vehicles,’ which includes the costs of renting, maintaining, fuelling, branding and insuring vehicles used in the implementation of the programmes.
- ‘Equipment,’ which includes insecticide tanks, tank service kits, nozzles and caps.
- ‘Protective gear,’ which includes the gear used and/or worn by spray operators, specifically boots, masks, hats, visors, goggles, gloves, respirators and overalls.
- ‘Storage and waste disposal,’ which includes expenses related to ensuring the safe storage and disposal of insecticide, as well facilities related to the cleaning and washing of equipment.
- ‘Training’ refers to training of staff in the mixing, application and disposal of insecticide, the transport of spray operators to and from the training facility, and training materials.
- ‘Insecticide’ refers to the cost of the insecticide used during the implementation of the programme.
- ‘Salaries and wages’ include payments made to staff employed in various roles in the implementation of the programme. It includes spray operators, team leaders, drivers, warehouse staff, IEC community mobilisers, wash personnel, accountants and IT specialists, vector managers, field officers, district and provincial health managers.

- 'Advocacy and IEC' costs refer to costs incurred in community awareness campaigns that were run during the course of the year.

- 'General expenses' includes administrative costs, specifically travel and accommodation costs for staff required to travel to both areas to monitor programme implementation; stationery and printing; airtime and internet; detergents and soaps for cleaning of equipment and spray operators; and the annual Christmas party held for staff. Total programme costs in each category are outlined in Table 12 below, with an indication of whether each category is a fixed and/or variable cost to the programme, as well as the financial cost per person protected.

Table 12: Total set-up and operational costs per category for the peri-urban and rural area programmes implemented in 2017.

Cost Category	Peri-urban area	Rural area	Cost type
Vehicles	$13 365,11	$ 70 208,26	Fixed & Variable
Equipment	$16 539,67	$26 215,61	Fixed
Protective Gear	$15 595,95	$37 695,62	Fixed & Variable
Spray Operation Facilities	$3 381,12	$9 743,63	Fixed
Training	$10 857,00	$10 479,64	Fixed
Insecticide	$938 162,16	$165 967,62	Variable
Operational Wages	$44 073,88	$51 233,54	Variable
Management Salaries	$82 668,50	$72 627,52	Fixed
Advocacy and IEC	$4 166,18	$4 166,18	Fixed
General Expenses	$18 227,54	$34 436,51	Fixed & Variable
TOTAL	**$1 147 037,11**	**$482 774,13**	
No. of people protected	170 397	43 641	
Unit cost per person protected	**$6,73**	**$11,06**	

5.2 Category Analyses

1. Vehicles

The daily transportation of spray teams between the central warehouse or storage facility, where spray equipment and insecticide are stored, to the area to be sprayed each day, is a critical part of an IRS programme. Each morning spray teams meet at the storage facility to collect their equipment and insecticide for the day. They are then dropped off in the targeted area for that particular day, which may be a significant distance from the warehouse, and collected and returned to the warehouse once spraying has been completed. In cases where the structures to be sprayed are widely dispersed, such as the rural area under study, it is not feasible for spray operators to walk long distances between structures with their heavy equipment, so transport is imperative (WHO, 2015).

There was a substantial difference in vehicle related costs between the two programmes, as outlined in Table 13 below. This can be attributed to the government sponsorship of three vehicles used in running the peri-urban area programme, while five vehicles were rented in the rural area at a total cost of $60 099,44 to the programme. Given that the vehicles in the peri-urban area were sponsored and not rented, general maintenance ($1 499,82) and insurance ($3 199,63) needed to be paid for by the programme. Maintenance of the rental vehicles in the rural area was covered by the rental agency, and insurance included in the rental cost. Fuel costs in the peri-urban area were 34% lower because only three vehicles were used, compared to five in the rural area, and the distances travelled were shorter in the peri-urban area.

These findings are comparable to those discussed in Study 1 in the Literature Review, where Conteh et al (2004) found vehicle costs to be lower in the peri-urban area under study since fewer vehicles were required, given that the houses targeted for spraying were more easily accessible to the spray team by foot (Conteh et al, 2004).

Overall, vehicle costs accounted for 1,7% of the total programme costs for the peri-urban programme, and 14,5% of the rural programme.

This cost category is overall a fixed cost category. Vehicle rental, branding, insurance and maintenance are all fixed cost items, while fuel is a variable cost as consumption is dependent on the distance covered daily throughout the duration of the programme. Given the investment in vehicles by the rural area programme, economies of scale can be realised should the programme be expanded, using the same number of vehicles.

Table 13: IRS programme vehicle costs for the peri-urban and rural programmes in 2017

Vehicles		
	Peri-urban area	**Rural area**
Vehicle rental	$0,00	$60 099,44
Vehicle Branding	$1 999,76	$1 999,76
Fuel	$6 665,89	$9 998,83
Insurance	$3 199,63	$0
Maintenance	$1 499,82	$0,00
Number of vehicles	3	5
Total	**$13 365,11**	**$70 208,26**

2. Equipment

Spray equipment is an investment at the start of an IRS programme, and can used over several spray seasons (Sine et al, 2011). As a fixed cost, spray pumps are typically expected to last for a period of five years, and as such decrease operational costs after year one, and for the duration of their lifespan (Chanda et al, 2015).

The cost of equipment for the peri-urban programme was 32% lower than that of the rural programme because some equipment from a programme run previously in the area was used. The cost for service kits, 8002E nozzles and nozzle caps was higher for the rural area because of the larger number of spray operators.

This is a similar finding to the three-year costing for Study 3 in the Literature Review, where the cost of spray equipment was lower in the first year than the second year across seven of the twelve countries studied due to their use of equipment from previous programmes. The cost of equipment as a percentage of the overall programme cost across the 12 countries in Study 3 ranged between 0% in Malawi, Senegal and Rwanda (where equipment from a previous programme was used) and 4% in Ethiopia.

The equipment costs in this Study accounted for 1,4% of the overall programme costs of the peri-urban programme, and 5,4% of the overall programme costs of the rural programme. The overall cost for the rural area is comparable to the findings of both Study 1 and Study 2 in the Literature Review. Study 1 found equipment costs to be 5% for the rural area, and 1% for the peri-urban area, whereas it was 4% to 5% of total programme costs in Mozambique, Benin and Mali in Study 2. While the proportion spent on equipment was much higher in Ghana (10%) and Ethiopia (17%) in Study 2, the authors attributed this to high shipping costs, noting that shipping costs varied between 1% in Mozambique to 6% in Ethiopia (Sine et al, 2010). As discussed, the peri-urban programme costs in this category were exceptionally low due to the availability and use of equipment from a programme previously run.

Table 14: IRS programme equipment costs for the peri-urban and rural programmes in 2017

Equipment		
	Peri-urban area	**Rural area**
Hudson X-Pert 15L tanks	$10 718,75	$15 720,84
Hudson service kits	$3 887,81	$4 859,77
Hudson 8001E nozzles	$0,00	$2 783,68
Hudson 8002E nozzles	$1 860,61	$2 658,03
Hudson nozzle cap	$72,49	$193,31
Total	**$16 539,67**	**$26 215,61**

3. Protective Gear

Similar to the spray equipment, several protective gear items are also an investment at the start of an IRS programme, and are expected to last over a period of two to three years (Sine et al, 2011). This includes items such as boots, hats, sling bags, visors, gloves and overalls – the purchase of which will result in a decrease in operational costs after year one, and for the duration of their lifespan. Other items, such as dust masks, plastic spray sheets and disposable filters are variable items which will need to be purchased annually.

As with the Equipment Cost category, the cost of protective gear for the peri-urban programme was lower (42% lower) than that of the rural programme because some unused gear from a programme previously run in the area was provided at no cost to the programme, or was sponsored. Boots, gloves and overalls were sponsored by the government in the peri-urban area, while these items needed to be purchased for the programme for the rural area. Unused mask respirators and disposable filters from the previous programme run in the peri-urban area were used for both the rural and peri-urban areas, incurring no cost.

New hats, sling bags, spray sheets, visors and goggles had to be purchased for both programmes. The costs for these were higher for the rural programme given the larger number of spray team operators on the rural spray team. Overall, protective gear accounted for 1,4% of the overall cost of the peri-urban programme and 7,8% of the rural programme. The significant difference between these two can largely be attributed to government sponsorship of boots and masks, which are high cost items, as well as the larger number of sprayers in the rural area, requiring the rural programme to purchase more gear. Only the findings of the peri-urban programme are comparable to those of Study 3 in the Literature Review, which found PPE costs for large IRS programmes to account for around 2% for smaller programmes in year 1 (which are of a similar size to this Study).

When compared to the costs of protective gear for Study 2 in the Literature Review, the percentage spent on this category varied substantially, from 1% in Mozambique to just under 7% in Ethiopia. This variation was attributed to higher shipping costs in some countries, as with the spray equipment.

Table 15: IRS programme protective gear costs for the peri-urban and rural areas in 2017

Protective Gear		
	Peri-urban area	**Rural area**
Boots	$0,00	$6 210,03
Dust masks	$10 470,28	$15 705,42
Hat with neck protector	$579,08	$836,45
Sling bag	$858,57	$1 572,02
Spray sheets	$1 260,85	$2 308,61
Visors	$1 215,39	$1 580,01
Goggles	$1 211,78	$1 750,35
Gloves	$0,00	$889,05
Mask respirators	$0,00	$0,00
Disposable filters	$0,00	$0,00
Cotton overalls	$0,00	$6 843,70
Total	**$15 595,95**	**$37 695,62**

4. Spray Operation Facilities

In order to implement an IRS programme, requisite physical infrastructure needed to be built at a central site, including warehouses, washing areas and waste disposal systems (WHO, 2015). Both areas under study required the building of some infrastructure to ensure the smooth running of the respective programmes.

In the peri-urban area some infrastructure existed from the previous programme, including a warehouse and soak pit, however a water tank and bathrooms used by the spray team were required. The central site in the rural area had bathrooms but there was no electricity, and a soak pit needed to be constructed (See Table 16).

Given that the peri-urban area already had a soak pit, the cost of facilities development was significantly less than that of the rural area. Furthermore, connecting the bathrooms in the rural area to the electricity grid also came at a high cost ($2923,09) since Mozambique's electricity capacity is very low – a mere 15% of the population in rural areas have access to electricity (USAID, 2014 & Power Africa, 2019). The cost of facilities development as a percentage of total programme costs for the peri-urban programme were therefore much lower, 0,3%, compared to the rural area where they were 2%.

Out of the three studies discussed in the Literature Review only one referred to capital investments in facilities such as soak pits and washing bays. Study 2 noted that such costs had been included but had not been amortised due to the manner in which these expenses had been documented, making it challenging to unmistakably differentiate them from other spray operating expenses (Sine et al, 2010). The exact cost of these investments, where applicable, was not provided, so no direct comparison can be made to this Study.

The set-up of the spray operation facilities for both programmes were once-off fixed costs, associated with year one of the programme, and as such there will be a decrease in operational costs in the following years for these items, for the duration of their lifespan.

Table 16: Spray operation facility costs for the peri-urban and rural area programmes in 2017

Peri-urban Area	Cost		Rural Area	Cost
Water tank for washing up	$49,97		Provide electricity to bathrooms	$2 923,09
Construction of bathrooms	$3 331,15		Construction of soak pit	$6 820,55
Total	**$3 381,12**		**Total**	**$9 743,63**

5. Training

Training of staff is a fixed operational cost item, which takes place on an annual basis. It is critical in ensuring the effective and safe management, and implementation of a programme, and ultimately in achieving the programme outcomes for malaria control (WHO, 2015).

Table 17 outlines the training costs of various personnel involved in the implementation of both of the IRS programmes under study. The costs of training provincial managers fell within the budget of the peri-urban area as that is where they were based, even though they would be responsible for the programme implementation in the rural area.

Training costs are standardised across roles – for example, vector manager spray costs in both the rural area and peri-urban area were the same. Costs were higher for the rural area in instances where more people were to be trained in their particular role, such as the spray operators and IEC personnel, which totalled 120 in number in the peri-urban area, and 156 in the rural area. Training related transport costs were greater for the peri-urban area given the greater distance to the training centre than the rural area.

While the cost of training was similar for both programmes, the cost as a percentage of total programme costs for the peri-urban programme were 0,9%, compared to 2,2% for the rural area. The average cost per day of training was $0,5 for both programmes despite the rural programme training significantly more staff (325 staff) compared to the peri-urban programme (254 staff). This was due to the peri-urban area programme taking responsibility for training the provincial staff (Province Malaria Programme Chief, province driver and NMCP IRS manager), which accounted for an extra 24 days of training in total for the peri-urban programme.

Training as a cost item was not listed as an individual cost category for Studies 2 and 3 in the Literature Review, so no direct comparisons can be made to this Study. Study 1 noted training accounted for 3% of the total spent on both the rural and peri-urban programme, which is somewhat more than the programmes in this Study. Given that a more detailed breakdown for training costs for Study 1 are not provided, it is difficult to gauge why the costs were higher.

Table 17: Training costs for the peri-urban and rural area programmes 2017

Training costs	Peri-urban area			Rural area		
	Number	*Days*	*Cost*	*Number*	*Days*	*Cost*
Training of spray operators & IEC personnel	120	12	$3 597,65	156	12	$4 676,94
Warehouse staff	2	10	$499,68	2	10	$499,68
District driver	1	2	$41,66	1	2	$41,64
Province Malaria Program Chief	1	10	$283,15	0	0	$0
Province driver	1	4	$83,28	0	0	$0
NMCP IRS manager	2	10	$566,29	0	0	$0
Vector manager	2	12	$679,56	2	12	$679,56
Field officer	3	12	$599,61	3	12	$599,61
Water tanks for training camp	2	12	$841,85	4	12	$1 683,70
Training materials		1	$1 665,58	1	1	$999,35
Transport	120		$1 998,69	156		$1 299,16
Total	**254**	**85**	**$10 857,00**	**325**	**61**	**$10 479,64**

6. Insecticide

Insecticide costs, a variable cost, are typically one the biggest cost categories when running an IRS programme. As Study 3 notes, the cost of insecticide can change significantly from one year to the next and is dependent on the amount ordered. Given more countries are moving away from pyrethroid based insecticides to considerably more expensive carbamate based insecticides, the cost of insecticide as a proportion of overall programme costs is likely to rise (Sine et al, 2011). Economies of scale can be achieved by larger IRS programmes through discounts for bulk purchases of insecticide, which can reduce the cost per person protected compared to smaller programmes, ordering less insecticide, not receiving the same discount.

Insecticide costs for the peri-urban programme, at almost $1000 000, accounted for 81,8% of the total programme cost, compared to the rural area where insecticide costs accounted for 34,4% of the overall programme cost. The percentage was lower for the rural programme given that less insecticide was required for the rural programme, which had 2,04 structures per house, requiring 0,33 tanks to spray each house, compared to the peri-urban programme which had 3,55 structures per house requiring 0,56 tanks. Table 18 provides a breakdown of insecticide costs and usage.

Following a similar trend, Study 1 found insecticide to account for 29% and 45% of the overall programme costs for the rural and peri-urban programmes respectively. Insecticide costs, as a percentage of overall programme costs, were much lower for Studies 2 and 3, averaging 12,6% for the five countries covered in Study 2, and 13% and 10% for large and small programmes covered in Study 3, respectively. The reason for this may be that the type of insecticide used for the programmes in Studies 2 and 3 was cheaper.

Table 18: Insecticide costs and usage peri-urban and rural programmes 2017

Insecticide	**Peri-urban area**		**Rural area**	
	Quantity	*Cost*	*Quantity*	*Cost*
Insecticide (litres)	31 932	$938 162,16	5 649	$165 967,62
Structures sprayed	209 684	$4,47	37 428	$4,43
Number structures per house	3,55		2,04	
Houses sprayed per tank	1,79		3,00	

7. Salaries and Wages – Programme Management and Operational

The salary and wage costs for personnel employed by both programmes was broken down between management and operational functions. The Management category included fixed salary costs for staff responsible for the oversight of the programme, such as accountants, IT specialists and district/provincial directors. The Operational wage category included staff responsible for the implementation of the programme, such as the spray operators, supervisors and drivers. Operational wages are variable costs, as these staff are employed on a contract basis for the duration of the spray season.

The fixed Management salary cost category was a higher cost than the variable Operational wage cost category for both the peri-urban and rural programme (see Tables 19 and 20). As the programme scales up, the operational costs are likely to increase through the employment of more spray operators, team leaders and IEC community mobilisers, however the overall cost per person should decrease as more structures will be sprayed, and thereby more people will be protected.

When comparing the salaries and wage costs for the Management salary category for both areas, the difference was relatively significant. The peri-urban costs were $82 668,50 compared to $72 627,52 for the rural programme. This is due to the number of days worked/time dedicated by staff such as the IT specialist, vector manager and programme managers on each area. More time was spent on the peri-urban area, given the larger scale of the programme, which required more management and co-ordination. It is worth noting that the Mozambican health department covered the costs of district and provincial staff in the peri-urban area, and not in the rural area, the time and costs of these personnel were therefore not included in the peri-urban costing.

The Operational wage category was closer in overall cost with the peri-urban area totalling $44 073,88 compared to the rural area at $51 233,54. The rural programme employed a larger number of staff than the peri-urban programme – notably 104 spray operators compared to 80 spray operators for the peri-urban programme. Both programmes paid the spray operators the same daily rate, as per government policy, to ensure equality among spray operators employed by programmes run across the country. While the rural programme employed more spray operators than the peri-urban programme, they were employed for a total of 66 days compared to 89 for the peri-urban programme, based on the greater number of structures requiring more spray days. This difference in how many days spray operators were contracted resulted in the cost of wages for spray operators being similar between both programmes.

The employment of 'mop up' spray operators in the rural area came at an additional cost compared to the peri-urban area which did not require such staff. As noted by Sine et al (2011) in the Literature Review, rural areas are typically home to widely dispersed and nomadic populations. Structures are often not accessible for spraying when spray teams visit, requiring spray operators to return at a later stage to perform follow-up or 'mop-up' spraying and therefore, additional days' worked (WHO, 2015).

Overall the total cost of salaries and wages between the two programmes was similar, at $126 742,38 for the peri-urban programme and $123 861,03 for the rural programme. However, as with Study 1 in the Literature Review, the cost of salaries and wages as a percentage of total programme costs for the peri-urban programme, at 11%, was lower than that of the rural programme at 25,7%.

When compared to the Studies explored in the Literature Review, a similar trend was noted for Study 1, where personnel costs as a percentage of the overall cost of each programme, were higher for the rural area than the peri-urban area, at 17% and 14% respectively. Study 2 reported overall costs for both local and international staff between 7,3% in Ethiopia, to a significantly higher cost at 21,8% in Mali. Labour costs in Mozambique were 11,3% which is similar to that of the peri-urban area in this Study. Sine et al, 2011 noted that the market prices and quality of local inputs, such as labour, can lead to variations in unit costs, which do not reflect the efficiency or cost effectiveness of an IRS programme, using the example of the cost of labour in Ethiopia, which is significantly cheaper than in other countries.

In Study 3, the combined overall percentage cost for local and international labour was 13% for the larger programmes, and 19% for the smaller programmes. This is in keeping with the finding of the smaller rural area programme in this study reporting a higher cost in this category than the larger peri-urban programme.

Table 19: Programme management salary costs for the peri-urban and rural programmes 2017

Fixed Programme Management Salaries	**Peri-urban area**			**Rural area**		
	Number	**Days**	**Total Cost**	**Number**	**Days**	**Total Cost**
Head Office Admin						
Accountant	1	12	$7 994,78	1	6	$7 495,11
IT specialist	1	12	$9 993,47	1	6	$7 495,11
Head Office Management						
Programme managers	2	12	$39 973,89	2	8	$33 311,57
Local office admin						
Accountant	1	89	$222,35	1	70	$174,89
Local Office Management						
NMCP IRS managers	2	4	$1 132,60	2	4	$3 664,27
Province director of health	1	4	$0,00	1	4	$799,47
Province medical chief	1	4	$0,00	1	4	$799,47

NMCP chief	1	4	$0,00	1	4	$799,47
Vector control manager	1	12	$21 985,64	1	8	$14 657,09
District director of health	1	4	$399,74	1	4	$799,47
District medical chief	1	4	$399,74	1	4	$799,47
Province malaria program chief	1	4	$566,29	1	4	$1 832,13
Total	**14**	**165**	**$82 668,50**	**14**	**126**	**$72 627,52**

Table 20: Operational wage costs for the peri-urban and rural area programmes 2017

Variable Operational Wages	**Peri-urban area**			**Rural area**		
	Number	**Days**	**Total Cost**	**Number**	**Days**	**Total Cost**
Spray operators	80	89	$17 788,38	130	66	$17 148,80
Spray operators (mop up)	0	0	$0,00	52	26	$3 377,80
Team leaders	20	89	$5 336,51	26	66	$5 144,64
IEC community mobilisers	20	89	$4 447,10	26	66	$4 287,20
Warehouse managers	2	89	$533,65	2	66	$395,74
Field officers- programme	2	12	$11 592,43	3	7	$10 143,38
Field officer - government	1	4	$1 665,58	1	5	$2 081,98
Driver	1	6	$1 998,69	1	7	$2 331,81
Wash personnel	2	89	$444,71	3	66	$494,67
Data digitiser	1	89	$266,83	1	66	$197,87
Province driver	1	4	$0,00	2	4	$799,47
NMCP driver	1	4	$0,00	1	4	$832,79
District supervisor	1	4	$0,00	1	4	$2 998,04
Province supervisor	1	4	$0,00	1	4	$999,35
Total	133	572	**$44 073,88**	250	457	**$51 233,54**

8. Advocacy and IEC

Advocacy and information, education and communication (IEC) is critical in community sensitisation of the impending implementation of an IRS programme, to achieve social mobilisation around it (WHO, 2015). Spray operators need to gain entry to people's homes for a period of time, and move the furniture in each room, to spray the walls. Without understanding or buy-in from a community, a programme cannot achieve the required minimum target of number of structures sprayed in a certain area, and make progress toward the achievement of malaria prevention (WHO, 2015).

Advocacy and IEC costs for both the peri-urban and rural programme were a set, fixed budget in the form of radio advertising. Radio was deemed to be the most effective means of reaching and communicating to the programmes' target audiences.

This cost category accounted for 0,4% of the overall cost of the peri-urban programme and 0.9% for the rural intervention. The rural programme was just over double that of the peri-urban programme due to the fact that the total programme cost was just under half that of the rural programme. It is not possible to compare Advocacy and IEC costs with the studies discussed in the Literature Review as these costs were included in the total cost of the spray operations category for Studies 2 and 3, while there was no mention of them at all in Study 1.

Advocacy and IEC costs are fixed, annual costs, which may decrease over time as local communities, become familiar with the programme.

Table 21: Advocacy and IEC costs for the peri-urban and rural programmes area 2017

	Peri-urban area	Rural area
Advocacy & IEC	$4 166,18	$4 166,18
Total	**$4 166,18**	**$4 166,18**

9. General Expenses

The General Expenses cost category includes cost items such as travel and accommodation of programme employees – specifically programme managers based in South Africa required to travel to the peri-urban and rural areas to monitor programme implementation; as well as items required for running the programme such as stationery, airtime and laptops.

This cost category accounted for 1,6% of the overall cost of the peri-urban intervention and 7,1% of the rural intervention. The significant difference in the proportion of this cost category as part of the overall costs for the rural programme, when compared to the peri-urban programme, is largely due to higher expenditure for 'airtime and internet'. Given the higher number of spray operators for the rural programme, each requiring internet access and airtime to upload their daily activities to the programme app, for ongoing reporting, monitoring and tracking purposes, data costs were lower than for the peri-urban programme, with fewer spray operators. The cost of 'soaps and detergents' were higher for the rural programme for the same reason – the rural programme employed more spray operators who used cleaning materials to clean their equipment and for personal washing on a daily basis. The cost of the annual Christmas party was also higher for the rural programme then the peri-urban programme given the greater number of spray operators employed.

'Travel and accommodation' costs for both programmes were similar. They were slightly higher for the rural programme given its remote location, with programme managers travelling further to visit the site of implementation. 'Stationery and printing' costs were lower for the peri-urban programme as it was based at one of the offices of the department of health, which covered some of the stationery and printing. Laptop costs were the same, as both programmes required two laptops. It is not possible to compare the general expenses category with the other three studies covered in the Literature Review as specific costs for general administrative items were not provided.

This cost category includes both fixed and variable costs. Airtime and internet, laptops and the annual Christmas party are fixed costs, while travel, accommodation, stationery, printing, detergents and soaps are variable costs. As each programme scales up and employs more spray operators, these costs will increase, however, they should be offset by an increase in the number of houses sprayed, which will reduce the cost per person protected.

Table 22: General expenses cost breakdown for the peri-urban and rural programmes 2017

General Expenses	Peri-urban area	Rural area
Travel & accommodation	$7 124,37	$8 722,22
Stationery & printing	$634,92	$1 428,57
Airtime & internet	$7 619,05	$20 634,92
Detergent & soaps	$555,56	$1 111,11
Laptops	$793,65	$793,65
Christmas party	$1 500,00	$1 746,03
Total	**$18 227,54**	**$34 436,51**

10. Unit cost per person protected

In calculating the unit cost per person protected, the total cost of each programme was divided by the number of people protected, as outlined in Table 23. The unit cost per person for the peri-urban programme was $6,73 per person, while the unit cost per person protected for the rural programme was almost double, at $11,06. This finding is similar to all three Studies in the Literature Review; where the larger the population covered by a programme, the lower the cost per person. For example, in Study 1, the cost per person protected in the peri-urban area, with a population of just over 1,8 million was $4,65 in 2019 terms, while the financial cost per person in the rural area, of more than 71 000 people, was $7,79 in 2019 terms.

This also supports the theory put forward by Studies 2 and 3 that economies of scale are achieved by larger programmes covering bigger population sizes. Study 3, in which the intervention run in Mozambique over a three-year period fell under the 'large country programme' category covering more than six million people, found economies of scale were achieved over time. After adjusting the costs of the study for inflation, the cost per person was $5,25 in 2008, $3,48 in 2009 and $3,25 in 2010. The same can be expected for the programmes considered in this Study as both programmes scale up to reach more households, and in doing so, protecting more people.

Table 23: Unit cost per person protected for the peri-urban and rural programmes in 2017

	Peri-urban area	**Rural area**
Total population	178 032	44 371
Population protected	170 627 (96%)	43 602 (98%)
Total Programme Cost	$1 147 052,23	$482 774,13
Unit cost per person protected	**$6,73**	**$11,06**

5.3 Summary

In this Chapter, the financial costs of the programme were presented and analysed, with comparisons made against the IRS programmes discussed in the Literature Review. Clarification was provided as to whether each cost category were fixed or variable costs, and how this relates to the programme either achieving economies of scale, or reductions in the financial cost per person protected.

Image 6: Spray operators walking long distances between homes, which they will spray with insecticide, in a rural area in Mozambique (Source: Author's own)

Chapter 6: Discussion

6.1 Key findings of the Study

In this Chapter, the results and findings of the analysis will be discussed. The analysis confirms several key arguments raised by the studies explored in the Literature Review, building on existing evidence that:

A. Costs are influenced by the context in which an intervention is delivered.
B. The nature and quantity of subsidised inputs impacts on the costing and programme sustainability.
C. The stage at which an intervention is costed is important.

First, the variations in the financial costs of implementing an intervention reflect the varying contexts of where they are delivered (WHO, 2018). As Sine et al (2011) and Abbott et al, (2014) note, cost analyses of IRS expenditures can vary widely due to individual programmatic and geographical conditions. In this Study the peri-urban programme, with a big population living in a small area, compared to the rural area with its small and more widely dispersed population living in a large area, resulted in a significantly higher cost per person in the rural area, despite its total lower overall programme cost. This supports the findings of the Studies discussed in the Literature Review, which found economies of scale were achieved by interventions covering large populations in smaller areas compared to those covering small populations living in larger areas. In particular, Study 3 found economies of scale were achieved for programmes covering populations of 150 000 people and more, which is in line with the findings for the peri-urban area which protected just over 170 000 at a cost of $6,73 per person, compared to the rural area which protected around 43 000 people at a cost of $11,06 per person.

Furthermore, the larger area to be covered in the rural area required 104 spray operators to be employed, compared to 80 spray operators working for the peri-urban programme. This did equate to additional costs for the rural intervention in terms of purchasing more spraying equipment and gear, as well as higher spray operator training costs. It did not impact significantly on the Wages and Salaries category as the peri-urban programme required spray operators (paid per day worked) to work more days in order to cover the greater number of houses and structures in the area. More vehicles were also required for the rural area programme, incurring an additional cost, due to houses being widely dispersed, making it unfeasible for spray teams to walk from one house to the next with their heavy equipment.

Second, the stage at which a programme is costed is important (Sine et al, 2011). As noted in the Literature Review, if a programme is in the start-up phase, such as the rural area programme in this Study, where an IRS programme had never been run before, capital expenditure will be high, as high cost items will need to be purchased and infrastructure built (Sine et al, 2011). The peri-urban area benefited from unused resources that were made available to the 2017 programme from an IRS programme run previously. This benefit was most evident for the 'Equipment', 'Protective Gear', and 'Spray Operation Facilities' cost categories, where unused items such as nozzles, mask respirators and disposable filters were given to the peri-urban programme at no cost, while the rural area programme had to invest in new equipment and gear for spray operators. The rural programme also had to build a soak pit, which the peri-urban already had from the previous programme, at an additional expense of almost $7000.

Third, the nature and quantity of inputs subsidised or paid for by stakeholders contributing to a programme made a substantial impact on the programme costs (Sine et al, 2011). This is evident for the 'Vehicles' and 'Protective Gear' cost categories. The peri-urban programme benefitted substantially from government sponsorship of three vehicles, incurring zero cost for vehicle rental. The rural area programme did not receive any sponsorship in this category and had to rent five vehicles at a total cost of $60 099,44 to the programme. Boots, gloves and overalls for the peri-urban programme were also sponsored by the government, while the rural area programme had to invest in these items, at a total value of just under $14 000. This was a similar amount spent by the peri-urban programme on the entire 'Protective Gear' cost category at $15 595,95.

Both programmes benefited from Global Fund sponsored insecticide. In order to achieve the most accurate costing of each programme, the cost of the insecticide was calculated based on how much was used by each programme. As Study 3 notes, the cost of insecticide can change significantly from one year to the next as market prices and exchange rates fluctuate and is dependent on the volume ordered (Sine et al, 2011). Furthermore, carbamate based insecticides like the one used for both the peri-urban and rural programmes, are more expensive than pyrethroid insecticides, which increases the cost of insecticide as a proportion of overall programme costs (Sine et al, 2011). This argument held true for this Study, as insecticide was the largest cost category as a proportion of the overall costs for both programmes at $938 162,16 (81,8%) for the peri-urban programme and $165 967,62 (34,4%) for the rural programme.

The sponsorship of insecticide by the Global Fund was a substantial saving to both programmes, demonstrating the impact subsidies can have on the feasibility of implementing an IRS programme, particularly for cash-strapped health departments such as those in most African countries. It does raise the challenge of programme sustainability. Given the recent plateau in financial support by development partners for health-related programmes, such as malaria prevention and elimination, due to funds being channelled toward other global imperatives, African governments find themselves having to play a more significant and creative role in raising the funds required to safeguard ongoing malaria control programmes (Shretta et al, 2017 & Rees, 2018).

As this Study clearly shows, governments receiving sponsorship of high cost items, such as insecticide, must have a strategy in place to cover these costs if the sponsorship is withdrawn or run the risk of having to discontinue their IRS programmes.

6.2 Generalisability, reliability and limitations of the Study

Overall, the generalisability of the results of this Study are relatively poor. While some overall trends can be identified, the significant dependence of the costs on the context in which the intervention was delivered makes it difficult to generalise outside of their specific context. Furthermore, to improve the generalisability of the results, the same costing methodology as this study would need to be taken.

The reliability of the data used in this study is relatively high as the private sector organisation involved in both programmes undertook detailed costings. However, given the involvement of other stakeholders, specifically the Mozambican government, which also contributed resources to the programme and played a role in monitoring both programme's rollout, there are likely to be some resources that were utilised and not reported or recorded in the budget.

The results of this Study are limited by three factors. First, only one year of financial costs for the IRS operations of both programmes was measured. As Studies 2 and 3 showed in the Literature Review, economies of scale can be expected over a period of time, once initial set-up costs and capital investments in equipment and infrastructure have been made. Measuring costs over a longer period allows for trends to be identified, areas where cost savings can potentially be made, and provides a more accurate representation of the long-term sustainability of an IRS programme in a particular context. Second, the lack of detail reported in peer-reviewed literature on IRS programmes in Africa, particularly around the processes and methods followed when undertaking financial cost analyses, made it difficult for the author to use similar methods for this Study. This limited the opportunity for trends to be fully explored around how and why results varied between this Study and those undertaken in different locations. Third, according to Bergmo (2015), costings, which include only direct financial costs such as this Study, are considered partial economic evaluations. While these may be useful for understanding the costs associated with an intervention, they cannot be used to make conclusions about the cost effectiveness of an intervention (Bergmo, 2015). Decision-makers should also consider economic, social, technical and feasibility factors when making a final decision as to whether to proceed with an intervention or not (Cameron et al, 2011).

Despite this, the results are valuable to government decision-makers broadly, and in Mozambique in particular, when considering investments into IRS programmes. Having an in-depth understanding of what resources are required for the implementation of an IRS programme, and how they could be measured in financial terms, is important when attempting to find a balance between limited budgets and competing demands (Ranson, 2018). This Study highlights the need for meticulous and effective budgeting and planning to ensure the implementation of a programme achieves maximum efficiencies, coverage and impact, with the funding available (Pindolia & Dolenz, 2017).

6.3 Summary

In this Chapter, the results and findings of the analysis were discussed. The analysis confirmed several key arguments raised by the studies explored in the Literature Review, notably that costs are influenced by the context in which an intervention is delivered, the nature and quantity of subsidised inputs impacts on the costing and programme sustainability, and the stage at which an intervention is costed is important.

Chapter 7: Conclusion

The aim of this Study was to estimate the financial costs of IRS interventions in four districts in Mozambique between 2013 and 2016. However, due to constraints accessing the financial costings and budgets for all four districts, only two were covered in this Study. Furthermore, costing data was only made available to the author for 2017. Despite this limitation, a comprehensive analysis of the two districts, for which costing data and budgets were made available, was undertaken. As a result, this exploratory Study aims to contribute to the field of Development Studies by providing decision-makers and policy-makers with a view of the potential costs of an IRS investment, particularly when resources are limited, and decisions need to be made around whether to initiate a new programme.

Financial cost information is important to decision-makers when making health intervention investments, particularly when resources are limited (Sine et al, 2011), and the appraisal of costs provides evidence to review an intervention's worth as it moves through its various stages, including conceptualisation, trial, scale-up, assimilation and ultimately, sustainability (LeFevre, 2017).

While this Study was limited by considering the financial costs incurred in one year only, which offers no opportunity for the analysis of trends over time, it did offer the opportunity to identify and compare cost drivers between the two different areas where the programmes were run, and the outcomes each programme faces. As an exploratory Study, it also provides a starting point for future studies of programmes run in both areas, and the opportunity to compare the findings to other programmes run in different countries. While it was also limited by the fact that it was a partial economic costing, as it only looked at financial costs, several key findings were made which support the conclusions of similar studies. These include:

A 'one-size-fits-all' approach to the design or delivery of IRS programmes does not work as the specific local environmental and contextual conditions must be taken into account to maximise both the efficient use of resources, as well as the programme outcomes (Tediosi & Penny, 2016). As Sine et al, (2011) and Abbott et al, (2014) note, cost analyses of IRS expenditures across different programmes can vary widely due to individual programmatic and country specific conditions. Some variations between countries, which impact directly on programme costs, are due to factors unrelated to the structure and implementation of an IRS intervention. These factors are considered cost drivers, as they change the overhead costs of an activity – in this case the overhead costs of an IRS intervention.

This Study highlighted the impact of population size to be covered by an IRS programme, size of the area to be covered and the sponsorship and subsidy of resources as significant cost drivers.

While a lack of heterogeneity in the implementation of IRS programmes across countries and regions makes the comparison of different studies challenging, if the cost drivers and different conditions between interventions are understood, trends can be identified; particularly when considering whether economies of scale can be achieved over time (Sine et al, 2011). Importantly, the question of what factors might mitigate cost savings and what factors might lead to cost savings, can be identified (Sine et al, 2011). This Study clearly demonstrated how costs are influenced by the context in which an intervention is delivered, the impact of the nature and quantity of subsidised inputs on the costing and sustainability of IRS programmes, and how the stage at which an intervention is costed can result in higher or lower expenditures.

This Study provides an important and useful assessment of the financial performance of the two IRS programmes reviewed, which can be used by policy and decision-makers when assessing and looking at areas where improvements might be made, as well as offering guidance when allocating resources for current and future programmes. When planning a new programme this Study may be used to identify some basic costs which can be assumed, however, it is critical that each IRS intervention is designed and implemented around the local context of where it will run (Sine et al, 2010). Ultimately, a Study such as this contributes knowledge and an understanding of the financial cost variability of IRS interventions. It can assist intervention designers and managers in the planning phase and provides the opportunity to benchmark interventions against one another in terms of their cost drivers and efficiencies (Sine et al, 2010).

One of the most important outcomes of this Study is the conclusion of how critical it is for countries working with international organisations responsible for running health-related interventions to have an accurate record of how much an intervention costs, so that if there is a handover of the programme to local authorities at some point, the government has full clarity on what it will cost to continue to run the intervention successfully (Sine et al, 2010). This Study, which involved the Global Fund and an international private sector organisation working with the Mozambican government, is an ideal example of this, as both the Global Fund and private sector organisation provided significant funding to the programmes. Given that financial support to the Mozambican government from external parties is not guaranteed in the long term, the financial costing analysed in this Study would be of value should the government need to implement an IRS programme without support, in terms of matching available resources with available budget.

As Larson et al, (2016) note there is often little detail reported in peer-reviewed literature on cost analyses for a malaria programme. The ‘costing’ section typically offers a concise summary of the generic methods used, or the costing methodology is summarised in the appendices with few examples (Larson et al, 2016). Such lack of detail not only makes it even more challenging for academics, researchers and malaria control programme staff to make use of similar methods for their own studies, but also limits the opportunity for them to understand and explore trends around why and how results differ across different locations and time periods (Larson et al, 2016). This Study, offering a detailed costing and analysis of two IRS programmes, contributes to addressing this challenge, as ultimately, effective budgeting and planning are critical to ensuring the implementation of a programme achieves maximum efficiencies, coverage and impact with the funding available (Pindolia & Dolenz, 2017).

Recommendations for future work

Recommendations for future work in further developing this Study, and knowledge and understanding of the financial costs associated with the implementation of IRS programmes in different contexts, include:

Financial costings for subsequent years of both programmes should be undertaken so as to identify cost trends over time, the cost drivers behind any changes in costs, and the long-term sustainability of both programmes.

A full economic costing of both programmes should be undertaken so as to calculate the true costs and benefits of each programme, and identify their overall net present value, as well as the opportunity costs if the resources were to be used for another purpose.

Further research should be undertaken into the role and impact of multiple donors, subsidies and sponsorships on the short and long-term viability and outcomes of IRS programmes. Given the reliance of the programmes in this particular Study on subsidies and sponsorships, it is recommended that future studies consider how such programmes could move towards becoming self-sustainable to ensure their long-term viability.

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Appendices

Key informant interview questions:

A. IRS Programme Financial Manager

1. What is your role at on the programme?
2. Where does the funding for the interventions come from?
3. What are the challenges in managing the costs of the interventions and sticking to the budget?
4. Have there been unanticipated costs and what were they?
5. What is the biggest single cost in running the IRS interventions?
6. How does the Metical – dollar exchange rate impact on your budget and programme costs and how do you manage this?

B. IRS Programme Operations Manager

1. What is your role on the programme?
2. Please can you walk me through how the programme has been rolled out, in terms of the IRS component?
3. What challenges do you face running the IRS programme in Mozambique?
4. What partners/stakeholders do you work with and what is their role in the malaria programme?
5. Who is responsible for training the sprayers?
6. What targets do you have for each area?
7. Who pays for the insecticide?
8. Who is responsible for the transport of the insecticide to the areas that will be sprayed?
9. Where is the insecticide stored?
10. Is there security protecting the insecticide, and if so, who pays for this?
11. Is there a site manager in each district/town that GBM sprays?

C. IRS Spray Operator

1. Do you live in this town where you work as a sprayer?
2. How long have you worked as a sprayer?
3. Did you work as a sprayer for another company or the government before you started working for this programme?
4. What does your job as a sprayer see you do on an average/typical day?
5. Do you have another job or source of income?
6. Do you need a qualification or licence to spray?
7. Who trained you to become a sprayer?
8. How long is the training programme and where does it take place?
9. How often do you work as a sprayer?
10. What are your working hours as a sprayer?
11. What is the most difficult part of your job as a sprayer?
12. How many houses do you typically spray in a day?
13. How long does it take to spray at house on average?
14. How many people typically live in a house based on your experience?
15. Is the community happy to let you spray inside their homes?
16. How does the community know where and when you will be spraying in their area?
17. Do people have to take time off work, so they are at home when you are coming to spray?

D. IRS Programme Manager for the Mozambican Department of Health

1. What is your role on the programme?
2. Where does the funding for the interventions come from?
3. What are the challenges in managing the costs of the interventions and sticking to the budget?
4. Have there been unanticipated costs and what were they?
5. What is the biggest single cost in running the IRS interventions?

25 April 2017

Ms Liezl Knoll 991231644
School of Built Environment and Development Studies
Howard CollegeCampus

Dear Ms Knoll

Protocol Reference Number: HSS/0154/017M
Project Title: Estimates of the cost of Goodbye Malaria's (GBM) indoor residual spraying (IRS) operations to reduce the malaria incidence in the district of Boane, Magude, Marracuene and the town of Xinavane in Mozambique from 2013-2016

Full Approval – Expedited Application

In response to your application received 14 February 2017, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours [redacted]

....

Dr Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

cc Supervisor: Dr Gerard Boyce
cc. Academic Leader Research: Professor Oliver Mtapuri
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