Addressing Malaria determinants using multisectoral response in Sudan

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A thesis submitted in partial fulfillment of the requirement for the degree of Master of Public Health

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List of Abbreviations

ACT	Artemisinin-combination therapy
AIDS	Acquired immunodefi ciency syndrome
API	Annual parasite index
CDs	Communicable Diseases
DDT	Dichloro-diphenyl-trichloroethane
GDP	Gross domestic product
GNI	Gross national income
HIV	Human immunodefi ciency virus
IDPs	Internally displace persons
IEC	Information, education and communication
IOM	International Organization for Migration
IPTp	Intermittent preventive treatment in pregnancy
IRS	Indoor residual spray
ITN	Insecticide-treated mosquito net
IVM	Integrated vector management
LLIH	Long-lasting insecticidal hammocks
LLIN	Long-lasting insecticidal nets
LSM	Larval source management
MDG	Millennium Development Goal
MMAP	Multisectoral Malaria Action Plan
MoH	Ministry of Health
MVP	Millennium Villages Project
NCDs	Non Communicable Disease
NGO	Non-governmental organization
NMCP	National Malaria Control Programme
PHC	Primary Health Care
RBM	Roll Back Malaria Partnership
RDT	Rapid diagnostic test
SES	Socio-economic status
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
USD	United States Dollar
WHO	World Health Organization
HRH	Human Resource for Health
NHA	National Health Account

Definitions

Artemisinin-based combination therapy (ACT). A combination of artemisinin or one of its derivatives with an antimalarial or antimalarials of a different class.

Drug resistance. The World Health Organization (WHO) defines resistance to antimalarials as the ability of a parasite strain to survive and/or to multiply despite the administration and absorption of a medicine given in doses equal to or higher than those usually recommended but within the tolerance of the subject, provided drug exposure at the site of action is adequate. Resistance to antimalarials arises because of the selection of parasites with genetic mutations or gene amplifications that confer reduced susceptibility

Plasmodium. A genus of protozoan vertebrate blood parasites that includes the causal agents of malaria. *Plasmodium falciparum, P. malariae, P. ovale* and *P. vivax* cause malaria in humans. Human infections with the monkey malaria parasite, *P. knowlesi* have also been reported from forested regions of South-East Asia

Rapid diagnostic test (RDT). An antigen-based stick, cassette or card test for malaria in which a coloured line indicates that plasmodial antigens have been detected.

Severe anaemia. Haemoglobin concentration of < 5 g/100 ml (haematocrit < 15%).

Severe falciparum malaria. Acute falciparum malaria with signs of severity and/or evidence of vital organ dysfunction.

Transmission intensity. The intensity of malaria transmission measured by the frequency with which people living in an area are bitten by anopheline mosquitoes carrying sporozoites. This is often expressed as the annual entomological inoculation rate (EIR), which is the number of inoculations of malaria parasites received by one person in one year.

Insecticide resistance: defined as ability of an insect to withstand the effect of an insecticide by becoming resistant to its toxic effects by means of natural selection and mutations.

Abstract

Background: Despite the progress that has been made in malaria control, still malaria in Sudan is the biggest health problem and constitute major burden to health care delivery system.

The objective of this study is to analyze determinants of malaria control in different sectors in order to suggest implementable actions to improve malaria control interventions and achieve sustainable malaria control and elimination

Methods: Descriptive literature review utilizing multisectoral action framework for malaria

Findings/results: The study found that current malaria control is mainly health sector response with minor efforts to involve other sectors to contribute to malaria response. Inequitable distribution of resources and power between different states and individuals resulted in inequity in access and use for malaria preventative and curative services. Low socioeconomic status with its implications such as limited education, unemployment and poverty led to increased susceptibility and vulnerability of certain population groups such as pregnant women and children. These aggravated by low nutritional level, hazardous occupations. Some environmental factors have positive or negative impact on malaria control. Agricultural practices, housing, urbanization and large economic project have those effects. Environmental impact assessment before large project ignored the consequence and impact on malaria control of those projects.

Conclusion and recommendation: to control malaria, multisectoral response is required to support ongoing progress of malaria control. Many innovative actions are available and practical that can enhance malaria control through other sectors. Finance, agriculture, work, infrastructure, irrigation, education, and social protection sectors can contribute and work jointly with health sectors for malaria control.

Key words: Sudan, malaria, multisectoral response, Agriculture, insecticide, resistance, vector, socioeconomic and inequity.

Word account: 13107

Introduction

Malaria is a disease caused by plasmodium parasite infection. There are five plasmodium species, P.Falciparum, P.Vivax, P.Malariae, P.Ovale and P.Knowlesi. Anopheles genus is only genus can transmit the parasite to human which happened when the parasite bite human being.

Malaria has big global concern because it causes 207 million cases worldwide and 627,000 deaths. 80% of cases and 90% of deaths occurred in Africa and 77% among children under five. In Sudan, 27 million of people are at risk of malaria, with annual 30,739 cases and 1,125 deaths and accounting to the 25% of hospitals consultations causing high burden on health system and the productivity with impact on socioeconomic status.

Although the malaria control program in Sudan made a remarkable progress since 2000 after commencement of the Roll Back Malaria (RBM) initiative but still there are gaps.

After graduation from university, I worked in federal ministry of health at school health program and then after that I moved to emergency and humanitarian action department. So, I don't have direct experience with malaria control program, but indirectly in school health programs and more involvement during the emergency periods of seasonal floods when malaria cases increase sharply. Also, I have personal experience of getting infected by malaria several times and I was wondered why this happened despite the presence of good medicine and laboratory diagnoses. So, malaria for me, my family, my neighbors and all people in my area especially in the rainy season regarded as a monster killer.

Therefore, I really want to found out solutions for this historical problem so can help malaria control program to achieve its intended goals and enjoy our life with better health and wellbeing without fear from infection. Finally, am planning to move to malaria control program to contribute to fight against this serious killer.

Chapter One: Background

1.1Geographical information:

Sudan is located in Northeast Africa and extends over an area of 1.8 million square kilometers. It shares borders with 7 countries namely; Central Africa, Chad, Libya, Egypt, Eritrea, South Sudan and Ethiopia. Traversed by the Nile and its tributaries, Sudan also has access to the Red Sea with a costline of 853 kilometres and 18,900 sq km irrigated land (FMOH 2011a).
Sudan's climate is generally hot and dry, and it is arid desert in North, tropical in South. The rainy season varies by region (April to November). During the period (1900 and 2009) Sudan had experienced dramatic climate change in respect of temperature and rainfall, with a series of environmental challenges; dust storms, periodic droughts and flooding. The country faces soil erosion, desertification, inadequate supplies of potable water and inadequate sanitation (FMOH 2011 and UNDP 2014a).

1.2 Population characteristics:

According to World Health Organization (WHO) 2013, total population of Sudan is 37 million with growth rate of 2.8%. About 49% of population lives in urban areas while 8% of population is Nomadic. Internally displaced persons (IDPs) constitute around 2% of population of which 1.4% resides in institution while the rest resides in the cattle camps. The crude birth rate 31.2 birth/1000 population and the Crude death rate 16.7 deaths/1000 people. Life expectancy at birth is 63 years while the fertility rate is 3.9%. The average household size is 5-6 persons (CBS 2009 and FMOH 2011a).

1.3 Economic situation

Despite being rich in natural resources (oil, agriculture and livestocks), Sudan is yet one of the low income countries. Nominal resources increased during the period 2006-2009 by 9% per annum despite the global recession with inflation rate of 37.4%. However, there is financial pressure due to loss of oil revenues to south Sudan after its secession in 2011 (FMOH 2012 and WB 2014)
Although gross domestic product (GDP) increased from 9.9 billion USD in 1980 to $66.6 billion in 2013, the GDP growth rate has fallen from 10 to-6% over the period of 2007 to 2013 (WB 2014). According to UNDP 2014 Human Development Report, Sudan ranks at position 166 of 187. Poverty remains widespread with 46.5% of the general population living below the poverty line and 8% are in extreme poverty (WB 2014).

1.4 Political environment

Sudan recently splits into two countries after long political instability that extends over 25 years due to armed conflict between north and south regions/parts of the Sudan. Moreover, the civil conflict in Darfur region since 2003 has flared up the longstanding political instability. These armed conflicts have impacted the national health system by increasing rates of morbidity, mortality, malnutrition, and consequently poverty (FMOH 2011a). Sudan is comprised of 17 states. Each state is subdivided into localities, with a total number of 144 localities. Sudan government is a multilayer system; federated republic with powers devolved to states under local government act often referred to as the decentralization (FMOH 2012).

1.5 Education

Education system suffers from low enrollment and high dropout rates in Sudan. Only 53% of children were attending primary school (SHHS 2006). Average adult literacy among those 15 years old and above is 62%; 79% in urban population and 51% in rural population. Gender inequality exists with 73% male literacy rate compared to 52% female literacy rate. The overall enrolment rate improved from 53.7% in 2006 to 67% in 2009 but still there is large gap between the different states and urban and rural areas. The lowest school enrollment rate was registered in Western Darfur State (54%) and the highest school enrollment rate in Khartoum State (85%) (CBS 2009 and NBHS 2009).

1.6 Health system:

1.6.1 Governance and leadership

The national health system consists of three levels; federal, state and locality. The federal level is responsible about formulation of policy and guidelines, planning, distribution of resources, harmonization and corporation, monitoring and evaluation and external relationships. On the other hands, the state level is responsible for planning, implementation and supervises the third level; the locality level. Localities are mainly responsible for health services delivery to general population (FMOH 2011a).

1.6.2 Human resource for health

Despite of policies to enhance human resource for health (HRH) and large number of human resource production, there is still a shortage in health workers especially nurses and midwives due to disparity between the skills needed and the available qualified health personnel .Furthermore, there is maldistribution, migration and poor retention of health staff in addition to low productivity of available health personnel (Badr 2007).
There are about 100,000 health workers in Sudan. 80% of health staff is employed by public sector. However, majority of health staff (70%) serve around 30% of general population. Moreover, density of physician, nurses,

and midwives in Sudan is 1.23 per 1000 compared to 2.3 per 1000 recommend by WHO. Furthermore, 36% of outreach health facilities were not functioning in 2006 because of shortage of HRH (FMOH 2011a).

1.6.3 Health care delivery

Health services are offered by public and private sectors (for profit and not for profit) in addition to other health services providers; police, army, and NGOs (FMOH 2011a).

The Facilities coverage is one per 6,816.86 populations and there is variation between states and within the region (urban versus rural areas). 14% of the health facilities are not functioning due to shortage in human resource, building situation, security and war problems. Only 19% of PHC facilities covered by minimum packages of services, and it is better in hospitals and urban centers compared to lower level health facilities and rural centers (see figure1). The most available health services are treatment of common diseases, pharmacy, immunization and antenatal care (figure2) (FMOH 2010).

Figure1: Coverage by the Minimum Package of PHC Facilities of PHC Services in States
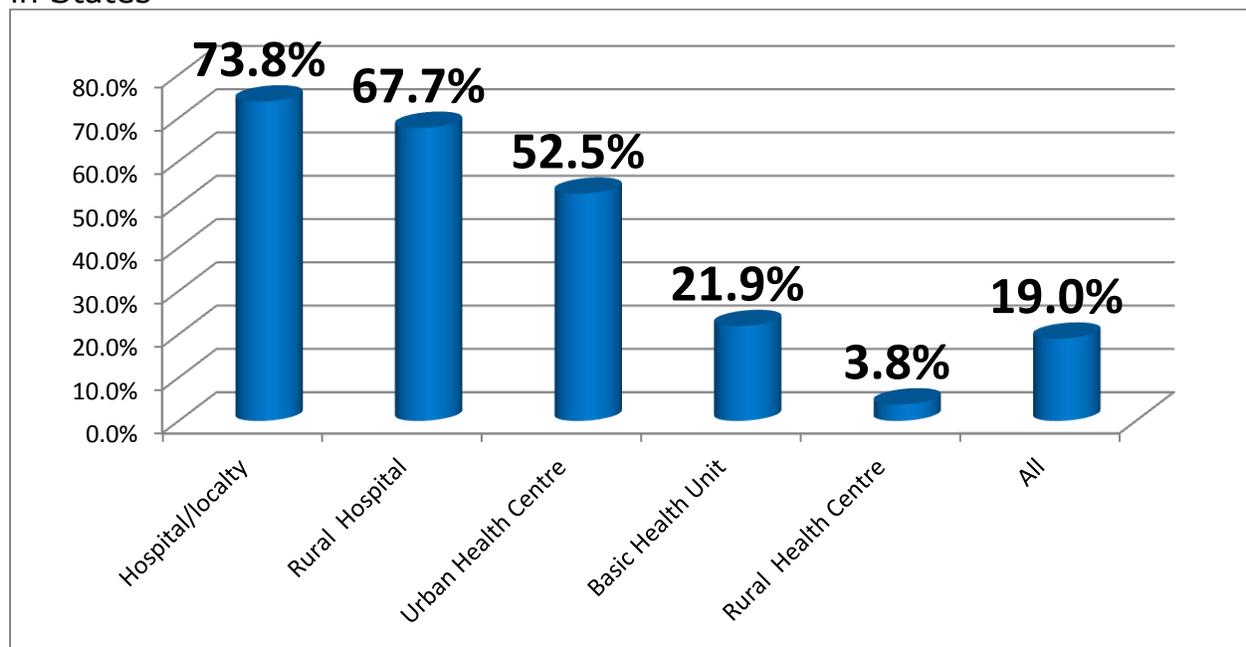
Source: Parimary Health Care Facility Survey, 2010.

Figure 2: Coverage of PHC Facilities by individual services of PHC Package in Sudan states .
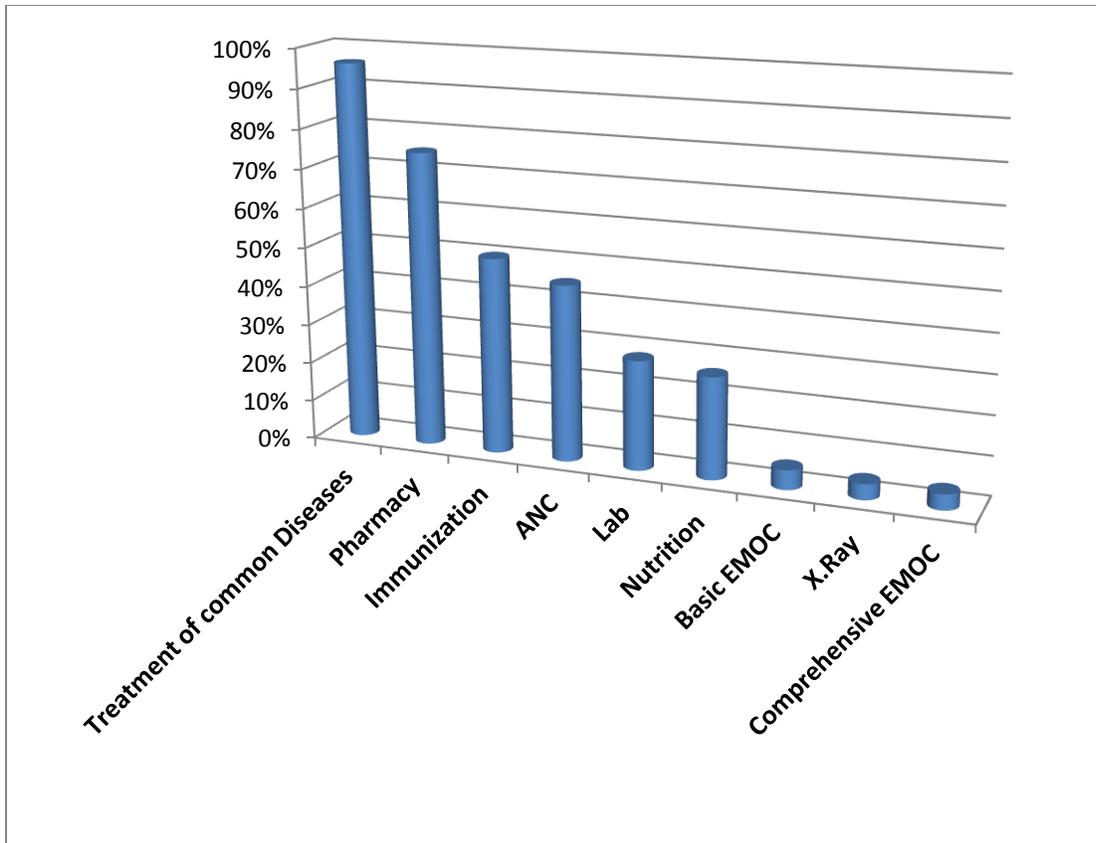
Source :Parimary Health Care Facility Survey, 2010

1.6.4 Health care finance

According to National health account 2008, Sudan allocated 5.6% of GDP for health. The total health expenditure (THE) is around 7.1 billion SDG, by spending SDG 232 (US$111) per capita. There are striking inequities in per capita spending between states; whereas Khartoum State spends two or three time higher per capita than South Kordofan State. The shares of out of pocket health expenditure, public expenditure and donors out of THE are 64.4%, 28.90% and 4.16% respectively. Total private expenditure (out of pocket + other private) is 66.94% (NHA 2008). At facility level, user fee is also applied as a source of fund to support health service delivery (FMOH 2010).

National policy mentioned that the healthcare in Sudan should be free. However, this is not the case since people still pay for consultations, diagnosis and treatment (FMOH 2007).

Figure (3) Agents of health expenditures
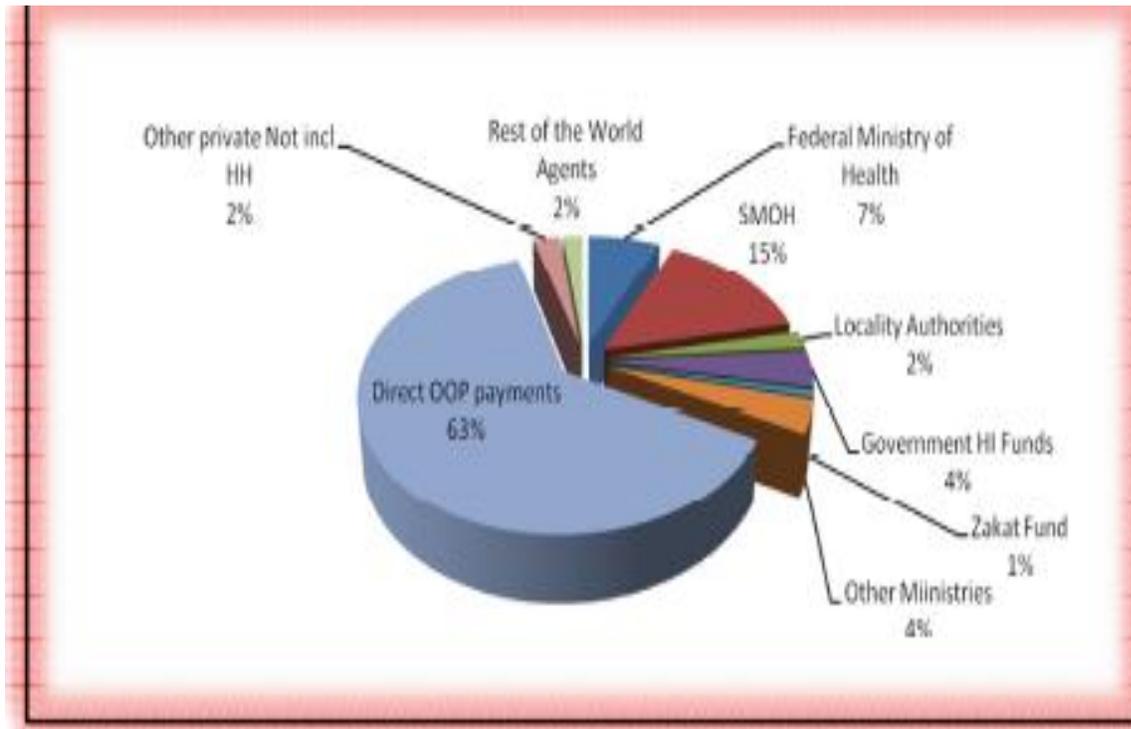
Source: National Health Account 2008

1.7 Health problems in the country

The epidemiological profile of Sudan dominated with communicable diseases (CDs), whereas non-communicable diseases (NCDs) are on the rise (table 1). The common CDs at health facilities are malaria, respiratory diseases, pneumonia, diarrhea and gastroenteritis and toxemia. The most common NCDs in the period between 2006 and 2010 are injuries, diabetes, heart disease, hypertension, cancers and psychological problems (FMOH 2011b).

The infant mortality rate is estimated at 57 per 1000 live births and more than half of these deaths are neonatal deaths (33/1000 live birth). Under5 mortality is estimated at 78 per 1,000 live births. The most important causes for under5 morbidity are pneumonia, malaria, diarrhea, typhoid, and respiratory tract diseases such as acute tonsillitis and acute bronchitis. The estimated maternal mortality rate is 215 deaths per 100,000 live births (FMOH 2011b and SHHS 2010).

Table (1) the leading diseases in health facilities (outpatients) per 1000 population

Disease	Cases	Percentage out of total cases	Per1000population
Malaria	12140404	9%	36
Pneumonia	1021087	8%	30
Typhoid	901126	7%	27
Other disease of respiratory system	629012	5%	19
Acute Tonsillitis	626745	5%	18
Disorders of Urinary tract	527902	4%	16
Diarrhea and Gastroenteritis	511193	4%	15
Essential hypertension	501623	4%	15
Diabetes Mellitus	426721	3%	13
Injuries	320546	2%	9
Total of 10 diseases	6679959	51%	197
Total of other diseases	6386739	49%	187
Grand Total	13044737	100	384

Source: Annual statistical report2011

3.1 Epidemiology of malaria in Sudan:

Most areas of Sudan are prone to malaria epidemics particularly during the recent decades. Epidemics were reported in Gazira, Khartoum, Sinnar, Blue Nile, White Nile, Al- Gadarif, Red Sea, Kassala, Northern, River Nile, W. Darfur, N. Darfur and N. Kordofan states. The main reasons behind these epidemics are climatic factors such as floods, rains, drought and famine, spread of the plasmodium resistance to chloroquine, increasing resistance of vectors to insecticides, migration of population from low to high endemic area, shortage of food and nutrients, problems related to health system in the neighbouring countries, refugees influx and establishment of large agricultural projects. All of these factors will be further explained in the next chapters (NMCP 2010).

The spread of malaria from North to South is seasonal based/depending on the rainfall level and irrigated schemes as it showed in figure (4). Agriculture schemes have longer malaria transmission period, which is up to 9 months while the urban cities may experience another transmission period during winter (December–February) due to broken water pipes (NMCP 2010).

Plasmodium Falciparum is accountable for more than 95% of malaria cases. Moreover, an increase in P. vivax cases has been reported. Anopheles arabiensis is a main vector and widely distributed in Sudan compared to A.

funestus, which has been reported in southern part of Sudan (white Nile state) (NMCP 2013).

Figure 4:The distribution of malaria according to the causes of it in Sudan.

Malaria Strata in Northern States of Sudan
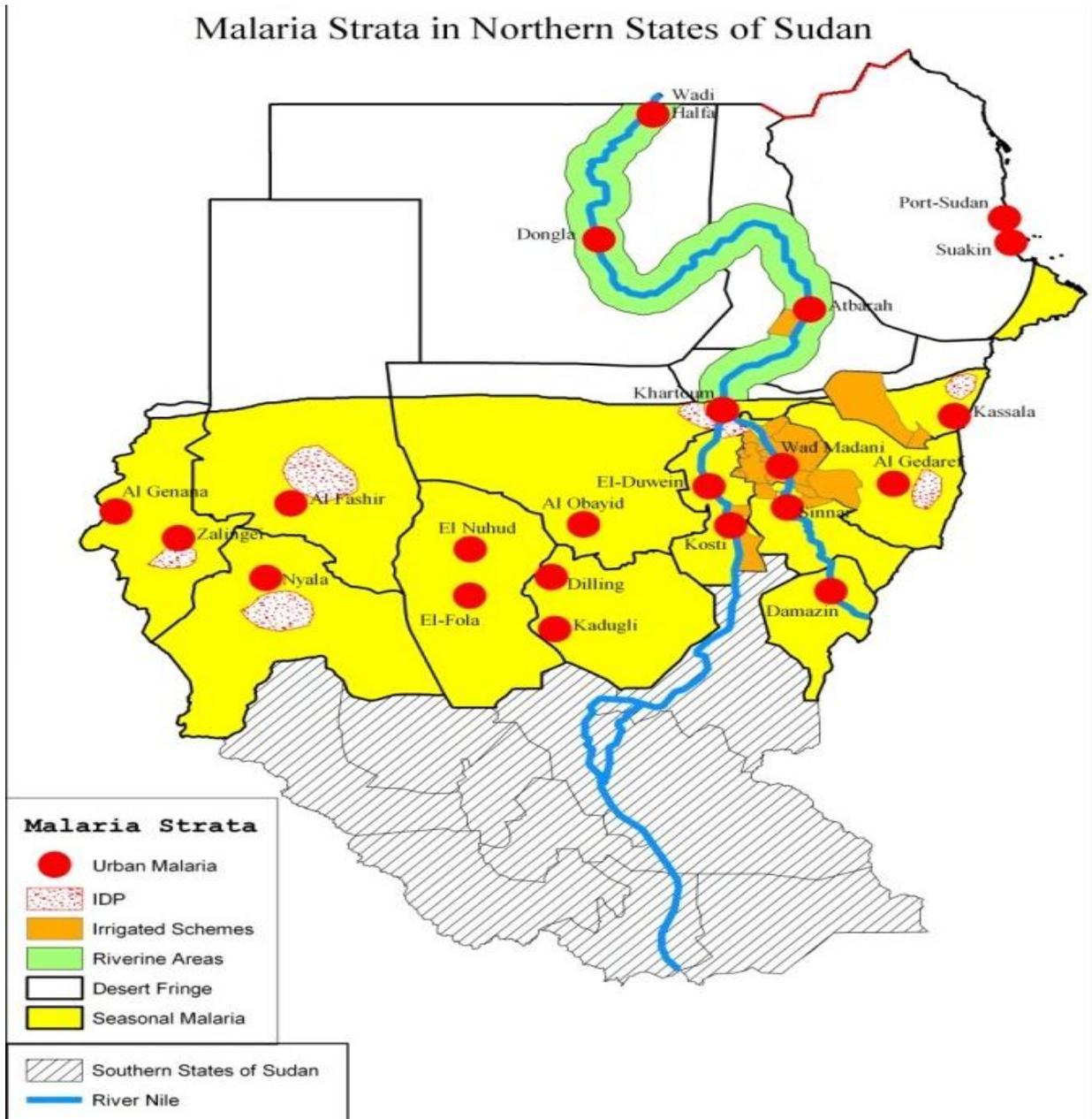
Source: National malaria control program 2010

Chapter two: Problem Statement, Justification, Objectives and Methods.

2.1 Problem Statement:

Malaria is an important public health problem worldwide where approximately 3.3 billion people are at risk. Annually, there are an estimated 627,000 deaths and 207 million cases of malaria worldwide. About 90% of this estimation occurs in sub-Sahara Africa and 77% of them are among children under5 years of age (WMR2013).

Malaria is a major public health problem in Sudan. It is on the top of 10 diseases that lead to hospital admission at the national level as shown in table1 (FMOH 2011b). Malaria accounts for 25% of hospital consultations and accounts for 16% of hospital deaths and represents around 21% of outpatient and 30% of inpatient (NMCP2010). Annual cases are 30,739 with 1,125 deaths (Hani et al 2013). About 75% of the populations are residing in endemic-malaria areas while 25% of them are residing in epidemic-malaria areas. The hardest hit groups or the most at risk groups are pregnant women and children under5. Plasmodium Falciparum is responsible for more than 95% of severe malaria cases (Abdallah et al 2013).

Worldwide, about 125 million pregnant women are at risk of malaria, of which 32 millions are in Sub-Saharan Africa (Awadalla et al 2013). Malaria causes serious adverse effects among pregnant ladies such as babies with low birth weight, abortion. Moreover, maternal anemia is the major cause of maternal deaths in Sudan (Adam et al 2005). Additionally, Malaria is considered as one of the leading causes of child mortality and morbidity. Malaria causes anemia in children and negatively affects their growth, development and education attainment (Hussein and Mohammed 2014).

Health system failure to address malaria problem in terms of inadequate diagnostic equipments to investigate malaria, lack of health staff, and unavailability of health services and facility has perpetuated malaria burden in Sudan (FMOH 2010). Despite the fact that anti-malaria treatment is free of charge but the challenge of other direct and indirect costs applied in some facilities like laboratory, consultation and transportation costs act as additional barriers to malaria treatment (MPR 2013).

There are several underlying socioeconomic determinants that contribute to malaria burden in Sudan such as poverty, educational level, nutrition and

housing conditions. Moreover, there are other factors which will be explored later in this thesis (Worrall et al 2003).

Looking at the magnitude of malaria in Sudan, an effective malaria control program in Sudan is urgently needed. The program shall strive to achieve its MDGs target; to have halted malaria-related mortality and morbidity by 50% by 2015 (MDGs target)(NMCP2010).

During the last few years, a dramatic reduction of disease burden has taken place as the number of malaria cases has dropped from 4 million in 2001 to 2, 5 million in 2009 along with a further decrease in the number of malaria deaths (35,000 in 2001 and 9,788 in 2009) (NMCP2010). Please see figure (5)

Figure (5) comparing the reduction in cases and deaths of malaria in Sudan from 2001 to 2011.

X axis is mortality per1000 and morbidity per 1000000, Y axis show the years
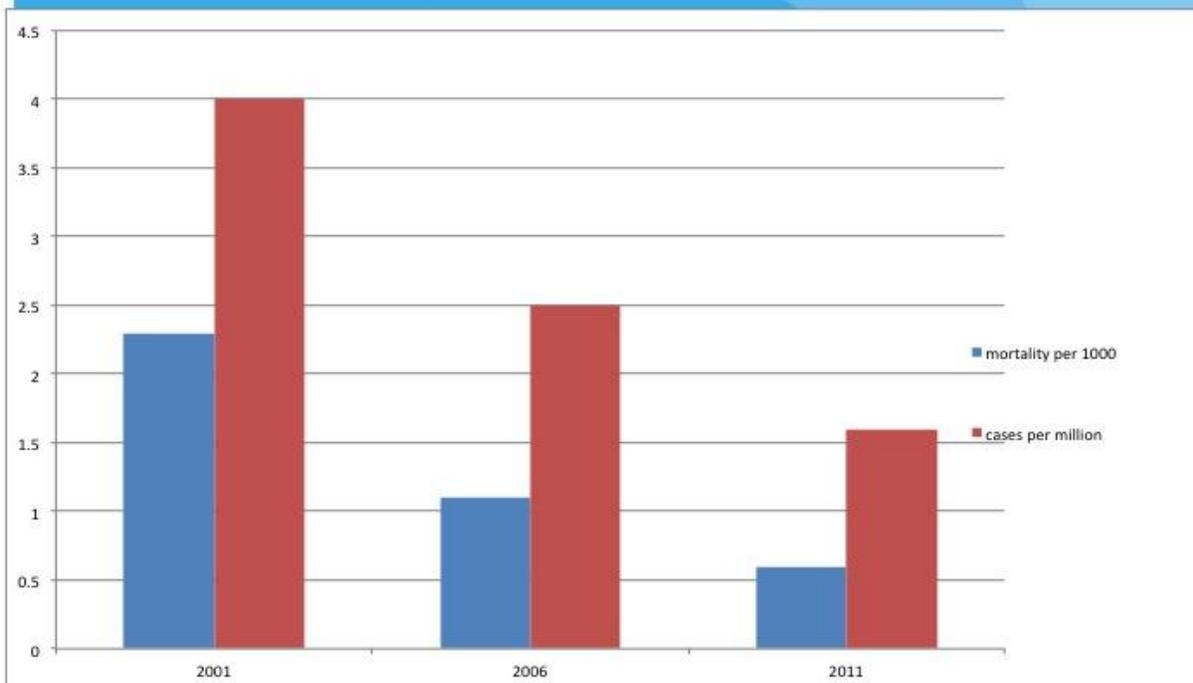
Source: NMCP2010 and MPR2013

Despite this dramatic reduction in malaria burden, there is an increase in parasite prevalence at national level which was 1,8% in 2009 and rised to 3.3% in 2012 as shown in figure 6. This increase in parasite prevalence reflects signs of reduction in malaria control activities an emerging resistance of malaria vectors that endanger the efforts of NMCP. These challenges have occurred despite continuous support from international communities and organizations such as Roll back Malaria, Global fund, UNICEF and WHO (NMCP 2010 & MPR 2013).

Figure (6) show that decrease the parasite prevalence from 2005 to 2009 and increase from 2009 to 2012 years in Sudan.
X axis is parasite prevalence, Y axis is the years
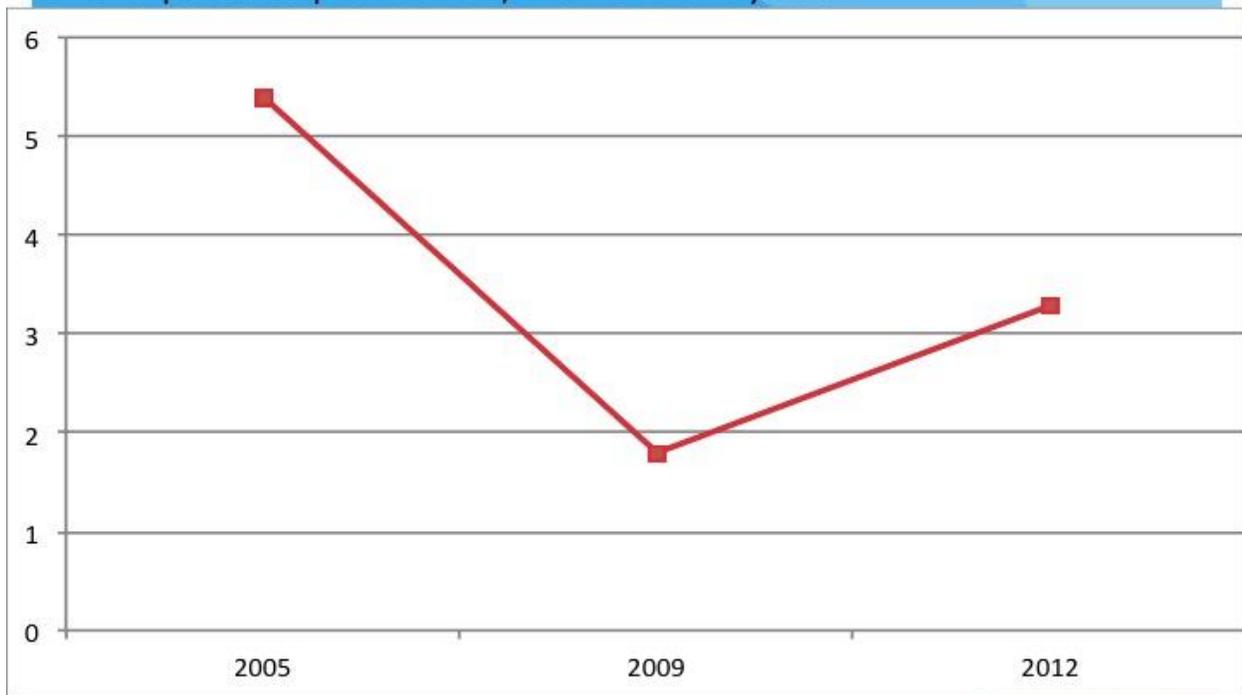
Source: NMCP2010 and MPR2013

2.2 Justification

Due to increased global investment and action in malaria control, substantial progress has been made since 2000 especially after the launch of RBM initiative which has provided advocacy and additional resources to address malaria globally. A 26% reduction of malaria morbidity has been noticed and over 1.1 million lives have been saved worldwide. Moreover, there is one third decline in malaria mortality rate in Africa (UNICEF 2013 and RBM 2014).

In Sudan, malaria is still a priority public health problem because it is the leading cause of morbidity and mortality. Malaria accounts for 25% of the total hospital consultations. It is considered as a major killer nationwide accounting for 16% of total deaths from all causes and stands at position two among the common causes of deaths in under5 children.

This study is meant to contribute to improving the performance of malaria control program in order to reach its target control levels (i.e. prevalence below 1% throughout the country.

Control Malaria will assist to achieving sustainable development goals for post 2015 agenda and poverty reduction as well as decreasing child and maternal mortality rates.

2.3 Objectives

2.3.1 Overall Objective:

To analyze determinants of malaria control in different sectors including health in order to suggest innovative implementable actions to improve malaria control interventions and achieve sustainable malaria control and elimination.

2.3.2 Specific Objectives:

- To identify major determinants of malaria in Sudan.
- To describe the current key strategies of malaria control in Sudan and identify responsible sectors for that.
- To identify interventions that can advance multi-sectoral response for Malaria control in Sudan.
- To explore the multi-sectoral best practices and lessons learned and employed by other countries.
- To provide necessary recommendations for malaria control programme and different sectors for better interventions in Sudan.

2.4 Methods

2.4.1 Methodology:

Study design: descriptive and analytical study on determinants of malaria in Sudan.

Search Strategy

Comprehensive literature review on malaria determinants are done using Kit and VU University Library, Google, Google Scholar and peer reviewed literature.

Data was obtained via consulting national health information management system (HIMS).

Grey Literature from WHO, UNFPA, WB, UICEF, CIA, UNDP, UNHCR published and unpublished full text reports and other document from the federal ministry of health were reviewed.

Inclusion criteria: quantitative and qualitative data are used

Excluded criteria: others languages apart from English and Arabic

2.4.3Key words and combinations used:

Sudan and Malaria, in combination with Socioeconomic status, Access to healthcare and use, Education, Infrastructure, Knowledge and awareness, Urban and peri-urban setting, Land use/management, Housing, Population movement, agriculture, Demographic change, climate change, Economic development projects, Gender and equity, Ethnicity and Provision of health care.

Limitation of the study: There is paucity in up to date data on malaria control in Sudan. Thus investigator has used literature from other countries with similar settings.

2.4.4 Conceptual Framework

Literature was searched for suitable conceptual framework to guide this study. At first, I selected the epidemiology framework (agent – host – environment) which can analyze malaria problem but after that I came across another framework called Multisectoral- Action Framework for Malaria (figure 7). I preferred to use the latter framework because the framework called to add development dimension to malaria control by complementing existing malaria control strategies and supporting long-lasting progress. I have designed/made it into figure from Multi-sectoral Action framework developed by Roll Back Malaria and UNDP (UNDP & RBM 2013).

The framework analyzes social, economic and environmental determinants of malaria at four levels as follows:

1- Society level which explains societal factors that affect control of malaria such as inequitable distribution of resources, gender inequity, demographic change, and ethnicity.

2- Environment level, which explains environmental factors that affect malaria for example agriculture and urban and peri-urban settings, housing, land use and economic development projects.

3- Population level, which explains characteristics of individuals that make them vulnerable/susceptible to malaria which are poverty and education, population mobility, nutrition, occupation and community control.

4- Household and individual level. This level explains factors affecting health-seeking behavior such as adoption of malaria-safe habits, awareness and knowledge, access and use of health care services.

In the framework all factors from (society to individual) are interlinked and determinants in society affect all or most of the other levels.

Figure 7: explain Multisectoral actions framework developed from Multi-sectoral Action framework developed by RBM and UNDP.

Society

Inequitable distribution of power and resources across the country.

Government ability to manage land, tax revenues and to regulate.

Demographic change: population growth, family/household size and structural population movements.

Organization of societies and services.

Social status: gender, ethnicity.

Environment

Agricultural practices and production Systems

Urban and per-urban settings and Infrastructures

Housing

Land use/management

Economic development projects

Population Group

Poverty and education
Population mobility (internal and International migration)
Nutrition
Occupation
Community control

Households and Individuals

Choice and adoption of malaria-safe Habits
Awareness and knowledge
Access to and use of health care
Provision of health care

Malaria Morbidity & Mortality

Source: UNDP/RBM2013

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3. Chapter three: Major Determinants of Malaria in Sudan

This chapter showed analysis of major determinants of malaria based on multisectoral actions framework.

3.1 Society:

This level analyzes different societal factors that affect malaria throughout different sectors including health sector. The factors included are; inequitable distribution of power and resources across countries; demographic change; government ability to manage land, tax revenues and to regulate; organization of societies and services in addition to social status.

3.1.1 Inequitable distribution of power and resources across country

There are significant disparities in funding of health sector between states. State allocation to health depends on the overall resource allocation to the state. So unequal distribution of resources across states clearly explains inequitable distribution of fund within the states, which inevitably affects malaria control. At the intra-state level, there are also variations in fund flow from state to locality level then to the facility level (WB 2011).

Public expenditure tracking survey compared per capita expenditure of northern states with prevalent poverty rate between 2000 and 2009. The survey found that the states having lowest per capita expenditure had the highest poverty rate such as White Nile, South and West Darfour and North Kordofan, beside high parasite prevalence as shown in table (MIS2009). Northern states with higher per capita expenditure and lowest poverty rate such as Khartoum, River Nile and Northern (WB 2011), had low parasite prevalence (MIS 2010).

There are variations between rural and urban settings are contributing to increase urban informal sector that accounts for 60% of Sudan GDP. Quality of services and resources are more favorable in urban than rural communities (KAPSurvey 2011). This discrepancy has increased rural–urban movement affected agriculture productivity in rural areas due to lack of workforce. Literacy rates are significantly higher in urban areas while incidences of poverty (46%) are higher in rural areas (SHHS 2010). In addition to poverty, parasite prevalence is also higher in rural area as shown in table 2. These inequities have resulted in malaria prevalence being higher at rural settings compared to urban settings (UNDP2014).

Table (2) Distribution of poverty and parasite prevalence between states in Sudan.

State	Parasite prevalence %	Poverty %
Blue Nile	12.5	57
West Darfour	7.1	56
North Kordofan	2.6	58
South Kordofan	2.1	60
White Nile	1.8	56
Gederif	1.6	50
South Darfour	1.2	61
Gezira	1.2	38
Kassala	1.1	36
Sennar	1.1	44
North Darfour	1.1	69
Khartoum	0.1	28
River Nile	0.5	32
Northern	0.0	36
Red Sea	0.0	58

Source: (MIS 2010 and WB 2011)

States differ widely in total resource flow and their utilization of the health services. As example; Khartoum, River Nile and Northern states have highest average per capita expenditure for health between 2000 and 2009. Conversely, North Kordofan, White Nile and South, North and West Darfur states have very low levels of expenditure on development and health. As an example, River Nile State spent about 41 SDG per capita whilst South and North Kordofan States spent 10 and 13 SDG per capita respectively (WB 2011, MOH 2012).

The introduction of user fee as part of health system reform in Sudan creates inequity between the wealthy and the poor in accessing health services (FMOH2007). A major share of resource inputs at facility levels is from user fees account for 32.1% of total inputs rather than state and locality budgets. User fees revenue is used as bonuses and allowances on top of regular salaries paid from federal and state budgets (WB 2011). Hence, financial barriers are created for the poor people and hinder them from accessing healthcare services including malaria diagnosis and treatment services. This inequity has further increased the spread of the disease.

3.1.2 Government ability to manage land, tax revenues and to regulate

Total revenue of state is transferred from federal revenue as well as state own revenue. Revenue has increased substantially over the past decade. However, states have increased their dependencies on federal allocation to meet their responsibilities. Weak transfers and revenue unpredictability from federal level negatively affected service delivery at the lower administrative levels. Consequently, significant implications affected states' budget planning and hence execution of malaria control activities, which is influenced by financial shortage (FMOH2012).

3.1.3 Demographic change: population growth, family/household size and structural population movements

Natural disasters and socioeconomic changes have resulted in high level of people movement from country-to-country. The displacement of great number of people enhances malaria transmission especially refugees, internally displaced population (IDPs) and other migrants as they are non-immune to malaria due to shortage of food, they contribute to the spread the disease to other areas as they move from malaria-endemic areas where they can acquire the infection(Materns and Hall 2000). It is estimated that more than million refugees are currently residing in Sudan mostly from Eritrea, Ethiopia and the number is still increasing (UNHCR 2014). This influx of refugees explains the importance of cross border approaches in addressing malaria transmission (Taem and Smith 2010).

Large Population growth raised demand for food, which can exceed agriculture production. However, large-scale irrigation projects such as reclamation of arid and semi-arid areas for farming the crops have improved food production. Although crop irrigation is a solution to alleviate food shortage and support economic growth, irrigation has often been blamed for aggravating the malaria and the changes in its transmission patterns (Ijumba and Lindsay 2001).

Annual population growth rate in Sudan is high and is estimated to be around 1.8% (UNHCR 2014). The rapid growing population combined with high poverty rate have contributed to increased population movement and hence malaria spread. Increased city's population (urban) enhances demand for food production. This demand is covered by more cereal production, which is achieved by increasing irrigation, and hence resulted in an increase in malaria burden.

3.1.4 Organization of society and services

Ministry of health (MOH) is the main healthcare provider in the country. MOH generates funds and represents the largest provider of care and other collective health prevention services (NHA 2008). Ministry of finance allocates or distributes fund to the states. These funds are used to finance services provided by the state such as health services including community-based interventions that target malaria activities (WB 2011).

Good planning, structure and quality of housing affect malaria burden from different aspects. Good housing condition reduces malaria by preventing contact between vector and human and hence improves the health and socioeconomic status of people by reducing costs incurred by acquiring vector-born diseases and increasing productivity and incomes (Ye et al.2006).

Ministry of education has great impact on health in general and malaria in particular by increasing the number of educated people. High educational level is associated with better knowledge and awareness about malaria; malaria risk factors and protective factors; and improved healthcare-seeking behaviour (KAP 2011).

Social contribution is important to improve utilization of health services, such as Alzaka. Alzaka is a mandatory tax for all rich Muslims (2.5% of their annual income), and accounts for a significant financial contribution for healthcare delivery as it is used to purchase health insurance cards and expensive services for poor families.(NHA 2008).

International donor organizations such as UNDP through global fund project and UNICEF were the largest donor. Their funds comprise more than third of total aid given to Sudan. WHO, UNFPA and other international organizations provide the remaining funding (NHA 2008).

3.1.5 Social status: gender, ethnicity

Low socioeconomic status (SES) is related to higher risk of malaria transmission compared to higher SES status. Poor people are predisposed to disease and more vulnerable to the expenses of disease, which aggravate their financial risk (Tusting et al.2013). Women are frequently disadvantaged by culture and social norms. In Sudan, men in general are free to move, better seek and access healthcare. Women in some areas in Sudan have to ask for permission in order to spend money for healthcare. According to Omer et al, women's lower decision-making capacity delays their healthcare-seeking behaviour and hinders them from accessing healthcare services and hence diagnosis and treatment of malaria (2011).

There is correlation between malaria among pregnant and socioeconomic status. Pregnancy is an important risk factor for malaria because pregnancy decreases women immunity and make them more susceptible to malaria.

Worrall (2003) reviewed that Women and men have equal percentage of getting malaria illness in case of susceptibility and exposure except pregnant women. Moreover, anemia is an important cause of death of pregnant women. On the other hand, ethnicity was found to be not associated with increased malaria infection (Omer et al.2011).

In some states, due to political problems such as war and displacement, tribes/ethnic background, people are marginalized do not have access to basic human rights such as education, jobs and even health. This inequity affects access for malaria treatment and prevention services particularly in Darfour and Kordofan states (Personal observation).

3.2 Environment

The malaria is conquered by a number of environmental factors that affect its distribution, seasonality and transmission density including: multitude of surface water with pollution and vegetation, its chemical composition, which determine the proliferation and intensity of vector. Temperature and atmospheric humidity determine survival of vector and ability of parasites to develop. Furthermore, preference of human and animal blood through contact between vectors and human which is determined by human gathering and types of housing (Najera 1994).

Climate change has an impact on raising and distribution of mosquitoes. Whereas in dry season, continuous breeding activity of vectors A. Arabiensis results from leakages from water pipes. Those water-leaking pipes were found to be the most attractive breeding habitats for vector to lay its eggs. Those water-leaking pipes result from soil movements which is associated with climactic conditions such as temperature as temperature affects the clay soil expansion and contraction and may cause pipes to leak (Himeidam et al.2008).

3.2.1 Agricultural practices and production systems

Malaria transmission is generally higher in agricultural areas due to irrigation, and concentrated farming and drainage (Himeidan & Rayah 2008). However, the usage of certain production systems and cultivation of particular crops such as bananas, rice, vegetables and fruits are connected to increased malaria due to irrigation and micro water pools (Basurko et al.2013). Maize cultivation aggravated malaria morbidity due to its direct effect on breeding of vectors mosquitoes. In breeding sites close to pollen sources, mosquito larvae feed from pollen that falls into larval habitats (Kebede et al.2005).

Study in eastern Sudan indicated that existence of A.arabiensis throughout rainy and irrigation seasons of the scheme is due to availability of mosquitoes reproduction sites that were formed from the puddles of irrigation canals around the area. Thus A.arabiensis has become perennial

instead of seasonal because of irrigation and agriculture practices. Furthermore, optimal temperature (28.9 – 30.1 C) and high relative humidity had led to high-breeding density during the rainy season (Himedian et al 2004).

In Sudan, insecticide treated nets (ITNs) and indoor residual spraying (IRS) are the most important vector control interventions and have resulted in remarkable reduction of malaria associated mortality and morbidity (NMCP2010). However, resistance to pyrethroid; the insecticide that used in malaria interventions as well as control of agriculture pests, have been noticed. Sudan is one of 27 countries in sub Saharan Africa that reported mosquitoes' resistance to the pyrethroid in some part of the country (Ranson et al 2011).

Another study showed that DDT was previously used for vector control and in agriculture before the study. Now it is replaced by organophosphates and pyrethroids because A.arabiensis has developed resistance for it. Finding of this study indicate that there is increase in knockdown frequencies (Kdr) although it is low, but there is concern about spread of pyrethroids resistance (Himeidan et al 2007a, Abuelmaali 2013).

3.2.2 Urban and peri-urban setting and infrastructures

Urbanization has greater impact or relationship in eliminating or decreasing malaria transmission. Moreover, it has major effect on improving socio-economic status and physical landscapes as well as allocation of greater resources to malaria control and hence reducing malaria transmission (Tatem et al. 2013). Khartoum state is a good example because resources and efforts are focused mainly on it. Socio-economic status of people such as education, income and infrastructure are better in Khartoum state compared to other states. These discrepancies contributed to enhancement of malaria control activities at Khartoum state compared to other states (MPR 2013).
Study conducted in peri-urban irrigated area of eastern Sudan found that, malaria transmission was seasonal and has become perennial due to introduction of agriculture that resulted in higher vectoral capacity of A.arabiensis (Himedian et al. 2007b).

Immigration from rural areas to urban areas and from malarious areas, has increased malaria transmission in many formerly malaria-free cities. When people travel to city, they carry malaria parasite along with them in their blood. Existence of malaria vector will spreads malaria infection within households and communities particularly in people who do not use protection methods such as INTs and IRS (El Sayed et al. 2000).

An other study conducted in Khartoum state has compared two peri-urban and suburban areas, found that mosquitoes densities or number of mosquitoes in dwellings were lower in suburban than in peri-urban area. This discrepancy was attributed to fact that peri-urban areas have poor quality of housing and residual closer to cultivated and irrigated land (El Sayed et al. 2000).

3.2.3 Housing

Design of houses significantly influences incidence of P.facliparum infections and is considered as one of the risk factors of malaria. Better housing is one of factors that reduces malaria infections in many countries. Housing conditions take part in adjusting exposure of populations to mosquitoes. Roof types also determine indoor temperature and is also connected with malaria transmission (Ye et al 2006).
Major types of housing in Sudan are straw mats, tent, gottiva mat, gottya mud and other type such as houses with one floor muld (CBS 2008). Those housing types are associated with greater exposure to outdoors due to lack of window screens. Houses with greater exposure are more common among people with lower SES, Furthermore, presence of thatched roof increases contact between individual and vector and hence malaria transmission..
ELSayed et al. (2000) conducted study in Khartoum that compared two areas with different types of housing. In the first area; houses were made of traditional Sudanese mud and brick construction while in the second area; houses were made of concrete. They found that houses from mud have higher number of mosquitoes compared to concerte houses.
Another study conducted in North West of Burkina Faso found that among under five children living in iron sheet roofed houses have lower risk of getting P.Falciparum compared to those living in houses with mud roofs (Ye et al 2006).

3.2.4 Land use/management

Land use may influence Malaria and other mosquito-borne diseases. Spread of these diseases was attributable to inadvertently introduction of mosquito vectors into environment in appropriate area out of their usual ranges. Although rainfall and temperature have critical control on mosquito life and its parasite, land change/use may assist the spread of malaria vectors (Fuller et al.2012).

A study in Sudan and Upper Egypt found that land use/change and distribution of A.arabiensis species were associated with potentially changes in vector habitats. Tropical deforestation and urbanization process are methods for land cover changes and thus they influence vectors distribution

(Fuller et al 2012). Change in land use may influence malaria transmission positively by decreasing breeding sites as well as costs of disease.

3.3.2.5 Economic development projects

The establishment and operation of agriculture and water resource development projects are important elements in increasing malaria transmission. Those projects constitute the main economic supply for Sudan and account for 80% of workforce (UNDP 2013). Study in New Halfa town on vector in an irrigated area confirmed that A.arabiensis is the predominant malaria vector in that area. However, the study found that introduction of permanent irrigation system increased/potentiated two essential ecological factors for larval development; breeding habitats and humidity (Himeidan & Rayah 2008).

The impact of irrigation was more pronounced during the cool dry season when main crops (cotton and wheat) are cultivated in the country. Water intended for crop irrigation was significantly associated with an increase in density of immature stages of vector. Poor maintenance of irrigation canals has led to water logging and hence creation the optimal breeding sites for A.arabiensis (Himeidan & Rayah 2008). Recently, the cotton project is stopped producing. Nevertheless, irrigation canals are still present and carry the same risk for malaria infection.

3.3. Population group:

Some risk factors that are associated with increased vulnerability and exposure to malaria, are present collectively in some population groups. These factors include poor education and low income level, poor sanitation, malnutrition, overcrowded houses and limited access to and usage of health services. (Blas and Sivasankara2010)

3.3.1 Poverty and education

There is evidence that vulnerability to malaria and its negative sequelae is associated with lower SES (Tusting et al.2013). In Sudan, approximately half of population are under the poverty line (46%). Poor people are affected by malaria due to lower SES; low income, poor housing conditions and lack of education. Children of low SES have double risk of malaria than those of high SES within the same area. Low SES not only makes people more susceptible to the disease but also increases their vulnerability to costs of disease with a further downfall into poverty (Tusting et al.2013). Similarly, another study found that high SES was positively related to expenditures and use of vector control methods; richest households spent more money to prevent malaria than poorest ones. Thus, the poor are more susceptible to

malaria infection and consequently getting the disease which reduces their productivity and ultimately aggravated their poverty (Onwujekwe et al.2005).

Knowledge of malaria is associated with high SES. The malaria indicators survey (MIS) 2010 found that richest quintile households have 5 times better attendance for malaria-related formal or informal meetings compared to poorest quintile. Moreover, access to media was significantly in favour of the richest quintile. Parents' education was significantly associated with seeking consultation from health worker and getting malaria treatment (MIS 2010).

Study in rural areas in Sudan conducted among mothers indicated that 58.3% of mothers were illiterate 94.8% were solely housewives and farmers. Based on type of housing, family's source of income and presence of domestic animals; 82.3% of mothers have low to moderate socioeconomic status (Malik et al.2006).

3.3.2 Population movement

Population Census conducted in 2008 estimated that internal migration is about 3.7 million and constituted almost 10% of the total population. Civil war that lasted for more than 20 years, draught and desertification are the major causes of population movement. Migration is related to socio-economic changes and pushing factors such as lack of employment opportunities. Additionally, during climatic or other ecological conditions, migration is predicted to be mainly towards naturally better-endowed or more advanced areas in the country. Urban areas suffer more from migration than the rural areas .Khartoum state accommodates about 49% of all migrants followed by Red Sea and Gadarif states; 2.2% and 1.4% respectively. The major states that loose people are North Kordofan and West Darfur states (CBS 2008).

Population movement plays a key role in spreading of malaria especially when it is from low- to high-transmission areas. Those displaced populations are more vulnerable to malaria infection than permanent residents of high transmission area because they lack immunity against malaria. Spread of malaria parasites by human migration can quickly undermines the successful interruption of disease transmission and challenges its control efforts (Tatem and Smith 2010).

3.3.3.3 Nutrition:

Malnutrition is considered as the underling cause of more than 50% of childhood deaths as well as increased susceptibility to severe diseases such as malaria. Over half of malaria deaths among children under 5 have been

attributed to being underweight or deficient in micronutrients: 20 % to zinc and 19% to vitamin A deficiency (Caulfield et al.2004). In Sudan, 39% of population are below minimum level of dietary consumption. Study in eastern Sudan found that among children with malaria infection, plasma's zinc concentration was very low (Saad et al.2013).

Another study conducted in Northern state of Sudan to explored the prevalence of anemia in preschool children found that 80.4% of children suffer from anemia (Hussein and Mohamed 2014).

Pregnancy is an important risk factor for malaria due to reduction of women overall immunity that leave them susceptible to malaria. Malaria causes severe complications such as maternal anemia, low birth weight and stillbirths (Adam et al.2005). Similarly, Bader et al. (2013) found that pregnant woman with malaria past history had 3 times higher risk of stillbirths.

3.3.3.4 Occupation

Some jobs exposed individuals to higher risk of malaria infection than others. Agriculture labourers put themselves at higher risk through increased contact with malaria vector. Migration for labour may place others at higher risk by contribution to the spread of disease (Worral et al. 2003). Study in Ethiopia found that seasonal labour migration from high land to malarious low land lead to continuation of disease transmission and the rise in Chloroquine-resistance throughout country (Ghebreyesus et al.2000). Migration placed workers at higher risk as well as limiting their access to malaria diagnosis and treatment particularly if agricultural labor sites are located far away from health facilities. Additionally, workers have to stay in fields, which possibly increase their vulnerability of getting malaria. Malaria infection is higher in lower SES occupational categories compared to higher ones (Worral et al 2003).

3.3.3.5 Community control

Cording to UNDP and RBM 2013 "Lack of community control over ecosystem and irrigation system along with rapid growth of population size and migration of young people have contributed to degradation of land, wreaking of social solidarity, and inappropriate preservation of environment. Additionally, modifications in land tenure and use, propagation of mosquito breeding sites promote a renaissance of malaria transmission"

Study in Tanzania showed that communities, where payments mechanism are introduced to finance ecosystem services, have great impact on malaria control. Those community developed financial mechanism with the purpose of generating revenue that would be used for protection of ecosystem and its bio-diversity. Through giving rewarding for the responsible of ecological

services. Also, community paid to enforce voluntary restrictions on agriculture cultivation and permanent settlement in area of land. This initiative was developed after expansion in agricultural areas and it is community based conservation to reconcile between relative to land and tenure pastoralist livelihood (Nelson et al. 2010). It was found to be cost-effective and instrumental for malaria control because the community assisted and participated in malaria control activities and became accountable for its control. In Sudan, people often assist the poor people in the community. Social solidarity is considered as one of Sudanese values and it could be utilized to enhance adoption of Tanzania experience for malaria control.

Yasuoka (2006) found community-based education enhanced community actions for mosquito control. Increased knowledge on malaria and different actions were undertaken by farmers to address mosquito breeding sites. Mosquito density was reduced through using new agriculture practices such as land leveling, canal cleaning, draining and decrease in pesticide use. Other actions that reduced mosquito density are environmental awareness regarding predator conversation of mosquito, pest control and ecosystem management through reducing use of chemical (Nelson et al. 2010).

3.4 Households and individuals:

This section explained determinants related to households and individuals such as choice of malaria-safe habitats, poverty, education, nutrition, access and use of healthcare services.

3.3.4.1 Choice and adoption of malaria-safe habits

Selection of malaria-safe habits that could be undertaken at household and individual level including personal safety measures such as get better quality of house, peri-domestic sanitation, use of IRS and ITNs, chemoprophylaxis during pregnancy and anti-malarial treatment. These diverse choices came up with their costs; household has to pay for perceived benefits along with costs of other priorities needed (UNDP and RBM 2013). In Sudan, choice of malaria-safe habits is determined by availability of methods such as ITNs, knowledge and awareness and ability to pay after covering all other priorities for individuals and households.

The SES of household is determinant of adoption of malaria protection methods. According to a study conducted in Sudan, richer households spent more money or had greater access and use than poorest one (Onwujekwe et al.2005). Overall Knowledge about malaria is only 4% according to malaria indicator survey done in 2009, which had influenced adoption of malaria-safe habits. Another study conducted among pregnant women in Sudan showed that many cases of malaria did not seek malaria diagnosis and treatment. Knowledge of malaria will basically enable them to protect themselves

against malaria such as use of different malaria-safe habits; ITNs, replants as well as seeking health care when it is needed (Gabbad et al.2014)

3.3.4.2 Awareness and knowledge

The level of education is important for seeking help when child has fever. Hence, Mothers having primary or no education are less likely to visit health facility first in comparison to mothers with secondary education (Worrall et al. 2003). Study in eastern part of Sudan conducted among three hundred fifty housewives showed that 85.7% of respondents had at least basic education and 67.7% of mothers were found to have adequate knowledge about malaria. Malaria was perceived as a cause of low grade fever by only 40.9% of respondents. However, the percentage was almost doubled in case of high fever.

Similar finding were found with respect to the selection of treatment sources and use of anti-malarial drugs. High fever urged 91.1% of mothers to seek advice from a health worker and 80.3% of mothers to take drugs other than chloroquine (Salah et al 2007).

Other study conducted among 96 mothers in rural areas in Sudan with high seasonal transmission indicated that fever was recognized by 70.8% of mothers as hot body or as a syndrome including hot body and other symptoms headache, restlessness. Malaria was correctly defined as fever or fever with other symptoms or signs and was recognized as a common cause of fever followed by chest infection. Fever was considered as a dangerous feature that leads to severe complications or death (Malik et al 2006).

3.3.4.3 Access to and use of health care (Health seeking behavior)

Generally, health coverage is better in urban areas with 88% of the population having access to healthcare compared to 61% in rural areas. Low geographical accessibility is perceived to be a barrier to utilization of health care services, which is aggravated by rainy season condition, lack of functioning health care facilities, and lack of transportation. Other factors related to provision of health care affect use of health services such as shortage of qualified health staff, perceived poor quality of health services and inconvenient working hours (2009).

In Sudan, majority of people believe in traditional medicine and practice self-medication (Awad et al.2005).

A KAP survey conducted in Sudan (2011) found that lack of health awareness and low educational level among the local communities especially women hinder access and use of health services. The high cost of health services induces more inequitable negative burden on the poorest quintile leading to denial of access to health care and forcing household to suffer from catastrophic expenditures in order to secure the needed money or borrowing the needed expenses, getting partial treatment for their health

conditions and selling of their household assets. Hence, insured people have higher utilization rate than non-insured (FMOH 2011c).

The use of both private and government services is increased by household wealth. Thus there are discrepancies across states and among urban/rural areas. The use of diagnosis and treatment services is higher in urban than rural areas and among the wealthy than the poor resulting in fewer opportunities for the poor to use health services or not using them at all (FMOH 2011c).

In a study conducted among mothers in Sudan, Health care seeking behavior is determined by availability of health facility, user fees, believe in traditional medicine, difficulty to reach and satisfaction with services provided (Malik et al. 2006). Another study found that exemption from user fees enhanced health utilization services, improved malaria treatment seeking behavior and promoted early diagnosis (Abdu et al. 2004).

Elmardi carried out study in South Kordofan state to explore the feasibility and accessibility of home management of malaria strategy (HMM) using the Artemisinin-based Combination Therapy (ACT) and rapid diagnostic test (RDT). The study revealed that adherence of volunteers to project protocol in treatment and referring cases was acceptable and use of RDT has improved the level of accuracy and trust in diagnosis. Recruitment of volunteers from the village has a positive role in improving the acceptability of HMM design and its effectiveness and has increased accessibility to ACTs from 25% to 64% as well as enhancement of treatment seeking behavior from 83.3% to 100% before and after HMM implementation (Elmardi et al. 2009).

In Sudan Self-medication with Anti-malarial drugs is alarmingly high and has led to development and spread of anti-microbial resistant malaria. Awad conducted study in Sudan in 2005 showed that Self-medication with anti-malarial drugs was significantly associated with age group (which age group)(p< 0.001), gender (p = 0.008), monthly income (p <0.001) and level of respondent's education (Awad et al. 2005).

3.3.4.4 Provision of health care

Provision of health care is supposed to be through primary health care facilities (public or private sectors). However, traditional practitioners still exist and provide health services (FMOH 2010). The coverage of PHC facilities is one per 681,686 individuals and 86.6% of them are currently functioning. Unequal distribution of health facilities across the states raised equity issues with regard to the national health system coverage since most facilities are concentrated in Khartoum State relative to other states. Moreover, there is shortage in human resources for health in many facilities

(Badr 2007). However, urban facilities are better in term of quality of services provided (FMOH 2010).

In the functioning facilities in 2012, coverage of malaria diagnosis with RDTs was more than 80% in basic health units while malaria microscopy technique is available in health centers with various qualities but there is no recent data to estimate its percentage. ACTs was provided in 78% of health facilities according to national treatment policy. Home management services expand to reach 48% of targeted communities. However, there is a weak referral system and an increase in population compliance to protocol. In National policy for malaria, there is no clear indication that malaria diagnosis and treatment must be free. RDT and ACT are free in public health facilities but not microscopy diagnoses (MPR 2013).

Chapter four: Current and Proposed Multisectoral Interventions

This chapter discussed current malaria control strategies in Sudan and the proposed interventions to enhance a multi-sectoral response for malaria.

4.1 Current Malaria Strategic interventions

Current interventions for malaria control in Sudan are vector control (long lasting insecticide-treated nets (LLINs)), indoor residual spraying (IRS), environmental management, use of chemical larviciding and limited biological control, case management (diagnosis and treatment) and malaria in pregnancy intervention. Health is the responsible sector for these interventions in coordination with agriculture, irrigation and environment sectors. Interventions will be explained according to levels of thesis framework; society, environmental, population group and individuals and households.

4.1.1 Society level interventions

Currently, there are no interventions of malaria control program to address this level.

4.1.2 Environmental level interventions:

This intervention aims to reduce density of the vector. Health sector in coordination with environment, irrigation and agriculture sectors are the main responsible bodies for this intervention.

Indoor Residual Spraying (IRS)

This intervention aims at controlling malaria in irrigated systems. Currently is operational in many areas and projects such as Elrahad, Gezira, New Halfa, Zeidab, Suki and Sugar cane projects. The NMCP's target level for operational coverage of annual indoor residual spraying by 2015 is 85%. However, only two states (Gazira and Sinnar) have managed to exceed the targeted coverage (above 90%). Nevertheless, operational challenges such as insufficient insecticide stocks, inadequate logistical support and operational cost have delayed expansion of IRS to others targeted states (NMCP2010).

Larval control

Using chemicals such as Temephos EC 50% is the main control methods for larval stage. Urban settings in big cities and riverine areas are the targeted areas. On the other hand, environmental management is limited to agricultural irrigation schemes through drainage as well as intermittent irrigation. Using of larvicidal fish as a biological control method is implemented on a small scale in some irrigated agricultural areas and constant stagnant big bond. The larval source management was important component of the malaria free initiative (MFI) launched in Khartoum (Capital city) in 2002 and contributed to the significant decline in malaria prevalence from 29.2% in 2002 to 0.35% in 2008 (MPPR2013). The target coverage of larval control intervention, outside of Khartoum state is only 33.7% far below the national target of 85% by 2015 (NMCP2010).

Fogging

In Sudan Fogging is not a priority method for malaria vector control except in urban areas where it is used in complex emergency and during water borne disease outbreaks; yellow, dengue and rift valley fevers (NMCP2010).

Entomological surveillance

The monitoring of insecticide resistance and residual efficacy is important because vector control relies on use of insecticide. Over the years, vector control has been monitored in several states with evidence of resistance to organophosphates, DDT and recently to pyrethroids. A combination of entomological inoculation rates crudely could be a good measure of intervention's impact where feasible and recommended to be done routinely (NMCP2010).

4.1.3 Population level interventions
These following interventions address the population group and health sector is responsible body for this intervention.

Long lasting insecticidal nets (LLINs):

Implementation of Long-lasting insecticidal nets (LLINs) in Sudan is based on providing universal access to LLINs in malaria-risk areas. The aim is to providing one net for every two persons in order to reach universal coverage goal (NMCP 2010).
Based on the results of Sudan household survey, household ownership of ITNS increased from about 41% in 2010 to 51% in 2012. On the other hand, the proportion of household that has at least one LLTN per 2 persons in household was only 16% and the proportion of household members who had slept under LLIN did not change between 2009 and 2012, which was 10.5 % and 10.8% respectively (MPR 2013).

4.1.4 Household or individual interventions

The current interventions that malaria control program have adopted to address determinants at household and individual levels will be discussed in this section. Health sector is the responsible body for these interventions.

4.1.4.1 Case management

Malaria diagnosis

Currently, there are many laboratories performing blood slide examination in main urban centers. On the other hand, diagnosis of malaria in rural areas is presumptive.

National policy is still not clearly indicating that malaria diagnosis and treatment must be free as part of communicable diseases strategy to stop transmission of the disease. ACT and RDT are free in public health facilities as they are widely distributed widely in public, NGOs treatment centers and health facilities (MPR 2013). However, patients have to pay for microscopy diagnosis.

Treatment:

The national drug policy was changed in 2004 for uncomplicated falciparum malaria from mono-therapy to Artemisinin-based Combination Therapy (ACT). This modification has been adopted following evidences that showed there is high efficacy of ACT in >43% Chloroquine (CQ) resistant malaria areas. The use of AS+SP has increased very minimal from 44% in 2004 to 47.7 % in 2012.

Based on National malaria control strategy (NMCS); 95% of malaria patients in Sudan should receive effective treatment by 2015. A 78% of health facilities were providing ACT according to national treatment policy. Recently ACTs has been availed through Global Fund and UNICEF covering all states. Severe malaria drugs have been distributed free of charge in more than 64 hospitals in severe malaria areas (NMCP 2010).

Home based management of malaria (HMM) has expanded to reach 1,131 communities with a coverage rates of only 44% in 2009 and 48% in 2012 of total targeted communities far below the 65% national target level. Weak supervision and drop out of volunteers are main challenges of the HMM services. Sentinel surveillance system established in 2002 with WHO support operates in 6 sites. It supposed to continuously monitor the efficacy of anti-malaria drugs in different parts of northern states of Sudan (NMCP2010).

Malaria in pregnancy

The recommended interventions for controlling malaria in pregnancy are LLIN and proper case management including intermittent therapy. The strategy aims at provision of all pregnant women with LLIN in the targeted

areas. Recently, this policy has become of lower effect at community level based on the success in reducing malaria prevalence and incidence. The responsible sector for this intervention is the health sector (NMCP2010).

4.2 Interventions suggested by UNDP/RBM to enhance multisectoral response

In this section, actions to determinants of malaria will be analyzed that enhances collective multisectoral actions to impact malaria. These interventions were suggested by UNDP and RBM as implementable actions and innovative interventions to contribute to malaria control.

4.2.1 Society level interventions:

The benefits of these interventions are not limited to malaria control program; but extend to other sector as they enhance equity, social and economic development through reduction of malaria morbidity and mortality and hence improved productivity.

4.2.1.1 Inequitable distribution of power and resource across country

Rwanda has made significant progress with regard to Paris declaration and set an example to be followed by other countries. Rwanda has succeeded in achieving progress in all five major areas of Paris declaration when compared with Sudan, especially management for results and mutual accountability in addition to adoption of sector-wide approach as shown in tables 3 and 4 below. So according to UNDP/RBM will add value for malaria control(OECD 2011a and OECD 2011b).

Table (3) Rwanda progress in Paris declaration

	ACHIEVEMENT OR *CHALLENGE*	LESSON OR *PRIORITY ACTION*
Ownership	**Achievement:** Rwanda's Economic Development and Poverty Reduction Strategy 2008-2012 (EDPRS) is integrated with a long term vision and sectoral strategies, and encompasses a comprehensive set of prioritised targets.	**Lesson:** Ensure national development strategies are well integrated and serve as a reference point for sub-national and sectoral strategies.
Alignment	**Achievement:** There has been a significant improvement in the proportion of disbursed aid accurately recorded in the national budget.	**Lesson:** This has been facilitated through the strengthening of the Development Assistance Database (DAD) to ensure timely and reliable data is collected. A shift towards budget support modalities has also contributed to the proportion of ODA reported on budget.
Harmonisation	**Achievement:** Strengthened the use of programme-based approaches through national policy documents.	**Lesson:** Extend sector-wide approaches (SWAps) to all sectors and strengthen their scope and coverage.
Managing for results	**Challenge:** Quality of monitoring and evaluation data is weak, and as there is no evidence that data collection provides comprehensive information to track the targets of the national development strategy (NDS).	**Priority action:** Improve the statistical generation and analytical capabilities of ministries in order to ensure adequate frequency and quality of data for monitoring and evaluation purposes. Ongoing efforts to strengthen NISR's capacity to support improvements in data collection and analysis would further contribute to this.
Mutual accountability	**Achievement:** Rwanda has developed frameworks for Donor Performance Assessment and Development Partner Co-ordination. **Challenge:** Parliament and civil society organisations remain excluded from the performance assessment of government and donors, although they did engage in the aid co-ordination architecture, which provides the national mutual accountability framework.	**Priority action:** Enhance parliamentary oversight of aid transparency and engage civil society groups and parliament in mutual accountability systems. The Government of Rwanda notes that while international NGOs and local civil society groups participate in co-ordination meetings, only the GoR and donors are subject to transparent assessments of performance in the context of Rwanda's mutual accountability framework.

Source:(OECD 2011a)

Table (4) Sudan progress in Paris declaration

	ACHIEVEMENT OR CHALLENGE	LESSON OR PRIORITY ACTION
Ownership	**Achievement:** Sudan has substantially improved the operationality of its national development strategy. It is linked to a long-term vision, supporting sectoral and sub-national strategies and has prioritised targets and links to the Millennium Development Goals and cross-cutting issues.	**Lesson:** Progress in achieving prioritised targets is documented through regular reports that are cross-checked with independent evaluation and site visits. The links to the Millennium Development Goals are strengthened through country localisation and integration into sector strategies and annual targets. Specific mechanisms ensure linkages with cross-cutting issues.
Alignment	**Challenge:** The reliability of country public financial management systems is low.	**Priority action:** Sudan currently has a wide range of reforms in action. The challenge is to ensure that these are effectively followed through.
Harmonisation	**Challenge:** Almost no use of programme-based approaches.	**Priority action:** Ensure donors increase use of budget support and programme-based approaches in accord to priorities set out in the forthcoming national development strategy.
Managing for results	**Achievement:** Coverage of the monitoring and evaluation framework is sectorally and geographically comprehensive, with progress against the national development strategy reported regularly.	**Lesson:** More reliable indicators were made available after the conclusion of the fifth population census in 2009 and the Sudan Household Survey – conducted in 2010 with the help of international partners and line ministries.
Mutual accountability	**Challenge:** A mutual accountability framework is not in place.	**Priority actions:** Ensure government-donor forums (currently in place), and the Sudan aid information database form an effective basis for developing a mutual accountability mechanism.

Source :(OECD 2011a)

4.2.1.2 Government ability to manage land and tax revenues and to regulate

According to UNDP/RBM (2013) good governance and improvement of country's regulatory system will positively impact on malaria control. Participation of the most vulnerable in society in decision-making process will ensure equity and accountability. Transparency, by making information available to people, will be affected by the decisions and enforcement of the law. (UN n.d.)

According to OECD (2013), strengthening of the country tax system will increase resource generation and allocation: South Africa implemented South Africa revenue service (SARS) that emphasizes outreach and public education and awareness. These interventions have improved compliance of people to pay tax and hence increased tax revenue from 1% in 2006 to 95% in 2009. Moreover, GDP rose from 25.3% in 2004 to 29.4% in 2008(OECD 2013). The responsible sectors of these actions are detailed in table (5).

4.2.1.3 Demographic change

Achieve universal education by targeting poor and disadvantage areas. (UNDP 2013). In Nigeria people having high level of formal education are more likely to identify mosquito as cause of malaria ($p < 0.05$) (Dike et al.2006). The responsible sectors of these actions are mentioned in table (5).

4.2.1.4 Organizations of Societies and Services

Involving civil societies, media, parliament and private sector strengthen accountability for better outcomes. The involvement of all partners should be throughout entire process from planning, allocation, spending and monitoring of the public resources (WB n.d). The responsible sectors of these actions are shown in table (5).

4.2.1.5 Social status-gender, ethnicity, and distribution of power and resource within countries

Human right, equity and sustainability: planning is based on value of human rights; equity and development sustainability. Will be the basis for future development plan. As in post 2015 agenda, Equity between men and women and all the ethnic groups or any other social group is a cornerstone of all planning initiatives (UNSTT 2013). The responsible sectors of these actions are as shown in table (5).

Table (5) showed sectors that are proposed to work at society level interventions and are classified according to level of the determinant.

The determinants	The responsible sectors of interventions for each determinant													
	Foreign affairs &int cooperation	Finance & economy	Food and Agriculture & irrigation	Trade & industry	Infrastructure , work	Education	Social protection	Justice	Environment	Communication & information	Security	Community development	Health	local government
In equitable distribution of power and resource across country	√	√		√				√	√	√	√			

	1	2	3	4	5	6	7	8	9	10	11	12	13
Demographic change			√			√	√	√		√	√	√	√	√
Government ability to manage land	√	√		√				√					√	√
Organization of societies		√			√	√	√	√	√			√	√	√
Social status		√			√	√	√	√			√	√	√	√

Source:(UNDP and RBM 2013)

4.2 Interventions for Environmental Level

4.2.1 Agricultural practices and production systems

Water management interventions:

In Ethiopia, implementation of intentional manipulation reservoir water had potentially reduced the larval abundance (IWMI2009).

Increase productivity and food security:
In Peninsula, food insecurity is main risk factor for clinical malaria (Escamilla et al.2009).

Collaboration with agriculture schools for integration of malaria with pest management programme. This will ensure future farmers are aware about malaria and its effects.

Increase distance between residential areas and crops will have impact on the decrease malaria transmission (Ljumb and Lindsay2001).

The responsible sectors of these actions are in mentioned in table (6).

4.2.2 Urban and peri-urban settings and infrastructures

UNDP/RBM (2013) identifies the people who are at greater risk of malaria. Prioritization of population is needed to improve or tailor interventions for diagnosis, treatment and vector control. Improving access to malaria services among poor could be assisted through involving private sector for wider coverage (Donnelly2005). The responsible sectors of these actions are shown in table (6).

4.2.3 Housing

Using of modification or set up of national building codes and low-cost models using better structure materials and supporting financing initiatives.

Kenya implemented this intervention, which has resulted in 84% reduction in odds of mosquito in modified housed (P<0.001) (Atieli et al.2009).

Limitation of number of people sleeping per house or room can contribute to reduction of malaria burden. In Gambia mosquito number increased by adding an extra person to the house. The responsible sectors of these actions are shown in table (6).

4.2.4 Land use and management

Egypt implement Environmental modification intervention from 1902-05 and managed to reduce the malaria cases from 2300 to 37 with relative ratio (0.01)(Keiser et al.2005). The responsible sectors of these actions are in table (6).

4.2.5 Economic development projects

According to water policy (2010), impact assessment is important to know the implications of projects on malaria before funding. This achieved through strengthening the capacity of national and local inspection and at same time regulation and enforcement of compliance (UNDP and RBM 2013).

Strengthening partnerships with the economic projects in country:
Although interventions for malaria such as treatment are available, they are inaccessible to many individual who are in need of them. Projects that support outreach activities are needed to improve coverage to malaria diagnosis and treatment. Some Firms have interest to be involved in malaria control since malaria affects business directly through its negative impact on workers by reducing their productivity, and indirectly through effect on economy (Bloom et al. 2006). The responsible sectors of these actions are shown in table (6)

Table (6) Sectors that are proposed to work in the environment level and classified according to the level of the determinant

	The responsible sectors of interventions for each determinant

The determinants	Finance & economy	Food and Agriculture & irrigation	Trade & industry	Infrastructure , work	Education	Social protection	Justice	Environment	Communication & information	Security	Community development	Health	local government
Agriculture practices and production system		√		√				√					
Urban and peri-urban setting and infrastructures	√	√	√	√	√	√		√		√	√	√	√
Housing				√	√	√	√	√			√		√
Land use		√	√	√			√	√	√	√	√		√
Economic development projects	√	√	√	√			√	√		√	√	√	√

Source:(UNDP and RBM 2013)

4.3 Population group interventions

These Interventions are intended to address factors that render human susceptible and vulnerable to malaria and hence enhance equity, economic, social and health development..

4.3.1Poverty and education

Intended to improve development, poverty alleviation and nutrition programs to poor communities. Evidence from UN MDGs report showed that implementation of these interventions has resulted in 31% reduction in child mortality in Africa (Gakidou 2007).

4.3.1.2 Credit with education (microfinance with education)

This intervention has been implemented in many African countries such as Ghana, Mali, Niger and Togo. It is an innovative way to fight chronic hunger and poverty by enabling access to credit and saving service. This intervention is an outreach one so to improve coverage of very far rural areas. In addition to develop education modules such as health, nutrition, business and money management. It is found to be effective, practical and

self-sustaining because it gives freedom from hunger especially for women living with poverty who hardly earn money or feed their children (FFH n.d.).

4.3.1.3 Commercial loans for low-income groups

Launching of Standard Bank Initiative helped people by providing money or house loan to poor people. This initiative has greater contribution on malaria control through assisting success of small enterprises. This initiative is adopted by several African countries and had greater impact on malaria control (SB 2014).

Conditional cash transfers:
This intervention has been implemented in many countries such as South Africa and Kenya. It enables poor families to spend on education; health and nutrition. It has resulted in improvement of the nutritional status and general health of the poor (Baird2011; Das et al 2005, Rasella et al. 2013).

4.3.2 Nutrition

Provide Vitamin A and Zinc supplementation in high transmission areas to population at high risk:
study done in Burkina Faso found that significant reduction in malaria prevalence in supplemented group 34% (P<0.001) (Zeba et al.2008).

Women empowerment and community contribution will lead to better health for them, their children, families and the whole community (ICPD 2013). The responsible sectors of all these actions mentioned in table (7).

4.3.3 Population mobility

Launching rights-based policies for migrants such as cross-border initiatives between bordering countries and prioritize access and coverage of health care for migrants (IOM 2012).

Implementation of cross–border BCC strategies through identifies mobile population that need to be covered with malaria prevention and treatment services. Generally, mobile population have poor access to health services and hence contribute to continuation of disease spreading (MS 2012).The responsible sectors of these actions mentioned in table (7).

4.3.4 Occupation:

Workplace interventions:

Promotion of staff accommodation by adding screens and a few number of workforces sleeping per room.

Provision of long lasting hammocks for staff that sleep outside temporary accommodation. Availing repellent soap and insecticides–treated clothes to prevent contact between vector and human (UNDP and RBM 2013).

Use of insecticide treated clothes for protection of mosquito: this intervention had been implemented in Kenya and resulted in 70% reduction of malaria infection (P: 0.001)(Kimani et al.2006)

Implement employer base malaria control programme: Standard bank implement malaria safe intervention for the employing because the worker miss one per five days of work because of malaria, so Increase malaria awareness among staff and ITNs distribution which make able to protect them self and families (Kim 2006, VFMFF 2014).

Several sectors are responsible for these actions as shown in table (7).

4.3.5 Community control

Improve Community participation

Improvement of community participation in Senegal resulted in strengthening delivery of health care, and improved health services utilization. Community participation strengthens delivery of health services, community ownership and hence management of health facilities and better access to drugs (Muhe2002).

Table (7) shows sectors that are proposed to work in the population group and they are classified according to the level of the determinant

The determinants	The responsible sectors of interventions for each determinant												
	Foreign affairs &int cooperation	Finance & economy	Food and Agriculture & irrigation	Trade & industry	Infrastructure , work	Education	Social protection	Justice	Communication & information	Security	Community development	Health	local government

Poverty and education		√	√	√	√	√	√	√			√	√	√
Population mobility	√		√	√	√	√	√	√	√	√	√	√	√
Nutrition		√	√	√		√	√		√		√	√	
Occupation			√	√	√		√	√	√	√	√	√	
Community control							√	√			√		√

Source:(UNDP and RBM 2013)

4.4 Household and individual level interventions

These Interventions aim at reduction of parasite load and drug resistance and hence enhance equity, social, economic and health development through improving access and use of health services.

4.4.1. Choice and adoption of safe malaria habits

4.4.1.1 NGOs housing projects with low–cost:
In Malawi, a five-years housing program has been implemented by the government to improve the traditional houses in collaboration with NGOs. This program has resulted in a significant reduction in malaria morbidity and mortality (44%) (Wolff et al.2001).

4.4.1.2 Combine of markets, free and voucher subsides:
Tanzania implemented this intervention to achieve high bednet coverage. This intervention resulted in more than 85% use of bednet last night with high coverage rates among vulnerable groups (Khatib et al.2008).
The responsible sectors for these actions are detailed in table (8).

4.4.2 Awareness and knowledge

4.4.2.1 Dedicated multisectoral community–focused malaria awareness programmes:
These interventions were implemented in Ethiopia and it is consisted of Behavior change communication (BCC). BCC has significant impact on raising awareness, use of bed nets, improving treatment and healthcare-seeking behavior (MC 2012).

4.4.2.2 Improved use of community radio:

Radio is an important tool for transferring malaria message and ensuring that information is communicated to the public. Information can encourage people to sleep under LLNs, pregnant women to seek health, mobilize family to spray and to seek health care (CMFD n.d.).

The responsible sectors of these actions mentioned in table (8).

4.4.3 Access to and use of health care

Malaria sensitive universal health coverage:
Rwanda has implemented community-based health insurance and managed to cover 90% of its population. This intervention decreased out of pocket expenditure for health from 28% to 12% and improved utilization of health services (Makaka et al.2012). The responsible sectors of these actions are mentioned in table (8).

Provision of health care

In Uganda, training of multidisciplinary (clinician, laboratory professional and health information assistant) for one year resulted in improving laboratory skills from 48.6% to 84% (p>0.036) and clinical skills for case management from 10% to 15% (RR:1.60)(Namaagembe et al.2012).

Improvement of services provided by medicine sellers through pre-training and post-training:
This intervention has been implemented in many of Sub-Saharan such as Kenya. The training of medicine seller in simple medicine use and proper practices for malaria management; increased from 46% to 70% and in Kenya seller who knew the appropriate antimalarial dose for children under5 increase from zero to 59% (Goodman et al.2007). The responsible sectors are mentioned in table (8)

Table (8) the sectors that are proposed to work at household and individual and levels are classified according to the level of the determinant.

	The responsible sectors of interventions for each determinant

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The determinants	Science and technology	Finance and economy	Food and Agriculture & irrigation	Trade & industry	Infrastructure, work	Education	Social protection	Justice	Environment	Communication & information	Security	Community development	Health	local government
Choice and adoption of malaria safe habits		√	√	√	√	√	√		√	√	√	√	√	√
Awareness and knowledge						√	√			√		√	√	
Access and use of health care		√				√	√			√		√	√	√
Provision of health services	√	√					√	√					√	√

Source:(UNDP and RBM 2013)

Chapter five: Best practices

1-Iran experience in Multisectoral approach

Iran has made significant progress in reducing its malaria over the last two decades. The Iranian control program has adopted good strategies that enabled them to eliminate malaria in almost all the country with a 91% reduction in malaria cases between 2000 and 2011. In 2010, only 3% of populations were at risk of malaria transmission. 90% of them resides in southern parts; provinces of Sistan and Blushestan in border with Pakistan and Afghanistan. The increase in Population movement as well as rainfall are the big problems and predisposing factors for disease spread (EMII2013).

Interventions

In addition to effective malaria control such as promoting access to malaria diagnosis and treatment and IRS, Iranian malaria control program has adopted a multisectoral approach that particularly focused on interventions operating at level one (society). The control program shifted focus of resources and power distribution towards affected areas and aims at poverty alleviation and improvement of economic situation. Furthermore, it improved its collaboration with countries sharing borders with Iran through improvement of surveillance and monitoring efficacy of antimalarial drugs at cross border region. Increased level of education has positively affected use of bednet Along with focus in provinces at risk on early warning system and outbreak preparedness plan for epidemic (Blas2013, EMII2013)

Lessons learnt

Increase in economic development will assist in control and elimination of malaria. To achieve elimination, we must focus on all levels of determinants of health. Equitable distribution of power and resources across country is a pre-requisite to reach elimination phase. Cross border and stakeholders collaboration is essential as well as Education, agriculture, Community mobilization and participation.

Kenya Millennium Villages Project (MVP)

Kenya has good experience in MVP that helps in achieving good malaria outcomes. MVP was introduced in Africa in 2004 following the facts that Sub Saharan countries are unlikely to achieve MDGs by 2015. In Kenya, the first MVP was set up in Sauri area based on assumption that targeting public sector investment in millennium village will raise rural productivity and hence increase household saving and investment (Wanjala & Muradian 2012).

Intervention
Combination of multiple sectors interventions targeted some locations. Interventions to improve empowerment and governance through formulation of committees on health, water, sanitation, education, irrigation, fertilizers distribution, water distribution and joint planning. Health's interventions focused on maternal and child health through provision of reproductive health, HIV, malaria and tuberculosis prevention and treatment. Improvement of nutritional and educational levels especially for girls leads to agriculture production booting activities and improvement of infrastructure (Wanjala & Muradian 2012)and (UNDPand RBM 2013).
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Impact of the project
The project has impact on productivity with higher level of access to food. Selection of the village was according to high hunger rate and food shortage. Increase local income resulting of household saving and microfinance become feasible as resulting of enhanced household income above subsistence (Wanjala & Muradian 2012).
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Lesson learn
The MVP is a good example of multi-sectoral approach due to the good results of the project in Sauri. It is a cost effective project. It suggests that addressing level 1 determinants will yield sustainable development and good malaria specific outcomes.

Chapter Six: Discussion, Conclusion and Recommendation

5.1 Discussion

Despite the progress that has been made in malaria control in Sudan, malaria is still the most important health problem and poses a major burden to healthcare delivery system. This entails changing the approaches and ways through which malaria control program is operating. This study had analyzed the multi-sectoral determinants of malaria in Sudan in order to suggest interventions which can help in accelerating/enhancing malaria control. Multisectoral action framework for malaria developed by UNDP and RBM. The framework addressed malaria from four aspects; society, environment, population groups and individual and families.

Our study found that Low SES and inequity are the commonest societal factors that determine malaria in Sudan. Malaria is more prevalent among people of low socioeconomic status because they have low education, limited access to treatment and prevention, low immunity and poor housing condition (Tusting et al.2013).

Moreover, malaria disease intensifies poverty as people of low SES have to borrow or sold their household assets in order to pay the user fees applied at health care delivery point. The costs incurred by the poor people pushed them into financial catastrophic expenditure and further impoverishment.

The study found that there is correlation between high malaria prevalence in different states and inequitable distribution of resources. Inequitable distribution of resources affected with the ability of states to generate and manage taxes and thus implementation of malaria interventions. As consequence, malaria remained high burden in poorest states. Low per capita government expenditure has increased inequity and gap between the wealthiest and poorest quintiles where only the rich can access services. Poor people cannot use health services due to high out of pocket expenditure (almost 70% of total health expenditure) Civil wars and political conflicts have aggravated and further violated rights of affected population to access services.

Other societal factors that are associated with malaria are gender, and ethnicity. Our study showed that there is no difference between men and women with regard to malaria susceptibility apart from pregnant women (Worall et al 2002). In Sudan, malaria is associated with gender inequity as women are not allowed to go to health facility without permission or have to wait for husband/family to give her money due to cultural norms.

The study explored population factors determining malaria burden in Sudan. Nutrition, Occupation, poverty and education, migration and community

control affect malaria prevalence. Malaria is strongly associated with nutrition, especially in children and pregnant women (Saad etal.2013; Bader et al.,2013). Migration is linked to this factor. Due to lack of enough food, people moved from one area to another or from one country to another looking or in search for food. Occupation is a strong risk factor of malaria and is usually associated with migration (Gnebreysus et al.,2000). People working in agriculture often move to work in other areas. Areas of population settlement increased their susceptibility to mosquito in the absence of ITNs use.

Several environmental factors are affecting malaria control such as housing, agriculture, urbanization and large economic development projects. Malaria is associated with agriculture, irrigation. Agriculture pesticide caused profound impact on resistance of vectors (Abuelmaali et al.,2013). Many studies conducted in Sudan showed an association between malaria and agriculture (Hiemeidan and Rayah 2008,Hiemedan 2007, Himedan et al 2004). Economic projects have good impact on development process. Nevertheless, they increase malaria transmission if planned without impact assessment.

Urbanization or urban residence is more likely to be a protective factor against malaria risk (Tateam et al 2013, and ElSayed et al.,2000). On the other hand, peri-urban settings or rural locations are associated with increased risk of malaria (Worral et al.2000). Malaria is less prevalent at urban areas as they have good infrastructure, housing, sanitation and better access for treatment compared to rural areas.

The author found that malaria is associated with design of houses (Ye et al.2006) and quality of houses in urban and pre-urban setting (Elsayed et al. 2000). Good houses reduced contact with malaria vector; hence poor people are more affected because their choices of establishing good houses conflict with other needs.

Poverty affects accessibility to healthcare, awareness and Knowledge on malaria transmission and treatment especially among poor people. Richer households spent more in treatment, prevention and education and therefore utilized the services better than poor. Malaria treatment is free of charge according NMCP policy but in reality only in hospitals. Hence, the majority of population seek healthcare at health centers near their locations due, so poor usually resort to self medication.

The thesis analyzed interventions suggested by RBM/UNDP that will impact on malaria control. Rwanda experience in applying Paris declaration is useful intervention and applicable with participation of all stakeholders. South Africa experience in strengthening tax system can be taken to increase revenue for malaria control and others. Also introducing earmarked tax is possible because already we have experience with for other services.

Increase food and food security are applicable because agriculture is the main economic resource for country. But increase distance between residential and crops are not applicable now because a lot of areas in Sudan grow crops in houses or farms are near houses. Using modification of houses and setting of national building intervention is applicable as in Kenya if the modification with low cost or loan because half of population under poverty line.

Provision of long lasting hammocks and using of insecticide treated clothes it is applicable but need to combine with employer base malaria control program to increase awareness among worker to use this protection methods and applied in similar context.

Participation of community as in Senegal will assist in improving the use and the management of health services and possible because in Sudan, community leaders take responsibility for doing anything they feel that they accountable for.

Evidence from Iran and Kenya showed that interventions in other sectors had better and quicker impact on improving malaria control actions. Equitable interventions with focus on most at risk regions in addition to overall economic development have made significant drop of malaria in Iran in just one decade. Kenya's MVP has made significant process in attaining MDGs related targets through raising rural productivity and private investment and saving. The impact project resulted in improved household income and saving and better access to food and healthcare and a subsequent reduction of malaria burden.

Although findings are presented independently but in reality all are interlinked and the author found that multisectoral framework is very helpful and creative in answering study questions and enabling in-depth understanding of different determinants of malaria. Hence, formulating the suggested logical actions that will potentially enhance other sectors to contribute to malaria response/control in Sudan.

5.2 Conclusion:

Despite the great efforts made by health sector to address malaria control, malaria is still a major public health problem and over-burdens national health system. The study has analyzed different societal, environmental, population and individual factors that determine malaria and provide evidence-based recommendations with a multi-sectoral approach to further spearheading malaria control.

The study found that, current malaria control response is mainly via the health sector with minor efforts been made to involve other sectors. Inequitable distribution of resources and power between different states and individuals has resulted in inequity in access and use for malaria preventative and curative services. Moreover, low SES with its subsequent implications such as limited education, unemployment and poverty led to increase susceptibility and vulnerability of certain population groups such as pregnant women. These factors are further aggravated by low nutritional level, and hazardous occupations.

Study has concluded that several environmental, social and economic factors have either positive or negative impact on malaria control. Agricultural practices, housing, urbanization and large economic project constitute an example. Environmental impact assessment before conduction of large projects ignored completely the consequence and impact on malaria control of that project.

A number of interventions and actions targeting societal, environmental, health and economic development of different population groups and individuals are available to effectively solve malaria problem. A few best practices are demonstrated and can be adapted to country context. Application of these interventions could be piloted and scaled up if succeeded in enhancing NMCP activities.

5.3 Recommendations:

Policy level

Advocacy: MOH should engage higher policy partners such as parliament, religious leaders in malaria control activities and advocate for greater participation of community and other sectors in malaria control.

Involvement of other sectors: MoH needs to exert more effort include all sectors in malaria response and empower other sectors through building their capacity to address malaria control issues within their sector-specific programs

Interventions level

Strengthening current malaria strategies: through improve coverage of bednet especially among out of reach populations who are at higher risk of transmission such as pregnant and under5 children as well as expansion of IRS and home-based malaria management services

Multisectoral (Health and other sectors)

Improve aid effectiveness through improving its ownership and leadership role, inclusive participation, delivering results and impact and building national capacity to manage and maintain development.

Ministry of education should target poor and underprivileged areas and households in addition to advocating for inclusion of malaria information in the educational curriculum.

Ministry of finance should introduce earmarked tax to generate additional resources for malaria specific interventions such as ITNs.

Agricultural and irrigation sectors must integrate malaria control interventions in all agricultural business enterprises and schools in addition to pest management programmes in addition to increase the food productivity

Infrastructure sector works to improve quality of housing: through modification or set up of national building codes and low-cost models by using better structure materials and supporting financing actions that can reduce vector density.

Social protection, environmental and health should do the impact assessment in all planned and newly proposed projects to be part of the design of the projects. These projects could be health social and economic projects

Social protection and finance should transfer Conditional cash to poorest families to improve the enrolment in education, uptake of health and improve nutritional status focusing on most at risk people.

Work/Labour sector responsible to Improve employment and working conditions, this could be achieved by implementing employer-based malaria control programmes that provide awareness, prevention and treatment services and engaging workers, senior management and supporting partners in the process.

Health and social protection should work on improving community participation: empowering people through their involvement in the design, implementation and monitoring of malaria specific interventions. This includes improving quality and reach of malaria interventions through community channels.

Research level

MOH should conduct further assessments for ongoing multisectoral experiences within MOH or other sectors to provide recommendations for operation.
Study the readiness of other sectors to participate in malaria response through capacity development assessment for all sectors.

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