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The Association of Vector Control By Indoor Residue Spraying And Insecticide Treated Nets, with the Prevalence of Malaria in Luapula Province, Zambia: A Retrospective Analysis of Surveillance Data.

By

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A Research Report submitted in Partial Fulfilment of the Requirements for the Award of Master of Science in Epidemiology.

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ACKNOWLEDGEMENTS

I would love to say thank you to my supervisors, Dr. B. Mudenda and Ms. L. Sitali for their valuable and professional guidance throughout the study.

A special thanks to the Ministry of Health for giving me access to their malaria data and additional relevant documents.

Also, my thanks go to the National malaria control centre for their input at every stage of the research.

I am grateful to Dr. B. Hamainza for National Malaria control centre for his assistance in statistical analysis and interpretation of data.

Lastly I thank my family and friends for their continued support and encouragement during the study.

DECLARATION

I Mwiche Sensenta declare that the work presented in this dissertation is my own work and that it has been produced in accordance with the guidelines for the Master of Science in Epidemiology dissertation for the University of Zambia. It has never been presented or submitted elsewhere in part or whole for the award of a degree or any qualification from any institution.

Signature: ……………………………

Date: ……………………………

CERTIFICATION OF APPROVAL

This dissertation authored by Mwiche Sensenta and entitled "The Association of Vector Control By Indoor Residue Spraying And Insecticide Treated Nets, with the Prevalence of Malaria in Luapula Province, Zambia: A Retrospective Analysis of Surveillance Data", has been approved as fulfilling the requirements for the award of the Masters of Science in Epidemiology degree, by the University of Zambia.

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LIST OFABBREVIATIONS AND ACRONYMS

An.	*Anopheles*
ACT	Artemisinine combination therapy
CDC	Centre for disease control
CX	Carbamates
DDT	Dichlorodiphenyltrichloroethane
DRC	Democratic Republic of Congo
GMCS	Global Malaria Control Strategy
GMEP	Global Malaria Eradication Programme
ITNs	Insecticide-treated nets
IRS	Indoor residue spraying
IVM	Integrated vector management strategy
IPTp	Intermittent preventive treatment during pregnancy
Kdr	Knock-down resistance
LLINs	Long lasting insecticidal nets
OP	Organophosphates
PCR	Polymerisation chain reaction
PMI	President's Malaria Initiative
MIS	Malaria indicator survey
MOH	Ministry of Health
HMIS	Health Management Information System

IRS	Indoor Residue Spraying
NMCC	National Malaria Control Centre
NMSP	National Malaria Strategic Plan
RBM	Roll Back Malaria
TDR	Tropical Diseases Research
UNICEF	United Nations International Children and Education Fund
UNEP	United Nations Environmental Program
WHO	World Health Organisation
ZDHS	Zambia Demographic Health Survey

DEFINATIONS

Anopheles: genus of mosquitoes comprising of numerous species that transmit malaria through a bite of its female.

Endemic: applied to malaria when there is a constant measureable incidence of cases and mosquito-borne transmission in an area over a succession of years.

Epidemic: Occurrence of cases in excess of the number expected with a specific geographical area and time period.

Endophilic: Vectors that tend to inhabit/ rest in indoor areas.

Exophilic: Vectors that tend to inhabit/ rest in outdoor areas.

Indoor residue spraying: the application of chemical insecticides on the interior 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.

Intensity of transmission: rate at which people are inoculated with malaria parasites by mosquitoes.

Malaria elimination: reducing to zero the incidence of locally acquired malaria infection caused by human malaria parasites in a defined geographic area through deliberate efforts, with continued measures in place to prevent re-establishment of transmissions.

Malaria incidence: the number of newly diagnosed malaria cases during a specific time period in a specified time in a specified population.

Malaria prevalence: the number of malaria cases existing in a given time in a specified time in a specified population, measured by positive laboratory test results.

Plasmodium: genus of parasite that causes malaria.

Vector: An organism which transmits an infectious agent from one host to another.

ABSTRACT

INTRODUCTION

Malaria remains a serious epidemic trait in Luapula province. To appropriately target the interventions to substantially reduce the current disease burden, there is need to assess the impact of the vector control measures such as Indoor Residue Spraying (IRS) and Insecticide treated nets(ITNs). Surveillance data forms a basis for monitoring the impact of control activities. The aim of this study was to assess whether there has been an association between vector control measures by IRS and ITNs, and the prevalence of malaria through the review of retrospective data.

METHODOLOGY

Data was extracted from Zambia Health Management Information system (ZHMIS), and the Malaria indicator surveys. Descriptive statistics were computed to determine malaria distribution in Luapula province and time series analysis were run to assess the trends of malaria morbidity and mortality, and then finally to assess the association of the IRS and ITNs with the prevalence of Malaria in Luapula province.

RESULTS

Malaria burden was found highest in Mwense district (55% prevalence) and lowest in Chienge district (19% prevalence) in the period, 2010-2015. There was a 40% increase in the prevalence of malaria in Luapula province from 2010 to 2015. IRS coverage, ITN coverage and ITN usage has been on the increase since 2010. There has been a 31% increase in ITN coverage, a 72% increase in ITN usage, and a 71% increase in IRS coverage, from 2010 to 2015.

CONCLUSION

Malaria prevalence was continuously increasing from the year 2010 to 2014, despite the increase in the both the interventions. However, the up-scale of in ITN usage in 2015 and the continued steady increase in IRS coverage related with the sharp decrease in malaria prevalence observed in 2015.

KEYWORDS: Malaria, Prevalence, Vector control, Indoor residue spraying, Insecticide treated nets.

CHAPTER ONE: BACKGROUND

1.1.1Malaria Burden and Situation

Malaria has plagued mankind throughout history and remains one of the major challenges to global health. The disease contributes a considerable burden in endemic countries with premature deaths, disability from illness and it impedes on social and economic development (Binka. F, 2000). According to the World Malaria Report 2015, the global burden of the disease was estimated at 214 million cases and 438 000 deaths worldwide, with the African region accounting for 80% of the cases and 90% of the deaths. Malaria prevalence is now at 15% in Zambia, and Luapula province reported the highest level of malaria prevalence, with 32.5%(Zambia MIS, 2015).

Almost all these cases and deaths are caused by *Plasmodium falciparum,* one of the four malaria parasite species that affect humans. The others are *P.vivax, P.ovale,* and *P. Malariae (* Philips *et al, 2001).* Most people at risk of the disease live in areas of relatively stable transmission, there, infection is common and occur with frequency that some level of immunity develops (WHO,2010). Malaria disease and deaths in other areas of the world occur mainly among individuals who lack immunity and are infected with *P. falciparum* in areas where appropriate diagnosis and treatment is not available. The total number of cases in sub-Saharan Africa is estimated at five million per year and yet the actual number is believed to be at least four times higher (Snow *et al*, 2005).

Despite these distressing burden records, there has been a reduction in the numbers of malaria cases and malaria-related deaths. The incidence of malaria which takes into account population growth is estimated to have decrease by 37% globally between 2000 and 2015. Malaria death rate has also decreased by 60%. These reductions are attributed mainly to vector control (WHO, 2015).

1.1.2 Malaria vector control

While anti-malaria drugs have existed for some time and vaccines development maybe underway, the most successful malaria eradication programs has thus far relied on attacking the mosquito vector that spreads the disease causing agent, *plasmodium* (Ramirez, 2010). Following the discovery that mosquitoes transmit malaria by Ronald Ross in 1897, attempts to control the disease focused on attacking the vector mosquitoes (Hay, 2004). Hay discussed that these early attempts focused on larval stages (which were easier to find than the mobile adults), using environmental management and larviciding. This approach was difficult to implement uniformly and effectively across wide geographic areas as vectors can use a diverse and extensive range of breeding sites and vary by species (Grillet, 2000). Larval management was basically by the use of Paris green (copper acetoarsenite) and petroleum by-products, but the use of these chemicals was to be discontinued because of their high toxicity and pollution of water sources (Walker, 2007). With the discovery of Dichlorodiphenyltrichloroethane (DDT), the focus of malaria control strategies shifted to managing the adult mosquito populations and resulted in the abandonment of early vector control approaches (Ramirez, 2009).

Insecticide treated nets (ITNs) and indoor residue spraying (IRS) are now the two of the most effective malaria prevention strategies recommended for use. The efficacy of pyrethroid-treated bednets is well known from its implementation in Asia, where it had successfully helped control malaria transmission (Hung, 2002). It was noted that in order to achieve a much greater control in Africa, ITNs need to be distributed among the population, and insecticide-re-impregnated services have to be provided at a relatively low cost if continuous protection is to be maintained (Curtis *et al*, 2000). The same is true for IRS, which requires frequent supervision and inspection as well as appropriate application to be effective (WHO, 2007; Shiiff, 2002).

The effectiveness of vector control by house spraying with DDT in the 1950's, led to the adoption of the Global Malaria Eradication Programme (GMEP), in 1955 – 1969 (WHO, 2006). Eradication was achieved in temperate regions of the world, however, this achievement eluded most African countries (WHO, 2014). A combination of factors such as emergence of drug and insecticide resistance, together with challenges in the feasibility and sustainability of malaria control programmes in areas with weak infrastructure and high transmission have conspired to make malaria a more serious problem now than it was during the first half of the twentieth century in the sub-Saharan Africa (McMicheal, 2003). The past efforts of GMEP were then abandoned when it became apparent that eradication in certain parts of the world was not a realistic goal (Sachs, 2002). Vector resistance to DDT and Dieldrin and concerns over their environmental impact, necessitated a revised strategy for control of malaria (Bruce-Chwart, 1987). WHO introduced a new Global Malaria Control Strategy (GMCS) that reflects an understanding of the importance of research, involvement of health services, and development of new anti-malarial drugs, alternative malaria control methods, improved surveillance, community partnership, decentralization and integration (Reubusk, 1986). Over the years, several initiatives such as the Roll Back Malaria (RBM) initiative were launched to coordinate global malaria control efforts. Other initiatives for drug discovery, vaccine development and increased funding followed suit, committed to accelerate malaria control (Hay, 2004).

1.1.2.1 Vector control in Zambia

A renewed effort to eliminate malaria is on the global agenda and the Zambian Government has endorsed the goal to eliminate malaria as a public health problem. A unique opportunity exists to scale-up malaria-related interventions, strengthen systems, and make a major effort to roll back malaria in Zambia. IRS began in Zambia in 2003, following the success of it in the private sector at the Konkola copper mines (AIRS Zambia, 2014). Currently, the National Malaria Control Centre (NMCC) of the Ministry of Health (MOH) is implementing IRS for malaria control as part of an integrated vector management strategy (AIRS, 2014).

From 2006 to 2010, Zambia implemented the National Malaria Strategic Plan (NMSP) 2006–2010, whose theme was, "Scale-up for Impact". The implementation of this strategic plan resulted in significant progress and impact on malaria burden, morbidity, and mortality in Zambia. Significant success was achieved in scaling up high-impact, internationally proven malaria control interventions in prevention and malaria case management. As a result of these efforts, the percentage of homes with at least one long-lasting insecticide-treated net (LLIN) increased from 13.6% in 2001 to 38% in 2005 and to 64% in 2010, and over 6 million LLINs were distributed. As of 2010, IRS had been successfully implemented in 54 districts, an increase from 5 districts in 2003. The percentage of targeted homes actually sprayed remained above 85% (in most cases over 90%), meeting, and exceeding expectations. Households that either owned an LLIN or had been sprayed increased from 43% to 73%. Intermittent preventive treatment during pregnancy (IPTp) and diagnosis and treatment activities were also significantly scaled up (MOH, 2012). Challenges were however, faced and these included: the resurgence of malaria in Luapula, Northern, and Eastern Provinces; emergence of insecticide resistance; human resource challenges, including shortages of health workers, and skills gaps; inadequate resources for malaria control commodities and activities; data and information management gaps; and organizational challenges (MOH, 2012).

It became necessary to develop a new strategic plan to provide the strategic framework for the next five years, from 2011 to 2015. The NMSP 2011–2015 seek to build upon previous successes and address current and emerging challenges in the fight against malaria. It therefore focused on sustaining impact, delivering an integrated package of high impact malaria control interventions by epidemiologic strata, strengthening provincial and district capacities for delivery of key malaria control interventions, scaling up expanded use of malaria diagnosis for effective case management, and improved targeting of interventions through strengthening of surveillance, monitoring, and evaluation.

1.1.3 Efficacy of Malaria Vector Control Programmes

Most malaria-endemic countries are deploying indoor residue spraying (IRS) and/or Long-lasting insecticidal nets (LLINs) to combat malaria transmission. In response to the huge malaria burden in sub-Saharan Africa (Snow, 2005) and the call by WHO for scale-up control efforts (WHO, 2006), coupled with unprecedented availability of resources, targets for malaria control and elimination have been established (Nyarango, 2006; Komatsu, 2007). Measuring the impact of malaria control on reducing disease mortality and morbidity is essential for ensuring the successful implementation of the programme. Traditionally, the impact of malaria control interventions have been evaluated using repeated population-based surveys to determine prevalence, clinical or laboratory confirmed disease incidence and all-cause mortality (WHO, 2009).

Chemical vector control has shown significant results in reducing the burden of malaria and a number of studies have been done to assess the impact of the two vector control strategies described. IRS programs have shown impressive success in malaria reduction throughout the world, and depending on location, malaria infections have been reduced from between 30 to 90% (Pluess, 2011). The immeasurable benefits include improved health status and life-expectance, increasing productivity and social well-being and potential future economic development at national, regional and international levels (Ter Kuile, 2003; Lengeler, 2003), while most countries in sub-Saharan Africa would need to toe the same path for a better outcome of investment in controlling malaria. Tambo et al (2012) discusses to say, both African countries and few endemic countries in P.R. China have recorded different degrees of scaling up impact through the national malaria control interventions thus, reducing the rate of morbidity and mortality in children under five and pregnant women. For example, promising results were obtained after expanded coverage of malaria interventions, principally LLINs reaching over 60% coverage of populations at risk in Ethiopia and Rwanda; malaria cases in Rwanda decreased by 64% and deaths by 66% between 2005 and 2007 among children under five. In Ethiopia, cases decreased by 60% and deaths by 51% in the same age group in the health facilities selected for studies (Roll Back Malaria, 2011).

Whilst Zambia has made appreciable progress in malaria vector control, the observed difference in intervention effect could reflect the challenge of inconsistent bed net utilisations and justifies the need for enhanced information education and communication, Behavioural change communication (IEC/BCC) and timely replenishment of worn out LLINs (Chanda, 2012). Despite the differences in efficacy, both IRS and LLINs have had significant impact on malaria cases, proportional malaria mortality and case fatality rates in Zambia. Chanda et al discusses that although there was an overall reduction in deaths and cases in children <5, as was noted in his study, there were a number of districts where these indicators remained persistently high. Pin-pointing precisely the factors responsible for persistence of high deaths and cases in these districts could be difficult, as the low impact of LLINs in operational settings could in large part be attributed to waning ownership, use and the physical and insecticide net durability. However, it has been reported that by April 2009, overall proportional malaria mortality reported from health facilities had declined by 66% in Zambia following scaling up of LLINs and IRS between 2006 and 2008.

Towards the goal to eliminate malaria, WHO recommends the quantification of the burden of malaria using the number of cases and malaria-related deaths as core-indicator (Breman, 2007). Health management information systems (HMIS) including routine surveillance systems at health facilities have proved to provide evidence of the burden of diseases including malaria (Rowe, 2006). Surveillance data forms a basis for planning and monitoring the impact of prevention and control activities as well as targeting interventions and advocacy (Chibulski, 2009). All-malaria affected provinces in Zambia, including Luapula province, maintain malaria surveillance systems with valuable malaria epidemiological data essential for monitoring and evaluating the impact of malaria control tools. Within this context, this study aims to use existing malaria surveillance data to assess the effect of vector control by IRS and ITNs, on the prevalence of malaria in A seven-year period of study.

1.2 Problem Statement

Luapula province according to the latest malaria indicator survey, has the highest malaria prevalence in Zambia. This is alarming because the same malaria indicator survey indicates that this province receives just as much control interventions by IRS and ITNs,as any other province in Zambia. There are many factors that may be associated with the high malaria burden it is experiencing but this study was just interested in seeing whether or not there had been an association between the control interventions and the disease endemicity noted from the year 2010 to 2015.

According to the Zambia's NMSP and the Millennium Development Goal (MDG) 6, malaria should have been halted by 2015 and the incidence would have had began to reverse by now. However, Malaria parasite prevalence in Zambia is estimated to be at 15%, among children less than five (MOH, 2012). Zambia has therefore been lagging in meeting this MDG and it is probably because of the situation in Luapula province that is contributing to the lag noted.Current research shows findings that the prevalence rate continues to rise to about 53% in one of the province's district, Nchelenge (Mukonka, 2014).

1.3 Significance

Despite several years of control programs in Luapula, there has been noticeable high malaria prevalence in the province compared to other provinces. No study has been done to assess the association and impact of the control measures that are being conducted, mainly by ITNs and IRS, with the prevalence of malaria in Luapula province. The study therefore aims to provide the program planners with information on the progress, to identify the gaps in the implementation of Millennium development goals, so then to inform the effective implementation of the Sustainable development goals (SDGs) in Luapula Province.Moreover, the study aims to contribute to knowledge on the burden of malaria in Luapula province, with a view to stimulate further research.

1.4 General Objective

The aim of this study was to assess whether there has beenan association between vector control measures by IRS and ITNs, and the prevalence of malaria through the review of retrospective data collected routinely by surveillance from 2010-2015, in Luapula Province, Zambia.

1.5 Specific Objectives

1. To assess the malaria burden andits geographical distribution over the districts in Luapula province, from 2010 to 2015.
2. To assess the trends of malaria cases and deaths from 2010 to 2015.
3. To assess the trends of IRS percentage coverage, ITN percentage coverage, and ITN percentage usage, from 2010 to 2015.
4. To assess the association of IRS percentage coverage, ITN percentage coverage and ITN percentage usage, with the prevalence of malaria in Luapula province, from 2010 to 2015.

CHAPTER TWO : METHODOLOGY

2.1 Study setting

The study was conducted in Luapula province of Zambia. It is located north of the country, in the high rainfall belt of the central African Plateau. Climatically, the year is divided into a dry season (April-November) and a rainy-season (December-March). The province extends along the north and eastern banks of the river from Lake Bangweulu to Lake Mweru, including waters and islands of those lakes. The waters cover up to 43.5% of the land, and, the population consists of 991,927 people (Census, 2010).

Fig 1: Map of Luapula Province

2.2 Study Design

The study was a cross-sectional study based on the retrospective analysis of routine surveillance data. Data on malaria in Luapula province are relatively complete, regularly reporting monthly to the Health Management Information System (HMIS). A desk-based analysis was used to assess the programmatic implementation and epidemiological impact of IRS and ITNs on malaria prevalence, from 2010 to 2015.

2.3 Data collection

The following retrospective information was collected: malaria cases and deaths, IRS and ITNs data.

2.3.1 Malaria cases and deaths data.

This data was extracted from the HMIS.

A confirmed malaria case was defined as a patient with clinical features of malaria and *plasmodium* parasites detected on peripheral blood smears by microscopy or by rapid diagnostic tests (RDT's) at health care facilities or at community level through active surveillance.

Malaria-attributed mortality was defined as patients in whom malaria was recorded as a cause of death on the death certificate.

2.3.2 Spray and bed nets data.

Vector control programmes are coordinated by the Ministry of Health through National Malaria Control Programme (NMCP). Bed net and spray data is recorded at district level by the District Health Management Teams (DHMT). Data was exracted from the DHMT. The malaria indicator surveys (MIS) was used for comparative and consistency checks, and also for missing data. The number of structures sprayed, the total number of households and number of households with ITNs, were the variables of interest.

Table 1 below shows the variables that will be used in analysis of the data.

Table 1: Variables that will be used in the analysis of data

Measurement scale	**Type**	**Variable**
Categorical	Independent	Year
continuous	Dependent	Malaria in-patient confirmed cases
Continuous	Dependent	Malaria prevalence
Continuous	Dependent	IRS Percentage Coverage
Continuous	Dependent	ITN Percentage coverage
Continuous	Dependent	ITN Percentage usage
Categorical	Independent	District

The Health Information Officer assisted in the extraction of HMIS data at the provincial office in Mansa.

2.4 Sampling

Luapula is divided into 11 administrative districts which are run by local authorities. The districts are basically planning levels for health service delivery. Routine surveillance data from all the 11 districts will be included in the analysis.

2.5 Data Analysis

Data was first checked and validated, and then was entered and analysed using Stata. Descriptive statistics which included the means, standard deviations, proportions and 95% confidence intervals, were computed. Malaria prevalence rates per district were estimated by dividing the total number of cases, from 2010 to 2015, in each district, by their respective mean population estimates of each district.

$$\textit{District's malaria prevalence from } 2010 \textit{ to } 2015$$
$$= \textit{District's total number of cases in the period from } 2010 \textit{ to } 2015$$
$$/\textit{District's mean population estimate in the period from } 2010 \textit{ to } 2015$$

Time series were then used to assess the trends of Luapula's malaria cases and deaths recorded in the HMIS from 2010 to 2015. Trends of the IRS percentage coverage, ITN percentage coverage and IRS percentagewere extracted from the MISs.

The prevalence of malaria in Luapula province each year of the period of study, from 2010 to 2015, were computed by dividing the total number of cases in that particular year by the population estimate in that particular year.

$$\textit{The prevalence of malaria in Luapula in a year}$$
$$= \textit{The total number of cases in that year}$$
$$/ \textit{ the population estimate in that year}$$

To assess the association of IRS and ITNs on malaria prevalence, the trends of the control interventions were compared with that of malaria prevalence over the five year period of stidy. The t tests and chi square tests for trend were used to assess trends over the six-year period. Differences at P< 0.05 were regarded as statistically significant.

2.5 Data Quality

As this study relied entirely on surveillance data, it was highly expected that the quality of data would be subjected to reporting inconsistencies, incompleteness of notification forms, and flawed data capturing and, therefore presenting missing data variables. Despite these shortcomings, it is worth noting that routinely collected data through provincial malaria surveillance system remains the basis for measuring malaria trends over time when cautiously analyzed and interpreted. The findings of this study are therefore not expected to be substantially affected by data quality.

2.6 Ethical Concerns

Ethical clearance and approval was sought from the University of Zambia Biomedical Research and Ethics committee (UNZABREC/Assurance No. FW A00000338/IRB00001131 of

IORG0000774). Permission to access malaria data was asked at the Provincial health office in Mansa district and from the Ministry of Health head office.

Data from the two main sources of data, the HMIS and the MISs is de-identified data so the issue of privacy was cleared. Other than this, the data being secondary, had less ethical considerations to be considered.

CHAPTER THREE: RESULTS

3.1 Malaria distribution and trends

3.1.1 Malaria distribution by District

Table 2: Malaria cases and prevalence by district, Luapula Province, from year 2010 to 2016.

Mean Population (2010-2015)	Malaria prevalence (%)	Mean notified cases (SD)	Number of notified cases(%)	District
169,365	37	62,005 (22514)	372,031 (18)	Samfya
167,163	34	57,521 (25595)	345,128 (16)	Nchelenge
49,937	42	20,756 (5862)	124,537 (6)	Milenge
95,711	47	45,160 (14265)	270,958 (13)	Kawambwa
206,583	45	92,733 (33336)	556,399 (26)	Mansa
145,47 3	19	27,333 (15004)	163,997 (8)	Chienge
85,010	55	46339 (21955)	278,035 (13)	Mwense

Table 2 shows that the highest risk of malaria lies in Mwense district whose prevalence rate was at 55% during the six-year period from 2010-2015, followed by Kawambwa district with prevalence rate at 48% during the six-year period from 2010-2015. The least risk was in Chiengi district whose prevalence rate was 19%, during the years 2010 to 2015.

3.1.2 Malaria morbidity and mortality trends.

Table 3: Reported malaria cases and malaria-attributed deaths, Luapula Province, year 2010-2015.

Year	Total number of reported cases	Mean notified cases (SD)	95% CI	Total number of Malaria deaths	Mean malaria deaths (SD)	95% CI
2010	186,225	28,432(18,030)	11,754 – 45,108	324	46(28)	22 – 71
2011	275,225	39,322(18,905)	21,838 - 56,806	397	56(38)	22 – 92
2012	348,678	49,811(22,266)	29,219 - 70,404	468	66(51)	20 – 114
2013	381,562	54,509(25,504)	30,922 - 78,096	377	53(45)	12 – 95
2014	573,276	81,897(39,694)	45,186 - 118,607	375	53(42)	15 – 93
2015	346,089	49,441(26,803)	24,652 - 74,230	221	31(27)	5 – 58
Total	2,111,055	351,843(129,04)	216,422 487,263	2,162	360(83)	274-447

Table 3shows that from 2010 to 2015, a total of 2,111,055 (mean 351,843; 95% CI, 216,422 - 487,263) confirmed malaria cases were reported in Luapula Province. The number of cases per year ranged from 189,225 cases in 2010 to 346,089 cases in 2015, with the mean(SD) ranging from 28, 432(18,030) to 49,441(26,803) cases. The number of reported cases show increasing trends from 2010 (186,225) to 2014 (573,276), then a decreasing trend from 2014 to 2015 (346,089).

3.2. IRS coverage and, ITN coverage and Usage in Luapula Province

Table 4: IRS coverage, ITN coverage and ITN usage in Luapula Province, 2009 to 2015.

Percentage of households sprayed (IRS percentage coverage)	Percentage of households with an ITN to sleeping space ratio of at least one to one (ITN Percentage usage)	ITNs percentage coverage	Year
9.2	.	59.9	2009
18.0	20	49.9	2010
17.0	26	70.0	2011
16.0	31	90.0	2012
23.8	51	88.3	2013
23.8	51	88.3	2014
31.6	72	86.5	2015

Table 4 shows a summary of yearly interventional activities in Luapula Province from 2009 to 2015. . The highest IRS% coverage was attained (23.8%) and the least was attained in 2009 (9.2%). The highest ITN% coverage was attained in 2013 and 2014 (88.3%), and the lowest was attained in 2010 (49.9%). Usage of ITNs was highest in 2015 (72%) and lowest in 2010 (20%).

IRS coverage,ITN coverage and ITN usage has been on the increase since 2010. There has been a 31% increase in ITN coverage (t=3.33. P=0.021),a 72% increase in ITN usage (t=7.67, P=0.002), and a 71% increase in IRS coverage(t=5,26, P=0.003), from 2010 to 2015.

3.3 The effect of vector control interventions on malaria morbidity.

Figure 5 presents data on IRS coverage, ITN coverage and usage, in relation to malaria prevalence in Luapula Province. Malaria prevalence had increased by 190% (t=6.06, P=0.009), from the year 2010 to 2014, despite the increase in the both the interventions. However, the up-related scale of and in ITN usage in 2015 with a 47% decrease (X^2=8.32, P=0.0039) in malaria

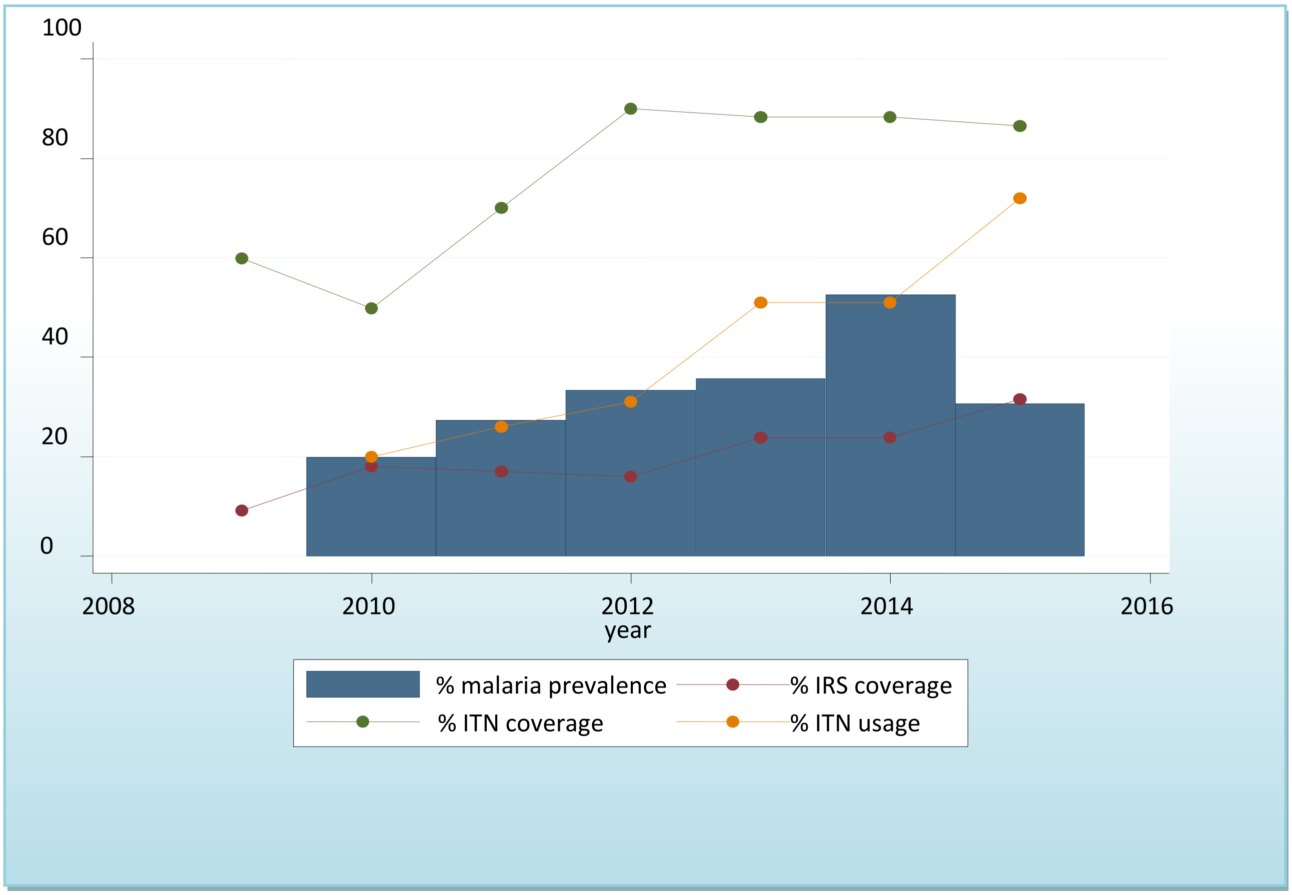

Fig 2: IRS coverage, ITN coverage and ITN usage in relation to malaria prevalence in Luapula Province, 2010 -2015.

CHAPTER FOUR : DICUSSION

We set out to assess wether or not ther was an association between the vector control interventions by IRS and ITNs and the prevalence of malaria in Luapula province, in Zambia., in the time period of 2010-2015By province, Luapula reported the highest level of malaria prevalence, with 32.5% of children testing slide positive. Muchinga, Northern, and North-Western provinces reported the next highest levels of slide prevalence with 31.4%, 27.6% and 22.6%, respectively. Lusaka and Southern provinces reported the lowest levels of slide-positive children with less than 3% RDT positivity. Over time, North-Western Province has reported a large increase in slide prevalence, from 2010 to 2012 and on to 2015 (Figure 12). This contrasts with the situation in Eastern and Southern provinces which reported a decline between 2012 and 2015. As with the rest of the country, it was noted that that trends in the coverage of both the interventions were steadily increasing in the six-year-period of study. There had been a 31% increase in ITN coverage and a 71% increase in IRS coverage from 2009 t0 2015. Again, as with the rest of the country, malaria vector control by ITNs is the main vector control intervention and IRS is the supplementary intervention (MoH, 2015). It was therefore noted that ITN coverage was generally higher than IRS coverage in the total time period and that although large numbers of ITNs are being distributed, the usage of these nets were still low and had never met the targeted goal of 80% coverage during the study period.

Despite the noted increase in the control interventions by ITNs and IRS, malaria still remained endemic and was increasing with time, during the period of study. The malaria indicator surveys which show declines in malaria transmission and prevalence throughout much of Zambia, identifies several transmission foci including Luapula province. Similar findings were recognized during the malaria programme review conducted in 2010 by an independent team of experts and concern was expressed about malaria control in Luapula Province (NMCC, 2010). This increase could be attributed to increased insecticide resistance among the mosquito populations, population movement across the borders or internally from endemic areas, increased outdoor transmission or increased access to RDTs for parasitological confirmations in highly endemic settings (Chanda, 2011; WHO, 2005). According to World malaria report of 2010 and the Malaria indictor surveys information, they reviewed that there had been a decreasing trend in malaria morbidity in Luapula province, in the previous years before 2009 and that malaria morbidity began to increase from 2009 onwards. This resurgence of malaria confirms with the findings of Masaninga et al, in 2013, when they set out to assess the epidemiology and trends of malaria in the entire country of Zambia. The reported resurgence was because of the increasing trends from Luapula province together with Eastern and Northern provinces, they reported. It has also been reported that the observed resurgence was attributed to the reduction in funds allocated for malaria control. From the year 2007, Zambia 's financial efforts pertaining to malaria control had not been sustained and had been dropped since then, making the delivery of interventions a challenging task and compromised people's health (Roll back Malaria, 2011).

A notable peak in the number of cases was observed in the period of study. This occurred in 2014, a year with 81, 897 cases reported. The prevalence rate in this year was at 526 cases per 1000 population. This peak was followed by a steep reduction of almost 40%, in the subsequent year. This decrease was due to the noted increase in the use of ITNs in 2015. Also, it can be attributed to the upscale of IRS coverage that may not have been reflected in the HMIS data, but actually, in 2014, there was an AIRS spray complain conducted in Luapula province that had covered about 87.8% of the houses. As earlier stated, malaria mortality show a decreasing trend. This decrease can be attributed to an increased access to ACTs or/and anti-malarial drugs or even an increase in early diagnosis of the disease.

The general distribution of malaria by district was assessed as well. Results indicated that malaria distribution varied significantly across the districts. Mansa district had the highest number of cases in the total period of study (26%), whilst Milenge district with 6% of the total cases, had the lowest number of cases. This was so probably because of the population sizes of the district. Mansa in this case has the biggest population size in Luapula province, whilst Milenge is one of the districts with a small population size (CSO, 2010). We then went forth to assess which district had the highest and lowest risk of malaria. Mwense district had the highest risk with 55% prevalence, followed by Kawambwa district with prevalence rate of 48%, during the six-year period, from 2010-2015. The least risk was in Chiengi district whose prevalence rate fell at 19%, during the years, 2010 to 2015. The high prevalence noted in Mwense district could be due to its close proximity to the Democratic Republic of Congo, but, it is not the only district in Luapula province that is in close proximity with DRC. Actually, most of Luapula's districts boarder with DRC. Probably the people in this district are highly mobile compared to other districts. Therefore, further research has to be done to assess the main reason behind the high burden of Malaria in Mwense. One the other hand, the high burden of malaria in Kawambwa can be attributed to its intensive agricultural activities practiced, especially those among the tea plantations. The link between malaria and agriculture has a long history, in particular irrigation, by creating suitable breeding sites that facilitate malaria transmission (Bruce-Chwatti, 1993), and insecticed resistance developed by the mosquitoes due to their overuse during agricultural practices (Albuelmaali, 2013). In addition to the many water bodies situated in the district, It also has been reported that Kawambwa has the longest rainy season in the province, that stretches from October to May, and has had flood outbreaks in recent past. It actually has been nick-named the water district by the daily mail newspaper over the years. This abundance of water therefore has contributed to the high malaria burden noticed.

In general, Luapula has a very high burden of Malaria and it records to be the province with the highest prevalence in Zambia (MIS, 2015). Importation of cases from DRC should be considered as it may be expected that the high burden malaria in DRC could be affecting the province. Reports confirm that the burden of malaria in DRC continues to increase and that Congo is now the country with the second highest prevalence of Malaria, after Nigeria (WHO, 2015).

It is evident from this study that there has been no direct link between the vector control interventions by ITNs and IRS, and malaria morbidity in the six years period of study, except from the period 2014 to 2015. During this period, as earlier stated, the significant increase of ITN usage, as well as the continued steady increase in IRS coverage led to the sharp reduction of in malaria cases. Factors such as an increased use of other preventive interventions or improved education and awareness or improved socioeconomic indices may have equally played a role in the marked reduction of the burden in the province. Countries like Namibia have significant reductions malaria morbidity and mortality at national level, but has had some districts in the Northern parts of the country that still are recording an increase in malaria cases and deaths over time (Loide, 2016). For the past three years, regions in the northern borders of the country have reported increases in the numbers of malaria cases and deaths, with Kavango East and West topping the list, followed by Zambezi, Omusati and Ohangwena (Loide, 2016). In Tanzania, an increasing trend was observed in 2007 despite the scaling up of ITNs. It was argued that, despite the coverage increasing with time, the burden still increased due to underuse of ITNs, low net re-treatment rate and insecticide resistance developed due to overuse in agricultural activities (Leonard, 2007). Also, a study in Western Kenya reviewed findings that there was a resurgence of parasite prevalence and malaria vectors in two of the study sites despite a high ownership of ITNs. The factors that were likely to contribute to malaria resurgence included reduced efficacy of ITNs, insecticide resistance to mosquitoes and lack of proper use of ITNs (Zhou, 2011).

It is acknowledged that this study has several limitations given that it mainly relies on surveillance data. Firstly, the problem with surveillance data is that the quality might be subjected to reporting inconsistencies and incompleteness, emanating from incorrect completion of notification forms, lack of systematic inclusion of data from other sources such as traditional healers, faith-based organizations and self-treatment cases. Secondly, over-reporting of cases could have also occurred in the high-risk areas due to high awareness and advocacy regarding malaria among health care providers and workers. Finally, it is possible that some confounding factors that may have influenced the changes in the burden of malaria were not assessed in this study, such as the effect of other preventive interventions, changes in vector population, human population movements, and increased access to health care services, ACT and more sensitive and specific tools and socioeconomic factors

The other major limitation encountered by the study was with the sources of data. Because of the inconsistence of ITN and IRS data from district health management units, we extracted data from the Malaria indicator surveys (MIS). Malaria indicator surveys are not routinely done on a yearly basis. The surveys were conducted in the years 2006, 2008, 2010, 2012 and 2015, and this study utilised data from 2009 to 2015. The survey data were therefore averaged for the missing years. It should be acknowledged that the trends of the two interventions may not have been truly reflected, like for instance in 2014, the averaged data did not reflect the massive AIRS complain that covered about 87% of the households (AIRS, 2015), and this is believed to have had a significant contribution to the reduction in the malaria prevalence as discussed earlier. Also, it was intended that the study included the informattion on when exactly the spraying was done per season in the total period of study, but the districts did not have this data, except from that of the year 2015. This information was vital for this study as it is known that the time of spray strongly associates with whether or not the spraying reduces the malaria burden in a particular season.

The study encountered an administrative limitation too. It was covering the time period from 2009 to 2015. It is during this period that the Patriotic front in government, under the leadership the late President Micheal Chilufya Sata, had added 4 more districts, Chipili, Chembe, Lungu and, Mwansabombwe to the seven districts, adding up to a total of 11 districts. This administrational change had an effect on the analysis of the geographical distribution of malaria by district, as the new districts had less surveillance data recorded. Their records were initially incorporated in the parent district each was coming from. To avoid complications, the initial 7 districts were assessed without including the 4 new ones. However, it is noted that the true geographical distribution of malaria reported may have been compromised.

Despite the above stated shortcomings, it is worth noting that routinely collected data through provincial malaria surveillance system remains the basis for measuring malaria trends over time when cautiously analyzed and interpreted. The findings of this study are therefore not expected to be substantially affected by data quality.

4.1 Conclusion

The data presented in this study documents increased malaria morbidity with a marked reduction in 2015, and a general decrease in malaria mortality, in the six-year study period (2010-2015). The conclusion that can be drawn from this study is that there had been no association between the general progress in scaling up of vector control activities by ITNs and IRS with malaria prevalence. The burden remained high and continued to increase, except in the 2014/2015 malaria season, where a significant increase in ITN usage led to the significant reduction of the prevalence of malaria.

4.2 Recommendations

The national malaria control programmes should device interventions that will further increase ITN usage in the province, e.g, net hanging campaigns.

Secondly, the national malaria control programmes should consider in scaling up both IRS and ITN coverage if local upscale of ITN alone is insufficiently effective and cannot be improved. A key consideration would be the additional cost of providing the combined intervention. It would be prudent for malaria control programmes to implement the two methods simultaneously to monitor the impact and cost-effectiveness of the combination to verify whether the additional resources have the desired effect.

The importation of malaria cases should be addressed by intensifying regional cross-border collaboration efforts in order to lower the risk of re-importation of malaria. Internally, the province may need to institute initiatives addressing immigrant carriers to restrict the importation of cases such as assessing the feasibility of boarder screening.

Last but not the least, IRS should be done at a time just before the onset of the rain for effect to be seen, and this information on when exactly the spraying is done should be recorded per spray season as this would help in impact assessment of the intervention.

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6.0 APPENDICES

6.1 Consent Form

6.2 Permission Letters

6.3 Ethical Clearance