Global Development Network

Strengthening Institutions to Improve Public Expenditure Accountability

Vector Control in Malaria Policy Simulations on Combined Use of ITN and IRS

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April 2013

GDN Global Development Network
The Global Research Capacity Building Program™

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1 Background

Malaria is a blood disease commonly caused by the parasite *Plasmodium Falciparum,* which is transmitted to the human body through the *Anopheles* mosquito. The disease is known to digest the haemoglobin in the red blood cells, thereby altering the properties of the cells it inhabits. It is predominant in Sub-Saharan Africa and is one of the leading causes of morbidity and mortality. The World Health Organization (WHO) estimates that 80 percent of cases of malaria and 90 percent of malaria-related deaths occur in Africa region, with children below five years and pregnant women being the most vulnerable (WHO, 2012). In Kenya, approximately 30 percent of outpatient visits and 19 percent of hospital admissions can be attributed to malaria. Each year, around 14,000 children are hospitalized on account of malaria, and there are an estimated 34,000 malaria-related deaths among children below the age of five. Moreover, an estimated 6,000 pregnant women suffer from malaria-related anaemia, and 4,000 babies are born with low birth weight each year as a result, according to the United States Agency for International Development (USAID). Malaria causes substantial losses to both individuals and governments. Costs to individuals are associated with the purchase of drugs for treating malaria at home, expenses associated with travel to and from dispensaries/clinics/hospitals, lost days at work, absenteeism from school, and burial expenses in cases of malaria deaths. The costs to government include the maintenance of the health facilities, purchase and supply of drugs, malaria prevention costs and loss of income due to malaria. Leighton and Foster (1993) estimated the production loss associated with malaria illness to be approximately 2 to 6 percent of the Gross Domestic Product (GDP). This loss is associated with workers contracting malaria or workers taking care of children and infants suffering from malaria.

Malaria is largely controlled within two major domains: prevention and case management, so that the transmission of the malaria parasite to humans is reduced. In the prevention of malaria, two interventions, Insecticide Treated Nets (ITNs) and Indoor Residual Spraying (IRS) are used. These interventions (which are the main focus of this study) are intended to provide protection to individuals against malaria-transmitting mosquito bites and to reduce the intensity of local malaria transmission (WHO, 2012). In SSA, the possession of ITNs by households has been scaled up largely due to the WHO recommendations and also because of an increase in development assistance (Flaxman et al. 2010). From a political perspective, the Abuja Declaration in April 2001 in Nigeria — where the heads of African states committed to halve malaria deaths by 2010 and to allocate 15 percent of their national budgets to health — has also resulted in the scaling up of ITN ownership. In most SSA countries ITNs and IRS have been used independently in the fight against malaria. However, there is little evidence of the combined use of these two interventions, even though empirical studies such as those by Okumu and Moore (2011) and Kleinschmidt et al. (2009) show that there is greater protective advantage in the combined use of ITN and IRS. Okumu and Moore further find that for there to be effective protection, both ITN and IRS should have divergent complimentary roles such as highly potent IRS compounds coupled with highly effective ITNs that would help overcome the challenge of insecticide resistance.

The Government of Kenya is pretty much a part of this fight against malaria, as is evident from her commitment to the Abuja Declaration to achieve significant countrywide targets for malaria control. Secondly, the GOK has developed a national malaria strategy (NMS) 2009–2017 in line with its first Medium-Term Plan of Kenya Vision 2030 and the Millennium Development Goals (MDGs). The first objective of the NMS is to ensure that at least 80 percent of people living in malaria-prone areas have adequate protection against the disease through the use of insecticide treated nets, indoor residual spraying in targeted areas for reduction in the burden of the disease; and for the prevention of malaria in pregnancy. Lastly for effective targeting, four malaria epidemiological zones have been established: endemic areas along the shores of Lake Victoria and the south coast where malaria transmission is perennial but peaks from June to August and again in late November; highly populated epidemic-prone areas in the highlands where transmission is highest from April through June; epidemic-prone areas in the arid/semi-arid lowlands which are sparsely populated; and very low-risk or transmission-free areas in the highlands above 2,000 meters.

The government, in its NMS 2001–2010 committed to the combined use of ITN and IRS in combating malaria. This combined approach commenced in 2010 even though both the approaches have been in existence for over 20 years; furthermore, with the emergence of insecticide resistance in over 64 countries cited by the WHO, and the changing malaria-vector biting behavior in cases where ITNs have been used, it is important to establish alternative strategies for effective targeting of malaria vectors if the MDG 6 on reversing malaria trends is to be achieved. This paper attempts to establish alternative strategies for malaria vector control by first presenting the problem and the objectives of the research paper. Section 2 looks at malaria vector control in Kenya; section 3 provides the methodology for establishing an alternative strategy while sections 4 and 5 present the findings and conclusions respectively.

1.1 The Problem

The intervention used in malaria prevention in Kenya takes cognizance of the epidemiological zones so that IRS is used in the epidemic highland region, given the behavioral attributes of the malaria parasites found in this region: *Anopheles gambiae s.l.* and *Anopheles funestus* that feed and rest indoors.

The universal coverage of ITN is defined as one net per two people for all populations at risk of malaria. The combined used of IRS and ITN as a policy is documented in NMS 2010–2017. However, while this policy has been put in place, ITN coverage by 2008 was 66 percent and IRS was only 10.5 percent; this decreased to 37 and 48 percent respectively in 2010. Given this trend, achieving MDG number 6 on halting and reversing the incidence of HIV/AIDS, malaria and other diseases will remain a challenge.

Secondly, malaria vector control uses insecticides from four chemical classes: *pyrethroids, organochlorines* (including *dichlorodipheyltrichloroeethane* or DDT), *organophosphates* (OPs), and *carbamates* (WHO, 2011). IRS can be carried out using any of the four classes of insecticides while for ITN only the pyrethroids class of insecticides can be used. Mosquito

parasites tend to develop “knock down resistance” i.e. the *anopheline* mosquitoes remain unaffected by insecticide, or “metabolic resistance” where increased levels or modification of a detoxifying enzyme system prevent the insecticide from reaching its intended target site. When insecticides develop resistance to chemicals used in ITNs, it is not easy to effectively combat malaria; this is when it becomes necessary to combine this intervention with IRS, which can use a wider range of insecticides for higher efficacy.

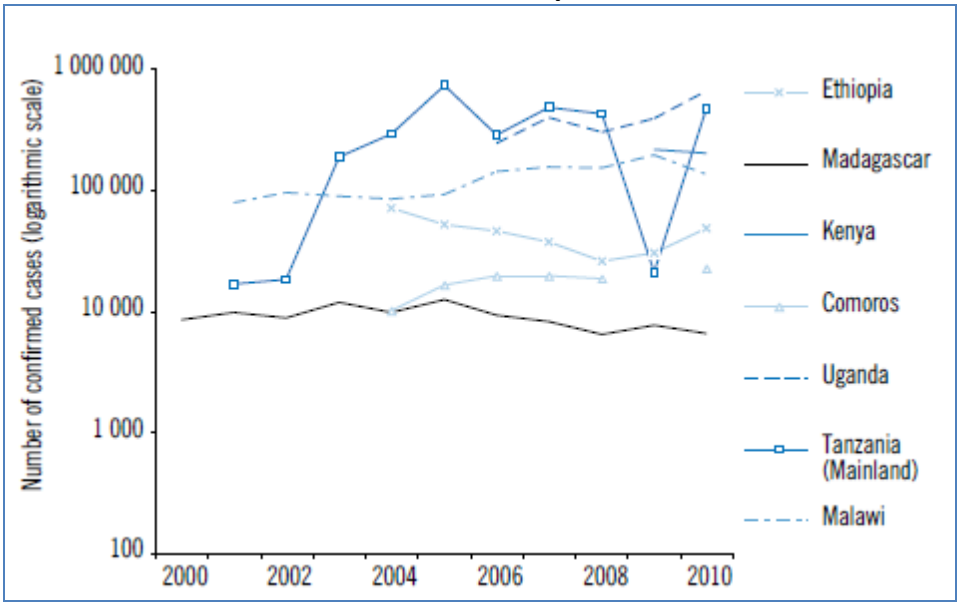
Furthermore, studies have shown that mosquitoes tend to adapt to bed nets by changing their biting habits, for example in the study by Moiroux et al. (2012), where after three years of implementation of universal coverage of long lasting insecticide treated nets (LLINs), the usual catching time for the mosquito *Anopheles funestus* changed from 2.00–3.00am to 5.00am while the proportion of outdoor biting increased from 45 percent to 68 percent after one year of sustained universal cover of LLINs. With this finding, the change in malaria vector biting behavior necessitates the examination of alternative strategies targeted at malaria vector control.

Kleinschmidt et al. (2009) went ahead and established the protective advantage of the combined usage of ITN and IRS in malaria vector control. They found that a combination of these two interventions in Kenya provided a 75 percent protective advantage compared to the use of ITN alone, which provided 63 percent advantage. With this finding, it is possible to simulate policy scenarios of malaria vector control and their likely outcomes: the use of ITN and IRS independently and the combined use of ITN and IRS as complements in an attempt to address the challenges of insecticide resistance, changes in mosquito biting habits and to also provide policy advice based on the evidence generated, given that Kenya has largely applied IRS and ITN independently within the epidemiological zones.

1.2 Significance of the Study for Policy Action

The Government of Kenya, in its economic blueprint “Vision 2030: A Globally Competitive and Prosperous Kenya”, acknowledges that preventable diseases such as HIV/AIDs, tuberculosis and malaria still take a heavy toll on the health of its population, despite the gradual fall in the incidence of these diseases. The government, under the national malaria strategy aims to reduce the incidence of malaria to below 25 percent (GOK, 2009). Furthermore, Kenya is committed to the MDGs where several development targets have been set. Of particular significance is goal 6, which is about combating HIV/AIDs, malaria and other diseases. Its aim is to first halt and then begin to reverse the incidence of these diseases by 2015 (UN, 2010). According to demographic data, Kenya is ranked among the countries where malaria control activities are widespread, i.e. they cover more than 50 percent of the population at risk. However, there is little evidence of improvement or sustained decrease in the incidence of malaria (ibid.), since Kenya ranks among the countries with either an increase or less than 25 percent decrease in the malaria incidence.

Figure 1: Countries with decrease or less than 25 percent decrease in malaria incidence



Source: WHO 2011

While this target falls within Kenya's malaria-control strategy, it is below that of the UN MDG of halting malaria deaths through the use of ITNs and IRS. Highly effective interventions are required to ensure sustained decrease in the incidence of malaria.

In 2006 when Kenya committed to using ITN, 57 percent of households had at least one ITN — an increase from the 48 percent coverage in 2003 (GOK, 2010). However, at this time, there was limited intermittent use of both IRS and ITN in malaria vector control, whereas according to Kleinschmidt et al. (2009), the combined usage of ITN and IRS was more effective in combating malaria as it provided a protective advantage of 75 percent for the overall population, compared to the use of ITNs only which stood at 63 percent. In 2010, approximately 44 percent of the households had at least one long lasting insecticide treated nets (LLINs) while 47 percent had at least one ITN.[1] The combined use of ITN and IRS remained low, at 5.1 percent (KMIS, 2010). It is, therefore, important to undertake a policy simulation to establish the impact of the combined usage of IRS and ITN for wider control of the malaria vector in order to inform the ministry of health, for this is a strategy that has already been accepted in the national malaria strategy but has not been implemented. The combination of the two interventions could also have cost savings advantages, which could facilitate need-based allocation of resources.

Moreover, this study will add value to the new WHO strategy of managing insecticide resistance, which according to the World Malaria Report of 2012 — the first pillar of the global plan for insecticide resistance management in malaria vectors (GPIRM) — calls for the planning and implementation of insecticide resistance management strategies in malaria-endemic

[1] ITN is a factory-treated net that does not require any further treatment (LLIN) or a net that has been soaked in K-O tab 1-2-3 or in insecticide for the past 6 months.

countries. This study, which will focus on the combined use of ITN and IRS, will feed into providing evidence that can be used to develop strategies for fighting insecticide resistance.

1.3 Research Objectives

1. Review the characteristics of the four malaria epidemiological zones and the alternative use of ITN and IRS in malaria vector control in Kenya.
2. Simulate the policy scenarios for the use of IRS and ITN as alternatives and as complements in malaria prevention.
3. Provide policy recommendations based on the findings.

1.4 Policy Goal and Simulation Scenarios

The main policy goal is to establish a malaria vector control strategy that will ensure rapid reduction of the malaria menace in Kenya, where currently, IRS and ITN are substitutes in malaria vector control. The proposed strategy combines these two interventions so that they complement each other in combating malaria. With this strategy, the benefit incidence and cost effectiveness will be established and compared to the current strategy where IRS and ITN are substitutes. This will involve building different scenarios as follows:

1. **Base Scenario – status quo**: the current coverage of 48 percent using only ITN or IRS while taking cognizance of the malaria epidemiological zones.
2. **Scenario 1 – alternative**: use the current coverage of 48 percent for combined use of ITN+IRS in all epidemiological zones, apart from low-risk zones where only ITN is used.

2 MALARIA VECTOR CONTROL IN KENYA

The intensity of malaria transmission in Kenya is determined by the differences in altitude, rainfall and temperature. This has resulted in the country having five distinct epidemiological zones (Table 1). The GOK adopted strategies for combating malaria in 2007 and 2010 for the different epidemiological zones.

Table 1: Malaria Vector Control in Kenya

Epidemiological zones	Characteristics	2007	2010
Semi-arid/Seasonal	• Transmission for a few months of the year • Malaria is contracted by communities residing near water bodies	LLIN for pregnant women and children under 1 year.	LLIN for pregnant women and children under 1 year.
Coastal Endemic Region	• Malaria transmission is throughout the year	LLIN	LLIN

	• Adult population acquire partial immunity • Children and pregnant women more prone to death from malaria • Exhibit stronger seasonality		
Highland Epidemic Region	• Low disease risk on an average per year • Variations in rainfall and temperature each year can lead to epidemic affecting the entire population	LLIN	LLIN
Lakeside Endemic Region	• Malaria transmission is throughout the year • Adult population acquire partial immunity • Children and pregnant women more prone to death from malaria	LLIN and IRS	LLIN and IRS
Low-Risk Region	Central area of the country: Nairobi, Nyeri, Nakuru. Almost no risk of malaria	Environmental management	Environmental management

Source: Kenya Malaria Indicator Survey (KMIS) 2007 and 2010

2.1 Framework for Distribution of ITNs and Implementation of IRS

2.1.1 Insecticide Treated Nets

The primary malaria vector control method in Kenya is the insecticide treated nets (ITN) particularly the long lasting insecticide nets (LLIN). The NMS target is to provide 60 percent ITN coverage to children under five and 60 percent coverage to pregnant women. The distribution of mosquito nets is done through antenatal and child welfare clinics, and comprehensive care clinics for those living with human immunodeficiency virus (HIV); this is applied in all epidemiological zones. Secondly, social marketing of nets is also undertaken through designated rural shops where both LLINs and untreated bed nets with long lasting insecticide treatment kits are sold at subsidized rates in all epidemiological zones. Thirdly, mass distribution of LLINs takes place in epidemic, lakeside and coastal endemic zones only. Lastly, LLINs are also sold at retail outlets at full cost in all the urban epidemiological zones. These mechanisms ensure that all population cohorts, categorized on the basis of their incomes have access to ITNs.

The 2007 KMIS report indicates that between the years 2001 and 2007, the social marketing program sold ITNs through rural retail shops and other private sector commercial outlets at a price of KSh100 resulting in bed nets worth KSh11,162,204 being distributed. The subsidized ITNs in malaria endemic and epidemic prone zones were sold at KSh50 each. Then there was mass distribution of 3.4 million of LLINs in malaria-prone districts. These initiatives resulted in 48 percent of households having at least one ITN and 23 percent having more than one ITN. The 2010 KMIS report indicates that between 2008 and 2010, 5.4 million ITNs were distributed through antenatal, child welfare and HIV care clinics. During the same period, 1.2 million nets were distributed through social marketing while about 500,000 nets were sold through retail. Nine districts in the lakeside endemic zones and all the 38 districts in the highland epidemic zones were sprayed. Consequently, in 2010 approximately 48 percent of households owned at least one ITN while 24 percent had more than one. ITN ownership has, therefore, largely remained unchanged since 2007.

2.1.2 Indoor Residual Spraying

IRS is used in the highland epidemic-prone areas and the lakeside endemic zones. It is also used to reduce the disease burden in areas neighboring the highland epidemic region. IRS requires two cycles of annual spraying together with the use of LLINs; so far there are 41 and 38 districts respectively in the lakeside endemic zones and highland epidemic-prone zones (KMIS 2010). For IRS approximately 38 percent of household in highland epidemic areas and 15 percent in lakeside endemic areas were sprayed. Only 5.1 percent of households had both IRS and at least one ITN. Kenya's IRS program is implemented at the district level. The procurement process of commodities and supplies is undertaken by a donor consortium in charge of procurement, warehousing and distribution to user end points at the district level. Supplies and commodities include insecticides, protective gear and spray pumps. These items are normally stored at the district medical stores or divisional health facilities. Following an operation, the remaining supplies are kept at the public health facility, the offices of the chiefs or at the operators' houses depending on which is closer to the operation areas. Training is handled at different levels: the training of facilitators is handled at the national level, of trainers at the district level and IRS supervisors and spray operators are trained at the divisional headquarters. Recruitment of spray operators is done through community leadership structures; therefore, village committees work in collaboration with the provincial administration and health officials.

As part of preparation for the spraying process, the Division of Malaria Control (DOMC) undertakes a pre-implementation baseline survey that collects the parasitological and entomological information. A post-spraying evaluation is also undertaken to provide comparisons. Publicity and advocacy is done at the district level with the district development stakeholders who play a critical role in social mobilization, sensitization and education of the community. These stakeholders largely include local provincial administration officials, school heads and teachers, religious organizations and leaders, community-based organizations and non-governmental organizations that are present. The ministry of health too holds media briefings to build the profile of the campaign. The government, through the DOMC, mainly handles operational activities which largely involve identifying target households for spraying,

spray-team deployment and coordination and supervision. There is a national steering committee whose mandate is to provide oversight direction and coordination at the national level and leverage on resource needs. This committee consists of stakeholders at the national level and the Malaria Inter Agency Coordinating Committee.

2.2 The Synergies of IRS and ITN

The use of ITN in malaria vector control was clearly stipulated in the NMS 2001–2010 where the Government of Kenya put in place the policy to increase ITN services among people at risk of contracting malaria, especially the young children and pregnant women. The institutional framework that would support this strategy is included in Annex 1, which shows the role of different institutions in the provision of essential health package that includes malaria. Within this framework, the Ministry of Health reported that in the year 2008–09 at least 57 percent of households had more than one net. The distribution of bed nets is done every three years to all households; this is done through schools and health facilities in malaria-prone areas. Pregnant women and children below one year are target recipients of bed nets at child health clinics (GOK, 2009).

The IRS program was adopted in Kenya under the NMS 2001–2010 when it became apparent that the country's existing health management system was unable to efficiently and consistently run a malaria early warning system; therefore, putting in place effective malaria interventions during the epidemic periods, especially in the western highlands of the country, was impossible (GOK, 2007). Currently IRS is being conducted at the lakeside, an endemic region which is in the western part of Kenya (Table 1). The DOMC under the Ministry of Health carries out IRS. This is usually an annual campaign 40–60 days before the peak transmission seasons between May and August. The ministry procures and supplies the commodities such as insecticides, spray pumps and protective gear. There is training of district and division supervisors involved in the IRS campaign so that the spraying exercise takes place between April and June each year. Before the spraying begins, the district stakeholders' forums (consisting of local provincial administration, teachers, church community organizations, and community-based organizations, among others) are held to sensitize the members of the community to the benefits of the exercise; the stakeholders in turn provide support in the form of social mobilization and education of the larger community.

ITN and IRS have conventionally been used in Kenya as substitutes in malaria vector control, because ITN has been cheaper to administer while IRS involves more complex procedures that are not resource friendly despite being quite effective in high transmission areas. Most studies have documented evidence of the impact of ITN on malaria vector control, compared to IRS. Binka et al. (1998) investigated the impact of insecticide treated nets on child mortality in rural northern Ghana. The study was undertaken in a randomized controlled trial test environment using insecticide treated nets in a highly malaria endemic area. They found a 6.7 percent decrease in under-five infant mortality for non-users a 100 meter away from the nearest compounds using the ITNs, implying that the insecticides protected the nearby non-users. Hawley et al. (2003) carried out a similar randomized test to establish the impact of the use of

ITNs on both users and non-users in Asembo, Western Kenya. They found a protective effect of ITNs on compounds without ITNs located 300 meters away, with positive impact on child mortality rates, anemia, parasitemia and hemoglobin levels. Moreover, they found that ITNs not only form a physical barrier protecting individuals under the net but also had an area-wide effect on the mosquito population.

There has, however, been limited research on the impact of indoor residual spraying. Based on the works of Pleuss et al. (2010), who reviewed several studies on the use of IRS for malaria prevention, it was found that in Tanzania, IRS was effective in protecting children under five from malaria infection by 54 percent as compared to Nigeria where the protective efficacy was 26 percent during the dry season. There have also been limited studies to investigate the effect of the combined use of IRS and ITN. Kleinschmidt et al. (2009) established that the combined use of these interventions helps reduce the transmission and thereby the burden of the disease more rapidly than may be feasible using only one method. Secondly, the combined use also has the advantage of overcoming mosquito resistance to certain insecticides, this is because with IRS, different classes of insecticides can be used, and this ensures a setback in the development of resistance. Kleinschmidt et al. (2009) in their study found that surveys in Bioko (E. Guinea) and Zambezia (Mozambique) showed strong evidence of protective effects of IRS combined with ITN (0.71 and 0.63 respectively) compared to those who had neither which was 0.46 and 0.34 for Bioko and Zambezia respectively.

Given the high protective efficacy of IRS due to its ability to use a wide range of insecticides and overcoming the challenge of insecticide resistance, an investigation of the combined use of IRS and ITN in Kenya would be imperative as an effective policy option for combating malaria and consequently reducing the high malaria-related mortality rate. Currently, a universal bed net coverage campaign is underway in Kenya based on the 2000 presidential declaration in Abuja. The IRS campaign has remained restricted to the highland epidemiological zone of the country. It is, therefore, important to undertake policy analysis on the implications of the combined use of ITN and IRS in order to establish its likely impact, given that empirical evidence points to improved efficacy of combined strategy.

3 METHODOLOGY

3.1 Measuring the Benefits of Status Quo and the Alternative

The measure of the benefits of the status quo (use of ITN and IRS as substitutes) and the alternative (IRS and ITN as complements) is the protective efficacy of each, as obtained from the existing literature on the benefits of IRS, ITN or the combined use of the two. Several literature sources were examined to establish the measure to be used for determining the benefits. The term ‘protective efficacy’ (PE) was found to be the common measure of benefits associated with the two interventions. PE in this case is the protective advantage that a malaria intervention has to offer in reducing the incidence of malaria infection when that particular intervention is used. PE is calculated by dividing the prevalence of infection when using the

intervention by the prevalence of infection without the intervention. Studies that were reviewed to establish the protective efficacy of the malaria vector control interventions were all undertaken in the Nyanza province in Kenya where malaria is rampant. Rachuonyo and Nyando districts lie within the lakeside endemic region while Kisii and Gucha districts lie in the highland regions as classified under the malaria epidemiological zones.

Hamel et al. (2011) studied malaria prevention in Rachuonyo and Nyando districts in Kenya by conducting a non-randomized test to establish the effectiveness of the combined use of ITN and IRS (ITN+IRS) and ITNs alone. Rachuonyo and Nyando districts lie within the lakeside endemic epidemiological zone where malaria transmission is perennial, with seasonal peals in April to July and November to December. These districts had malaria prevalence of 9 and 11 percent respectively. For IRS, households within 1 km of three health facilities in Rachuonyo and Nyando were selected for the study, following an IRS campaign that took place in the two districts two months earlier. ITNs were provided for every sleeping space and old ITNs were replaced with new ones in order to ensure uniformity of insecticide and durability. All participants provided blood samples for baseline malaria detection and hemoglobin measurement, and were provided a treatment course of *artemether – lumefantrine* (AL) at baseline to ensure that *p. falciparum* infection was treated. Participants were visited each month and those who were sick underwent tests and received malaria treatment. Malaria screening and treatment was done so at the end of the exercise, a total of 1,804 household members were enrolled, of which 919 were from ITN+IRS group while the ITN-only group had 885 members, given that they had completed the 9-month follow up period. Based on the procedures stated above, the protective efficacy of the combined use of ITN+IRS as compared to ITN only is 62 percent (Table 2). These results are significant at 95 percent confidence interval.

Table 2: Protective efficacy of ITN and IRS compared to ITN only (95% confidence interval)

Malaria Incidence	Adjusted Rate Ratio (RR)	Protective Efficacy
Overall	0.38 (0.28-0.50)	0.62 (0.50 - 0.72)
6 m- 14 years	0.33 (0.18-0.62)	0.67 (0.38 - 0.82)
5-14 years	0.37 (0.26-0.54)	0.63 (0.46 - 0.74)
> 15 years	0.34 (0.18-0.64)	0.66 (0.36- 0.82)

Source: Hamel et al. (2011)

Guyatt et al. (2002) conducted a study in the Kenyan highlands in Kisii and Gucha districts in order to establish the protective efficacy of using ITN and IRS. Kisii and Gucha districts are in the highland epidemiological zone at an altitude of 1400–2000m above sea level. Here, the transmission of *p. falciparum* is seasonal, between June and August. Homesteads that were operationally targeted during a district emergency response by an international relief organization were randomly selected for evaluation. A total of 590 homes were selected (200 with no vector control, 200 with ITN and 190 with IRS); residents in these homesteads were randomly sampled according to three age groups: 6 months to 4 years, 5 to 15 years, and above 15 years. Individuals from these age groups were randomly selected for testing the presence of

p. falciparum antigen and the results of the control, ITN and IRS homesteads were presented as the pre-intervention morbidity statistics, and this also included the hospital admissions. The period under study was between January to April 2000. Overall, sleeping under ITN reduced the risk of contracting malaria by 63 percent, while sleeping in a room sprayed with insecticide reduced the risk by 75 percent compared to households that neither had bed nets nor sprayed their houses. Table 3 provides the protective efficacy of the use of ITN and IRS by age cohorts.

Table 3: Protective efficacy of ITN and IRS

Outcome: Malaria Incidence	**Insecticide Treated Nets (ITN)**	**Indoor Residual Spraying (IRS)**
Overall	0.63 (0.58 - 0.68)*	0.75 (0.73 - 0.76)*
Less than 5 years	0.66 (0.51 – 0.84)[2]	0.72 (0.65 - 0.81)***
5-15 years	0.37 (0.02 - 1.00)[2]	0.68 (0.63 - 0.73)**
Above 15 years	0.70 (0.62 - 0.80)***	0.82 (0.81- 0.84)*
Age adjusted	0.59 (0.29 – 0.77)**	0.75 (0.58 – 0.85)*

Significant at 5% level, *P <0.001, **P <0.01, ***P <0.05 [2]not significant

Source: Guyatt et al. (2002)

3.2 Total Cost: Status Quo vs. Alternative

The status quo and alternatives costs were derived from different data sources since there was a major challenge in obtaining cost data from one malaria source, i.e. the Division of Malaria Control under the Ministry of Health. Cost data were derived from the Presidential Malaria Initiative (PMI) reports for Kenya, Kenya Malaria Indicator Survey (2010) and Government of Kenya reports by making several assumptions. Table 4 builds the government cost data for IRS and ITN. From the PMI action plan, which is prepared by the USAID in close consultation with the GOK, it was estimated that 7,400,327 nets were required to achieve universal coverage in 2010. However, given that there were no actual reports available to show the actual coverage achieved by government, it was assumed that all funding for malaria prevention came from development partners. Table 4 provides the total cost of IRS and ITN by all development partners taking part in malaria prevention and treatment.

Table 4: Development partners budget for vector control intervention, 2010

Vector Control Intervention	**Amount (USD)**
ITN	
Procurement of LLIN	12,500,000
LLIN routine distribution	2,500,000
ITN mass campaign	650,000
TOTAL	**15,650,000**
IRS	
IRS implementation and management	6,800,000

Vector Control Intervention	Amount (USD)
Epidemiological surveillance	150,000
Entomological monitoring of IRS effectiveness	150,000
Environmental monitoring	30,000
Technical assistance	24,200
TOTAL	**7,154,200**

Source: PMI Initiative 2010

3.3 Measuring Equity

Equity in the status quo and the alternative was measured using household quintiles and location, i.e. rural and urban areas. Household quintiles were derived from the wealth index constructed using the Filmer and Pritchet (2001) approach. In this approach, household assets from the Kenya Malaria Indicator Survey 2010 data were used to construct the wealth index which was then used to establish household quintiles for measuring equity. The statistical procedure principal component analysis is used to determine the weights for an index of the asset variable. Using this approach, a set of N variables, a_{1j}^{*} to a_{Nj}^{*} represent ownership of N assets for each household j. The principal component specifies each variable normalized by its mean and standard deviation so that $a_{1j}^{*} - a_{1}^{*} / s_{1}^{*}$ where a_{1}^{*} is the mean of a_{1j}^{*} across households and s_{1}^{*} is the standard deviation. The principal component, therefore, finds a linear combination of the variables with maximum variance — the first principal component and then a second linear combination of the variables orthogonal to the first, and so on. The full workings of the model are explained in Filmer and Pritchet (2001: 116-117).

3.4 Data Sources

- (KMIS) 2010. KMIS provides periodic measurements on the progress of key malaria indicators against national and international targets. The 2010 data was collected between June and August during the peak malaria transmission season. The 2010 KMIS data was richer since it captured both coverage of ITN and IRS as compared to 2007 KMIS which collected IRS only under vector control.
- Direct costs components for IRS and ITN will be obtained from the Division of Malaria Control (DOMC) while other costs will be derived from a combination of information from DOMC and the presidential malaria initiative data.
- Presidential Malaria Initiative (PMI) data for Kenya 2010.

4 RESULTS AND DISCUSSION

4.1 Cost Effectiveness

Estimation of cost effectiveness requires the total cost associated with both the status quo and the alternative. Obtaining the cost data for malaria remained a major challenge as several players were involved in malaria campaigns in Kenya; this was further complicated by the fact that the malaria budget fell under the development expenditure and largely depended on donor funding: Presidential Malaria Initiative (PMI), Department for International Development (DFID), the Global Fund, United Nations Children's Fund (UNICEF) and other donors. Even though the Kenya government equally contributed to malaria prevention, most of the funds came from the global fund.

4.1.1 Base Scenario – Status Quo

Table 5 provides a summary of the malaria cost data for Kenya in 2010.

Table 5: Cost Effectiveness Analysis for Base Scenario- Status Quo

INTERVENTION	AMOUNT (USD)
ITN	
1. Total cost of ITN in Kenya (from Table 6)	15,650,000.00
2. Number of individuals protected under ITN = (number of ITN distributed) * PE of ITN*number of individuals per net = ((15,650,000/5)*0.48)*0.63*2	1,893,024.00
Cost Effectiveness of ITN = (1)/(2)	**8.27**
IRS	
3. Total Cost of IRS implementation and management (Table 6)	7,154,200.00
4. Number of individuals protected under IRS = coverage of IRS *PE of IRS * average household size= (7,154,200/25) *0.75*4.3[2]	922,891.80
Cost Effectiveness of IRS= (3)/(4)	**7.75**

Source: Authors Calculation from KMIS 2010, PMI 2010 reports

In order to derive the cost effectiveness of IRS and ITN, a common base was established so that both approaches could be compared. The reason for this is that ITNs are distributed to individuals while IRS is sprayed in households. It was, therefore, important to establish the number of individuals protected for each vector control method. For ITN, the total cost included: procurement, distribution and campaigns, because these associated costs are important in ensuring that households use the ITNs correctly. Considering the wastage/ misuse

[2] The average household size is 4.3 according to KMIS 2010 and Census 2009

of bed nets, as evidenced by Minakawa et al. (2008) — where these nets are used as fishing nets or for drying fish — mosquito net utilization rate of 48 percent was factored in based on the KMIS 2010 household coverage of ITN. As a result, the cost effectiveness, found to be USD 8.27 for each person protected under ITN, was used. A similar approach was adopted to obtain the cost of IRS in order to establish the number of individuals protected, and here, USD 7.75 was used as per person protection amount. Table 5 provides the cost effectiveness measure for the base scenario, so that IRS is found to be more cost effective than ITN.

4.1.2 The Alternative Scenario

Building the alternative scenario entailed the use of both stylized facts as well as making several assumptions.

4.1.2.1 Stylized facts

1. According to the Kenya National Bureau of Statistics (KNBS) population projections for 2009, the number of people at risk of malaria living in endemic, highland epidemic-prone and seasonal areas is 27,596,285. The number of pregnant women and children below five years living in these areas is 8,392,725.
2. The average household size in Kenya is 4.3 based on the Kenya population census of 2009 and KMIS 2010.
3. The combined use of ITN and IRS has a protective efficacy of 62 percent compared to ITN only. The protective efficacy of ITN and IRS is 63 and 75 percent respectively. Given that the combined use of IRS and ITS is compared to ITN only, the protective efficacy of ITN and IRS is 1.02 (0.62/0.63).

4.1.2.2 Assumptions

1. The cost of IRS per household is USD 25; this includes the purchase of chemicals, training, equipment maintenance and facilitation.
2. The cost of an ITN was taken to be USD 5; this was the cost associated with procuring the bed net.
3. There are economies of scale associated with the combined use of ITN and IRS.
4. The current 48 percent coverage of ITN was assumed to be the same coverage for IRS+ITN in the alternative scenario.

The main challenge in the costing of this data was our inability to obtain simple coherent cost data from one source. For this reason stylized facts, assumptions and different data sources were used to derive the combined cost of IRS and ITN. The administration of this combined approach would ride on the IRS implementation framework described in section 2.1.2. When comparing the ITN and IRS framework, the latter is much clearer and would be very appropriate as it rides on the existing national administrative framework. The cost of ITN was derived by obtaining the number of malaria vulnerable population multiplied by the ITN coverage and then dividing the result by the average household size in order to get the number of ITNs distributed

to households, assuming that each household has at least one ITN. Multiplying the total number of ITNs by the cost of an ITN gives the total cost. For the IRS, the same approach was used to obtain the cost of spraying the households. Thus, the number of malaria vulnerable population was multiplied by the ITN coverage (see assumption iv) and then divided by the average household size to obtain the number of households sprayed. This was then multiplied by the cost of spraying one household.

Within the IRS implementation framework, the cost of ITN campaigns was taken to be the same as that of campaigns for the combined use of ITN and IRS. The cost of epidemiological surveillance, entomological monitoring of IRS and ITN effectiveness, environmental monitoring and technical assistance were taken to cover both IRS and ITN and were derived from the IRS cost data. In total, approximately USD 60.6 million is estimated to be used for combined vector control in malaria. In order to obtain the number of individuals protected by the combined use of IRS and ITN, we used assumption (iv) of ITN+IRS coverage, which is assumed to be 48 percent, multiplied by the population at risk of malaria and the protective efficacy. Given that bed nets are distributed to individuals when spraying is done in a house, a common base for comparing the cost effectiveness needed to be obtained. In Table 6, the number of individuals who gained from both IRS+ITN was obtained by multiplying the population vulnerable to malaria by malaria coverage and the protective efficacy of IRS+ITN (see stylized fact iii). Table 6 summarizes the results of the cost effectiveness of the alternative scenario. With the combined use of IRS+ITN, USD 4.57 would be spent on protecting an individual at that point in time.

Table 6: Cost Effectiveness of Alternative Scenario

Vector Control Intervention	**Amount (USD)**
Cost of Combined use of ITN+IRS	
Procurement of at least one LLIN for 48% of households within the malaria risk population= 0.48*(27,596,285/4.3)*USD 5	13,370,293.00
IRS implementation and management for 48% of households within the malaria risk population= 0.48*(27,596,285/4.3)*USD 25	46,207,773.00
ITN/IRS mass campaign	650,000.00
Epidemiological surveillance	150,000.00
Entomological monitoring of IRS+ITN effectiveness	150,000.00
Environmental monitoring	30,000.00
Technical assistance	24,200.00
(1) TOTAL	**60,582,266.00**
(2) Number of individuals protected under IRS+ITN = ITN+IRS coverage*number of malaria risk population * PE (ITN+IRS)= 0.48*27,596,285*1.0	13,246,218.60
Cost Effectiveness= (1)/(2)	**4.57**

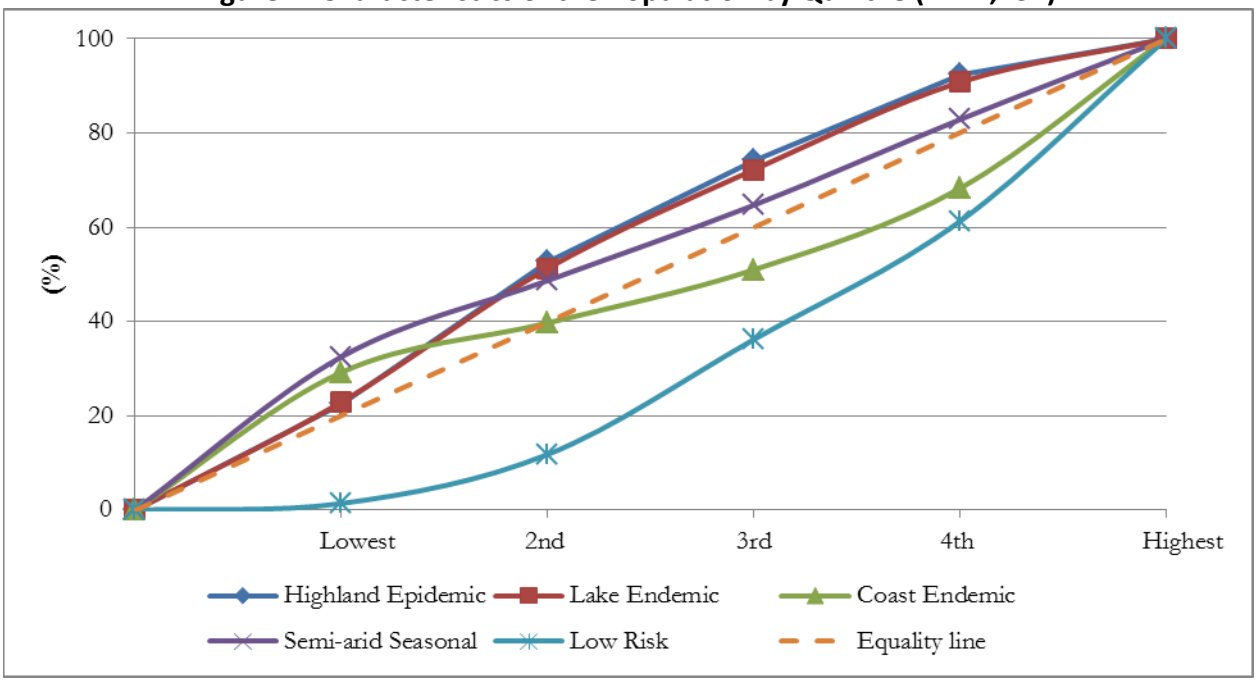
Source: Authors Calculation from KMIS 2010, PMI 2010 reports

4.2 Benefit Incidence Analysis

Benefit Incidence Analysis (BIA) is important for establishing who gains from the benefits that accrue from government projects or any other project targeted at a population segment. BIA can, therefore, be used to establish equity in distribution.

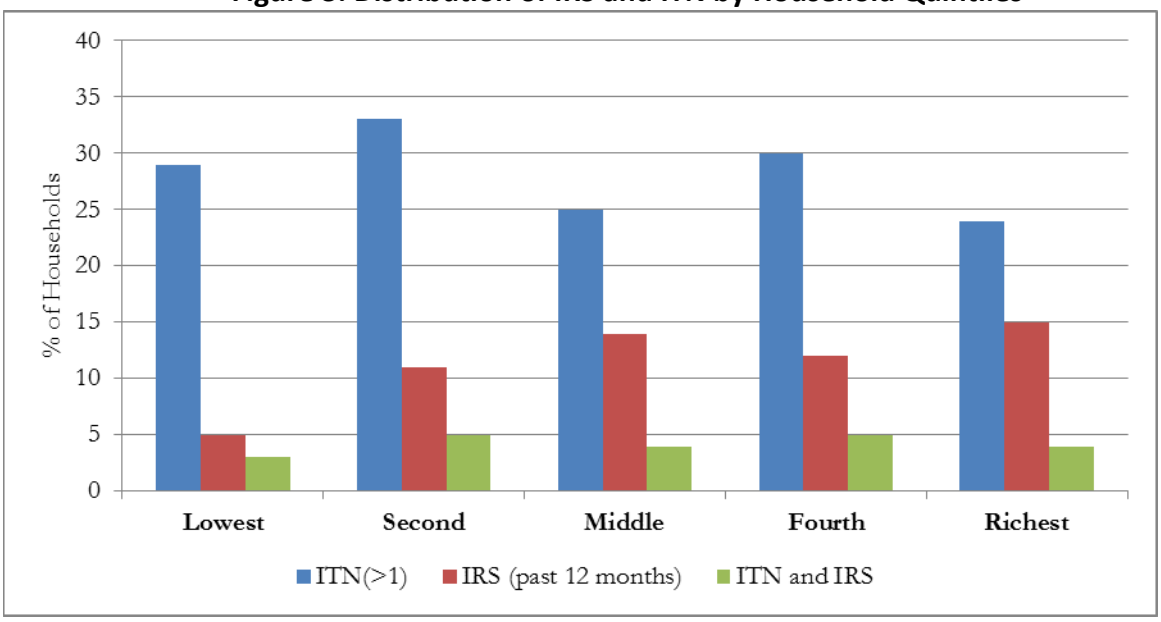
Households were divided into quintiles using an asset-based index derived from the work of Filmer and Pritchett (2001). In examining the issues of equity, it was important to first establish the characteristics of the household population that was interviewed using the quintiles developed. In this way it would be possible to obtain the living standards of the population and link these to the malaria vector control intervention used. Figure 2 shows the population quintiles of the Kenya Malaria Indicator Survey 2010. The inequality line is used to establish which regions have high incidence of inequality so that if a curve falls below the inequality line there is a high level of inequality in that particular region. Low-risk areas — largely Nairobi and certain parts of the central provinces of Kenya — have high income inequality for all the quintiles. Given that these areas are largely urban, income inequality here is much higher compared to rural areas (Omolo, 2012). For the coastal endemic region, inequality is higher in the 3rd to 5th quintile. The semi-arid, lakeside endemic and highland epidemic areas are above the inequality line, implying that the incomes here are much better distributed among the population quintiles.

Figure 2: Characteristics of the Population by Quintile (n=27,134)



Source: Author's calculations from KMIS 2010 data

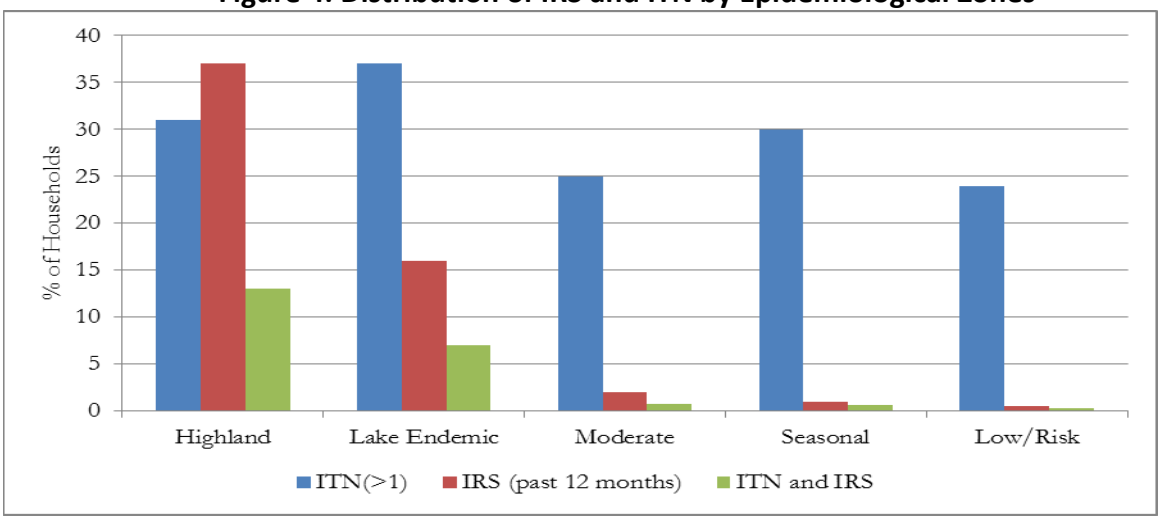
Figure 3: Distribution of IRS and ITN by Household Quintiles



Source: Author's calculations from KMIS 2010 data

Equity in the combined use of ITN and IRS has been illustrated using the location, household quintiles and the malaria epidemiological zones. The main indicators for vector control, as outlined in the national malaria policy guidelines, are households that own at least LLIN and households sprayed in the last 12 months. The distribution of ITNs is highest in the 2nd quintile —approximately 33 percent (Figure 3). This distribution can be explained by the free mass distribution mechanism adopted for poorer populations. The incidence of IRS is quite high for the richest and middle-quintile households, implying that greater targeting of IRS is required if low-income households are to be reached. The combined use of ITN and IRS is quite low (not more than 5 percent) in all the quintiles. The distribution of IRS and ITN by epidemiological zones (Figure 4) shows that more households use ITN compared to IRS.

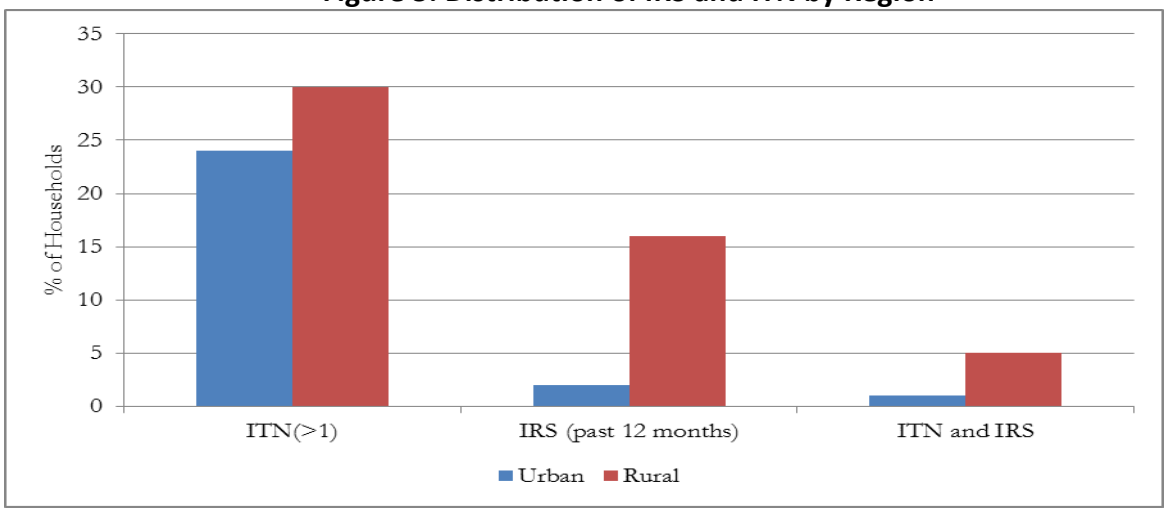
Figure 4: Distribution of IRS and ITN by Epidemiological Zones



Source: Author's calculations from KMIS 2010 data

The use of IRS is much higher in the highland epidemic region compared to the lakeside endemic region, even though the IRS use in these two regions is much higher compared to moderate and seasonal epidemiological areas. The combined use of IRS and ITN is still quite low in most of the areas even though in the highland region over 10 percent of the households were sprayed. This can be explained by the fact that most of the districts that were initially sprayed were largely in the highland zone. The use of ITN is highest in rural areas (Figure 5), while the combined use of IRS and ITN is still very low despite the fact that this approach has been emphasized in the national malaria strategy. The distribution of ITNs is largely done in the rural areas and hence the high incidence of ownership of nets by households. Secondly ITN distribution in the rural areas has largely been done during the ITN campaigns when the nets are distributed free of cost, while in urban areas the ITNs are sold at retail outlets.

Figure 5: Distribution of IRS and ITN by Region

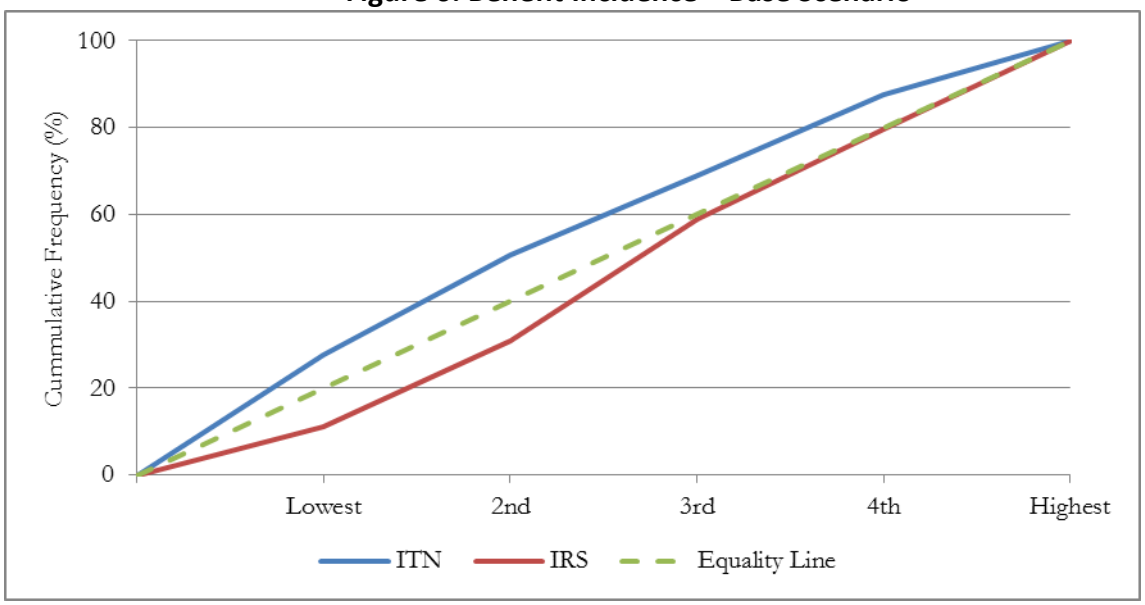


Source: KMIS 2010

4.2.1 Base Scenario – Status Quo

Figure 6 presents the benefit incidence associated with both IRS and ITN in the base scenario. Expenditure on IRS is not pro-poor as the expenditure curve lies below the equality line. However, parity is almost achieved for the median to the richest quintile for IRS. The distribution of ITN, on the other hand, is pro-poor since the expenditure curve for ITN is above the equality line. This finding is important for developing health related anti-poverty strategies. ITN distribution is a good tool for poverty reduction since it has high protective efficacy, which in turn reduces malaria morbidity and mortality for all the vulnerable and poor populations.

Figure 6: Benefit Incidence – Base Scenario

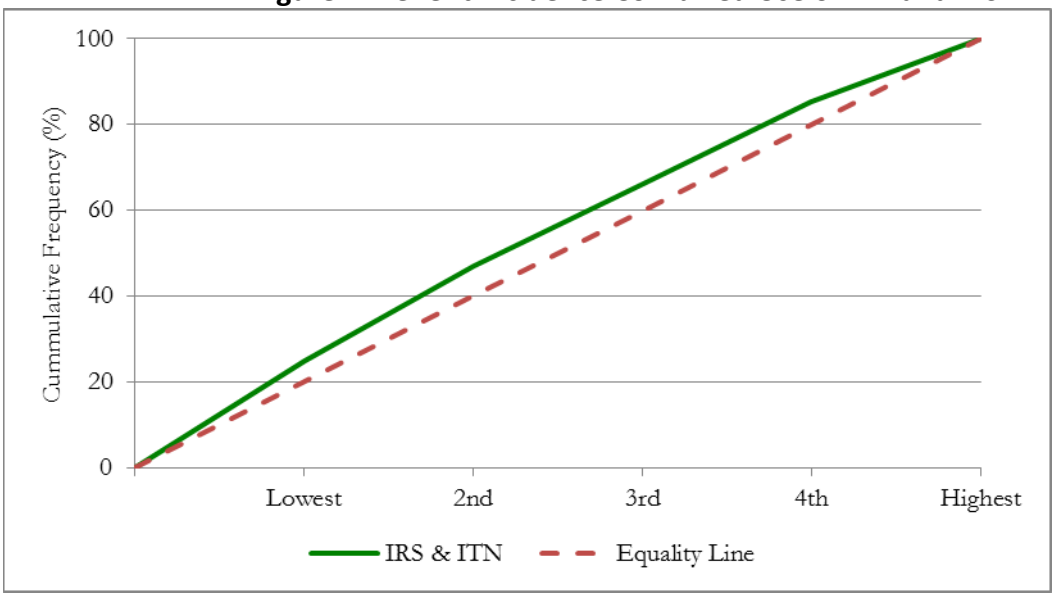


Source: Author's simulation from KMIS 2010

4.2.2 The Alternative Scenario

Expenditure on the alternative scenario, i.e. the combined use of IRS and ITN was found to be pro-poor since the combined expenditure line was above the equality line, implying that for effective malaria vector control that is cost effective and at the same time pro-poor, ITN should be combined with IRS to achieve optimal results.

Figure 7: Benefit Incidence Combined Use of ITN and IRS



Source: Author's simulation from KMIS 2010

5 DISCUSSION AND CONCLUSION

This study set out to establish which malaria control strategy will ensure rapid reduction of the malaria incidence. This was to be achieved by examining an alternative policy option where the use of ITN and IRS are considered as complements and not as substitutes. To this end two simulations were conducted: a base scenario where IRS and ITN are considered as substitutes, and an alternative scenario where they are complements. The aim of this study is to establish a faster way to combat malaria for the following reasons: first, more than 50 percent of Kenya's population is at risk of contracting malaria; it is also one of the countries that has a number of ongoing malaria prevention activities, albeit with little evidence of substantial or sustained reduction in the malaria incidence. The malaria menace has been acknowledged in Kenya's economic blueprint, popularly known as "Vision 2030". More importantly, the government, through the Division of Malaria Control (DOMC) has adopted a malaria monitoring and evaluation plan whose main objective is to provide a comprehensive tracking system that enables transparent and objective management of information on malaria control program activities for effective implementation of malaria interventions in Kenya (GOK, 2009). This study, therefore, provides evidence on the costs and benefits of integrating malaria vector control into one activity.

The cost data for examining the cost effectiveness of ITN, IRS and ITN+IRS was largely obtained from the USAID's presidential malaria initiative reports and budget. The combined use of IRS and ITN was found to be more cost effective since USD 4.57 was used to avert one case of malaria compared to ITN and IRS separately which were USD 8.27 and 7.75 respectively. ITN+IRS was not only found to be cost effective but it was also pro-poor. When IRS was used alone, the associated expenditure was more in favor of rich households, while ITN only went in favor of poor households. When ITN+IRS scenario was simulated, the result was more proactive. This can also be explained by the fact that the simulations undertaken targeted households that had mosquito nets distributed to them. A major advantage of the combined use of the two interventions is that the challenge of insecticide resistance and the changing biting habits of mosquitoes are dealt with since IRS targets mosquitoes at the larvae stage. IRS equally has strong externality effects relating to inhibiting mosquito breeding in neighboring compounds. There is a need for further simulations and sensitivity analysis on the impact of targeting households for bed net distribution and spraying using the IRS framework.

While the combined use of ITN+IRS was found to be superior, the implementation framework for this new approach mattered equally. In the distribution of ITNs, the framework used by the government was not clear since most bed nets were distributed through clinics, targeting pregnant women and children. It is not clear how the men obtained their bed nets. Moreover, the collection of bed nets from the clinics is more on individual basis. The targeting of households for both spraying and the distribution of bed nets is a more effective and efficient way of eradicating malaria, given that while 27 percent of the population fall ill, only 70 percent of those who are ill seek medical care and approximately 52 percent of those seeking healthcare go to public facilities (Omolo, 2012). Given that these nets are largely distributed at public health facilities, the population vulnerable to malaria can miss out. For the combined use

of IRS+ITN to take effect, targeting should be at the household level, where GPS data on households can be shared between the DOMC and the Kenya National Bureau of Statistics who have the national sample frame.

Lastly, discussion on the data sources used for the analysis is quite important for future work and for policy action. Obtaining cost data for malaria vector control was a major challenge. While the budget estimate documents are available for malaria, the disaggregated data for undertaking cost effectiveness analysis was not easy to come by. In fact several assumptions had to be made in order to derive the combined costs of ITN and IRS. This challenge can easily be overcome by stronger monitoring and evaluation M&E initiatives that ensure accurate tracking of malaria vector control expenditure. The implementation of the combined use of ITN and IRS as an alternative option will not require any new infrastructure within the health sector but could use the existing IRS procurement and commodity supply structures. Stronger collaboration with the Kenya National Bureau of Statistics for effective targeting of households would help in strengthening data collection, as discussed in the malaria program monitoring and evaluation plan.

5.1 POLICY RECOMMENDATIONS

Based on the findings and discussions of this study, the following are the recommendations for government action:

1. The Government of Kenya, through the Division of Malaria Control (DOMC) should adopt the combined use of IRS+ITN in all malaria-prone regions, except the low-risk areas where spraying will not be necessary. This is because of the evidence of cost effectiveness and higher protective advantage that the approach exhibits.
2. The framework for the implementation of this approach is key to the success of vector control in malaria. While the IRS system is wrought with challenges largely associated with inefficiency and poor coordination, strong efforts geared towards dealing with the inefficiencies can ensure that the IRS framework that targets households will be a more effective way of distributing bed nets as well.
3. A stronger initiative aimed at harmonizing data sources such as Health Management Information System (HMIS), and strong collaboration between KNBS and DOMC would ensure the success of integrated vector control in malaria.

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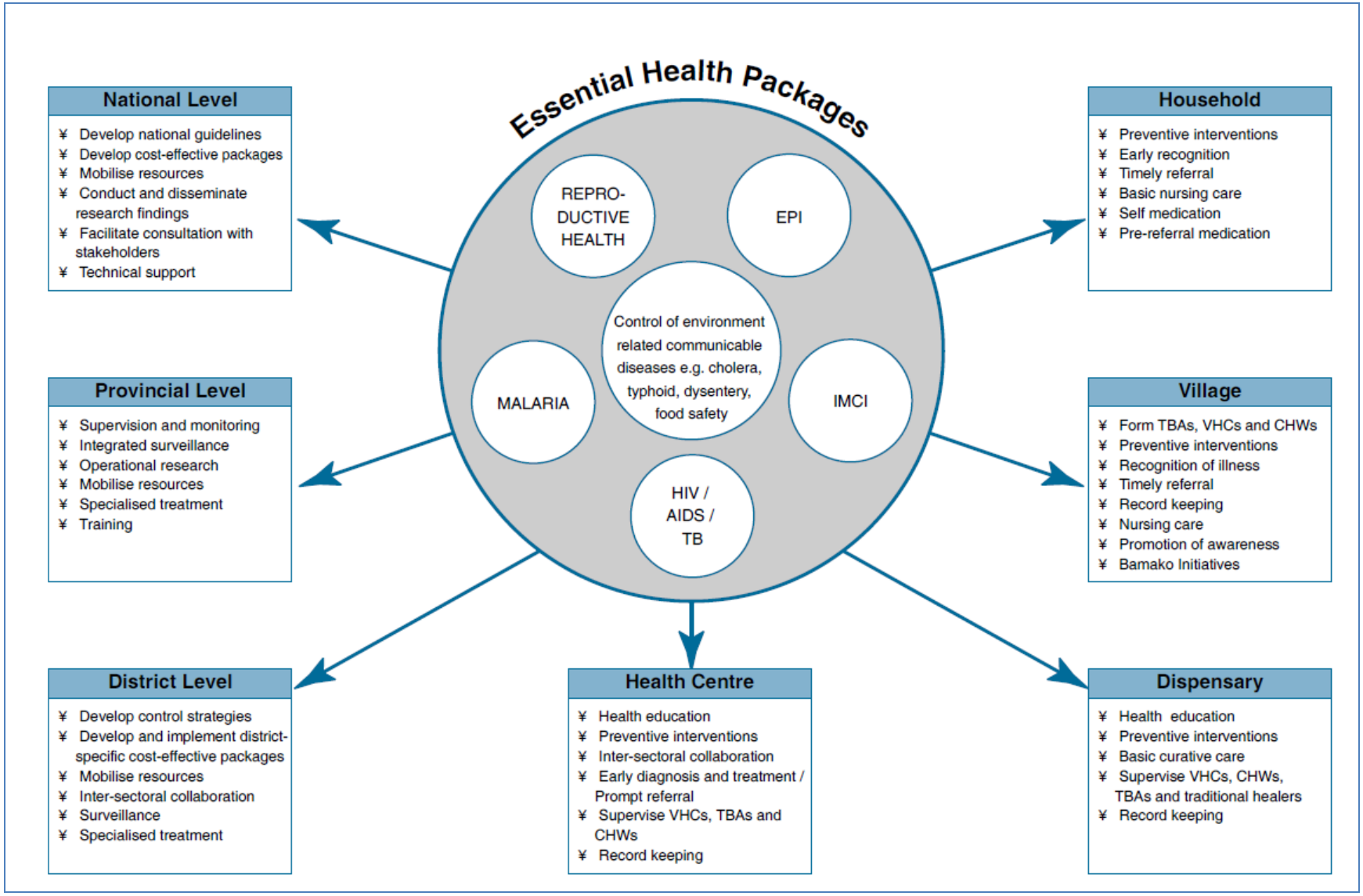
Annex 1: Institutional Framework for Malaria Prevention



Source: GOK, 2001