THE ADDITIONAL EFFECT OF FOCAL INDOOR RESIDUAL SPRAYING ON INCIDENCE OF MALARIA IN A SETTING WITH HIGH INSECTICIDE TREATED BED NET COVERAGE IN MANSA DISTRICT, LUAPULA PROVINCE

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DECLARATION

I **Akatama Biggie Inambao** do declare that this dissertation represents my own work and that it has neither in part nor in whole, been presented as material for award of any degree at this or any other University. Where other people's work has been used, acknowledgements and references have been made.

Signed: …………………………………………...

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CERTIFICATE OF COMPLETION OF DISSERTATION

I, **Akatama Biggie Inambao** hereby certify that this dissertation is the product of my own work and, in submitting it for the degree of Master of Science in Public Health by Research (Field Epidemiology), further attest that it has not been submitted to another University in part or whole for the award of any programme.

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APPROVAL

The University of Zambia approves this dissertation of Akatama Biggie Inambao in partial fulfillment of the requirements for the Award of the Master of Science in Public Health, by Research (Field Epidemiology)

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Examiner 3………………………... Signature …………………… Date ……………………

Chairperson ……………………… Signature …………………… Date ……………………
Board of examiners

Supervisor ………………………. Signature ……………………. Date ……………………

DEDICATION

I would like to dedicate this work to the following: my wife Mary Wamundila and my children Namangolwa, Trevor, Annie and Mwala Inambao for their emotional support, being so understanding during my absence from home and for encouraging me to pursue my dreams.

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ABSTRACT

Malaria is a leading cause of morbidity and mortality especially in children under 5 years and pregnant women in Zambia. Environmental factors and behavioral patterns of vectors and human populations combine to provide favorable conditions for malaria transmission. Focal-Indoor Residual Spraying (IRS) was first conducted in Zambia's Luapula Province in 2014 in areas with high burden of malaria.

A quasi experimental study design comparing incidence of malaria pre and post-IRS intervention was used. Malaria is diagnosed by use of rapid diagnostic test or microscopically. Malaria incidence was calculated based on extrapolated census data for health centres. We extracted malaria morbidity data from the Health Management Information System from 2013 to 2015. There was no physical contact with participants as only secondary data were used. Epi-Info version 7 was used to analyze the data. Associations between variables were tested using a Chi-square with the level of statistical significance set at desired accuracy of 5% and 95% confidence interval.

A total of 11 of 25 (44%) health facility catchment areas conducted focal-IRS in 2014 in addition to Insecticide Treated bed Nets (ITNs) use. Six of 11 (55%) IRS health facility catchment areas recorded spray coverage of above 85%. Of the 11 IRS health facility catchment areas, 5 (45%) recorded decrease in incidence of total malaria (clinical and confirmed) in 2015 compared to 2013 whilst 6 (55%) recorded increased incidence post spraying. About 5 of 14 (36%) ITN only health facility catchment areas recorded decrease in incidence of total malaria in 2015 compared to 2013. Only 1 of 11(9%) IRS-health facility catchment areas (Muwanguni RHC) recorded decrease in incidence of lab-confirmed malaria while 91% recorded increase in 2015 compared to 2013.

Use of focal IRS strategy in addition to ITNs in Mansa district did not yield additional effect compared to use of ITNs only. This strategy needs to be redesigned to ensure that questions of its efficacy and operationalization are well understood before scale-up of the concept is enhanced.

Keywords: Malaria; Incidence; focal indoor residual spraying; insecticide treated net.

ABBREVIATIONS AND ACRONYMS

AIRS	Africa Indoor Residual Spraying
CSO	Central Statistical Office
DCMO	District Community Medical Office
DDT	Dichloro – diphenly – trichloromethane
DHIS2	District Health Information System version 2
FETP	Field Epidemiology Training Program
FIRS	Focal Indoor Residual Spraying
GDP	Gross Domestic Product
HC	Health Centre
HFCA	Health Facility Catchment Area
HMIS	Health Management Information System
IRB	Institutional Review Board
IRS	Indoor Residual Spraying
ITNs	Insecticide Treated mosquito Nets
IVM	Integrated Vector Management
KCM	Konkola Copper Mines
LLIN	Long Lasting Insecticidal Nets
MDGs	Millennium Development Goals
MOH	Ministry of Health
NMCC	National Malaria Control Centre
NMCP	National Malaria Control Program
NMSP	National Malaria Strategic Plan
OPD	Out Patient Department
PMI	US Presidential Malaria Initiative
RDT	Rapid Diagnostic Test
UNZA	University of Zambia
WHO	World Health Organization

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CHAPER ONE

INTRODUCTION

The study has focused on the additional effect of focal indoor residual spraying on incidence of malaria in a setting with high insecticide treated bed nets coverage in Mansa district, Luapula province. It covers the background of the study, statement of the problem, objectives of the study, and justification of the study.

1.1 Background of the study

Malaria is a major public health problem. It is transmitted to humans by an infected female anopheles mosquito bite (Cook & Zumla, 2009). Malaria is a completely preventable disease; however, about 3.4 billion people – almost half of the world's population – are at risk of the disease globally with 1.2 billion people at high risk (World Health Organization, 2014).

Environmental factors and behavioral patterns of vectors and human populations combine to provide favorable conditions for malaria transmission (Boutin et al, 2005). Geographic distribution of malaria around the world where malaria is found depends mainly on climatic factors such as temperature, humidity, and rainfalls, where malaria is transmitted in tropical and subtropical areas. In Africa, an estimated 74% of the population lives in areas that are highly endemic and 19% lives in epidemic prone areas (WHO, 2014). About 30% of outpatient consultations, 20-50% of hospital admissions, and 20% of under-5 mortality are due to malaria (WHO, 2003). In 2013, there were about 198 million malaria cases and an estimated 584 000 malaria deaths (WHO, 2014). Increased prevention and control measures have led to a reduction in malaria mortality rates by 47% globally since 2000 and by 54% in the WHO African Region (WHO, 2014).

Malaria is also endemic in Zambia and a leading cause of morbidity and mortality, especially in children under five years and pregnant women (NMSP, 2011). Fighting the disease is a national priority that requires a focused, comprehensive, and consistent approach in order to achieve the vision of “a malaria-free Zambia by 2030” (MOH, 2011). As part of Zambia’s National Malaria Control and Elimination Strategy, a number of interventions has been launched to reduce malaria, including universal insecticide treated mosquito net (ITN) coverage and indoor residual spraying (IRS) in targeted areas. The plan also includes strategies to: improve malaria case management;

improve diagnostic testing capacity and quality; increase coverage of three doses of sulfadoxine - pyrimethamine (SP) for intermittent preventive treatment in pregnancy (IPTp); strengthen social behavior change and communication (SBCC) for malaria prevention and treatment; and establish a robust surveillance, and monitoring and evaluation framework (MoH 2011).

IRS, while typically used for low malaria risk or epidemic prone regions (WHO, 2007), has been further advocated for use in high and medium malaria transmission settings (Kolaczinski et al, 2007, Kim et al, 2012). In 2011, 30 (of 44) countries in Africa with ongoing malaria transmission used both IRS and ITN in at least some areas to further reduce the malaria burden (WHO, 2012). The proportion of at risk populations protected by IRS in Africa has increased from less than 5% in 2005 to 11% in 2011 (WHO, 2012).

Beyond mathematical modeling of ITNs and IRS on health outcomes (Chitnis et al, 2010, Griffin et al, 2010, Yakob et al, 2010), few studies have empirically measured the combined effectiveness of the two interventions. In rural Gambia, a community-based trial is currently exploring the effectiveness of having ITNs and IRS against clinical malaria (Pinder et al, 2011). In Kenya, Hamel and colleagues showed that household members who were exposed to both ITNs and IRS had significantly greater protection against malaria infection than those who only used ITNs (Hamel et al, 2011); however, the study did not include a comparison group of IRS - only users. In southern Benin, on the other hand, no significant protective benefits against malaria parasite density were provided by ITNs and IRS combined, as compared to ITNs only (Corbel et al, 2012).West et.al (2012), found that implementing IRS in addition to ITNs was beneficial for individuals from villages with a wide range of transmission intensities and net utilization levels. Net users received additional protection from IRS. These results demonstrated that there is a supplementary benefit of IRS even when ITNs are effective. Mamta et al. (2009) proved that in spite of the constraints associated with IRS, it still has a major role in the control of malaria if implemented with proper supervision, better coverage and community participation.

Zambia first introduced focal IRS in 2014. This was conducted in seven out of the eleven districts of Luapula province in targeted health facility catchment areas with high prevalence of malaria. These include Chienge, Kawambwa, Mansa, Milenge, Mwansabombwe, Mwense and Nchelenge districts (NMCC, 2014). Based on this activity, this study therefore focuses on effects of focal IRS in a setting with high coverage of ITN in Mansa district of Luapula province pre and post 2014 spraying season.

1.2 Statement of the problem

Luapula province is one of the 3 poorest provinces in Zambia (World Bank, 2015). Fishing and farming are the main economic activities. The province has experienced a general increase in malaria cases since 2010. Zambia's Health Management Information System (HMIS) revealed that the province had the total incidence of 715 per 1000 persons by end of 2013 from 625 per 1000 persons in 2012. The HMIS also shows that the province recorded highest incidence of malaria among pregnant women (119 per 1000 persons) compared to other provinces in 2013 inspite of the provision of malaria preventive interventions such as use of ITNs.

Despite the high incidence of malaria recorded in Luapula province and Mansa in particular, the province opted to conduct focal IRS in areas with high prevalence of malaria as opposed to blanket IRS being conducted in other provinces. This was implemented in seven out of the eleven districts of Luapula province. Mansa, which is the provincial capital, was one of the seven districts where focal IRS was conducted. In this district, only eleven out of twenty five Health centre catchment areas were sprayed in 2014 while no spraying was done in 2013.

Currently, there is no information published on effect of IRS and its additional effect when combined with ITNs on incidence of malaria in Mansa district in particular and Luapula province of Zambia in general. This study sought to understand the effectiveness of focal IRS in combination with ITNs/LLIN in reducing incidence of malaria.

1.3 Justification for study

IRS and ITNs remain the frontline interventions for malaria vector control in Zambia (Pluess et al, 2010). The country is using these primary interventions of proven efficacy recommended by the WHO Global malaria programme for effective malaria control, set to be scaled up if countries were to move towards achieving the United Nations Millennium Development Goals by 2015 (WHO 2006, WHO 2007). In 2014, Ministry of Health supported 83 out of 103 districts for IRS and sprayed 1,224,774 out of 1,403,709 (coverage of 87.3%) targeted structures (semi and permanent) in areas that have the highest prevalence and the population protected was 5,487,916 (NMCC 2014). In 2012, Luapula province reported 90% of households with at least one ITN.

Focal IRS strategy was piloted in Zambia in the districts of Luapula province in 2014 for the first time. From the inception of focal IRS concept, no study has been done to evaluate the effect of focal IRS in combination with ITNs in the prevention and control of malaria compared to ITN usage alone after programmatic shift from generalized IRS to focal IRS in Luapula province.

Our study was therefore designed to determine whether combined interventions of focalized IRS and use of ITNs provided significantly different protection against malaria from the use of ITNs alone. The study also helped Mansa district understand their administrative local context with regard to the impact of IRS and guide implementation of programs and add to the existing pool of knowledge that can be of benefit for policy direction in similar settings and elsewhere.

1.4 Objectives

1.4.1 General Objective

To determine whether Focal IRS in combination with ITN use is more effective in preventing malaria than just ITN use alone

1.4.2 Specific Objectives

1. To establish IRS coverage in health centre catchment populations that received focal IRS;
2. To establish ITN/LLIN coverage in all the health centre catchment populations of Mansa District from 2013 to 2015;
3. To compare change in incidence of malaria in IRS health centres catchment populations to ITN only health centres catchment population pre and post focal IRS in Mansa district.

1.5 Hypotheses

H0: There is no difference in effect of focal indoor residual spraying on incidence of malaria between IRS health facilities and ITN only health facility catchment areas in a setting of high insecticide treated nets in Mansa district over one year period.

1.6 Organization of the Dissertation

This chapter gives an introduction and background to the study. The background brings out the gaps which this study intends to fill up. The statement of the problem, justification of the study, the objectives, hypothesis are presented in chapter one. Chapter two presents literature review which covers the Global malaria control situation, Sub - Saharan Africa malaria control, Malaria Control in Zambia, diagrammatic representation of various effects of ITNs and IRS on mosquitoes that enter or attempt to enter houses and addresses the development of insecticide resistance. Chapter three discusses the methodology that was used in this study and of course the study design which guided this study. Chapter four presents the findings of the study while chapter 5 presented the discussion and interpretation of the findings of the study. Lastly, conclusions and recommendations of the study are made in chapter six. The necessary research instruments for this study were appended just after the references.

CHAPTER TWO

LITERATURE REVIEW

2.1 Global malaria control situation

Malaria transmission occurs in all six World Health Organization (WHO) regions. Globally, an estimated 3.2 billion people are at risk of being infected with malaria and developing disease, and 1.2 billion are at high risk (more than 1 in 1000 chance of getting malaria in a year). According to the latest estimates, 198 million cases of malaria occurred globally in 2013and the disease led to 584, 000 deaths. The burden is heaviest in the WHO African Region, where an estimated 90% of all malaria deaths occur, and in children aged l-5 years, who account for 78% of all deaths. People living in the poorest countries are the most vulnerable (WHO 2014).

Globally, 123 million people were protected from malaria through the use of IRS in 2013(WHO 2014). This represents 3.5% of the global population at risk. The Global Malaria Action Plan (GMAP) (WHO, 2009) outlines the Roll Back Malaria Partnership's vision for a substantial and sustained reduction in the burden of malaria in the near and mid-term, and the eventual global eradication of malaria in the long term, when new tools make eradication possible.

To reach this vision, the targets of the GMAP are to:

- *Achieve* universal coverage, as recently called for by the UN Secretary-General, for all populations at risk with locally appropriate interventions for prevention and case management by 2010 and sustain universal coverage until local field research suggests that coverage can gradually be targeted to high risk areas and seasons only, without risk of a generalized resurgence;
- *Reduce* global malaria cases from 2000 levels by 50% in 2010 and by 75% in 2015;
- *Reduce* global malaria deaths from 2000 levels by 50% in 2010 and to near zero preventable deaths in 2015;
- *Eliminate* malaria in 8-10 countries by 2015 and afterwards in all countries in the pre-elimination phase today; and
- In the long term, *eradicate* malaria world-wide by reducing the global incidence to zero through progressive elimination in countries.

2.2 Sub - Saharan Africa malaria control

In the past 10 years there have been unprecedented reductions in malaria in many parts of sub-Saharan Africa. Scale-up of the use of long-lasting insecticidal nets (LLINs), indoor residual spraying (O' Meara et al, 2010), and prompt treatment of clinical cases with artemisinin combination therapies (WHO, 2013)have resulted in at least eight countries in the region meeting the Millennium Development Goal of reducing the incidence of malaria. Despite this major public health achievement, in 2012 there were an estimated 207 million cases of malaria and 627 000 deaths due to malaria worldwide, with an estimated 90% of these deaths occurring in sub-Saharan Africa.

In sub-Saharan Africa, the proportion of the population protected by at least one vector control method has increased in recent years, and it reached 48% in 2013 (WHO, 2014). The universal coverage with either LLINs or indoor residual spraying (IRS) is the major malaria prevention strategy and in many settings where IRS is used, ITNs/LLINs are already deployed. The number of LLINs delivered in sub-Saharan Africa increased from 6 million in 2004 to 145 million in 2010, with 54% of households having at least one net in 2013 and about 36% of the population sleeping under a LLIN (WHO, 2013). Although the protection afforded by ITNs (Lengeler, 2004) and IRS (Pluess et al, 2010) alone is well known, the joint effect of these interventions is poorly understood (Okumu et al, 2011, Kleinschmidt et al, 2009). Evidence about this crucial issue is contradictory. Only one experimental hut study has been done to investigate this issue and showed no additional benefit of using IRS with LLINs (Okumu et al, 2013). However, analysis of survey data from African countries (Corbel et al, 2012) showed that the use of LLINs and IRS together was associated with lower malaria prevalence than the use of LLINs alone (Fullman et al, 2013), and a review of non-randomized studies showed that addition of LLINs to IRS was associated with lower parasite rates than IRS alone (Kleinschmidt et al, 2009).Similarly, investigators of a non-randomized field trial in Kenya showed that use of a combination of pyrethroids IRS and LLINs provided 61% greater protection against the incidence of infection in children than the use of LLINs alone (Hamel et al, 2011).

In addition, Mabaso (2004) showed that in Southern Africa (South Africa, Swaziland, Namibia, Zimbabwe, and Mozambique) IRS protected the community after its introduction and in some areas managed to eliminate the disease. WHO (2011), observed that IRS programmes have expanded considerably over the years and the number of people protected in the African region increased from 10 million in 2005 to 73 million in 2009, which is equivalent to protecting 10% of the population at risk. According to Zhou et al. (2010), the wide-reaching benefits of IRS in reducing vector prevalence and disease incidence was observed for at-least six months, suggesting targeted IRS as an effective tool in malaria control. For Senegal, 2010 –2011 reports indicate that the country's national malaria control programme used a different insecticide solution for the 2010 spraying season, which resulted in a shorter duration of protectiveness provided by IRS nationwide (i.e., six months rather than the usual twelve) (PMI, 2012).

2.3 Malaria Control in Zambia

Zambia is one of the unique countries that have experienced swings in the prevalence of malaria in the past 60 years. Prior to 1970, malaria in urban areas in Zambia, especially towns along the line of rail (Copperbelt, Lusaka to Livingstone), was kept to a minimum due to effective implementation of prevention and control programmes of control measures, enforcement of public health laws and sound supportive economy (MOH, 2007).

Malaria control in Zambia commenced in 1929 (Watson, 1953) and has progressed through several stages. Pioneering interventions constituted environmental management and mosquito net use, coupled with diagnosis and treatment using quinine (Utzinger et al, 2002). The success of vector control was due to enactment of "the Mosquito Extermination Act Cap 312 of the laws of Zambia" (C. 312, 1964). IRS coverage was reduced by 30% by 1973 and stopped in the mid-1980s (Chanda et al, 2013). With reduced vector control and the development of drug resistance (Himpoo et al, 1967, Kofi et al, 2009) malaria cases increased from 21.5 per 1,000 in 1976 to 394 cases per 1,000 in 2002 (Utzinger et al, 2002).

2.3.1 Malaria vector control interventions

Vector control remains the main and most widespread preventive approach to prevent malaria transmission and therefore is one of the four basic technical elements of the global malaria control strategy. In Zambia, vector control is implemented within the context of the Integrated Vector Management (IVM) Global Strategic framework with strong adherence to its five key attributes (WHO 2004, Chanda et al 2008). The principal objective of vector control is the reduction of malaria morbidity and mortality by reducing the levels of transmission (NMCC, 2010). Programmatic deployment of interventions follows clearly defined eligibility criteria based on local evidence in conformity with national guidelines (MOH, 2011). However, the WHO has provided guidelines for individual countries to use when prioritizing IRS, ITNs or both (WHO 2006, WHO, 2007). For example in high transmission areas, it is recommended that children and pregnant women, who are most at risk, are preferentially covered while at the same time the countries should work towards ensuring that everyone gets and uses an insecticide-treated net. Moreover, in low transmission areas, public health authorities should establish priorities based on geographical distribution of malaria (WHO, 2007, WHO, 2008).

2.3.2 Single malaria vector control interventions

These interventions focus on use of either ITNs or IRS alone in malaria vector control in a particular setting. Pluess *et al* (2010), states that primary prevention of malaria is essentially achieved through two main vector control interventions: ITNs and IRS. Predominantly, ITNs are targeted at rural areas whilst IRS is targeted at urban and peri-urban areas. Larval Source Management (LSM) is deployed during the dry season and confined to the urban and peri-urban areas where the breeding sites for malaria vectors are discreet and accessible (MOH, 2011).

i) Insecticide Treated Nets

An insecticide-treated net (ITN) is a mosquito net that repels, disables and/or kills mosquitoes coming into contact with insecticide on the netting material (WHO, 2007). It is a form of personal protection that has been shown to reduce malaria illness, severe disease, and death due to malaria in endemic regions. The distribution of ITNs strives towards attaining a goal of universal (100%) coverage with at least 85% utilization rates in all eligible areas (MOH, 2011). They provide physical protection against mosquitoes and malaria transmission, which is largely conferred to the individual using the net. While these nets deter transmission to the individual, they also help prevent continued transmission to other household members and nearby community members (WHO, 2011).

There are two categories of ITNs: conventionally treated nets and long-lasting insecticidal nets (LLINs). A conventionally treated net is a mosquito net that has been treated by dipping in a WHO-recommended insecticide. To ensure its continued insecticidal effect, the net should be re-treated after three washes, or at least once a year. An LLIN is a factory-treated mosquito net made with netting material that has insecticide incorporated within or bound around the fibres. The net must retain its effective biological activity without re-treatment for at least 20 WHO standard washes under laboratory conditions and three years of recommended use under field conditions (WHO, 2007). One very significant shift from past practice is that LLINs, which are designed to protect people for up to 3-5 years of use, are now being prioritized over ordinary or conventional ITNs, which have a far shorter duration of insecticidal activity (WHO, 2009, WHO, 2007). Indeed it is expected that only LLINs will be produced in future (WHO, 2009).

The WHO has provided guidelines for individual countries to use when prioritizing IRS, ITNs or both (WHO, 2007). For example in high transmission areas, it is recommended that children and pregnant women, who are most at risk, are preferentially covered while at the same time the countries should work towards ensuring that everyone gets and uses an ITN. Moreover, in low transmission areas, public health authorities should establish priorities based on geographical distribution of malaria (WHO 2007, WHO, 2008). Universal coverage of the population at risk with ITN/LLIN is recommended by the WHO and most malaria endemic countries (32/44) in Africa have adopted this policy. In several countries in sub- Saharan Africa, household ownership of ITNs has been scaled up rapidly over the last few years (WHO, 2012, Flaxman et al, 2010). In addition, if high community coverage is achieved, the numbers of mosquitoes, as well as their length of life will be reduced. When this happens, all members of the community are protected, regardless of whether or not they are using a bed net. To achieve such effects, more than half of the people in a community must use an ITN /LLIN (WHO, 2007).

ii) Indoor Residual Spraying

IRS is one of the primary and formidable vector control interventions for reducing and interrupting malaria transmission and one of the most effective methods which has made remarkable gains in the fight against malaria. It is the application of long-acting chemical insecticides on the walls and roofs of all houses and domestic animal shelters in a given area, in order to kill the adult vector mosquitoes that land and rest on these surfaces. The operational design for IRS has an annual cycle (MOH, 2009).The basic principle behind IRS is that, after biting, the female mosquito eventually rests on sprayed surfaces of the house, where it picks up a lethal dose of insecticide, thus preventing transmission of the parasite to others. Therefore, for IRS to be effective, the mosquito must rest indoors and be susceptible to the insecticide in use. Depending on the type of insecticides used, IRS is also found to protect inhabitants against mosquito bites by diverting the vector from entering a sprayed house, an effect known as excito-repellency.

The primary effects of IRS towards curtailing malaria transmission are twofold: i) to reduce the life span of vector mosquitoes so that they can no longer transmit malaria parasites from one person to another, and ii) to reduce the density of the vector mosquitoes (WHO, 2006). Scaling up of IRS has been endorsed by WHO since 2006 in Africa (WHO, 2006). In some situations, IRS can lead to the elimination of locally important malaria vectors. Some insecticides also repel mosquitoes and by so doing reduce the number of mosquitoes entering the sprayed room, and thus human-vector contact. In Asia, Russia, Europe and Latin America malaria was eliminated or greatly reduced as a public health problem through IRS (Pluess et al, 2010).

Zambia first initiated IRS with DDT in the1950s, at the same time malaria became a notifiable disease (MOH, 2000).The intervention has been expansively implemented with incremental scale up from 5 districts in 2003 to 36 in 2008 to 54 in 2010 and 72 in 2012. With the goal of covering at least 85% of eligible households in targeted areas, IRS is deployed through annual campaigns using pyrethroids at 25 mg/m^2 (deltamethrin and alpha-cypermethrin' (Bayer); and lambda cyhalothrin, (Syngenta), carbamates (Bayer), organophosphates (Syngenta) and DDT at 2 g/m2 (Avima). The spraying is carried out prior to the peak malaria transmission that coincides with the rainy season from November to April (MOH, 2009).IRS was at its highest in the local, municipal and mine controlled towns and this contributed to reduction in malaria incidence. From 2006 to 2009, all-cause mortality rates for children under five years old decreased by 29% according to 2012 Malaria Indicator Survey.

In 2012, 74 percent of households were covered with at least one ITN or recent IRS. Percentage of households that received IRS in the last 12 months increased from 10% in 2006 to 25% in 2012 (MOH, 2012). Indoor spraying with insecticides kills the mosquito vector and is effective for 3–6 months, depending on the insecticide used and the type of surface on which it is sprayed. Longer-lasting forms of insecticides are under development (WHO, 2014). Furthermore, studies confirm that IRS is cost-effective, although developments such as insecticide resistance could change the cost-effectiveness over time (Hanson et al. 2004).

iii) Focal Indoor Residual Spraying in Zambia

Focal indoor Residual Spraying (FIRS) has the same principles as of the generalized IRS, but is more limited to targeted areas especially with high malaria burden. Zambia first introduced focal IRS in 2014. This was conducted in seven out of the eleven districts of Luapula province in targeted areas with high prevalence of malaria. These include Chienge, Kawambwa, Mansa, Milenge, Mwansabombwe, Mwense and Nchelenge districts. The four districts that did not benefit from focal IRS were Chembe, Chipili, Lunga and Samfya districts (NMCC, 2014).

2.3.3 Combined malaria vector control interventions

The operational and biological mechanisms by which the combined use of ITNs and IRS may provide greater protection than each intervention alone is supported by field studies and modeling exercises. Subsequently, the combined deployment of ITNs and IRS target mosquitoes at multiple, complementary transmission points and is likely to most effectively minimize the number of opportunities for malaria vectors to reach any given individual compared a singular intervention (Okumu et. al, 2011). Also, when used in combination, the insecticidal protection provided by ITNs and IRS may last longer than when only one insecticide-based intervention is used (Protopopoff et. al, 2007).

On the other hand, IRS, which was previously recommended for use in epidemic situations, in isolated communities and in low to moderate transmission areas, is now recommended also for high transmission areas (Kolaczinski et al, 2007). Perhaps most interesting, is the recognition that either ITNs or IRS if used alone may not be sufficient to disrupt malaria transmission, especially in holoendemic and hyperendemic areas, and that these two methods should preferably be combined in such situations (Kolaczinski et al, 2007, WHO, 2007, Griffin et al, 2010).

Insecticides used on nets or for IRS affect mosquitoes at different levels along the path towards the individual or human inside the sprayed hut. Mosquitoes can be deterred and diverted before they enter houses, killed by the IRS or ITNs, or they can be irritated so that they exit the huts earlier than normal. Exit may occur before or after the mosquitoes have fed, but both the fed and the unfed mosquitoes may die later after they have left the huts due to sub-lethal effects of the ITN or IRS insecticides (Figure 1).

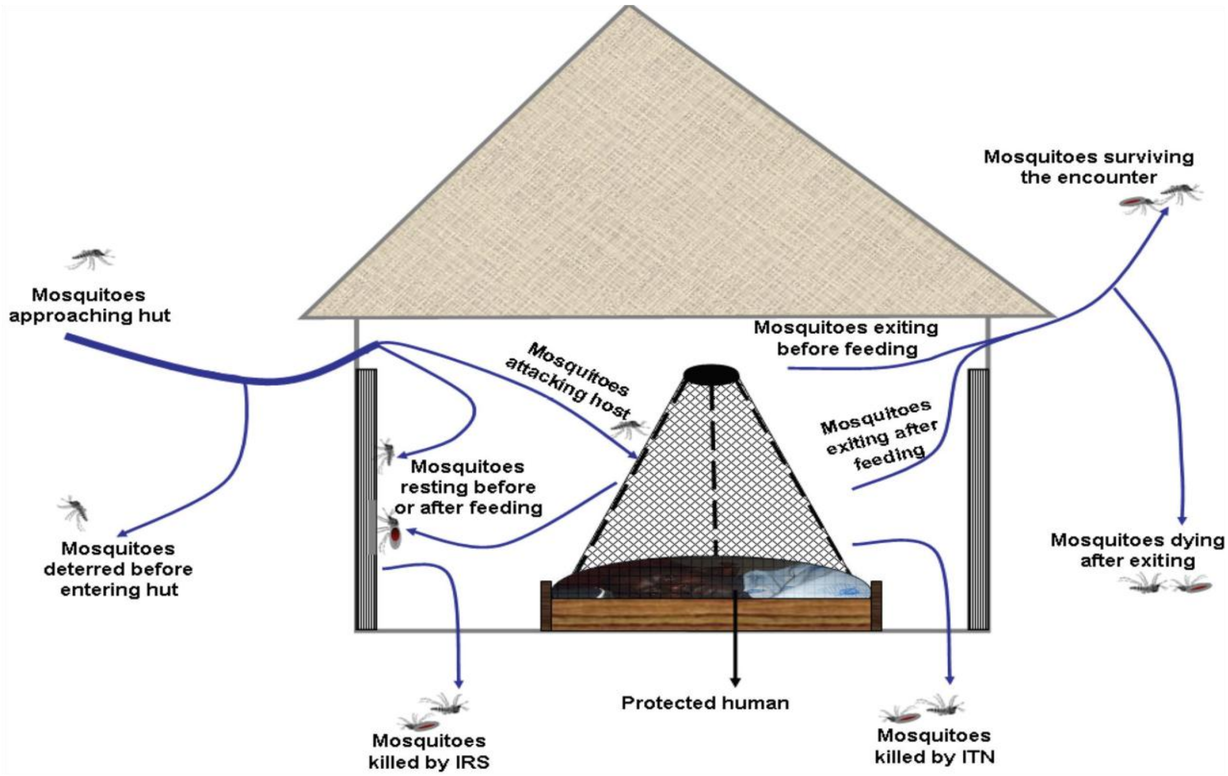

Figure 1: A diagrammatic representation of various effects of ITNs and IRS on mosquitoes that enter or attempt to enter houses.

Where ITN and IRS insecticides have overlapping modes of action, insecticide combinations may remain protective over longer times than in situations where only a single insecticide is used. Such an observation is exemplified in the work reported by Protopopoff et al (2007) in Burundi, where LLINs were provided to continue protecting people even after the residual activity of the IRS insecticides had ceased to be effective. The net and the IRS may also inhibit mosquitoes' ability to successfully take blood meals from the hut dwellers (Okumu et. al, 2011).

Some studies have also shown that it is beneficial to use IRS and ITNs in combination compared to using one method alone (Hamel MJ et al. 2011). According to West and colleagues, they found that children receiving both interventions were more protected than those with ITNS alone (West et al, 2014), but the evidence is inconclusive as other studies have shown no additional benefit (Keating et al. 2011, Corbel et al. 2012, Pinder et al. 2014).

Based on results from two areas in Mozambique, which would be classified as medium malaria transmission risk (Hay et. al, 2009), Kleinschmidt and colleagues documented that having both ITNs and IRS provides a multiplicative protective effect against malaria infection beyond the added benefits accrued by having each intervention alone (Kleinschmidt et al, 2009). The present study's findings support these results and strengthen the evidence base for viewing the protection offered by having both ITNs and IRS as synergistic, especially in settings under which medium malaria transmission are experienced.

Implementing both IRS and universal coverage of ITNs in the same geographical area could reduce malaria transmission by: 1) increasing the proportion of individuals protected by at least one intervention and 2) providing enhanced protection for individuals who are covered by both interventions compared to individuals protected by one method alone (Hamel et. al 2011, Okumu et.al, 2011). Factors which might explain the differences in effect include: insecticide used for IRS, IRS coverage, duration between spray rounds, community ITN usage, background malaria transmission, seasonality, insecticide resistance and, confounding with other interventions such as improved diagnosis and treatment or intermittent preventative therapy (West et al, 2014, Griffin et al. 2010, Okumu et al, 2011). It is on the premise of these studies that we also undertook our study to establish the effectiveness of focal IRS in setting with high ITN usage in Mansa District of Luapula province.

2.4 Developing insecticide resistance

The fight against diseases spread by mosquitoes has enormous environmental, economic and social consequences. Chemical insecticides remain the first line of defense but the control of disease is being undermined by resistance (David et al, 2013).

In Zambia, insecticides used for IRS and approved by ZEMA include two classes, the organochlorides (Dichloro-Diphenyl-Trichlorides) and pyrethroids (Alphacypermethrin, lambdacyhalothrin, and deltamethrin) (MoH, 2010). The development of resistance to insecticides constitutes a major threat to the chemical control of malaria vectors, as it compromises the insecticides. IRS can only be effective if the target vectors are susceptible to the insecticide in use.

There are specific interactions between insecticides and malaria vectors. Some insecticides tend to repel more than to kill vector mosquitoes. Changes in vector behaviour induced by insecticides may have important operational implications, and it is important to be aware of them when selecting insecticides for IRS.

Recent focused studies, however, have raised concerns that insecticide resistance maybe appearing and this is being investigated further (WHO, 2011). Kabula B. et al (2011) observed that Anopheles gambiaes.l. is becoming resistant to pyrethroids and DDT in several parts of Tanzania. This has coincided with the scaling up of vector control measures. Andrea M. R. et al (2011) observed that in Malawi, part of failure of the IRS program to have an impact despite high coverage of 80% was due to use of pyrethroid insecticide in areas where high levels of pyrethroid resistance had been observed.

According to studies conducted from 2003 to 2004 (MOH, 2011), malaria vectors were documented to be fully susceptible to insecticides used for vector control in Zambia. Resistance may impair the effectiveness of these interventions and therefore demands close monitoring and the adoption of a resistance management strategy.

CHAPTER THREE

RESEARCH METHODOLOGY

This section focused on the methodology that was used in the study. It dealt with study design, study setting, study population, inclusion criteria, sampling procedure, sampling methodology, estimated sample size, data collection and management, variables and interventions, data analysis plan, dissemination, notification, and reporting of results and ethical considerations.

3.1 Study design

A quasi experimental study design comparing incidence of malaria pre and post IRS intervention was used.

3.2 Study setting

The study was conducted in Mansa District in Luapula Province of Zambia. It is also the provincial capital. Mansa district had a population of 251,505 in 2014 and has a total of 30 Health facilities which include 1 level II hospital, 26 HCs and 3 health posts. Mansa serves administrative and commercial functions, being situated on a relatively featureless plateau between the Luapula River to the west and Lake Bangweulu to the east. Fishing and subsistence farming are some of the major economic activities.

3.3 Study population

The study population consisted of health facility catchment areas for 29 health facilities (excluding the hospital).

3.4 Inclusion and Exclusion criteria

3.4 .1 Inclusion Criteria

The study included all the 29 health facility catchment areas in Mansa district.

3.4 .2 Exclusion criteria

The study excluded the hospital because the population for the hospital encompasses that of all the 29 health facilities catchment areas for the district.

3.5 Sampling procedure

3.5.1 Sampling methodology

All the 29 health centre catchments in Mansa District were selected to determine effect of focal IRS on incidence of malaria because data was available for these catchment areas.

3.5.2 Estimated Sample size

All the 29 health centre catchments (11 focal IRS health facilities and 18 IRS only health facilities) in Mansa district were estimated to be used as study sample.

3.6 Data collection and Management

3.6.1 Data collection/extraction

Over three weeks period, Data on ITN coverage (sleeping bed spaces with ITNs), focal IRS coverage (structures sprayed over targeted, population protected) and type of insecticide used were extracted from ITNs and IRS record sheets respectively, from Mansa District Medical Office (DMO) for Health facility catchment areas. The Principal Investigator had traveled to Mansa district to access and verify available data on ITNs and IRS for the period under review (2013 to 2015). IRS was conducted in 2014 spraying season and never in 2013.

The DHIS2 database (web based) contains various data sets, but this study extracted data elements from HMIS dataset pertaining to malaria morbidity from 2013 (baseline data) to 2015. The malaria morbidity data elements included total malaria (clinical and confirmed), total tested cases and total confirmed malaria.

Malaria data were processed to establish the malaria incidence based on census data for health facility catchment area for a particular year. The age category included all age groups (both under five and over five year old).

3.6.2 Study instruments

This study used secondary data and therefore, no standardized questionnaires were designed to collect the data. However, a data extraction forms were used to capture from both focal spray data sheets obtained at the Mansa District Health Office for 2014 spraying season, and the web-based DHIS2 database.

3.7 Variables and interventions

Dependent and independent variables and sources of information where used in this study to determine the scale of measurement on specific indicators (Table 1).

Table 1: Variables

Type of variable	**Variable**	**Indicator**	**Source of information**	**Scale of measurement**	
Dependent	Change in incidence of malaria	Total malaria cases /1000 persons *(Pre and post-IRS)*	- HMIS - OPD registers	Change in incidence (-100 to 100) Percent difference in incidence *(Pre and post-IRS)*	Continuous
		Lab-confirmed malaria cases /1000 persons *(Pre and post-IRS)*	- HMIS - HC RDT/lab registers	Change in incidence (-100 to 100) Percent difference in incidence *(Pre and post-IRS)*	Continuous
Independent	Percent of IRS coverage	Number of structures sprayed over targeted in a Health facility catchment area	Focal IRS records	Percentage of IRS coverage	Explanatory
	ITN coverage (potential confounder)	No. of sleeping bed spaces with an ITN in a Heath facility catchment area	ITN distribution records	Greater than 80% = 1 Less than 80% = 2	Binary
	Timing of IRS	Months of spraying (spraying season)	Focal IRS records	Aug to Oct = 1 Nov to Dec = 2	Binary
	Population protected	Percentage of total population protected within a catchment area	Focal IRS and ITNs records	Greater than 80% = 1 Less than 80% = 2	Binary
	Insecticide used	Type of insecticide used	Focal IRS records	Recommended = 1 Not recommended = 2	Binary

3.8 Data analysis plan

3.8.1 Data entry, editing and management

Extracted data were edited and cleaned up to check on completeness of data. All information extracted was confidentially stored and data backup kept in an external hard drive at the end of the study for future reference.

3.8.2 Data analysis

The analysis was conducted to establish IRS coverage for the single spraying season (2014). We obtained total malaria and laboratory confirmed malaria morbidity data retrieved from HMIS on the web based DHIS2 database to calculate malaria incidence rates using pivot tables of Microsoft Excel sheet, based on Central Statistical Office (CSO) population data for health facilities in Mansa District. We determined the change in incidence of malaria pre and post focal spraying, 2013 data being the baseline when only ITNs were used.

Data were then transferred and entered into Microsoft excel sheet and Epi-Info statistical package to analyze and compare descriptive statistics and incidence rates for the two groups. Group 1 included the health facility catchment areas that received ITNS only during the study period and group 2 included health facility catchment areas that received both ITNS and focal IRS for malaria intervention.

The spraying related variables that include malaria incidence rate, proportion of structures sprayed, population covered by the spray and timing of spraying, and type of insecticide used were analyzed. Associations between variables were tested using a Chi-square with the level of statistical significance set at desired accuracy of 5% and 95% confidence interval to measure the public health impact of focal IRS. Risk Ratios were calculated to compare the level of association between IRS and ITN only areas.

In order to determine the additional effect of IRS, the monthly morbidity data for this study were aggregated to 12 months post IRS to analyze and evaluate the 12-month effect of focal spraying on malaria incidence for the 25 health facility catchment areas.

The **non-combined effect** was measured by taking into account pre-IRS malaria morbidity data where only ITNs were used to determine malaria incidence before focal IRS was implemented in 2013.The **combined effect** was measured by determining outcome of interest (malaria incidence) in 2014 when both focal IRS and ITNs where used as interventions to counter the transmission of malaria. The combined effect henceforth, were measured 12 months post focal IRS (by Dec 2015).

3.9 Dissemination, notification, and reporting of results

Study findings were communicated to the National Malaria Control Program and implementing partners through the Ministry of Health. Participating district received a copy of results/report.

3.10 Ethical considerations

3.10.1 Risks: There was no physical contact with participants as only secondary data was used. All information extracted was confidentially stored at the end of the study.

3.10.2 Benefits: The information generated from this study would help improve individual participation in future IRS services and offer better health service provision that would contribute to the reduction of malaria disease burden in the community as a whole.

3.10.3 Informed consent: The study used secondary data extracted from both focal spray data and DHIS without involving participants.

3.10.4 Approval: Ethics approval was received from ERES Converge. Permission to conduct the study was obtained from the Ministry of Health and via Mansa District Medical Office.

3.11 Limitations of the study

This study focused on the additional effect of focal indoor residual spraying on incidence of malaria in a setting with high insecticide treated bednets coverage in Mansa district, Luapula province. Thos being the case, the findings may not be generalized to other parts of Zambia since only health facility catchment areas in Mansa district provided information for this study.

CHAPTER FOUR

PRESENTATION OF THE FINDING

Of the 29 health facilities initially targeted for the study, only data for the 25 Health facility catchment areas were abstracted to calculate and analyze malaria incidence rates pre and post focal indoor residual spraying period for 2013 to 2015. Four of the twenty nine health facilities were excluded because 3 were aligned to the newly established Chembe district in 2014 whilst 1 health facility was opened in 2014 thus did not have 2013 base line data.

4.1 Demographic characteristics

Mansa district had a total population of 257, 517 by 2015 with a CSO 2010 projected annual growth rate of 2.1%. Of the total number of malaria cases (189,407) recorded in 2015, at least 163,135 cases (86%) were laboratory confirmed. Overall, the incidence of total malaria decreased by 0.4% from 739/1000 persons per year in 2013 to 736/1000 persons per year in 2015. With regard to lab-confirmed malaria, an increase of 74% occurred between 2013 and 2015. Total malaria was fluxuating somewhat while lab-confirmed malaria increasing substantially, largely due to increased confirmatory testing (Table 2).

Table 2: Demographic and Malaria disease characteristics, Mansa District, 2013 to 2015

Year	Population (CSO)	Projected annual pop growth rate	Total malaria cases	Lab-confirmed malaria cases	Total malaria incidence / 1000 persons	Lab-conf malaria incidence / 1000 persons
2013	245,510	2.1	181,384	89,472	739	364
2014	251,505	2.1	193,781	146,111	770	581
2015	257,517	2.1	189,407	163,135	736	633

4.2 ITN Coverage

The Mansa district recorded ITN coverage of 100% during 2013 to 2015. All the 25 health facilities received and distributed ITNs into the community according to the available sleeping bed spaces. This provided universal protection to the households of Mansa district.

4.3 Sprayed Unit Structures

A total 11 of 25 (44%) health facilities that conducted focal IRS in their targeted catchment areas in 2014 in addition to use of ITNs. At least 7 out of 11 (64%) IRS health facilities recorded spray coverage of above 85% in their catchment areas. Mibenge RHC (96%) had the highest IRS coverage followed by Mabumba RHC (94%) and Buntungwa UHC (93%). The lowest coverage was recorded in Senama UHC (65%) followed by Mutiti RHCs with 74%. All the targeted IRS health facility catchment areas used an insecticide commonly known as Actellic 300CS during the 2014 spraying season. Mansa district recorded average spray coverage of 84% during October to December 2014 spray season (Table 3).

Table 3: Coverage of Sprayed Unit Structures by Health Facility Catchment Area, October to December, 2014, Mansa District

Health facility catchment area	Total structures targeted (n)	Total structures sprayed (n)	Spray coverage (%)
Mibenge RHC	532	512	96%
Mabumba RHC	1,680	1,581	94%
Buntungwa UHC	2,566	2,386	93%
Mantumbusa RHC	757	688	91%
Matanda RHC	502	450	90%
Muwanguni RHC	427	366	86%
Chisembe RHC	516	436	84%
Central UHC	7,477	6,147	82%
Kabunda RHC	689	613	89%
Mutiti RHC	297	221	74%
Senama UHC	2,658	1,738	65%
Average	**18,101**	**15,138**	**84%**

4.4 Total Malaria Incidence

A total of 5 of 11 (45%) IRS health facilities recorded decrease in incidence of total malaria in their catchment areas in 2015 compared to 2013 whilst 6 of 11 (55%) IRS health facilities recorded increase in incidence of total malaria post spraying.

Central Urban HC (-46%) recorded the highest percent decrease in incidence of malaria after IRS followed, Mabumba RHC (-28%) and Buntungwa RHCs (-23%) by the end of 2015. Highest percent increase in incidence of malaria after spraying was observed in Matanda RHC (80%) followed by Mibenge (34%) and Mantumbusa RHC (28%) among others. On average, total malaria incidence among IRS-health facility catchment areas slightly decreased by 0.69% by end 2015 compared to 2013 (Table 4).

Table 4: Comparison of Total Malaria Incidence for IRS-Health Facility Catchment Areas Pre and Post Spraying Period, Mansa, 2013 and 2015

IRS Health facility	Total malaria incidence, 2013 (Pre-IRS)	Total malaria incidence, 2015 (Post-IRS)	Change in incidence	Percent difference	Comment on change in incidence
Mabumba RHC	1,824	1,315	-509	-28	**Decreased**
Kabunda RHC	1,795	1,700	-95	-5	**Decreased**
Chisembe RHC	1,032	1,158	126	12	Increased
Mutiti RHC	1,004	1,027	23	2	Increased
Central UHC	922	501	-421	-46	**Decreased**
Senama UHC	854	957	103	12	Increased
Mantumbusa RHC	817	1,046	229	28	Increased
Mibenge RHC	805	1,082	277	34	Increased
Buntungwa UHC	797	614	-183	-23	**Decreased**
Muwanguni RHC	785	767	-183	-2	**Decreased**
Matanda RHC	486	875	389	80	**Increased**
Average	**1,011**	**1,004**	**-7**	**-0.69**	**Decreased**

A total of 14 of 25 (56%) health facilities did not conduct IRS in their catchment areas but used ITNs only as a strategy to prevent malaria. At least 5 of 14 (36%) ITN only health facilities recorded decrease in incidence of total malaria in 2015 compared to 2013, whilst 9 of 14 (64%) recorded increase in incidence.

Lubende RHC (-36%) had the highest percent decrease in incidence of total malaria followed by Mano (-31%) and Moloshi RHCs (-21%). Highest percent increase in incidence of malaria after spraying was observed in Kansenga RHC (147%) followed by Musaila RHC (83%) and Nsonga HP (73%) by the end of 2015. On average, total malaria incidence for ITN only health facilities increased by 155/1000 persons (20%) by end of 2015 compared to 2013 (Table 5).

Table 5: Comparison of Total Malaria Incidence for ITN only Health Facilities Catchment Areas Pre and Post Spraying Period, Mansa, 2013 and 2015

ITN only Health facility	Total malaria incidence 2013 (Pre-IRS)	Total malaria incidence 2015 (Post IRS)	Change in incidence	Percent difference	Comment on change in incidence
Lubende	1,696	1081	-615	-36	**Decreased**
Kalyongo RHC	1,154	1640	486	42	Increased
Fimpulu RHC	876	1253	377	43	Increased
Paul Mambilima RHC	848	685	-163	-19	**Decreased**
Kalaba RHC	847	1179	332	39	Increased
Luamfumu RHC	808	643	-165	-20	**Decreased**
Mano RHC	754	519	-235	-31	**Decreased**
Ndoba RHC	746	1091	345	46	Increased
Kansenga RHC	725	1788	1063	147	Increased
Musaila RHC	656	1202	546	83	Increased
Katangwe RHC	469	528	59	13	Increased
Moloshi RHC	398	314	-84	-21	**Decreased**
Chisunka RHC	388	431	43	11	Increased
Nsonga HP	236	408	172	73	Increased
Average	**757**	**912**	**155**	20	**Increased**

4.5 Laboratory confirmed malaria incidence

At least 1 of 11(9%) IRS-health facilities (Muwanguni RHC) recorded decrease in incidence of lab-confirmed malaria by 238 (40%) while 10 of 11 IRS-health facilities recorded increase in 2015 compared to 2013. Highest percent increase in incidence was observed in Mabumba (136%), Buntungwa UHC (116%), Chisembe and Senama UHC catchment areas with 107% increase respectively. On average, confirmed malaria incidence in IRS health facilities increased by 63% by end of 2015 compared 2013 (Table 6).

Table 6: Laboratory Confirmed Malaria Incidence, IRS-Health Facility Catchment Areas, Mansa District, 2013 – 2015

IRS Health facility	Conf. malaria incidence 2013 (Pre IRS)	Conf. malaria incidence 2015 (Post IRS)	Change in incidence	Percent difference	Comment on change in incidence
Buntungwa UHC	208	450	242	116	Increased
Central UHC	377	395	18	5	Increased
Chisembe RHC	462	958	496	107	Increased
Kabunda RHC	1,221	1647	426	35	Increased
Matanda RHC	456	875	419	92	Increased
Mabumba RHC	552	1305	753	136	Increased
Mantumbusa RHC	642	1046	404	63	Increased
Mibenge RHC	497	964	467	94	Increased
Mutiti RHC	560	861	301	54	Increased
Senama UHC	446	925	479	107	Increased
Muwanguni RHC	599	361	- 238	-40	**Decreased**
Average	**547**	**890**	**343**	**63**	**Increased**

At least 1 of 14 (7%) of ITN only health facilities (Mano RHC) recorded a decrease (-2%) in incidence of confirmed malaria from 517 per 1000 persons in 2013 to 506 per 1000 persons in 2015 while a total of 13 out of 14 (93%) ITN only health facilities recorded increased incidence in 2015 compared to 2013. Highest percent increase in incidence of confirmed malaria was observed in Musaila followed by Kalaba and Kansenga RHC catchment areas by the end of 2015.

On average, total malaria incidence for ITN only health facilities increased by 430/1000 persons (120%) by end of 2015 compared to 2013. Based on the exposure – outcome analysis, the risk ratio of 0.98 (0.77 – 1.24) with p-value of 1.0 indicated non-statistically significant difference in incidence of lab-confirmed malaria between IRS and non-IRS health facilities (Table 7).

Table 7: Laboratory Confirmed Malaria Incidence per 1000 person, ITN only Health Facility Catchment Areas Pre and Post IRS, Mansa District, 2013 – 2015

ITN only Health Facility	Conf. malaria Incidence 2013 (Pre IRS)	Conf. malaria incidence 2015 (Post IRS)	Change in incidence /1000 persons	Percent difference	Comment on change in incidence
Luamfumu RHC	296	448	152	51	Increased
Kalyongo RHC	543	1632	1089	201	Increased
Lubende	868	1078	210	24	Increased
Kansenga RHC	510	1695	1185	232	Increased
Mano RHC	517	506	-11	-2	**Decreased**
Kalaba RHC	259	1165	906	350	Increased
Moloshi RHC	193	294	101	52	Increased
Paul Mambilima RHC	477	685	208	44	Increased
Ndoba RHC	514	862	348	68	Increased
Nsonga HP	210	401	191	91	Increased
Musaila RHC	86	966	880	1,023	Increased
Chisunka RHC	217	424	207	95	Increased
Fimpulu RHC	463	1183	720	156	Increased
Katangwe RHC	227	500	273	120	Increased
Average	**359**	**789**	**430**	120	**Increased**

CHAPTER FIVE

DISCUSSION AND INTERPRETATION OF THE FINDINGS

Overall, Mansa district recorded a slight decrease in total malaria incidence of less than 1% in 2015 (post IRS) compared to 2013 (pre-IRS). A proportion of more than 80% of recorded cases in 2015 were laboratory confirmed by either use of Rapid Diagnostic Test (RDT) or microscopically (Table 2). This signified an improvement in adherence to testing recommendations compared to 2013.

We found that the district recorded average spray coverage of more than 80% (Table 3) during 2014 spraying season using Actellic 300CS, a new long-lasting micro-encapsulated formulation of the organophosphate insecticide pirimiphos-methyl. This insecticide has been specifically designed for use in indoor residual spraying (IRS) programs to provide up to one year’s residual control of mosquitoes and other public health pests. Actellic 300CS is effective against pyrethroid resistant Anopheles, Aedes and Culex species (Syngenta, 2013). In 2013, Chanda et al conducted a study to assess and compare the residual efficacy of an organophosphate insecticide pirimiphos methyl at 1 g/m2 and the pyrethroid deltamethrin at 20 mg/m2 for indoor residual spraying on cement and mud-rendered walls inside houses. According to their findings, the residual efficacy of Actellic 300CS on cement and mud walls lasted for 5 months on both surfaces, with complete mortality of Anopheles gambiae sensustricto in cone assays. By 8 months, the average residual effect of Actellic 300CS remained much better on cement walls than on mud walls but not significantly different from deltamethrin-treated cement walls. This entails the efficacy of its chemical properties. Pirimiphos methyl CS is recommended for intra-domiciliary spraying for malaria control and could replace dichlorodiphenyltrichloroethane within the context of an insecticide resistance management strategy.

Mansa district, conducted focal indoor residual spraying strategy in combination with ITN usage, targeting health facility catchment areas with high incidence of malaria and also considering cost effectiveness compared to carrying out generalized spraying. The combination can however, be used for different other reasons. With regards to household protection, the main reasons include ensuring protection where one of the interventions is weakened e.g. using ITNs where IRS activity decays after a short time and providing additional level of protection e.g. by deterring mosquitoes from entering houses where people use toxic bed nets. However, with regards to community level protection, combinations may be used to increase overall coverage with vector control where complete coverage with only one of the interventions is unfeasible throughout all endemic communities.

In view of this , Mansa district conducted focal IRS in a total of 11 out of 25 health facilities from October to December of 2014 in addition to use of ITNs with over half (63%) having achieved spray coverage of above 85% (Table 3). However, we observed that conducting IRS during this time frame (from October to December) may have a negative impact on the coverage due to high refusals and or poor community acceptability of the programme presumably due to heightened rainfall and busy farming schedules by some of the community members. Commencing IRS slightly earlier would improve spray coverage.

The results further showed that almost half of the IRS health facility catchment areas had recorded relatively reduced incidence of malaria after spraying compared to the incidence they had before spraying (Table 4). The decrease in incidence signified probable effect of spraying in addition to use of ITNs. Conversely, half of the health facilities that achieved spray coverage above 85% recorded increase in incidence of malaria, with Matanda RHC almost doubling the incidence in 2015 compared to 2013. This seemed unusual and prompted me to further ask myself questions concerning some operational dynamics, e.g. whether the insecticide solution wasn't well formulated, maybe rightful residue was not applied on the walls, whether all the rooms were sprayed or not or emerging insecticide resistance among others. The average effects of spraying showed insignificant decrease (0.69%) in incidence among sprayed health facilities comparing the 12-month malaria incidence rates for unsprayed health facility catchment areas (20% increase) in 2015 with the similar period in the preceding 2 years, 2013.

The findings on incidence of total malaria in ITNs only health facilities demonstrated that 5 out of 14 (less than half) of the facilities recorded a decrease in incidence of malaria while about 64% of health facilities recorded increased incidence in 2015 compared to 2013 (Table 5). Comparatively, we observed that incidence of total malaria either increased or decreased in both sprayed and non-sprayed health facility catchment areas regardless of spray status. This also demonstrated that there was an insignificant difference in change of incidence of malaria between IRS and ITN only health facilities. The exposure – outcome analysis indicated the risk ratio of 0.89 (0.43 – 1.65) demonstrating a non-statistically significant difference in incidence of total malaria between IRS and ITN only health facilities. It is suggestive that provision of focal IRS and ITNs was relatively not protective compared to use of ITNs only.

We further analyzed incidence of laboratory confirmed malaria for both IRS and ITN only health facilities. Among the IRS health facilities, Muwanguni RHC was the only health facility that recorded decrease in incidence of lab-confirmed malaria in 2015 (Table 6) while, only Mano RHC recorded decreased incidence among ITN only health facilities (Table 7). Based on the exposure – outcome analysis, the risk ratio of 0.98 (0.77 – 1.24) indicated non-statistically significant difference in incidence of lab-confirmed malaria between IRS and ITN only health facilities.

In view of the analysis above, these results demonstrates that there was no difference in effect of both interventions on incidence of lab-confirmed malaria post IRS period entailing that there were no advantages of combining IRS with ITNs relative to using ITNs alone in Mansa district. We are however, mindful that this outcome may be different in certain situations, since there are numerous confounding factors that can affect the results.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Based on the findings of the study, it became clear that even though combining IRS and ITNs is increasingly being practiced and are already known to confer significant benefits against malaria, the results for Mansa district could not give us sufficient evidence as to whether it is indeed better than ITNs on their own. This is especially evident when we analyzed incidence of laboratory confirmed malaria that showed no difference in outcome between IRS and ITN only health facilities. We therefore concluded that, use of focal IRS strategy in addition to ITNs in Luapula province and Mansa district in particular did not yield additional effect compared to use of ITNs only.

6.2 Recommendations

As correlations between these two methods and accrued health benefits become better understood, their acquisition and utilization will require that the implementation is monitored closely to ensure proper use, optimal efficacy and maximum cost effectiveness, but also to prevent problems such as insecticide resistance and funding fatigue. Health authorities in Mansa district must ensure that important gains so far achieved from existing interventions are not lost especially as malaria control enters the phase of intensive and sustained vector control.

6.3 Recommendations for further research

The area is still fertile for further research since there are few studies that have been done in Zambia on this topic. An operational research may be done to ensure that raised questions of its efficacy and operationalization are well understood by stakeholders before scale-up of the concept is enhanced. Therefore, to maximize any possible additional benefits from IRS/ITN co-applications, rigorous field evidence, supported by mathematical modeling where necessary should be pursued to support the entire process of decision making. Different kinds of studies on combined ITN-IRS use to should include: 1) experimental hut investigations where efficacies of the combinations are directly assessed against wild free-flying malaria vectors in malaria endemic areas, 2) mathematical simulation incorporating characteristics of candidate insecticidal applications to estimate likely benefits of the combinations in different scenarios, and 3) cost benefit analysis of the combinations compared to individual methods on their own and also to other existing interventions.

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APPENDICES

Appendix 1: Data Extraction Form

Health facility: ……………………………… District: ……………………………………......

Province: ………….…….…………….. Data extracted by…………………………………

Date: ……….……………………………..

1. Insecticide Treated bed Nets

Year	Total sleeping bed spaces	Total ITNs distributed		Coverage (%)	Total no. of people protected (Multiply by 1.8)
		Routine (ANC/U5)	Campaign		
2013					
2014					

2. Focal Indoor Residual Spraying

Year	Period of spray	Total structures targeted (n)	Total structures sprayed (n)	Coverage (%)	Type of insecticide used	Total no. of people protected
2013						
2014						

3. A Malaria disease burden 2013

Month	Health facility catchment population	Total confirmed malaria cases (n) (RDTs/ Microscopy	Total clinical malaria cases (n)	Total malaria treated
Jan				
Feb				
Mar				
Apr				
May				
Jun				
July				
Aug				
Sept				
Oct				
Nov				
Dec				
Total				

3. B Malaria disease burden 2014

Month	Health facility catchment area population	Total confirmed malaria cases (RDTs/ Microscopy)	Total clinical malaria cases	Total malaria treated
Jan				
Feb				
Mar				
Apr				
May				
Jun				
July				
Aug				
Sept				
Oct				
Nov				
Dec				
Total				

3. C Malaria disease burden 2015

Month	Health facility catchment area population	Total confirmed malaria cases (RDTs/ Microscopy)	Total clinical malaria cases	Total malaria treated
Jan				
Feb				
Mar				
Apr				
May				
Jun				
July				
Aug				
Sept				
Oct				
Nov				
Dec				
Total				