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Effectiveness and impact of Malaria control interventions on the malaria burden in Northern Sudan over 9 years program (2000 to 2008): a retrospective study on the basis of yearly national reports

By:

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To my parents, my wife and my kids…

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ABBREVIATIONS

ACT	Artemisinin-based Combination Therapy
ARIs	Acute Respiratory Tract Infections
AS	Artesunate
CPA	Comprehensive Peace Agreement
CQ	Chloroquine
DHS	Demographic and Health Surveys
DSS	Demographic Surveillance Systems
DTP	Diphtheria, Pertussis and Tetanus
FMoH	Federal Ministry of Health
GDP	Gross Domestic Product
GFATM	Global Fund to Fight AIDS, Tuberculosis and Malaria
GoNU	Government of National Unity
GoSS	Government of South Sudan
HIV	Human Immunodeficiency Virus
IDB	Islamic Development Bank
IDPs	Internally Displaced Persons
IPT	Intermittent Presumptive Therapy
IPTi	Intermittent Presumptive Treatment of Infants
IRS	Indoor Residual Spraying
ITNs	Insecticide Treated Nets

IVM	Integrated vector management
LBW	Low Birth Weight
LLINs	Long Lasting Insecticide Treated Nets
MDGs	Millennium Development Goals
MICS	Multi-indicator Cluster Survey
MMR	Maternal Mortality Ratio
MSF	Medecins Sans Frontieres
NGOs	Non Governmental Organizations
NMCP	National Malaria Control Programme
P. falciparum	*Plasmodium Falciparum*
PHC	Primary Health Care
RBM	Roll Back Malaria
RDTs	Rapid Diagnostic Tests
SHHS	Sudan Household Health Survey
SMCP	State Malaria Control Programme
SMoH	State Ministry of Health
SP	Sulfadoxine/pyrimethamine
SPLM	Sudan People Liberation Movement
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
WHO	World Health Organization

ABSTRACT

Background: Malaria is a major health problem in North Sudan with 80% of the population at risk of malaria infection. The country is divided into six malaria strata. The major malaria parasite subtype is *P. falciparum*. The ITNs and IRS coverage have been scaled up during the period 2000 to 2008, with increased funding to the national control malaria program. The country adopted ACT in 2004 and IPT in 2005. The objective of the study is to assess the impact of malaria control activities implementation on the malaria epidemiological burden in Northern Sudan for the period 2000 to 2008.

Design: It is a retrospective study, before and after time series analysis.

Results: The coverage of ITNs and IRS reached 100 % in the year 2008. The implementation of ACT and IPT was in 2004 and 2005 respectively. The prevalence of malaria per 1000 population is decreased to 100 cases per 1000 population in 2008 compared to 160 cases per 1000 in 2000. The total number of malaria case in outpatients decreased by 25 % in 2008 compared to 2000, for both all age patients and patients under 5 years old. While the proportion of the malaria cases in outpatients department increased by 25% for the all age patients and increased by 50 % for the under 5 years old patients. The numbers of malaria cases admitted to hospitals increased for both age groups by 25 % for all age and 50 % for the under 5 children. However, the proportion of malaria cases in the all cases admitted to hospitals decreased by almost 50 % for both age groups. Malaria attributed death in the admitted patients showed a decrease to more than 50 – 75 percent for both age groups. But the all cause under 5 years old death is increasing. The total number of malaria test positives increased by 25% in 2008 compared to 2000.

Conclusion: ITNs, IRS, ACT and IPT have been scaled up in north Sudan during the period 2000 to 2008. This interventions had an impact on reducing the prevalence of malaria ,number of malaria cases in outpatient department, proportion of malaria cases admitted to the hospitals and numbers and proportion of malaria attributed death in the hospitals for all cases and for the under 5 children. Suggesting that the malaria program in Sudan could achieve the objective of reducing the morbidity and mortality of malaria by 50% by 2012 all over the northern Sudan (compared to reported cases in 2005).

1. BACKGROUND

1.1 North Sudan:

The political system in Sudan is a decentralized system, which has three levels federal, state and local government. According to the Comprehensive Peace Agreement (CPA) signed in 2005 between the Government of Sudan and Sudan People Liberation Movement (SPLM) the Government of National Unity (GoNU) was formulated at the national level, with an autonomous government for the South of Sudan (Government of South Sudan (GoSS)) which is overseeing and coordinates the Sothern states affairs (including malaria control). There are 25 states in whole Sudan, 15 in the North and 10 in the South. In 2011 the people of south Sudan will vote and choose whether to be part of the whole country or to get independent and have a separate country. (1) This thesis will study the malaria control efforts in the North Sudan.

1.2 National Malaria control Program in North Sudan:

History of malaria control in Sudan started in 1904 when Andria Baflour (1904) initiated a campaign (larval control using retained oil) and succeeded to eradicate malaria from Khartoum.(2) Since then the battle against malaria in Sudan continued with some major breakthrough along the road. Sinnar pilot project during the eradication era ended in 1960s with success. The Blue Nile Health Project with partnership between government of the Sudan, World Health Organization (WHO), World Bank, Kuwait, Japan, USA and others. This project decreased the malaria prevalence from over 20% to less than 1% for more than 10 years. Sudan was one of the first countries to meet the requirements for the Roll Back Malaria (RBM) initiative and the country incorporated Abuja declaration targets in developing its RBM strategic plan and other sub-strategic plans.(2)

The ongoing control activities were based on the RBM national strategic plan which was developed in 2002 with main 4 strategic directions: i) early diagnosis and prompt treatment; ii) multiple preventions; iii) forecasting, early detection and containment of epidemics; iv) capacity building (3). The strategic plan have been updated in 2007.(4)Some of the program achievements in the period 2000 – 2008 are the use of

artemisinin-based combination therapy (Artesunate plus SP as first line); exempting taxes and tariffs on Insecticide Treated Nets (ITNs) and weekly-based notification system from the states with feedback. The main challenges are reduction of staff turnover, increasing regular financial resources, availing Long Lasting Insecticide Treated Nets (LLINs) particularly to rural population and increasing access to ACTs through implementation of malaria home management.(2) Malaria control in Sudan is part of the national health system. Diagnosis and treatment is fully integrated with primary health system. There are no malaria specific clinics. At state level the vector control activities are part of municipal activities.(2)

The malaria program in Sudan is under the umbrella of the undersecretary assistant for preventive medicine and primary health care in the Federal Ministry of Health (FMOH). It is one of the communicable disease control department's programs. The program vision is "the reduction of malaria–related morbidity and mortality in a way that malaria is no longer a major cause of working days loss, school absenteeism and not the leading cause of outpatient attendance and hospital admission."(4) And a mission of the program is to "sustain a partnership at all level that enables delivery and use of cost effective and evidence–based malaria control interventions." While the goal of the 2007 to 2012 plan is to "contribute to the improvement of the health status in northern part of Sudan through reduction and prevention of morbidity and mortality associated with malaria" the objective the plan is to "reduce the morbidity and mortality of malaria by 50% by 2012 all over the northern Sudan (compared to reported cases in 2005)."(4)

The program targets by end of 2010 are, 80% of malaria patients are diagnosed and treated with effective anti-malarial drugs within one day of the onset of fever, 80% of people at risk for malaria are protected with the appropriate vector control methods, 80% of pregnant women received intermittent preventive treatment and 60% of malaria epidemics should be detected within two weeks of onset and responded within two weeks of detection.

The national strategic plan for Role Back Malaria in Sudan 2007 – 2012 determined the strategic directions of malaria control in the country through:-

1. Prompt and reliable diagnosis and effective treatment.
2. Effective prevention measures in the framework of Integrated Vector Management.
3. Detection and control of malaria epidemics
4. Strengthening of the malaria control program
5. Malaria surveillance and M&E and Operational research
6. Partnership and private sector.

The NMCP deliver malaria control services to the general population through States MCP. Other partners provide the curative malaria services also such as NGOs (provide preventive services as well), insurance program, military and police. UNICEF in collaboration with NGOs is responsible of providing malaria services to displaced people living in IDPs camps. UNHCR is coordinates the malaria efforts with NGOs in the refugees camps in eastern part of Sudan. (4)

1.2.1 Diagnosis and treatment:

Confirmation of malaria diagnosis using microscopy is curial for malaria control. But the reliability of microscopy depends on the user's skill, study in central Sudan showed that the rate of false positive diagnosis of malaria was 75.6% and false-negative diagnosis was 0.01% with a US$100 million cost of diagnosis and treatment of malaria in Sudan in year 2000 , whereas the calculated cost of true malaria is approximately US$14 million.(5) This is resulted in unnecessary use of anti-malarial drugs based on clinical algorithms which appear to have little utility in malaria diagnosis, especially in older age groups. (6) Without accurate microscopy diagnosis, malaria is over-diagnosed, threatening the sustainability of artemisinin combination treatment supply. Moreover the treatable bacterial diseases are likely to be missed.(7) In the artemisinin era, the Sudan national malaria program aims at increase the confirmation of the malaria diagnosis using microscopy. RDT is to be used in areas where there is no microscope and for outbreak investigation.(4)

There was growing evidence that the chloroquine-resistant Plasmodium falciparum has spread in sub-Saharan Africa which caused increased incidence of mortality, severe disease and emergence of epidemics (8) in Sudan the efficacy of chloroquine and sulfadoxine/pyrimethamine monotherapy was assessed, revealing that the chloroqquine failure rates in the northern Sudan was 43.4%.. Sulfadoxine/pyrimethamine had an overall failure rate of 4.4%. Combination of the 2 drugs had a failure rate of 14.5% (9) Treatment failure was significantly higher in children than adults (9-10) and in parasitaemia that took 3 days to clear (10) the studies on AS plus SP showed that 99.3%of the patients demonstrated Adequate Clinical and Parasitological Response with a gametocytaemia detected during the follow-up in 0.37%, while adverse drug effects were detected in11.9% of the patients in Sudan.(11)

Accordingly the first-line drug has been changed from chloroquine (CQ) to artemisininbased combination therapy (ACTs) in 2004 which have been supplied by the Global fund and UNICEF (2) the policy is to use AS plus SP as first line and to use artemether/lumefantrine as second line. A survey done in 2005 showed that ACTs use is 10.5%, but since March 2007, ACTs is available free of charge in all states (With the support from the GFATM) and the use is expected to be high. This may be hampered by the fact that 43.4% of cases sought health care services for malaria associated fever within 24 hours of the onset of fever. (12) The public health system coverage is affecting the accessibility to ACTs in many parts of the country(13). The Home Management of Malaria is not widely adopted.(2)

1.2.2 ITNS and IRS:

ITNs are highly effective in reducing childhood mortality and morbidity from malaria, hence the WHO is advocating for wide access to ITNs, which is faced by the financial ,technical, and operational constrains.(14) A community randomized controlled trial in western Kenya showed that increased adherence to bed net use in children younger than 5 years, decreased the mean number of Anopheles mosquitoes per house by 77% up to 3 to 4 years after, this was accompanied by a significantly reduction in All-cause mortality rates in infants aged 1 to 11 months and these low rates were maintained after up to 6 years of bed net use.(15)

The protective efficacy of ITNs and IRS on reducing malaria-attributable mortality in children age 1–59 months is 49–61% in *P. falciparum* settings.(16) The bed nets resulted in a 10-fold reduction of malaria parasite prevalence in Zanzibar which is bringing some hope that the Millennium Development Goals of reducing mortality in children under five and alleviating the burden of malaria are achievable in tropical countries.(17) The targeted free mass distribution of LLINs can result in high and equitable bed net coverage among children under five, but in order to sustain high effective coverage a complimentary distribution strategies between mass distribution campaigns is need. Moreover, one should consider the community's preferences prior to a mass distribution. addressing the communities concerns through information, education and communication, which have been found to improve the LLIN usage.(18)

ITNs and IRS in Sudan are implemented in the context of the integrated vector management (IVM) approach which is based on inter and intra-sectoral coordination with strengthening of the synergy of the different interventions.(4) History of ITNs use in Sudan was started when a limited numbers of ITNs had been in use for some time in Sennar (Sennar pilot study, 1995) and El Dueim in central Sudan. In 1996 UNICEF implemented small-scale pilot intervention project, where initially 13,000 ITNs were used by 33,000 internally displaced persons (IDPs). In 1998 an evaluation of Sennar and El Dueim project revealed that 83.5% Households (HHs) slept under ITNs during July December1996, With 76.5% of HHs with consistent ITNs use, 80.9% of children were put under ITNs after sunset, 69.6% HHs never reported any fevers among members during the same period.(19)

In 2000 a Multi-indicator Cluster Survey (MICS2000) done by UNICEF and FMOH, showed that Under-5 children sleeping under ITN, in the 2 weeks prior to the survey was 7.2% in north Sudan.(20) MSF implemented a project in Gedaref state in 1999, where more than 260,000 fine mesh ITNs distributed. 2 years later 35% of ITNs were no longer available, 55% of ITNs were either missing or badly damaged/torn and the use of ITNs was most frequent during the rainy season, which was more than 50%.(19) Between 2001 -2005 the long-lasting Insecticide nets (LLINs) were distributed in certain states in collaboration with UNICEF and WHO and later by Global Fund grant for Round 2. The Financial and Investment bank was taking the efforts of importation and distribution of Nets, along with other partners in the private sector.(2)

In 2005 malaria indicator survey –household survey concluded that coverage with at least one mosquito net (any net) is 57.0% compared to 21% in 2000, coverage with ITNs increased from 0.4% in 2000 (MICS) to 21.7%. Sleeping under mosquito nets the night prior to the survey was reported by 35.1%, while the Indoor residual spraying in the targeted areas was conducted regularly but mostly in the urban areas. (2, 12, 20) the strategy in Sudan is to avail the nets free of charge and achieve full population coverage in targeted areas using the Long lasting insecticidal nets (LLINs).(4)

1.2.3 IPT:

Malaria accounted for 37.2% of maternal mortality in Sudan ,showed one study(21). The malaria prevention interventions in pregnancy (IPTp and ITNs) have a protective efficacy of 35% on reducing the prevalence of low birth weight (LBW) in the first or second pregnancy in areas of stable P. *falciparum* transmission. (16) The national strategy to control malaria in pregnancy in Sudan delivered as part of a comprehensive Antenatal Care Package (Access to ANC services in urban areas 88.8% and 65 % in Rural areas(12)) and composed of prompt diagnosis and treatment ,provision of LLINs for any pregnant women in the target areas, and the IPT using SP as directly observed treatment (2 doses after quickening and at least 1 month apart) in irrigated schemes in northern Sudan.(4) (22)

1.2.4 Malaria control program financing:

The cost for malaria control in north Sudan is estimated to be US$ 256 million for the period 2007 to 2012 (4) the sources for this funds are government funding, GFATM round 2 and round 7, Work Bank, WHO, UNICEF, Canar Company (private company), NGOs, Islamic Development Bank , Export Development Bank of Iran and others. The government support for malaria control is increasing over years, through the federal and state governments. The NMCP succeeded to create partnership with a number of demostic private agencies such as Sugar Cane Schemes (Kenana, Halfa, and Sinnar), irrigated schemes (Gazera Board), Canar Telecommunication Company and Islamic Development Bank (IDB). The gap in malaria financing is shown in the below table (Table 1) where is the total unmet need was US$ 94 , not taking into account the funds for the global fund round 7.(4) during the period of this study (2000 to 2008), the GFATM alone provided more than US$ 120 million to fight malaria in Sudan ,through the grant for round 2 (more than US$ 33 millions) and round 7 (almost US$ 95 million).(23) (24)

Table 1 financial gap analysis for malaria control program in Sudan (RBM Strategic plan 2007 - 2012)

Items	Actual		Planned		Estimated				Total for the period 2008-12
	2005	2006	2007	2008	2009	2010	2011	2012	
Overall disease specific needs	16,537,971	20,328,222	25,483,440	45,505,077	44,405,693	45,251,423	36,499,489	36,375,646	208,037,328
Total current & planned domestic resources	4,278,554	6,185,187	9,865,000	16,081,857	11,938,360	13,800,000	14,800,000	15,800,000	72,420,217
Total current & planned external resources	4,363,331	12,538,441	11,048,000	12,219,940	11,373,740	11,042,900	3,105,000	3,113,000	40,854,580
Total current and planned resources	8,641,885	18,723,628	20,913,000	28,301,797	23,312,100	24,842,900	17,905,000	18,913,000	113,274,797
Total Unmet need	7,896,086	1,604,594	4,570,440	17,203,280	21,093,593	20,408,523	18,594,489	17,462,646	94,762,531

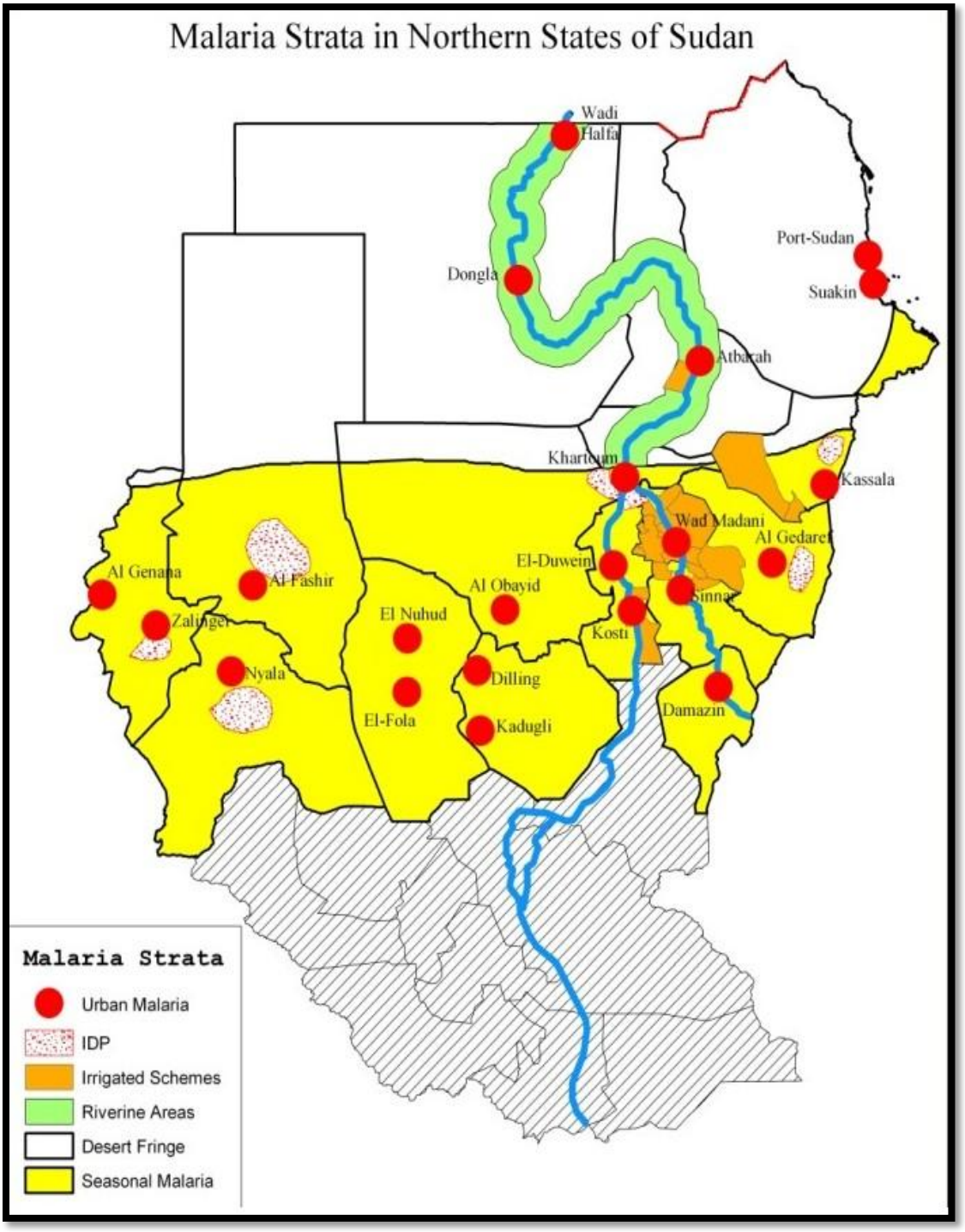
1.3 Malaria Epidemiological Situation in Sudan:

According to the national malaria control program in Sudan, the North Sudan divided into 6 malaria transmissions strata, as shown in the table (1) , and in the map (Figure 1) (4).

Table 2 ***Malaria Strata in Sudan (National Malaria Control Program Sudan)***

Strata	Transmission/ Risk	Population	Areas	Main Technical Interventions
Desert fringe	No transmission, malaria free	500,000	Desert fringe area in the north above Latitude 15^0 **except** cities, Riverine areas, irrigated scheme in River Nile State and delta Tokar in Red Sea	Case management, entomological/ parasitological surveillance
Riverine areas north of Khartoum	Epidemic prone seasonal unstable related to floods , dams	1,500,000	Area about 20 Km on both sides of River Nile above Latitude of 15^0	Epidemic Early warning, early detection and rapid response. Case management, entomological monitoring, Larviciding as appropriate
Seasonal malaria	Seasonal , low to moderate risk	14,000,000	Rural areas other than irrigated schemes in Greater Darfour, Kordofan, Blue Nile, White Nile, Sinnar, Gezira, Gedarif, Kassala and Khartoum	Case management, LLINs
Urban malaria	Seasonal transmission with low risk	9,000,000	Khartoum and all large cities e.g. Port Sudan, Wad Medani….	Case management, environmental management, Larviciding and Epidemic Early warning, early detection and rapid response .
Irrigated Schemes	Seasonal transmission from 6-9 months with low to moderate risk	3,500,000	All large- scale irrigated schemes (Gezira, Elrahad, Kinana, Asalia, West Sinnar, New Halafa and Elzidab,Suki,Khashm Elgerba)	Case management, IPT, IRS and LLINs
Emergency and complex situation	Epidemic prone or seasonal transmission	3,000,000	IDP and refuges (the number is as per 2007 and is subject to change)	Case management, LLINs

The duration of transmission is shown in the map (Figure 2), where we can notice that the transmission duration increases as we go to the south. The major vector for malaria transmission is the *anopheles arabiensis* with presence of *Anopheles gambiae* and *Anopheles funestus* in some areas. *Plasmodium falciparum* is the major parasite species causing malaria in Sudan (98.1%). (2) (5)



<u>Figure 1</u> Map showing *Malaria Strata in Sudan (National Malaria Control Program Sudan)*

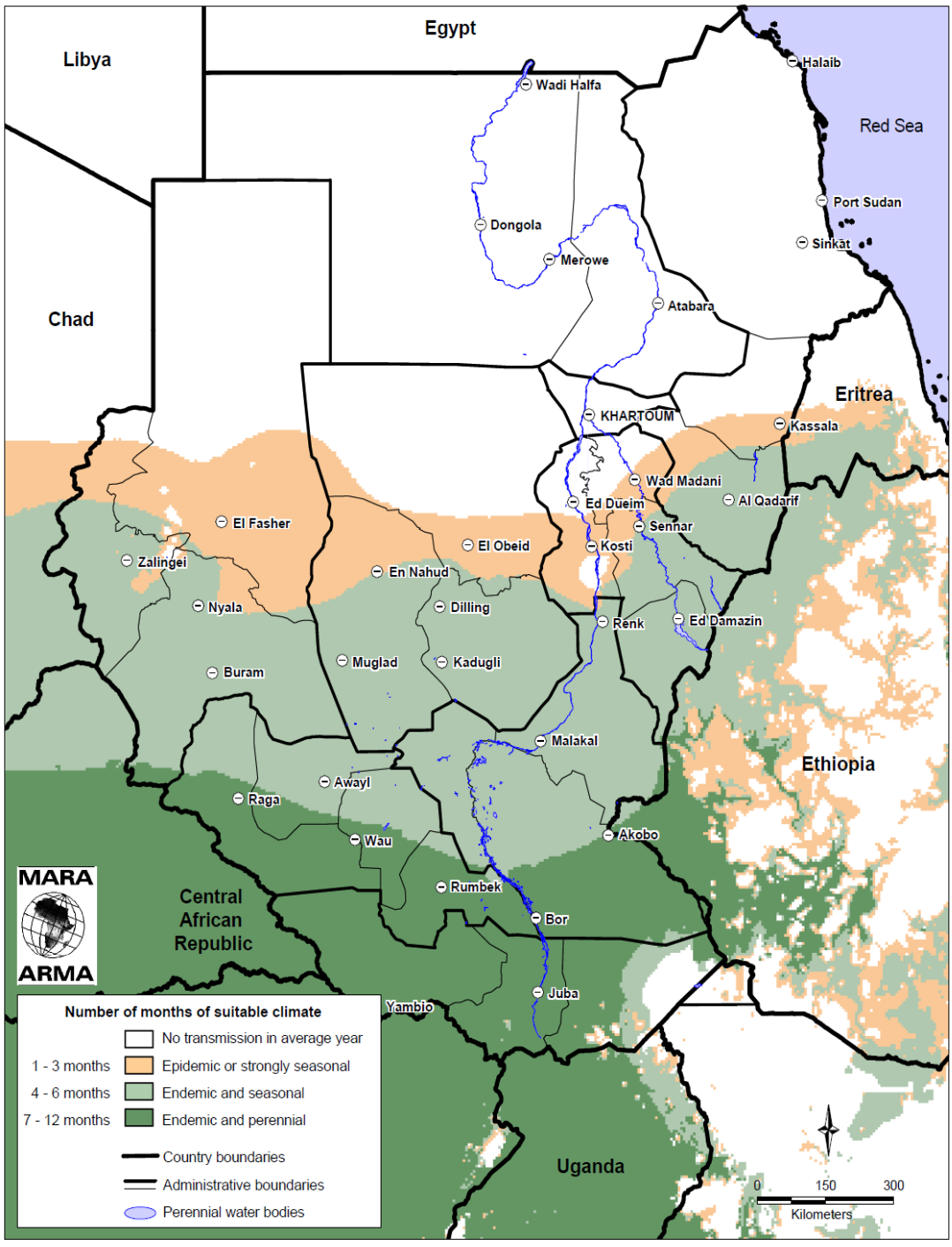


Figure 2: ***Duration of Malaria transmission Season in Sudan***

Malaria is a major public Health problem in Sudan, where an estimated 80% of the population living in northern Sudan is at risk of malaria infection and 8-16 million are at risk of malaria epidemics. A modeling study concluded that Malaria killed 44 000 in 2002 with an estimated incidence of 9 million episodes. The highest mortality and morbidity was in children under five years of age. The study suggested that the formal health system data underestimated malaria burden. (25)Malaria is a leading cause of death in children under five in Sudan. It contributes to anemia in children and is a common cause of absence from the school. (13). The prevalence of malaria among Under 5 years children is 0.4 -15.5% and among the pregnant 3.7%-10.3%. (13).

Coverage with at least one mosquito net of any type is only 57.0%. Coverage with insecticide treated nets is as low as 21.0% for both treated (11.5%) and long lasting nets (10.2%).39.3 % of the surveyed population reported history of fever in the two weeks prior to the survey with 21.6% malaria associated fever in the total population and 18.9 % among children below the age of 5 years, while the percentage was 26.6 among pregnant women. Coverage with intermittent preventive therapy namely two or more doses of fansidar was as low as 1.8%. Sleeping under any mosquito net was encountered among 42.9% of children below the age of 5 years, while the proportion among pregnant women was 34.8. Out of which only 12.7% of pregnant women reported sleeping under insecticide treated net whether temporary ITNs (6.1%) or long lasting ones (6.7%).(12) (13).

1.4 Assessing impact of malaria programs:

The millennium development goals (MDGs) aim at reducing under-five mortality by two third, while reducing the maternal mortality and compacting poverty. All these targets are seems to be difficult to achieve in sub-Saharan Africa without bringing malaria under control. That is because malaria causes 23% to 37% of child deaths in sub-Saharan Africa, and strongly associated with maternal mortality and with poverty. (26) . It is estimated that malaria is affecting 234 million cases in 2008 (85% in the African Region and 4% in Eastern Mediterranean Region),and 863000 deaths in the same year (89% in the African Region and 6% in Eastern Mediterranean Region) (27).

The Role Back Malaria (RBM) target is to halve the 1990 malaria morbidity and mortality by the year 2010. This is to be achieved through strengthen national health systems to ensure that patients will have access to appropriate treatment using good first line anti malarial drugs i.e. artemisinin-based combination therapies (ACTs) ; children and pregnant women will be protected using insecticide-treated nets (ITNs) which is expected to reduce malaria morbidity by 50% and all cause under five mortality by 17%; pregnant women will have access to appropriate malaria chemoprophylaxis or presumptive intermittent treatment; and epidemics will be detected within two weeks of onset, and responded to within two weeks of detection adding to this the new strategies like intermittent presumptive treatment of infants (IPTi) and strategies to reach children with higher quality interventions such as Integrated Management of Childhood Illnesses.(26). This accompanied by increased malaria committed funds from around US$ 0.3 billion in 2003 to US$ 1.7 billion in 2009 (27)

All these interventions if done appropriately will bring some hope that we can achieve the MDGs,as an effective malaria control measures can dramatically increase child survival.(28-29) but the question is, how could we know that we are able to achieve this targets, how could we evaluate the control activities and determine their impact on the malaria burden? Data to evaluate malaria programs could be collected at three levels, health facilities, households and remote sensing and modeling. Each one of these methods has its own advantages and disadvantages. (26)

The health facility data is not representative of the whole population (30), apparently because most of the malaria cases do not seek health and may die at home (The proportion of febrile children less than five years old who are treated with antimalarials ranges from approximately 2.5% to a maximum of 65% in sub-Saharan Africa). Not even mentioning the wide range of the barriers that may prevent people from seeking health such as geographical, socioeconomical and cultural barriers.(26). Moreover, this data do not cover patients in the private sector, and not all cases reported are laboratory confirmed. (27) .

The health facility data are useful to give trends because it is recorded continuously over time, reflecting changes in the implementation of interventions and climate conditions, besides the geographical coverage of these health facilities(27). However, this can be distorted by, for example, the improvement of reporting behaviors which may give false increase in the trend of the disease burden (26),or may be affecting by the change in the diagnosis policy i.e. confirmation of reported malaria cases may result in decrease in the malaria burden(30) . This data is useful also in monitoring health system performance that is by monitoring the case fatality rates for instance(26) . Health facilities data may yield better result if used in combination with data form representative community-based surveys of intervention coverage, all-cause child mortality, and biomarkers, such as parasite prevalence and anaemia (30)

Then one will ask what kind of data to collect that will enable us to evaluate the malaria control programs? WHO report 2009 suggests that we use the reported numbers of malaria cases and deaths as core indicators to follow the trends in malaria using the health facility data. (27). The same document suggest measures to be taken to deal with the limitations of health facility data, that is to take the confirmed malaria cases (Microscopy or Rapid Test) and to take the inpatients malaria cases in case of little case confirmation, annual blood examination rate, malaria positivity rate, % of admissions and deaths due to malaria, detection rate (for cases and deaths), examining consistency and monitor change in the proportion of plasmodium falciparum cases or cases in under 5 children.

All this is to rule out data-related factors like change in the reporting completeness or change in the diagnostic practices as an explanation of the change in the malaria burden.

(27).This approach will get increased sensitivity in reflecting the whole picture of the community using the health facilities data if the change in the malaria trend is large, if the public health coverage is high and the malaria control interventions are delivered at the community level. (27)

At the household level ,data could be collected through continuous surveillance such as the sentinel demographic surveillance systems (DSS), or retrospectively from periodic, cross-sectional national household surveys such as Demographic and Health Surveys (DHS),) or Multiple Indicator Cluster Surveys (MICS), these methods are good in reflecting what is happening in the population because of the large samples or even total coverage, but the cost, frequency, recall bias(for the retrospective surveys) and timing of the surveys(dry season) are some of the limitations.(26). The household survey may provide good data on the coverage of malaria interventions, but the problem of frequency makes it difficult to follow the trends over years. The trends could be followed using the data provided by ministry of health of the coverage of malaria interventions despite the gaps and inaccuracies in that data(27).

Routine remote sensing and modeling is a useful tool for input data on malaria control. It would a wise approach if data from all these resources is combined to give reliable evidence. .(26). Other factors that may affect malaria burden should be taken into account, such as climate variations, deforestation or improved living conditions. (27). Such data is difficult to find in most of the African countries.

The RBM Monitoring and Evaluation Reference Group suggested an approach to assess the impact of malaria control activities on the mortality. They conclude that to attribute mortality changes to malaria control efforts, a plausibility argument or ecologic association is required (30-31). They suggests that we measure the coverage of malaria control efforts and the burden of malaria in a series of surveys, and examine if the coverage increases and anemia, all cause child mortality decreases one can conclude that this reduction is due to the interventions.(31) . This approach has several limitations. As it has a relatively weak design for proving causality. However, stronger designs such as randomized controlled trials would be unethical. Moreover, correctly measuring and accounting for nonmalaria- program factors such as rainfall will be challenging and the

surveys that measure intervention coverage and mortality have limitations besides the time horizon is too short to account for very long-term effects.

The evaluation of the national response to malaria is a priority in Sudan, because Malaria is a major health problem in the country. Evaluation of malaria control strategies is one the FMoH research priorities stated in the Arabic version of the official website of the Ministry (http://www.fmoh.gov.sd/Research/index.php?id=4#محور_الطب_الوقائي) number 18 in the list. To determine the progress toward achieving the millennium development goals (MDGs) that aims at reducing under-five mortality, the country should have a system to evaluate the progress in Malaria control as it contributes to the under 5 children mortality. The increased funds for the fight against malaria in north Sudan makes it essential to study whether those investments had an impact on malaria burden in the country.

2. OBJECTIVES

To assess the impact of malaria control activities implementation on the malaria epidemiological burden in Northern Sudan for the period 2000 to 2008.

Specific Objectives:-

1. To assess the trend in the level of the burden of malaria over a 9 years period (2000 – 2008).
2. To evaluate the impact of ITNs ,IRS ,ACT and IPT on the malaria burden during 2000 to 2008.

3. METHODS

3.1 Study Design:

It is a retrospective study, before and after interventions to evaluate the effect of malaria control on the malaria burden. The design involves a time series analysis, which is suitable for evaluating programs.(32).

3.2 Study Settings:

3.2.1 Sudan:

Sudan is covering an area of around 2.5 million Km^2, which makes it the largest country in Africa. It shares borders with nine countries including Egypt and Libya to the north, Chad and Central Republic of Africa to the west, Democratic Republic of Congo, Uganda, and Kenya to the south and south west, Ethiopia and Eritrea to the East. (4) (33)Sudan is composed of 25 states, 15 in the northern part (which constitutes the North Sudan, the study area of this thesis) and 10 in the southern part, which constitutes the South Sudan; both parts are ruled by the Government of National Unity (GoNU). The population of Sudan is 41,348,000 (2008), 14 % of this population are under 5 years old children (34). and with majority (72%) of the population living in the rural area(13).

Sudan is characterized by a wide range of climatic and land nature variations. The Nubian dried desert in the north is followed by poor savannah, rich savannah and jungle in south. The rainy season extend from May up to November, varying from low rainfall in the north, to a high equatorial type of rain in the extreme southwest (4). Sudan is classified as a (Lower-middle-income economies) by the World Bank (35) , this an improvement in the country's economy which used to be classified as a low income country. The economy grew at over 10% in recent years thanks to oil production. Agriculture provides livelihood to 70 per cent of the population and contributes to 37 per cent of GDP and 15 per cent of total export earnings (13).

3.2.2Health System in Sudan:

3.2.2.1 Health system organization and service delivery:

Sudan is a multi-cultural multi-ethnic country, makes it logical to adopt the decentralized governance system. This was started in 1951 and followed a line of development through up to 1991(a presidential republic and a federal system) then in 2003 the Local Government Act was indorsed. This act gave the local government level more responsibilities specially on health, education and development.(33).The decentralized system is applied on the health system where it is organized at three levels: Federal Ministry of Health (FMoH) which is responsible for the development of national policies, strategic plans, monitoring, evaluation and supervision of health system activities. The second level is the state ministries of health (SMoH), with the responsibility of policy implementation and detailed health interventions programming. Then the Locality Health Authorities, which is taking care of implementing the national policies based on the primary health care concept.(33)

The ministry of health provides care through different levels; the teaching tertiary hospitals; states hospitals and primary health care facilities. There are other partners providing health care such as armed forces, universities, private sector (both for profit and not for profit) and civil society. However, the efforts are badly coordinated between all those service providers. Primary care is provided through a variety of outlets: urban and rural health centers, dispensaries, dressing stations and PHC units. Health Insurance is a major service provider as well. The private sector is growing rapidly and increasingly capturing the health market. (33)

The distances, poor roads and transport structure affect the health system coverage. The natural disasters like droughts and flooding cause humanitarian emergencies and ecological factors expose population to infectious and parasitic diseases including malaria, which represents the main causes of morbidity and mortality besides diarrheal diseases, ARIs and nutritional disorders. But, the most important factor that contributed the current shape of the health system was the civil war. The war in South Sudan continued for more than 20 years (1983 to 2005), and the war in Darfur started in 2003, with considerable numbers of internally displaced peoples.(33)

All this makes the access to local primary healthcare services as low as 40%-66% with greater urban and rural inequalities (84% of urban population has access to local health services, compared to only 58% of rural population).(36) These inequalities are there despite the fact we mentioned earlier that 72% of the populations live in rural areas(13). The distribution of health facilities is not homogenous between different states ranging from 5.2 hospitals and 246 hospital beds per 100,000 people in Northern State compared to 0.2 hospitals and 14 beds per 100,000 in South Darfur(36) the outpatient consultation is 0.8 per capita per year. The chronic conflict and scarcity of resources led to the poor infrastructure of health facilities, particularly PHC with 29% PHC health facilities (including first level referral rural hospitals) are not functional; and this situation varied in states. This situation also extends to diagnostic services, which are weak and fragmented between programs.(36)

3.2.2.2 Sudan Health profile:

According to the Sudan Household Health Survey (SHHS) conducted in 2006, the under - 5 mortality rate was 112 per 1000 live births during the 5-year period before the survey. 9.4 % of children under age five in Sudan were severely underweight, 15.2 % were severely stunted and 3.5 % were severely wasted. The SHHS results indicate that nationwide about 14.7 % of children aged 12-23 months were not vaccinated against any of the childhood diseases at any time before the survey. 69.6 % of pregnant women received antenatal care (ANC) one or more times during pregnancy and only 49.2 % of births occurred in the two years prior to the survey were delivered by qualified health personnel (a medical doctor, nurse, midwife or auxiliary midwife). Of the total births, 19.4 % were delivered in a health facility. The main complications experienced during pregnancy included headache (42.3 %), fever (42%), abdominal pain (30.5%), urinary pain (22 %) and edema (21.6%). The Maternal Mortality Ratio (MMR) was 1,107 per 100,000 live births (13) according to WHO in the year 2007 the life expectancy at birth in Sudan was 57 years for males and 58 years for female. The Under 5 mortality rate per 1000 live birth was 109 and the prevalence of HIV among adults (15 years old and older) was 1253 per 100000 adult 15 and older.) Tuberculosis prevalence was 402 per 100 000 population. The DPT3 immunization among 1-year-old was 60% in 1990 and more than 80% in 2007. (37)

3.2.2.3 Sudan Health Management Information System:

The health information system in Sudan is a health facility based system where the basic health facilities send their reports to the state ministry of health where those reports are compiled and send to the federal level. Not all health facilities are regularly reporting to the state level especially the health centers, the dispensaries and the PHC units. Moreover, community level information is not collected and if collected by vertical programs, it is not streamed into the health information system. Organizations like army, police etc. providing health care have their own information system. There are vertical information systems for data production, collection, processing, and reporting by the vertical programs, which is not consolidated into one system due to poor coordination. The private sector (including NGOs) data is not included in the national health information system. The federal level apply some data analysis process on the data and send a feedback to the states, but with lots of problems starting from quality of data , data collection , systematic storage, timeliness , utilization and dissemination as a result, it is difficult to install and operate a robust system for monitoring and evaluation. This is make it difficult to assess the progress of the country toward achieve the health system goals including the MDGs. (33)

3.3 Study population:

The study will cover data on the malaria burden and the interventions to control malaria for the period 2000 to 2008 on the population of North Sudan. All the data for the specified period at the national level will be exhausted. The year 2000 will be used as a base line for the study variables, because it was the year before the ongoing malaria interventions in Sudan in 2001 (24)

3.4 Data collection:

Malaria epidemiological data have been collected from the annual statistical report of the federal ministry of health Sudan, for the years 2004 to 2007, are available at the official ministry's website http://fmoh.gov.sd/indexAr.php?id=16 , the annual reports of the years 2000 to 2003 and the 2008 reports were collected through personal communication with the federal ministry of health statistics department. The data have been cross checked with data from WHO report for 2009 "available at http://www.who.int/malaria/publications/atoz/9789241563901/en/index.html". The differences were found to be very minor between the two sources. The epidemiological data is a health facility data collected at the health facilities from all over North Sudan, where data on the outpatients and inpatients are recorded continuously and compiled in a report and submitted to a local level, to state level and then to the federal level where the statistic department prepare an annual statistical report . This health facility data have been complemented with a number of surveys and other documents from the federal ministry of health Sudan and national Malaria control program, such as Multiple Indicator Cluster Survey 2000, Malaria prevalence and coverage Indicators Survey 2005 and Sudan Household Health Survey, 2006. Data on the malaria control interventions have been collected from WHO report for 2009 "available at http://www.who.int/malaria/publications/atoz/9789241563901/en/index.html" and complemented through personal communication with the national malaria control program manager in Sudan, and by a number of documents such as strategic plans, proposals to the Global Fund and gap analysis report.

3.5 Independent variables (the interventions):

The following interventions are studied:-

1. ITNs and IRS coverage.
2. Treatment using ACTs, The year when the program stated using the ACTs.
3. Intermittent Presumptive Treatment for the pregnant women (IPT), the year of the start of the intervention.

3.6 Dependent variables (the outcomes):-

The measurement of dependent variables will relay principally of the total number of malaria cases and deaths reported by the Federal Ministry of Health in Sudan. However, these parameters may fail to reflect the actual malaria burden in Sudan. That is because(27):-

1- This numbers depends on the number of reporting site, which might be fluctuating.
2- The health facility data is not representative for the whole community because it is missing cases from private sector and cases treated at home.
3- Not all malaria cases are confirmed cases.

To be able to minimize the effect of these factors we are going to examine the following variables which covers the number and deaths of malaria patients for the all cases and for the under 5 children, and then we calculate the proportion of these measures out the total consultations. The same approach will be repeated for the inpatients malaria cases (27). The following indicators will be observed for the years 2000 to 2008:-

1- Total number of malaria cases in the out-patients departments.
2- Proportion of the total malaria cases in out-patients department out of the total number of consultations in the out-patient department.
3- Number of malaria cases in the out-patients departments in Children under 5.
4- Proportion of the under 5 children malaria cases in out-patients department out of the total number of under 5 children consultations in the out-patient department.
5- Total number of malaria cases admitted in the hospitals.

6- Proportion of the malaria cases admitted out of all causes of admission in the hospitals.
7- Total number of malaria cases admitted in the hospitals in children under 5 years.
8- Proportion of the under 5 year's children malaria cases admitted out of all causes of admission in the hospitals in under 5 children.
9- Total number of malaria attributed death in admitted patients.
10- Proportion of malaria attributed deaths out of the total deaths in hospitals.
11- Total number of malaria attributed deaths in children under 5 admitted in hospitals.
12- Proportion of the under 5 children malaria attributed death out of the total number of under 5 children causes of death in the hospitals.
13- All cause under 5 mortality.

Additionally:-

1- Prevalence of malaria cases per 1000 population for the period 1996 to 2008.
2- Malaria positive test for the period 2000 to 2008.

3.7 Data analysis:

ITNs and IRS coverage is calculated using the following formula(27):-

100× (number of ITNs delivered in the past 3 years + number of people protected by IRS in the current year) / population at high risk.

This formula is designed using the following assumptions:-

1- Each bed net is used by 2 people,
2- The conventional nets are treated regularly.
3- The net is not replaced before 3 years.
4- Population covered by IRS is different from that covered with ITNs.

All the malaria burden indicators are translated to a percentages and assume that the year 2000 is 100%, then the figures in the following years will be related to that 100%, whether an increase or decrease. The malaria intervention indicators are already in a percentage, so we are comparing the increase in the malaria intervention and its effect on the malaria burden, the dose response is observed by examining the consistency between the two parameters.

4. RESULTS

Interventions for malaria control in Sudan scale up started in the year 2001. In 2002 the ITNs and IRS coverage was almost 60 % of the population at high risk of Malaria and in 2008 it was 100 %. ACT was implemented in 2004 and IPT was adopted in 2005. The prevalence of malaria in north Sudan showed a steady decrease over the period 1996 to 2008, as shown in (Figure 3) where the trend went down from more than 160 per 1000 population in 1996 to almost 50 per 1000 population in 2006 , with an increase again in 2007 and 2008 reaching 100 cases per 1000 population.

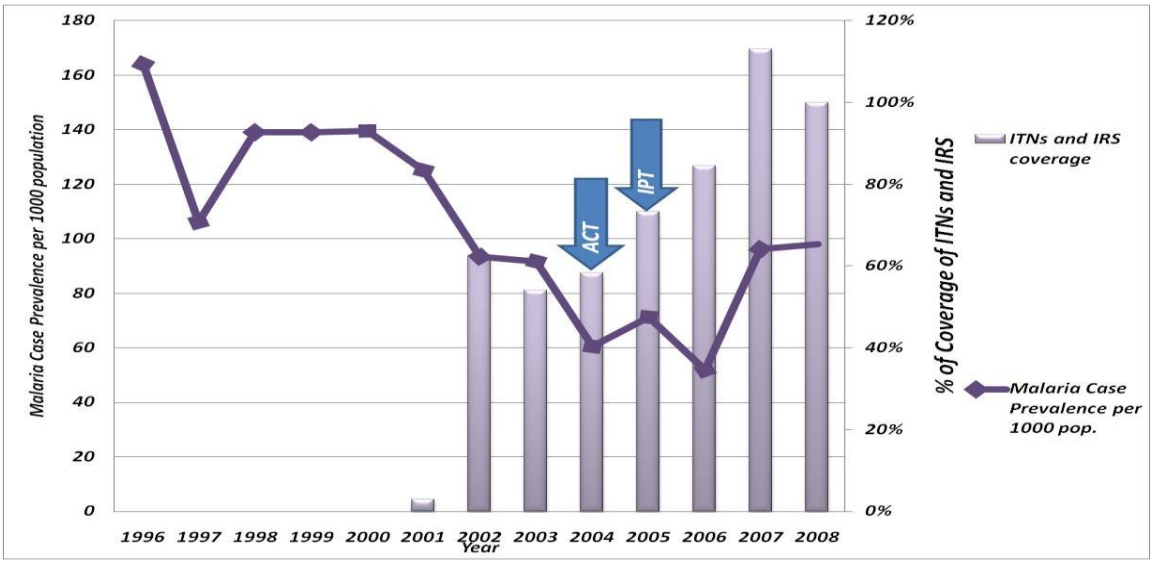


Figure 3*: the impact of malaria interventions (ITNs, IRS, ACT and IPT) on the malaria prevalence per 1000 population in Northern Sudan 1996 to 2008.*

The total number of malaria cases for all age groups in outpatients department decreased by more than 50 % in the year 2006(1589956 cases) compared to the year 2000(4332827 cases), with an increase again in 2007 and 2008, but still with a decrease of more than 25 % compared to 2000. While the proportion of the malaria cases in outpatients department for the all ages dropped by more than 25 % in 2004 (11.3 % out of the total outpatient attendance) where it started to increase again reaching more than 25% increase in 2008 (22 % out of the total outpatient attendance) compared to the levels in the year 2000(17 % out of the total outpatient attendance).

The picture was the same for the numbers and proportions of malaria cases in outpatients department for the under 5 years old children, as the numbers decreased by more than 60 % in 2006(379172 cases) compared to 2000 (1159328 cases) and almost 25% decrease in 2008(886294 cases) compared to 2000. However the proportion of malaria cases in the outpatients in the children under 5 years old showed an increase after the year 2004 where a decrease by more than 25% was recorded (12 % out of the total under 5 children outpatient attendance) to almost 50% increase in 2008 (28 % out of the total under 5 children outpatient attendance) compared to the year 2000 (19% out of the total under 5 children outpatient attendance). (Figure 4)

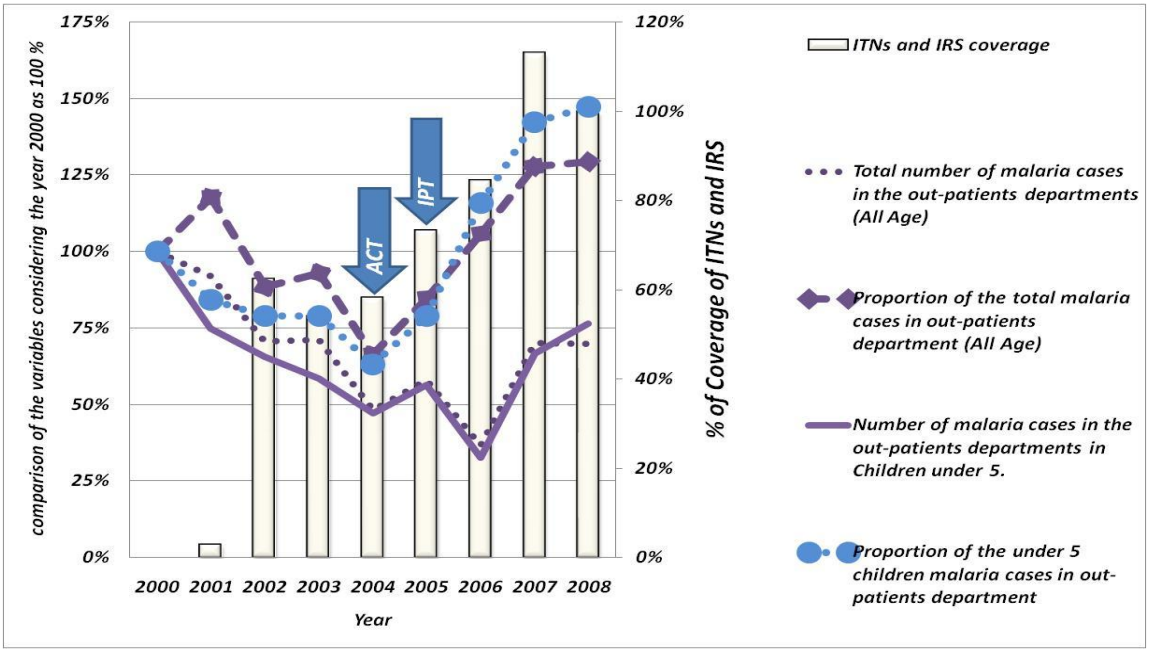


Figure 4: ***the impact of malaria interventions (ITNs, IRS, ACT and IPT) on the number and proportion of the malaria cases (all age and under 5 children) in outpatient departments in Northern Sudan 2000 to 2008.***

The total number of malaria cases admitted in hospitals for all ages showed consistent increase all through the period from 2000 to 2008, to more than 50 % in 2003 (152686 cases) and around 17 % increase in 2008 (111987 cases) compared to 95450 cases in 2000. While the proportion of malaria in all cases admitted to hospitals showed consistent decrease during the same period to 46.9 % decrease in 2008(14.1 % out of the total admitted patients) compared to 2000 (26.1% out of the total admitted patients).The trend was the same for the under 5 years old children admitted to hospitals during the period

2000 to 2008, where the numbers shows consistent increase from 26542 cases in 2000 to 40331 cases in 2008, and the proportion is decreasing from 35.6% out of the total under 5 children admitted to hospitals to 20.2% in 2008 (more than 43% decrease). The malaria attributed deaths in the patients admitted to hospital is showing remarkable decrease over the period 2000 to 2008 to almost 50% decrease in the number of malaria attributed death for the all age patients in 2008 (1125 deaths in 2008 compared to 2162 deaths in 2000), and more than 65% decrease for the proportion of malaria death out of all admitted patients in 2008(6.5 % of all deaths in admitted patients) compared to 2000(19.1 % of all deaths in admitted patients) for all age patients.

The decrease in malaria attributed death was also evident in the under 5 years old patients admitted to hospitals during the same period. Where is the number of under 5 children died in the hospitals due to malaria decreased from 798 deaths in 2000 to 359 deaths in 2008 gives rise to 55% decrease. The proportion of malaria death in the admitted under 5 children decreased from 23.3% in 2000 to 7 % in 2008, a 70% decrease. (Figure 5)

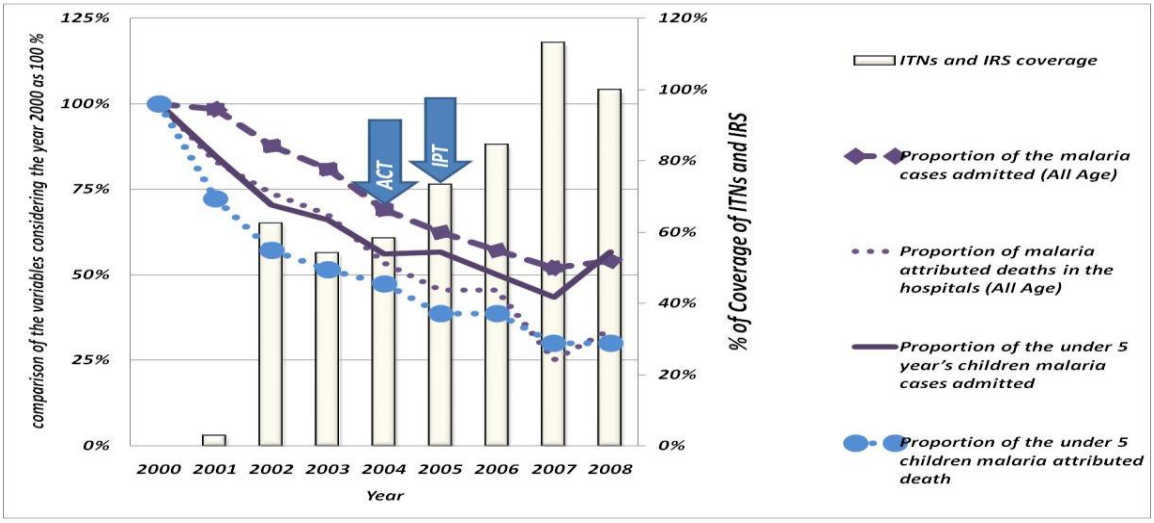


Figure 5: the impact of malaria interventions (ITNs, IRS, ACT and IPT) on the number and proportion of the malaria cases and deaths (all age and under 5 children) admitted in the hospitals in Northern Sudan 2000 to 2008.

The total number of under 5 years old children died in hospitals is showing consistent increase over the same period from 3419 deaths in 2000 to 53338 death in 2008 , 56% increase. (Figure 6)

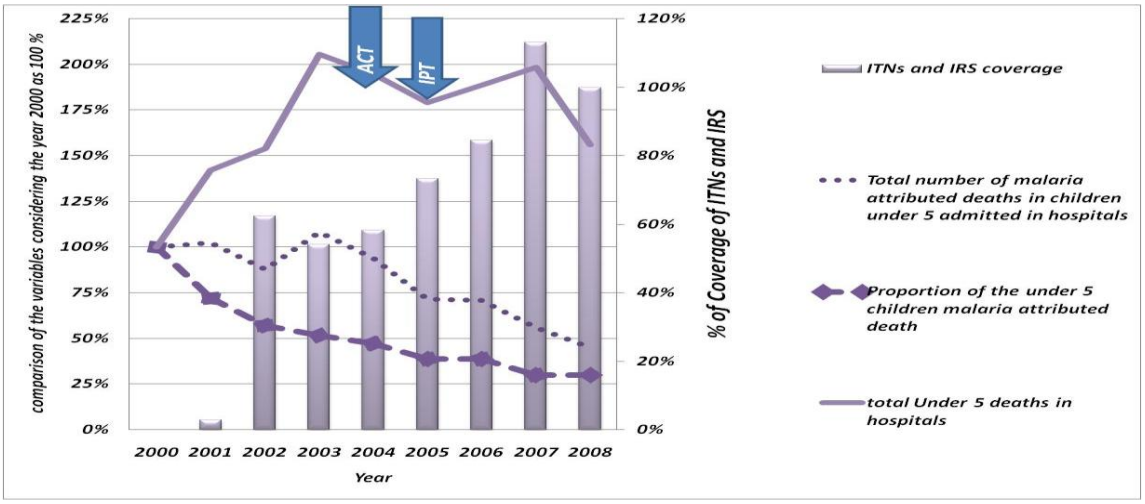


Figure 6 : the impact of malaria interventions (ITNs, IRS, ACT and IPT) on the number and proportion of the malaria attributed death (under 5 years old children) in admitted patients, and the total number of under 5 deaths in hospitals in Northern Sudan 2000 to 2008.

The number of positive malaria test showed little decrease in 2001 and 2002 and started to rise reaching more than 125% increase in 2003 compared to 2000, with almost 25% increase in 2008. (**Figure 7**)

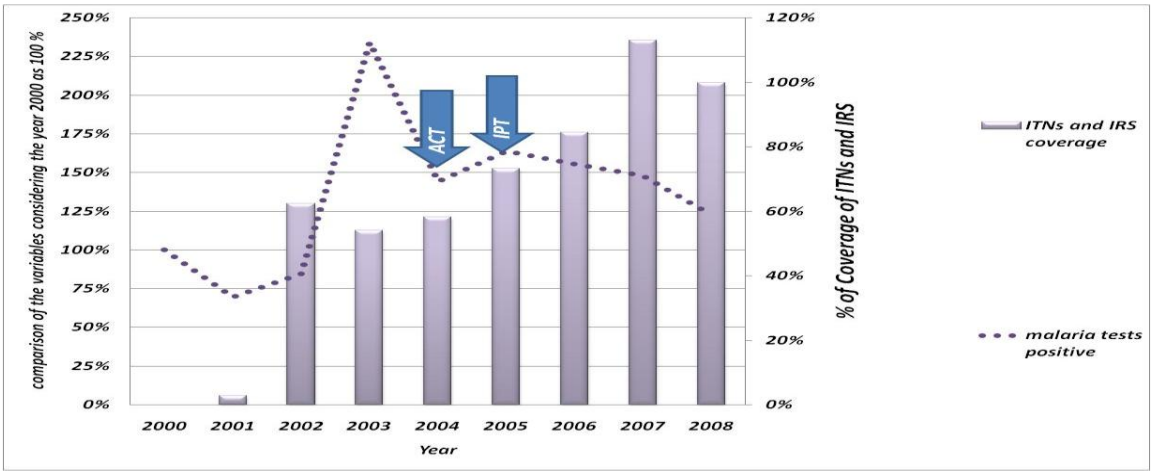


Figure 7 the impact of malaria interventions (ITNs, IRS, ACT and IPT) on the number of the positive malaria tests performed in Northern Sudan 2000 to 2008.

Table 3 **Malaria epidemiological indicators, north Sudan 2000 to 2008 (FMoH reports)**

Indicator	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*
Total number of malaria cases in the out-patients departments	4,332,827	3,985,702	3,054,400	3,084,320	2,083,711	2,515,693	1,589,956	3,040,181	3,024,664
Proportion of the total malaria cases in out-patients department	17	20	15	15.8	11.3	14.4	18	21.7	22
Malaria Case Prevalence per 1000 pop.	139.4	124.8	93.2	91.6	60.3	71	52	96	98
Number of malaria cases in the out-patients departments in Children under 5.	1,159,328	868,893	760,572	676,525	547,011	654,044	379,172	771,419	886,294
Proportion of the under 5 children malaria cases in out-patients department	19	16	15	15	12	15	22	27	28
Total number of malaria cases admitted in the hospitals	95,450	119,911	113,056	152,686	130,585	132,617	125,550	126,480	111,987
Proportion of the malaria cases admitted to hospiatls	26.1	25.7	22.9	21.1	18	16.3	14.9	13.6	14.1
Total number of malaria cases admitted in the hospitals in children under 5 years	26,542	34,750	34,216	45,736	38,495	41,725	39,615	38,547	40,331
Proportion of the under 5 year's children malaria cases admitted to hospitals	35.6	30.2	25.1	23.5	20	20.2	17.8	15.5	20.2
Total number of malaria attributed death in admitted patients.	2162	2252	2125	2479	1814	1703	1686	1254	1125
Proportion of malaria attributed deaths out of the total deaths in hospitals.	19.1	15.9	14.1	12.9	10.2	8.7	8.7	4.8	6.5
Total number of malaria attributed deaths in children under 5 admitted in hospitals	798	816	700	863	749	570	565	446	359
Proportion of the under 5 children malaria attributed death	23.3	16.8	13.3	12	11	9	9	7	7
Total Under 5 deaths in hospitals	3419	4855	5267	7031	6654	6116	6447	6779	5338
Positive Malaria tests	464,007	323,402	393,606	1,085,953	668,484	761,034	721,233	686,908	569,296

Table 4 **Malaria control interventions in north Sudan 2000 to 2008**

Indicator	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*
Number of households protected by IRS	0	0	565,605	494,795	465,454	555,311	595,486	641,123	456,337
Number of population protected by IRS	0	0	2,828,025	2,473,973	2,327,272	2,776,555	2,977,432	3,846,738	2,281,687
Number of ITNs and or LLINs	0	135,000	160,600	76,500	665,400	752,900	796,199	1,910,000	1,806,504
Number of first-line treatment courses received	0	0	0	0	1,165,019	3,613,133	2,888,943	3,337,103	3,073,996
Number of ACTs treatment courses received	0	0	0	0	0	0	2,814,000	2,077,199	3,073,996

5. DISCUSSION

In this study we examine whether the malaria interventions has had an effect significantly greater than the underlying trend (32) we also assume that without scaling up of malaria interventions , the malaria burden will fluctuate in response to climate changes in the short run, but still expected to show little change. Thus we can establish a plausibility relation between the malaria interventions and malaria burden if the scale up of the interventions followed by a decrease in malaria burden in Sudan .This plausibility relation can be supported if the magnitude in scaling up is consistent with the decrease in the burden and if the changes in the malaria burden could not be explained by other factors. (27)

This study design has its own limitations. (32) (27) The randomized controlled trail (RCT) design would have been the best design to evaluate malaria control program in north Sudan. However, randomization of the interventions and assigning part of the population as a control group is not an ethical approach. Moreover, the implantation of the control intervention took place already nationwide. So in this study there is no randomization and there is no control group, making it difficult to drive a causal relationship between the interventions of malaria control and malaria burden in north Sudan during the period 2000 to 2008.

The number of time points selected before the interventions might not be sufficient in reflecting the basic trends of the burden ,and makes it difficult to attribute any change in the burden to the interventions effect(32)

The study also did not take into account all other events occurring during the same study period which might have an effect on the trends and confound the result. These factors includes rainfall which is the most important climatic variable affecting malaria burden and the vector density in Sudan (38) (39). Other factors include the GDP, child health promotion interventions and increased accessibility to public health facilities.

The limitation of Health facility based data is an important limitation of this study as it may fail to reflect the actual burden of Malaria in the community. This is could be due to the fact that the access to local primary healthcare services in Sudan is as low as 40%-66%(36) and only 43.4 % for malaria associated fever sought health care services within 24 hours of the onset of fever while 29.5% sought health care after 48 hours of the onset of fever. However, more than 73.5% of malaria patients sought malaria treatment at the governmental health facilities, 21.9% at private sector and 4.5% NGos.(12) The reported malaria cases are not necessarily confirmed cases. Moreover, not all health facilities are regularly reporting to the higher level. Community level information is not collected and is not reflected in the health facility data. Data on cases and on interventions, from other organizations like army, police and from the private sector (including NGOs) is not included in the national health information system (33) The health facility data could be very helpful in assessing the impact of malaria burden if those data handled with care and transparency with full awareness of their limitations. (30)

A limitation related to the analysis ,is that we took the year 2000 as a baseline and assumed that it is 100% and we compared the other years to that 100%, which is apparently depends on the level of malaria burden in 2000. If we took another year as a baseline we will get different results. Taking the whole Sudan as one unite without looking at the sub national levels (States, or strata) ,is a limitation to this study, as malaria burden and the control interventions are not homogenous all cross the states or strata. Moreover, the analysis did not take into account the difference between the urban and rural areas, which is different in the burden of the disease and in the interventions coverage as well. (12-13)

The coverage of ITNs and IRS reached 100 % in the year 2008. The number of LLINs distributed in northern Sudan according to FMoH was more than 6 million for the period 2006 to 2009. The lack of sufficient data on ITNs and IRS before the year 2000 may affect the calculation used to assess the coverage, and we may conclude that the interventions have been intensified there after. The estimates of the population at high risk of malaria is affecting the calculation of this coverage as well(34).

The implementation of ACT and IPT was in 2004 and 2005 respectively. The prevalence of malaria per 1000 population is decreased to 100 cases per 1000 population in 2008 compared to 160 cases per 1000 in 2000. The total number of malaria case in outpatients decreased by 25 % in 2008 compared to 2000 ,for both all age patients and patients under 5 years old, while the proportion of the malaria cases in outpatients department increased by 25% for the all age patients and increased by 50 % for the under 5 years old patients. The numbers of malaria cases admitted to hospitals increased for both age groups by 25 % for all age and 50 % for the under 5 children, but the proportion of malaria cases in the all cases admitted to hospitals decreased by almost 50 % for the both age groups. Malaria attributed death in the admitted patients showed a decrease to more than 50 – 75 percent for both age groups, but the all cause under 5 years old death is increasing. The total number of malaria test positives increased by 25% in 2008 compared to 2000.

The prevalence of malaria in northern Sudan was more than 160 cases per 1000 population in the year 1996, and started to decrease and recorded the lowest level in the year 2006 when it was less than 60 cases per 1000 population. That was 2 years after the ACT introduction and an increasing coverage of ITNs and IRS. Then it rises again, but still less than the 1996 level as it was almost 100 cases per 1000 population in 2008. Although the trend in the prevalence was going down before the scale up of the malaria interventions, the marked decrease in the prevalence could not happened without this scale up. Malaria control interventions in “Khartoum free of malaria initiative” showed a reduction in the prevalence from 5% to less than 1% by 2004, supporting that the scale up of malaria interventions leads to a reduction in the

malaria prevalence (40) In Zanzibar, the artemisinin-based combination therapy (ACT) adopted in 2003 and long-lasting insecticidal nets (LLINs) in 2006 led to the reduction of the P. falciparum prevalence in children under five between 2003 and 2006 (29).

The increased prevalence despite the increased coverage of malaria interventions in 2007 and 2008 in north Sudan could be a normal fluctuation in the malaria burden or might be an improved reporting. This trend is also affected by the fact that not all these cases are confirmed malaria cases, so looking at this trend alone might not reflect the real impact of malaria interventions.(34)

The malaria cases in the outpatient department in northern Sudan showed consistent decrease over the period 2000 to 2008 ,that was true for the all age patients and for the under 5 years old children. The year 2006 was also the year of the lowest recorded number of malaria cases during this period. The number of malaria cases in outpatient department dropped to more than 50 % in 2006 compared to 2000, this was followed by an increase for the years 2007 and 2008 still with a decrease of more than 25% for the both age groups in comparison to 2000. This decrease was consistent with the increased malaria interventions coverage and the introduction of ACT and IPT, suggesting that there is a causal relation between the increased malaria control interventions and the decreased number of malaria cases in the outpatient department. In 2005, São Tomé e Príncipe used IRS, LLINs, ACT and IPT to compact malaria ,and three years later they succeeded to reduce malaria-attributed outpatient consultations by 85% in all age groups (41) In South Africa ACT and vector control caused the number of malaria related outpatient cases to fall by 99% from 2001 to 2003 (42)

The effect of changed diagnosis practice could not be ruled out as a cause of a decrease in the reduction of the number of outpatient malaria cases, because reporting of confirmed malaria cases my result in decreased malaria cases as fewer non malaria fevers were classified as malaria. (34).

When we look at the proportion of malaria cases out of the total cases of all causes in the outpatients department for the same period the picture is changed. The proportion of malaria cases out of the cases in outpatient department decreased to more than 25% in 2004 compared to 2000 for the both age groups, then it rise again and reached a 25% increase in 2008 compared to 2000. That was the same for the under 5 years old children but with a 50% increase in 2008 compared to 2000.

The proportion of the malaria cases in the outpatient's attendance is less sensitive to the change in the reporting behavior (34) raising the need to explain this increased proportion by examining the other causes of outpatient attendance. As the absolute number for the malaria cases in the outpatient department was decreasing, this increased proportion of malaria cases out of the total outpatient's attendance is more likely caused by a decreased in the other causes of outpatient's consultancies, giving malaria a bigger proportion despite the decreased numbers.

In contrast to this result the malaria control initiative in Khartoum in 2002 succeeded to decrease the proportion of malaria cases out of outpatients' attendance from 40% in 1990 to less than 20% in 2004 (40) In Eritrea the scale up of malaria interventions in the period 2000–2004 led to increased coverage of ITNs and IRS with change in treatment regimen. This led to an overall outpatient malaria incidence rate drop by 83.33% (43)

The inpatients malaria cases increased over this period of time despite the increased malaria interventions. In the year 2003 the inpatients malaria cases numbers increased by more than 50% and almost 75% for the all age patients and children under 5 years old respectively. Then it showed slight decrease but still 25% and 50% increase compared to 2000 for the all age patients and children under 5 years old respectively.

The numbers of admitted malaria cases may reflect the number of sever malaria cases. Moreover, the probability of the admitted cases to be confirmed cases is higher than the outpatient cases. Good explanation of this increased numbers could not be reached using the current data, but the improved reporting system could be a reason for such picture. This could be supported when we look at the proportion of the

malaria cases out of the total causes of admission which showed a marked decrease to almost 50% decrease in 2008 compared to 2000 for the both age groups, the change in the proportion is less sensitive to the change in reporting system, so it might reflect a real decrease in malaria admitted cases. The impact of malaria interventions scale up on the malaria attributed admission was evident in São Tomé e Príncipe where the malaria-attributed hospitalizations decreased by more than 80% in all age groups.(41) The same happened in Zanzibar where the scale up resulted in a reduction of 77% in the malaria-related admissions. (29) The distribution of LLIN and adoption of ACT in Rwanda reduced the in-patient malaria cases by 55% and by 73% in Ethiopia (44) In Zambia the IVM activities resulted in increased coverage and utilization of interventions and markedly reduction of malaria related morbidity and mortality .(45) The scaling up of malaria control strategies in Zambia has reduced the rates of in-patient malaria cases by 61% (42) and in South Africa the hospital admissions decreased by 99% from 2001 to 2003 in response to scale up.(42)

The malaria interventions had a marked impact on the malaria attributed death in the hospitals during the years 2000 to 2008 in Northern Sudan. The numbers of malaria attributed death decreased by almost 50 % for both age groups of patients. The proportion of malaria attributed death out of all causes of deaths in hospitals was almost 75% decrease in 2008 compared to 2000 for the both age groups. This marked decrease was also consistent with the scale up of malaria interventions, giving a suggestion that this is linked to the introduction of ACT as an effective treatment. Other interventions, like training of health personnel and incentives may contribute to this deceased burden of malaria death in the hospitals. This indicator is reflecting basically the health system performance.

Such reduction in the malaria attributed mortality was observed in Khartoum in 2004, where a 75% reduction was achieved in response to scale up. The malaria death reduced from 1070 in 1999 to 274 in 2004 in Khartoum.(40) In São Tomé e Príncipe the scale up of malaria interventions had even more impact on the malaria-attributed deaths, as it was decreased by more than 95% in all age groups.(41) In Eritrea the increased coverage of ITNs and IRS with change in treatment regimen decreased the

malaria case fatality rate from 0.21% to 0.14% (43) In Zanzibar malaria attributed mortality decreased by 75% between 2002 and 2005 in children under five. (29) and in Rwanda the malaria attributed deaths in children < 5 years old fell by 67% and in Ethiopia by 62%.(44) In Zambia the IVM activities resulted in increased coverage and utilization of interventions and markedly reduction of malaria related morbidity and mortality (45) the rates of malaria deaths decreased by 66% in Zambia compared with the 2001–2002 reference period. In South Africa the malaria-related deaths decreased by 97% and in Ethiopia the ACT half the rate of malaria-related deaths .(42)

It is clear from the above; that the scale up of malaria control interventions could impact the malaria attributed death. And it is the case in Northern Sudan for the period 2000 to 2008. However, when we examined the all cause mortality for the under 5 years children, there was an increased number of deaths in hospitals for the same period by almost 50% in 2008 compared to 2000 levels. This increased under 5 mortality in Sudan is causing an increasing trend in the under 5 years mortality for the EMRO region.(34) This increased numbers suggests a need to investigate other causes of mortality in under 5 children, and explain why the decreased malaria mortality could not impact this indicator. That is because malaria interventions known to have an impact on the overall under five mortality, in Zanzibar, the artemisinin-based combination therapy (ACT) adopted in 2003 and long-lasting insecticidal nets (LLINs) ,between 2002 and 2005 the crude under-five, infant (under age 1 y), and child (aged 1–4 y) mortality decreased by 52%, 33%, and 71%, respectively. (29)

The number of positive malaria tests showed an increase all through the period from 2000 to 2008. In 2003 it increased by more than 125% and it was 25 % increase in 2008. This wide fluctuation suggesting that there is a changing reporting behavior affecting this trend .

6. CONCLUSION AND RECOMMENDATIONS

ITNs, IRS, ACT and IPT have been scaled up in north Sudan during the period 2000 to 2008. This interventions had an impact on reducing the prevalence of malaria ,number of malaria cases in outpatient department, proportion of malaria cases admitted to the hospitals and numbers and proportion of malaria attributed death in the hospitals for all cases and for the under 5 children. Suggesting that the malaria program in Sudan could achieve the objective of reducing the morbidity and mortality of malaria by 50% by 2012 all over the northern Sudan (compared to reported cases in 2005)(4).

Scale up of malaria interventions is to be maintained and the successes are to be documented. The draw backs are to be analyzed and solutions are to be suggested.

More efforts are needed on the monitoring and evaluation system, to strengthen the tools used in evaluating the progress towards the program targets. Efforts should be made to use the increased malaria funds to develop an evaluation approach that can serve malaria and other diseases control programs in Sudan. The suggested evaluation system could make use of the available data sources and complement those data by a predesigned data collection tools. The malaria program might need to reinforce the capacity of the program in analyzing those data and disseminate it to the concerned parties.

The coordination with the other health care providers in North Sudan would result in the inclusion of their data in the national health information system and improving the comprehensiveness of health facility data.

Using the health facility data is possible source to achieve the objectives of this study(30) efforts should be intensified to insure the quality and completeness of these data.

The increased reported all cause under 5 children mortality is to be investigated, and reasons for why the high scale up malaria interventions failed to reduce this numbers.

More attention is needed to look at the equity of the coverage of the malaria control interventions between urban and rural areas. We could not reach a conclusion on this issue using this study method and data. So we suggest that the study could be conducted using stratified sampling. Taking each one of the malaria epidemiological strata as first layer, then within each stratum, the localities will be sampled. Then within each selected locality the health facilities will be stratified to urban and rural and randomly sampled. The data on malaria burden indicators will be collected at the health facility level. The data on malaria control interventions will be collected at the locality level. This approach will minimize the reporting problems and will allow the study of different strata of malaria in north Sudan.

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