The Republic of Sudan
Federal Ministry of Health
National Malaria Control Programme

Malaria Indicator Survey
Northern States of the Sudan
October - November 2009

July 2010

The 2009 Sudan northern states Malaria Indicator Survey (SNMIS) was implemented by the National Malaria Control Programme of the Federal Ministry of Health (FMOH) of The Sudan from October to November 2009. Funding for the Sudan MIS was received from the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) through the Principal Recipient- the United Nation Development Programme and the sub-recipient, the World Health Organization-Eastern Mediterranean Regional Office (WHO-EMRO), and from the Government of Sudan's FMoH. Technical assistance was provided by the WHO-EMRO, the Kenya Medical Research Institute/Wellcome Trust Research Programme, and the University of Khartoum, Department of Community Medicine. The Sudan NMCP staff, FMOH representatives, and Sudan Malaria CCM subcommittee were part of the technical taskforce for the survey. These participants include, but not exclusively, the following people:

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Recommended citation:
Federal Ministry of Health (2010*). Malaria Indicator Survey 2009 in the Northern states of the Sudan*. Submitted to the World Health Organization, Eastern Mediterranean Regional Office, Cairo, Egypt. March 2010.

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Partners

Kenya Medical Research Institute/Wellcome Trust Research Programme
Malaria Atlas Project
National Central Bureau of Statistics
University of Khartoum
United Nations Children's Fund
United Nation Development Programme
World Health Organization

Abbreviations

ACT	Artemisinin-based Combination Therapy
CQ	Chloroquine
EA	Enumeration Area
ELISA	Enzyme-Linked Immunosorbent Assay
GFATM	Global Fund to Fight AIDS Tuberculosis & Malaria
GIS	Geographical Information System
IDP	Internally Displaced Person
IPT	Intermittent Preventive Treatment
IRS	Indoor Residual Spraying
ITN	Insecticide Treated Net
LLIN	Long Lasting Insecticidal Net
MERG	Monitoring and Evaluation Reference Group
MICS	Multiple Indicators Cluster Surveys
MIS	Malaria Indicator Survey
FMOH	Federal Ministry of Health
NGOs	Non Governmental Organizations
NMCP	National Malaria Control Programme
PSU	Primary Sampling Units
RBM	Roll Back Malaria
RDT	Rapid Diagnostic Test
SP	Sulphadoxine-Pyrimethamine
WHO	World Health Organization
UNDP	United Nation Development Programme
UNICEF	United Nations Children Fund

Acknowledgements

We would like to thank all departments within the Federal Ministry of Health involved in the survey and the Central Bureau of Statistics for providing us with sampling frame for the survey. We would also like to thank the Assistant Under-Secretary of the Federal Ministry of Health, Department of Disease Prevention, Dr. El Fatih M Malik, for his constant support. We are grateful to the WHO-EMRO Roll Back Malaria offices in Cairo and Khartoum, and in particular to Dr Hoda Atta, Dr Ghasem Zamani and Mr Mahmoud Wais for their facilitation of survey and funding of the technical assistance for the survey. We thank Dr Mohamed Abdurrab, the WR of WHO office, Sudan for his support. Our gratitude goes to the Global Fund through UNDP and WHO-EMRO/RBM for funding this survey. We are enormously grateful to the field workers and above all the household members who participated in the survey. We acknowledge the contribution of the University of Khartoum's Department of Community Medicine, the Kenya Medical Research Institute/Wellcome Trust Research Programme in Nairobi (www.kemri-wellcome.org and the Malaria Atlas Project (www.map.ox.ac.uk) in providing technical assistance for the survey. Finally we thank Prof Bob Snow, Head of the Malaria Public Health & Epidemiology Group of the KEMRI/WTRP in Nairobi for his invaluable scientific advice in the development of survey protocol, questionnaires, and the report.

Preface

Malaria remains an important public health problem in the northern states of the Sudan. The Federal Ministry of Health, through the National Malaria Control Programme and in collaboration with the Roll Back Malaria Partners has engaged in a process of scaling up malaria control interventions such as long lasting insecticidal nets, insecticide spraying, intermittent presumptive treatment of pregnant women and improving the treatment of malaria by providing effective artemisinin combination therapies in the public health system and training the health workers in appropriate malaria case-management. These projects have been outlined in detail in the National Malaria Strategic Plan 2007-2012.

Over the last few years millions of Sudanese Pounds have been invested in achieving the high targets set in the National Malaria Strategy and to understand the progress we have made so far, we need empirical evidence to assess where we are now and to plan better for the future so that we can significantly reduce the burden of malaria in the Sudan.

The Sudan Northern States Malaria Indicator Survey 2009 represents the first malaria survey to cover all 15 states of the northern Sudan. Although an MIS was done in the Sudan, this survey in 2005 covered only 10 states country-wide, 8 of which were part of the northern states. The 2009 survey covers all 15 northern states and importantly looks at key malaria indicators across all age groups.

The results of the survey show that significant progress has been made over the last few years. Household ownership of at least one insecticide treated net is at 41%; over 50% of all individuals who visit health facilities with malaria-like symptoms undergo parasitological diagnosis, 44% of all individuals who were treated for uncomplicated malaria were treated using the recommended first line drug AS+SP, ITN use among all ages is 11%, among children under the age of five years was 16% and among pregnant women was 16%. Encouragingly, parasite prevalence was less than 2% overall.

While significant progress has been made on key malaria indicators, there remain some challenges. First, intermittent presumptive treatment of pregnant women remains very low even in the target states, there is need to improve use of treated nets by individuals living in households who already own nets, and urgent attention needs to be paid to the rising problem of using artemisinin monotherapies in the treatment of uncomplicated malaria to prevent the rise of parasite resistance to these very important arteminsinin-based antimalarials. Also, although overall prevalence rates were low, there were some states where rates were still above 5% among all ages. These challenges need to be the focus of the future malaria control activities.

The progress achieved thus far is the result of the combined efforts of the Federal Ministry of Health's National Malaria Control Programme and generous partners. We have a wonderful basis on which we can build a very successful malaria control in the northern states of the Sudan and we should strive even harder to make sure we achieve all our targets.

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SUMMARY OF SURVEY RESULTS

Background

The northern states of the Republic of the Sudan have a mixed malaria ecology that supports generally low transmission of malaria with pockets of moderate transmission in parts of the states bordering the malaria endemic southern states. Over the past few years, the GFATM has approved 33 million US dollars for malaria control in the northern states of the Sudan in round 2 that started in 2005 and extended through to 2009. The first large scale malaria indicator survey (MIS) in the Sudan was done in October 2005, but this covered only 10 states, of which 8 were among the 15 northern states surveyed in 2009. Significant investments have been made over the past five years in malaria control including the distribution of over 6 million long lasting insecticide treated nets, the supply of artemesinin combination therapies to over 90% of government health facilities; the scaling up of insecticidal spraying in several areas; and the training of large number of health workers in appropriate malaria case management. Therefore in 2009, the National Malaria Control Programme (NMCP) decided to undertake a second malaria indicator survey (MIS) covering all the northern states to assess the progress made in malaria control and to inform the national strategy for the next decade, including the implementation of the financial support from the GFATM malaria round 7 grant and other initiatives.

The main objectives of the Sudan northern states MIS (SNMIS) in 2009 were to assess: household ownership of insecticide treated nets (ITN); use of ITN among all age-groups, and particularly among children under the age of five years and pregnant women; the prevalence and prompt treatment of fevers among the children under the age of five years; the sources of treatment and the type of drugs used to treat fever; the prevalence of malaria parasite infection; and the general population access to malaria-related information. Sampling of the survey was done to be representative of urban and rural areas and the 15 states in the north of the country.

Characteristics of households and respondents

The survey began on the 17th October 2009 and ended on the 5th November 2009. All 300 sampled clusters and a total of 5,980 of the 6,000 sampled households were successfully surveyed resulting in a household response rate of 99.6%. These households yielded a total of 30,504 individuals who slept at the household the night prior to the survey. Of these, 4,094 (13.5%) were absent on the day of survey and on subsequent follow-up either because they had travelled on the day of survey or were out to work at the time of survey. This was particularly a problem in the main urban centres of the states. Of the remaining 26,471, 7,048 (26.7%) were women aged 15-49 years. Of these only those who were ever married were considered eligible for the women's questionnaire due to local sensitivities regarding questioning an unmarried woman about their reproduction. In total, 5,054 women of the age 15-49 who had ever married were successfully interviewed. Among 26,471 individuals who were surveyed, however, 4,503 refused to provide blood samples for testing malaria infection and parasite exposure resulting in a response rate of 83% for this indicator.

Over 87% of households were headed by a man. Of the 26,344 individuals seen during the MIS more than half were older 15 years of age or older. Mean household size was 5.3 with household size marginally higher in urban areas. About 41% of households had access to piped water. About 9% of households had access to a flush toilet while 62% used a pit latrine. Among rural households, however, 28% disposed of excrements in the bushes or uninhabited fields. About 68% of urban households and 27% of rural households used electricity for lighting. Majority of households used natural gas followed by firewood and kerosene for cooking. Most of the houses, even in urban areas had earth floor. Almost 62% of households owned a radio, 43% owned a television, 58% owned a telephone and 28% owned a refrigerator.

Ownership and use of mosquito bed nets

Household ownership of at least one mosquito net, insecticide treated net (ITN) and long-lasting insecticidal net (LLIN) was 55%; 41% and 40% respectively and 97% of all ITNs in the households were LLINs. Household ownership of one or more mosquito nets, ITNs and LLINs was 36%; 23% and 22% respectively. On average there was 0.7 LLIN per household. Ownership of nets/ITNs/LLINs was marginally higher in rural areas with no major differences by wealth status.

Household ownership of at least one LLIN was >40% in Blue Nile, Gedarif, Gezira, North Darfur, North Kordofan, River Nile, Sennar, South Darfur, South Kordofan and White Nile. Two states, Khartoum and Red Sea, reported household ownership of at least one LLIN of less than 30%. Only Blue Nile state, however, had 40% or more of households reporting ownership of two or more LLINs.

Among individuals of all age groups, 11% slept under an LLIN the night before the survey but increased to 25% when only those in households with LLINs were analysed. Among children under the age of five years and pregnant women 16% slept under LLIN the night before survey increased to 34% and 36% respectively among individuals in households with LLINs. Only Blue Nile, South Darfur and White Nile states reported LLIN use among all ages of ≥ 20%. LLIN use in Khartoum, Red Sea and Northern was ≤ 3% among all ages. Among children under the age of five years however, Blue Nile, Gezira, North Darfur, South Darfur, West Darfur and White Nile reported LLIN use of ≥ 20%. Over 30% of pregnant women in Blue Nile and West Darfur reported sleeping under LLINs the night before survey. When households with at least one net/ITN/LLIN were considered 40% of all household members and/or children under the age of five years and/or pregnant women in Blue Nile, Gezira, North Darfur, South Darfur, West Darfur and White Nile slept under an LLIN the night prior to survey.

Indoor residual spraying of households with insecticides

Indoor residual spraying (IRS), as a vector control strategy, is targeted in selected areas in the Gezira, Kassala, River Nile and Northern. In 2009, a number of IRS activities had been implemented in all these target states primarily by the NMCP except in Gezira state due to funding and logistical problems. Overall, only 192 households had reported exposure to IRS and these represented 2.4% of urban households and 3.4% of rural households. Since only a small number of households were sprayed, these were considered too few to be presented by state or wealth index. About 21% of the 192 households were in Kassala state; 10% in Northern and 6% each in Gezira. It is important to note, however, that by far the most common insecticide spraying activity in the northern states of the Sudan is the space spraying outside of households and fogging inside of household during peaks of mosquito densities and to avoid emergence outbreaks. Given this activity was not directed at the households the MIS was considered inappropriate for capturing this information and additional tools, outside of household surveys, need to be developed to assess the extent of insecticide spraying. Furthermore, because IRS activities are targeted in selected within four states, the national MIS is not appropriate tool to capture precise information on IRS coverage in such focal areas and results presented here are likely to represent an underestimate of actual coverage.

Prevalence and prompt treatment of fever

Among individuals who were interviewed, overall fever period prevalence (last two weeks) was 19% in all ages and 23% among children under the age of five years. Reported fever in the last two weeks was highest among children from rural areas and those from the poorest households. Treatment-seeking for fever was 39% with only 26% and 16% seeking treatment

within 48 and 24 hours respectively. By far a higher proportion of persons from the wealthier households sought treatment for fever compared to those from poorer households. Of those individuals who sought treatment for fever, 70% used medications obtained from the government health sector while 23% used medications from private clinic, pharmacy or shop. Government hospitals and health centres were generally equally used for the treatment of fevers while rural households were the predominant users of lower level basic health units. The majority of the fevers where action was taken (56%) were treated with drugs other than antimalarials, mostly antipyretics. Of the 45% who were treated with antimalarials for uncomplicated malaria; 44% were treated using the nationally recommended drug AS+SP; 13% with replaced monotherapies chloroquine or SP, while worryingly 34% were treated using arthemeter injections, a monotherapy which is regarded as the alternative treatment option for severe malaria in Sudan and which has implications for possible emergence of resistance to artemisinins. About 77% of individuals who used AS+SP, 57% of those who used SP or chloroquine, 85% of those who used quinine and 78% of those who used Arthemeter obtained these medications from a government hospital, health centre or basic health unit. Use of AS+SP ranged from 30.5% in West Darfur to 89% in Northern state, although only 8 individuals reported to have been treated for malaria in this state.

Prevalence of malaria infections

A total of 21,988 individuals consented and were selected for malaria parasite examination of which 482 were found positive for malaria parasite using RDTs representing an overall weighted prevalence of 1.8% nationally. Infection was marginally higher among male compared to female members of the household and almost three times higher in rural areas compared to urban. All states except Blue Nile (12.5%) and West Darfur (7.1%) reported prevalence of less than 3%. There were only marginal differences in infection prevalence by age. However, infection prevalence among individuals in the lowest wealth quintile was almost 7 times higher than those in the wealthiest quintile. Only 21/489 individuals (4.3%) who tested positive for malaria reported to have travelled the 8 weeks prior to survey. Only 117/300 clusters (39%) had at least one individual observed with malaria infection in their peripheral blood. None of the clusters in the Northern (desert) state reported a case of malaria infection.

Analysis of the blood slides for all individuals who had an RDT test revealed that a total 115 individuals were positive for malaria leading to a national prevalence of 0.5%. These individuals who were positive by microscopy included 22 who were reported negative for RDTs. However, there were a number of issues that render the microscopic results unreliable. A large number of slides were of poor quality, including all of those from the Northern state. Over 500 slides, including for those of RDT positive individuals were destroyed during repeated cross checking which was done at four different times. In addition, there were significant discrepancies between readings by different microscopists during crosschecking process. Because of the generally poor quality of slides and microscopy results, it is advised here that RDT results are used for estimation of prevalence in the Sudan MIS 2009.

Use of antenatal care services and intermittent presumptive treatment of pregnant women (IPTp)

Currently the NMCP has targeted 8/15 states for IPTp, of which Blue Nile, Gezira, Sennar and South Kordofan are wholly targeted while partial (selected localities) targeting has been implemented in Gedarif, Kassala, South Darfur and White Nile. Of the 5,054 women between the ages 15-49 years who were enumerated, 38% reported to have given birth in the last twelve months or were currently pregnant. About 29% of these visited ANC services during their

previous or current pregnancy with no significant difference by urban or rural setting although a significantly higher proportion of women from poorer households had either given birth in the 12 months prior to survey or were currently pregnant. ANC visits were lowest in North Darfur and Red Sea states but only North Kordofan and West Darfur reported ANC visits of ≥40%. Up to 55% of the women who used ANC services started within the first trimester, 34% in the second trimester and 11% in the third trimester. On average, women visited ANC clinics 4 times during their pregnancy with no major difference between urban or rural households.

The proportion of women who visited ANC clinics and were given at least a single dose of IPTp in the second or third trimester (any visit where 3 tablets of SP was given to the woman for malaria prevention i.e. IPTp1) was 7.4%. Overall usage of IPTp1 was highest (12%) in the 8 target states and 7.3% in the other states excluding Northern, Red Sea and River Nile where no woman reported usage of IPTp. Usage of the two required doses of SP for IPTp (IPTp2) was only 1.7% overall, 2.5% in the targeted states while surprisingly no woman was reported to have been provided with IPTp2 in Blue Nile, the state which reported the highest usage (29%) of IPTp1. There were no major differences in IPTp usage by urban-rural or by wealth quintile.

Malaria knowledge

Overall only 4% of households had a member who attended a malaria-related formal or informal meeting over the last 12 months. Almost five times as many households in the wealthiest quintile attended such meetings compared to those in the poorest quintile. With regard to accessing malaria information, 19% of all households (26% urban and 14% rural) have come across printed materials or sign boards related to malaria prevention and control. Blue Nile reported a significantly large proportion (62%) of household members who have come across malaria-related materials while all other states reported rates of 9% to 24%. 54% of household accessed malaria information through radio, TV or newspapers. Household members reported that the main medium for accessing malaria related information was the radio as reported by 32.2% of all households (33% urban, 32% rural). This was followed by the television (7.3%) used predominantly by urban households. Less than 5% of households reported to access malaria information through reading newspapers. Access to all media was significantly in favour of the households in the wealthiest quintile. Of those households where a radio was used, majority of households listened to the National Radio channel (70%), followed by state specific radio channels (15%) and FM 100 (7%). Except for the state specific radio channels, use of the other main radio channels was in favour of the wealthier households.

Progress in key malaria control indicators between 2005 and 2009

To assess the progress made in key malaria indicators in the northern states of the Sudan since the last MIS in 2005, results from the 8 northern states included in both surveys were compared as shown in the table below.

With generally similar sample sizes, the comparison of the 8 states show that overall in each of the main indicators significant progress was made. Household ownership of LLIN increased from about 10% overall in 2005 to 45% in 2009. Proportion of people sleeping under LLINs also increased from 6% in 2005 to 15% in 2009. Use of ACTs for treatment of fevers has almost quadrupled in the 8 states since 2005 from 11% to 40% in 2009. Use of IPTp by pregnant women has only marginally increased. Although parasite prevalence among all ages was also marginally lower in 2009 there is need, however, to reinforce these results with data from microscopy and seroprevalence and undertake detailed spatial and temporal analysis of infection prevalence.

Although difficult to attribute causality, the significant increase in the distribution in LLINs and increase in IRS in target areas over the last 4 years would have contributed to some reduction in infection prevalence.

	Number of households surveyed		% of HH with at least one LLIN		% of people sleeping under LLIN		Prevalence of fever among all ages		Among those treated for malaria. %treated with ACT		%women receiving full dose of IPTp		% parasite prevalence	
State	**2005**	**2009**	**2005**	**2009**	**2005**	**2009**	**2005**	**2009**	**2005**	**2009**	**2005**	**2009**	**2005**	**2009**
Gedarif	280	279	18.6	51.4	10.0	16.6	19.3	17.5	7.9	47.5	3.5	1.0	2.9	1.6
Kassala	280	338	5.7	32.3	3.1	7.9	24.4	20.2	12.1	58.0	1.0	3.6	1.5	1.1
North Kordofan	260	578	0.4	42.7	0.0	5.3	16.8	20.6	11.5	44.4	0.8	0.8	1.8	2.6
Sennar	340	279	1.5	42.4	0.5	13.3	30.3	29.2	9.8	31.3	1.0	4.6	3.2	1.1
South Kordofan	400	280	17.8	53.1	10.3	17.1	29.3	32.2	5.4	40.9	0.7	2.0	11.2	2.1
South Darfur	160	600	24.4	42.6	15.9	21.3	19.0	25.8	10.7	30.8	0.0	2.6	2.5	1.2
West Darfur	300	280	9.3	38.7	6.9	15.8	12.7	32.9	15.4	30.5	3.1	3.9	4.8	7.1
White Nile	280	360	1.4	53.2	0.5	23.6	24.3	23.9	11.9	35.0	1.8	1.3	1.3	1.8
Total	**2,300**	**2,994**	**9.9**	**44.6**	**5.9**	**15.1**	**22.0**	**25.3**	**10.6**	**40.0**	**1.5**	**2.5**	**3.7**	**2.3**

Recommendations

Although significant progress has been achieved in coverage of key malaria control indicators there is need for increased focus on a number of aspects of malaria control in the northern states of the Sudan based on the survey results:

1. There remains a weak congruence between household net ownership and use of these nets by members of households. The reasons for individuals in households that own nets not using them need to be investigated. The appropriateness of nets as a malaria prevention tool across the whole of the northern states of the Sudan need to be evaluated given its very low transmission ecology. To assess coverage of IRS, surveys that focus only the target areas in the states of Gezira, Kassala, River Nile and Northern should be implemented.

2. Overall treatment-seeking for fevers is low (39%) and below 20% when treatment seeking within 24 hours is considered. Affordability and access to health care and socio-cultural issues may play an important role in whether individuals seek treatment or not. Among those who sought treatment, however, over 70% used the government health sector. Consequently, it is important to investigate the reasons for low treatment seeking for fever. Recent survey of national health facilities showed that majority of patients seen at public health facilities and were diagnosed with malaria received appropriate case-management.

3. Among those who were treated for fever only 20% were treated with the recommended first line drug AS+SP representing 44% of all individuals who were treated with antimalarials. Worryingly, however, 15% of all those who were treated for fever or 33% of those treated with antimalarials used arthemeter injections, almost 80% of users acquired this drug from government health facilities. These results are supported by findings from a national malaria case-management survey of public health facilities undertaken by the NMCP. The widespread use of an artemesinin monotherapy such as arthemeter could lead to the rapid emergence of resistance to artemisinin products in Sudan and neighboring countries, undermining the effectiveness of the ACTs, such as AS+SP now used as first line therapy or

its potential replacement AL. Therefore there is an urgent need to regulate the use of arthemeter and other artemesinin monotherapies and severely restrict their use for treatment of uncomplicated malaria. IPTp remains low although there remains a debate of the benefits of this intervention in reducing disease burden in low and very transmission settings.

4. Overall prevalence as examined by the RDTs was low (1.8%) in the northern states of the Sudan. Among individuals who had fever in the two weeks prior to the survey, however, infection rates were twice as high at about 4%. Despite these overall low infection rates the states of Blue Nile and West Darfur reported relatively high rates, 12.5% and 7.1% among all ages and 20.3% and 9.2% among febrile individuals respectively. Additional investigations and quick interventions are required to address this two high prevalence states. The potential use of the parasite prevalence data in malaria stratification of the northern states of the Sudan should also be explored. The results of microscopy showed that only 95/489 individuals who were RDT positive and an additional 20 who were RDT negative were positive. However, there a series of problems with the quality of microscopy which rendered the findings unreliable. Consequently the RDT results were used as the final measure of prevalence during the MIS.

5. There is a need to further strengthen the NMCP's capacity to undertake high quality surveys. First the NMCP central laboratory doesn't have the required freezers for the long term storage of blood samples. Regular training and supervision of laboratory personnel is required to ensure that their readiness not only for routine work but also for large scale projects such as the MIS. In addition, in the Northern state, all blood slides could not be read because blood smears were not properly fixed and stained. Only one of the laboratory technicians within the NMCP has had training in ELISA for the serological analysis of the circa 10,000 survey samples. For immediate purposes the NMCP needs to co-opt other local or international collaborating institutions for the analysis of the serological samples. In the long term, however, the NMCP should be aim to fully equip its central laboratory with a fully functional ELISA kit and increase the number of technicians who can undertake serological analysis of blood samples. This is particularly important given the low transmission levels in the northern states in the Sudan.

6. There are a number of challenges that need consideration when undertaking a MIS covering all ages. First, there are difficulties in capturing the working members of the household, especially in urban areas and farming communities where adult individuals leave the house early in the morning and return in the evening. Although efforts to capture these individuals were made through call backs there was a still a considerable number who were missed. Second, school age children (5-17/18 years) are often away from home during school days. Although efforts were made to ensure school children participated in the surveys, this still remained a challenge. Finally, a good number of persons refused to participate in the testing of malaria. Future surveys should explore undertaking call backs during the evenings, implementing surveys during school holidays and implementing an intensive sensitization progamme to ensure most people provide blood samples for malaria testing.

CHAPTER 1: BACKGROUND

The Republic of the Sudan, located in the northeastern Africa with an area 2.5 million km^2, is the largest country in Africa and 10th largest in the world. It is bordered by Egypt to the north, Eritrea and Ethiopia to the east, Kenya and Uganda to the southeast, the Democratic Republic of Congo (DRC) and the Central African Republic (CAR) to the southwest, Chad to the west and Libya to northwest. On the northeast also lies the Red Sea (Figure 1.1). Africa's longest river, The Nile, flows through the middle of the country. The two main tributaries of the river, the White and the Blue Nile, converge into one at Khartoum, the Capital City, to form the River Nile, flowing through to Cairo in Egypt before joining the Mediterranean Sea. The historical and current development in the Sudan has been considerably influenced by the Nile. It is also regarded as an important determinant of the malaria ecology in the Sudan. The rainy season lasts for three months (July-September) in the north and six months (June to November) in the south with amount of rainfall increasing southwards. In the north, there is the sparsely populated Nubian Desert while the south is characterized by the swamps and marshes (Figure 1.2).

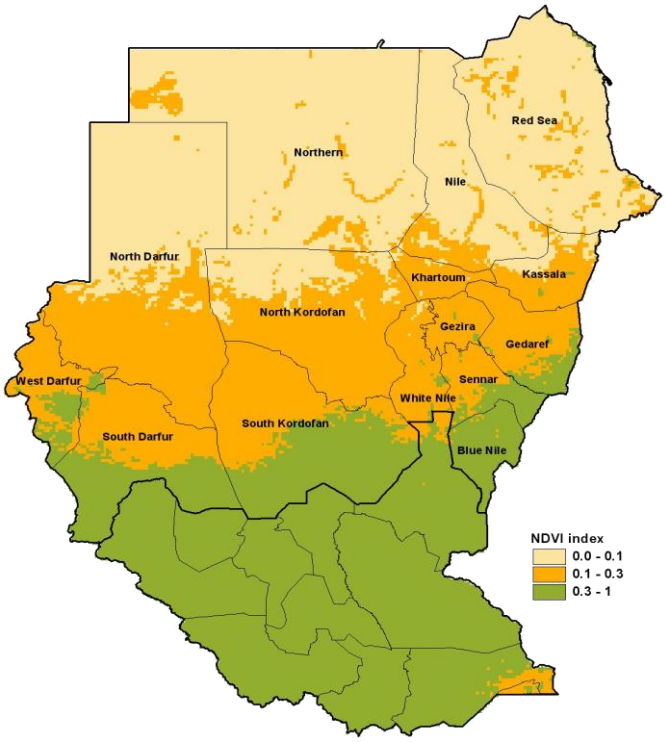
Figure 1.1 States map of Sudan showing the north (shaded) and the south (unshaded)

With a growth rate of 9% in 2007, Sudan's economy is considered one of the fastest growing in Africa although it is still faced with high levels of poverty and significant development

challenges. Currently oil is the main export and the revenues from this trade have contributed to the revival of the manufacturing industry in country and investment in major hydro-electric power projects. In spite of increasing oil exports, agriculture still remains a major economic sector, employing the majority of the workforce and contributing almost 40% of the country's GDP.

The Republic of the Sudan is made up of 25 states, 15 in the North and 10 in the South. The April 2008 census estimates the country's population at about 40 million with an estimated 21% living in the southern states and the rest in the north. Following the signing of the Comprehensive Peace Agreement (CPA) in the Sudan in 2005, a government of national unity was installed leading to the devolution of the responsibilities of several ministries and their agencies, including that of the National Malaria Control Programme (NMCP). Currently, there are two independent NMCPs, one responsible for the 15 northern states and the other for the 10 southern states. Both programmes are supported with funding from the Global Fund to Fight AIDS Tuberculosis & Malaria (GFATM) with UNDP and WHO- Eastern Mediterranean Region office (EMRO) as the principal and sub-recipients respectively of funding for the northern states while Populations Services International (PSI) is the principal recipient for the southern states.

Figure 1.2 A normalized difference vegetation index (NDVI) map of the Sudan. The smaller the value of the index the smaller the vegetation cover. The index ranges from 0 (no vegetation) to 1 (complete vegetation)



In Sudan, malaria is considered to be an important cause of morbidity and mortality representing 50% and 70% of the WHO/EMRO cases and deaths respectively with the risk significantly greater in the south (Abdalla et al 2007). In July-October 2000 UNICEF undertook a Multiple Indicator Survey in northern states of Sudan showed that ITN use among the under

fives was only 1.9% (UNICEF, 2007). In October 2005 a Malaria Indicator Survey (MIS) was undertaken across 10 states all over Sudan (northern and southern states) covering 2,460 households and 2,276 children below the age of five of whom 15.4% were sleeping under an ITN, 7.8% under a long lasting insecticidal net (LLIN) (FMOH/NMCP, 2005). Approximately 11% of children with fever were treated with ACTs while 5.4% of all individuals or 7.3% of children under five years of age were positive for malaria parasite infection [FMoH 2005]. Since then, however, the NMCP has significantly scaled up its malaria control operations and has since distributed several million LLINs, and supplied ACTs to over 90% health facilities. In a selected set of states, IRS and IPT have also been scaled up. Consequently, in 2009 the NMCP of the FMoH proposed to undertake an extended malaria indicator survey all northern states of Sudan to capture information on ITN coverage and use, coverage of IRS, treatment of fever and malaria infection among all age groups and more detailed enquiries on fever/malaria treatment actions, diagnostics used and appropriateness of timely treatment.

1.1 Malaria Monitoring and Evaluation in the Sudan

Monitoring the progress of indicators aimed at controlling malaria and the parasitological and clinical consequences of increased intervention coverage are fundamental requirements of all National Malaria Control Programmes. There are renewed efforts in ensuring that monitoring and evaluation (M&E) is a key component of management of national health programmes for a number of reasons. First there is a recognition that for efficient planning there is need for evidence for optimum resource planning and allocation. Secondly, it is now required that for national programmes that rely on donor funding to secure continued support, they provide progress on key indicators. Finally, most developing countries are now signatories to the Millennium Development Goals and the Roll Back Malaria projects both of which have clear time-fixed targets which require evidence-based approaches in documenting progress towards key targets and indicators. Therefore, in 2002, the RBM Monitoring and Evaluation Reference Group (MERG) was established to advise the RBM Partnership Board on monitoring and evaluation of RBM initiatives at all levels [http://www.rollbackmalaria.org/mechanisms/merg.html#MIS].

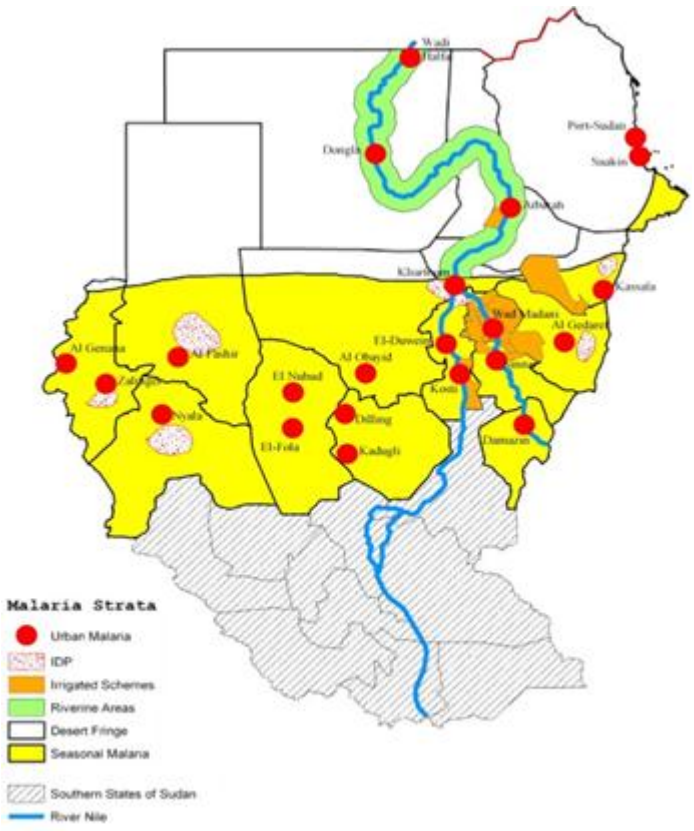
The RBM-MERG identified national cluster randomized household surveys as the main source of information on the progress of key malaria indicators. This stand-alone household surveys are aimed at collecting data at the national and regional levels from a representative sample of respondents to support national malaria control programs and international health organizations to make evidence based decisions in malaria control. The MIS addresses a number of topics including household ownership of insecticide-treated mosquito nets and their use by children under five years of age and pregnant women; intermittent preventive treatment against malaria during pregnancy; and the type and timing of treatment of fever in children under five years of age; indoor residual spraying of insecticide to reduce mosquitoes density; and the prevalence of malaria infection. It is recommended that MIS surveys are done during the high malaria transmission season to provide programmatically relevant information on the key indicators. To help countries undertake national MIS, the RBM-MERG [http://www.rollbackmalaria.org/mechanisms/merg.html#MIS] has provided detailed guidelines on survey design, sampling and implementation which form the basis of this proposal.

Within the NMCP, there is an M&E department which was established in 2005 tasked with the collection, tabulation, and analysis of data and generating reports and feedback to relevant departments and partners.

1.2 Malaria in northern states of Sudan

Using a disability-adjusted life year's model and routine health information system data, Abdalla et al. (2007) estimated that there were 9 million clinical attacks of malaria in 2002 and approximately 44,000 deaths in the Sudan. The latest World Health Report reported 5 million cases in 2006 (WHO, 2008). These disparities in estimations of the disease burden reflect not only the difficulties of using nationally reported cases data but also the inadequacies in current descriptions of populations at risk. The predominant human malaria across Sudan is *Plasmodium falciparum,* however *P. vivax* is less common but poorly characterized clinically and epidemiologically. Transmission is maintained largely by *Anopheles arabiensis*, with focal contributions by *An. gambiae* and *An. funestus.*

Figure 1.3 National Malaria Control Programme, Federal Ministry of Health expert-opinion map of six dominant malaria risk ecologies in northern states of Sudan (NMS 2006)



The 15 northern states of Sudan have historically been classified as covering a wide range of malaria endemicities (El Gaddal, 1985). In the recent National Malaria Strategy malaria risks are classified into six strata: very low risk desert fringe, riverine risks along the Nile, irrigated area risks, urban malaria risks, risks specific to internally displaced persons (IDPs) of which there are an estimated 3.5 million, and the remaining areas as seasonal transmission (Figure 3; NMCP 2006). These classifications serve as useful programmatic strata and largely based on expert opinion from detailed local knowledge of risks by state and federal level malaria control partners.

1.3 Malaria control in northern states of Sudan

The history of organized malaria control efforts in Sudan goes back to the beginning of the last century when malaria was eradicated from Khartoum in 1904 (Malik et.al. 2006). Now, a fully functional National Malaria Control Program (NMCP) is under the Directorate General of Preventive Medicine and Primary Health Care at the federal level, supporting malaria units at the State levels. The Programme consists of more than 50 technical staff, engaged in the planning, supervision, monitoring and evaluation of various activities related to vector biology and control, preparedness and control of epidemics, quality assurance, treatment; drugs and case management, training; capacity building and research, multiple prevention, State affairs, administration and finance. The main partners supporting the NMCP include the WHO, UNICEF and United Nation Development Programme, project-based partners supporting sub-national initiatives like the Islamic Development Bank (Jeddah) and the Government of Egypt. Over 40 NGO partners work in northern states of Sudan and many have a specific interest in malaria.

During the period 2005 - 2009 northern states of Sudan received 33 million USD from the Global Fund for Malaria (GFATM) during round 2 to support malaria control and prevention activities. Private sector support has been important beginning with the Savings and Development Bank's investment in ITNs and extended to partnerships with the Financial and Investment Bank. Canar, a telecommunication company, has contributed considerably to malaria control based on at two year business plan. Other private sector companies are joining the financial contribution to malaria control (including GlaxoSmithKline, DETASI, Coca Cola, Kenana Sugar Cane, Gezira Scheme Board). This is, of course, in addition to the financial commitments from national government, state contributions and locality governments. To fully implement the National Malaria Strategy 2007-2012 it has been that estimated that the strategic plan requires US$ 257 million to be completed and that these fund will be raised from the GFATM, WHO, UNICEF, Canar Company, MC and government funding (FMoH, 2006).

The strategic approaches adopted by northern states of Sudan follow largely those advocated as part of global RBM initiatives promoted during the Abuja Declaration including vector control with insecticide treated nets (ITN), Indoor Residual Spraying (IRS) and other measures, effective prompt case-management, management and prevention of malaria in pregnancy, epidemic detection and containment and supporting communications and behavioral change initiatives. These packages of interventions have been driven at State levels, modified depending upon epidemiology and ecology of the area, objectives, and resources.

1.3.1 ITN, IRS and larval control

The NMCP's strategy on ITN states as an aim to achieve over 80% of the "target" population sleeping under ITNs by 2008 (Malik et al., 2004) and the strategy is monitored and guided by a national ITN task force. The plan includes a Communication for Behavioral Impact (COMBI) Plan developed in collaboration with WHO-EMRO to phase the scale up of ITN use beginning in 2003. The private sector has been encouraged to participate in the ITN strategy through the abolition of taxes and tariffs. The Financial Investment Bank developed a Malaria Investment Syndication to provide 500,000 ITN before July 2004 to be distributed through the private sector as a starting point. Between 2001 and 2004 it was estimated that approximately 550,000 ITN had been distributed through the private sector. In 2003 116,500 ITN were distributed by UNICEF and WHO (NMCP, SA) and in 2004 UNICEF provided 145,000 Long Lasting ITNs (LLINs) using funds from JICA. To date, the total number of LLINs distributed all over the country through the government is almost 6.5 million (Table 1.1). During the 2000 MICS, 23.1%

of children less than 5 years slept under a net during the night preceding the survey but only 1.9% slept under an ITN (UNICEF, 2007). The MIS undertaken in 10 states in October 2005 showed that 43% of children slept under a net the previous night, but only 7.8% slept under an ITN. Differences were observed between States (lowest was North Kordofan) and lower usage rates in rural compared to urban areas (FMOH/NMCP, 2005).

Indoor residual spraying (IRS) in large irrigated schemes in epidemic prone areas is promoted and the insecticides predominantly used are pyrethroids. In addition, there has been a long-term and currently active IRS programme in north of the country along the River Nile as part of a joint effort between the governments of Sudan and Egypt. IRS has also been implemented in large scale in Gezira State, Kenana Sugar Cane area, New Halfa, Northern State and the Abohamad area in River Nile State. In 2008 the NMCP estimated that a total of 197,451 households had been sprayed representing a 24% coverage of the target households in the states of Gezira, Kassala, River Nile and Northern. There has also been the use of larviciding (with Temephos EC 50%) in urban centres and limited use of *Gambusia* fish for biological control of mosquito larvae in selected areas.

Table 1.1 LLINs distributed from 2006 – 2009* in the northern states of the Sudan

State	No. of LLINs distributed from 2006-2009
Blue Nile	323,300
Gedarif	392,253
Gezira	885,000
Kassala	336,000
Khartoum	560,000
North Darfur	286,000
North Kordofan	950,000
Northern	115,000
Red Sea	160,177
River Nile	275,650
Sennar	272,007
South Darfur	512,000
South Kordofan	453,900
West Darfur	435,000
White Nile	493,683
Total	**6,449,970**

1.3.2 Providing prompt effective treatment

Health care is provided at three levels: the primary care level constituting 95% of all formal health care facilities (including Basic Health units and health centres); the secondary referral level (including general or rural hospitals); and the tertiary level (provincial or specialist hospitals). Primary health care facilities, excluding health centres, are under the responsibility of the local administrative councils and responsible to the State Ministry of Health (SMoH). Secondary care facilities and health centres are under the exclusive control of the State Ministry of Health. Public health care services in Sudan is payable for both diagnosis and treatment exception is the emergency health care. Now the government is expanding these services to cover under 5 children treatment and some special services including surgery. It has been estimated that in 2002 only 15% of the total population have access to essential drugs (FMOH

Annual Statistics Report, 2002). In the majority of cases the diagnosis of malaria is still on clinical basis and scaling up of parasitological diagnosis has just only began.

An important meeting was held in October 2003 convened by Médecins Sans Frontières (MSF), the FMOH and WHO and led to the formation of the Technical Advisory Committee (TAC). In 2004 the TAC re-examined the evidence from drug sensitivity testing and sensitivity testing of other combinations at several sites across the country (Adam et al., 2004; 2005; van den Broek et al., 2003; Abdel-Hameed et al., 2001; Salah et al., 2005) and decided to abandon chloroquine as the first-line recommended therapeutic for uncomplicated malaria and replace the policy with co-blister of artesunate +sulfadoxine/pyrimethamine (AS+SP) from June 2004 with Artemether-Lumefantrine reserved as second-line treatment for treatment failures (Malik et al., 2006). Responsibility for drug procurement is with the Federal Central Medical Drug Supply agency through tendered purchase from international companies, but still the private sector plays an important role as well as the international donors and funds. In 2008, 2,755,700 treatment doses of AS+SP were procured and distributed in all northern states free of charge through GFATM and UNICEF funding mechanisms.

Sudan is a member of Horn of Africa Network for Monitoring Antimalarial Treatment (HANMAT) and has established a network of sentinel drug sensitivity testing sites to monitor parasite resistance to first-line and second-line drugs as well as testing potential new malaria treatments. The use of in-vivo methods and expanson in the use of molecular markers is also being explored. By 2008, the efficacy of the 1st and 2nd line treatment are 96.1% and 90.4% respectively.

Home-based management has received a lot of international attention and recent studies in Sudan suggest early successes with this close-to-home presumtive malaria treatment strategy (Elmardi et.al. 2009). The National Malaria Strategy 2007-2012 highlights the need to expand this approach during the next phase of malaria control by improving the practice of home and community-based malaria care by training and providing medicines to village or community health workers (FMoH, 2006)

In most major main urban centres laboratories perform blood slide examination to assist clinical diagnosis and managment of malaria, however across the rural areas diagnosis is largely presumptive based and based on IMCI guidelines. There are efforts to improve the quality and scope of functional parsitological diagnosis across northern states of Sudan. Almost all laboratories use the semi-quantitative method (the plus system) to quantify parasitaemia. A recognized improvement in microscopic diagnosis is noticed, but the false positive is still somewhat high (NMCP 2008). There is a proposal to expand the use of Rapid diagnostic tests (RDTs) in the public sector under the Islamic Development Bank and the round 7 GFATM support.

In October 2005 during the household sample survey across 10 states (FMOH/NMCP, 2005), 38% of the surveyed population reported experiencing a fever in the two weeks prior to the survey. 43% of patients sought treatment within 24 hours. Only 6% of fevers sought treatment at a Basic Health Unit facility, the majority (55%) sought treatment from a State health centre or hospital, 12% sought treatment from a private clinic, 19% sought treatment at a private pharmacy or drug store and 8% reported some form of self treatment at home. Only 0.3% used some form of traditional healer or treatment. Of the 4041 fevers reported in the last two weeks 2297 (57%) were reported to have been treated with some form of anti-malarial drug. Only 242 (10.5%) of the anti-malarial treatments were with AS+SP; 65% were chloroquine. In January 2006 importation of chloroquine was banned. And the low rates of AS+SP use reflect the early time-period between survey and effective implementation of the policy change (Malik et al.,

2006). Data on the proportions of fever treated with AS+SP within 24/48 hours was not provided in the report nor was any information collected on the proportions of fevers investigated using a diagnostic test.

1.3.3 Malaria in Pregnancy

It is estimated that 85% of women deliver at home. In general, providers are not authorized to dispense drugs. Pilot studies of Intermittent Preventive Treatment in pregnancy (IPTp) with SP have been undertaken in conjunction with the State level malaria programs, reproductive health departments and State obstetrician in Umgar and Kosti (White Nile State), Damazine (Blue Nile State) and Wad Medani (Gezira State). In collaboration with Malaria Consortium consultants, the Strategic Plan for Controlling MIP was developed (NMCP 2006).

During the October 2005 household survey (FMOH/NMCP, 2005) a total of 963 women reported a pregnancy that had ended in a live birth in the two years preceding the survey. 73% of women sought antenatal care at some stage of their pregnancy, with large differences between States: Bahr el Gabal (96%) versus West Darfur (25%) and differences between rural women (65%) compared to urban women (89%). Most ANC services were provided by State health centers or hospitals (60%) and some sought care from private clinics (13%). Only 1.8% of women reported receiving at least 2 doses of SP. However, 10% of women reported receiving some chemoprophylaxis during pregnancy with the majority of these receiving chloroquine.

Currently 8 states are targeted for IPTp, of which 4 (Blue Nile, Gezira, Sennar and South Kordofan) are wholly targeted while partial targeting has been implemented in Gedarif, Kassala, South Darfur and White Nile.

1.3.4 Malaria Epidemics

A Malaria Early Warning System (MEWS) has been established. It is not clear how effective this system is in detecting epidemics. Malaria surveillance system through different representative sentinel sites at all northern states has also been established. The aim is to detect early any malaria epidemics and responding effectively. The response to early detective system flags includes the use of buffer stocks of case management and preventive supplies including drugs and action has to be initiated at State levels and communicated to the NMCP at Federal levels.

1.4 Objectives of the Malaria Indicator Survey of 2009

The overall objective of the survey is to monitor the progress and to provide evidence for further investment and implementation of national malaria strategy by collecting information on the coverage of malaria indicators and the prevalence of malaria infection.

Specific objectives:

1. To examine the status of (ITN, ACT, IPT, IRS, and IEC) coverage and use among all age groups with certain consideration to children under five and/or pregnant women in Northern States of the Sudan.
2. To measure the prevalence of malaria parasite in all age groups using rapid diagnostic tests (RDTs) and microscopy.
3. To build capacity of the national malaria control programme and its partners in the implementation of MIS.

4. To provide strategic orientation of malaria control programmes using the results of the MIS.

1.5 Methodology

The survey covered all 15 northern states in Sudan and was based on a nationally representative sample of households to provide precise estimates of core malaria control indicators at the national and state levels and for urban and rural populations. According to the national census of 2008, these 15 states had a combined population of 30.58 million residing in 4,800,770 household of which 34.5% were urban.

1.5.1 Sample size estimation and sample selection

In developing the sampling strategy recent information on prevalence of key indicators and population distribution were required. The selected key indicator for sampling was the '*proportion of children below the age of five years who slept under an LLIN the night before survey*'. The estimate for this indicator was obtained from the MIS of 2005. Population distribution data, particularly the proportion of the population who were under the age of five years and the mean household size were obtained from the national census of the year 2008.

A traditional multi-stage cluster sample survey design (Macro International, 1996) proceeds by an initial random selection of population clusters (weighted by population where appropriate) and the subsequent random selection of households within each sampled cluster. Decisions on the sample size (the number of clusters, and households within each cluster, to sample) are generally based on a desired level of precision in indicator summary estimates, generally at a prescribed level of spatial aggregation defined by administrative units. Stratifications, such as between urban and rural areas, can also be introduced to ensure areas with known distinct characteristics are captured.

The sampling approach for the Sudan MIS had two stages. In the first stage, the traditional household cluster sample design (equation 1) was used to define the overall sample size as follows:

$$n = [4\,(r)\,(1 - r)\,(f)\,(1.1)] / [(e*r)^2\,(p)\,(n_h)] \quad \text{.....equation 1}$$

where

n = the required sample size for the KEY (rarest) indicator,
4 = a factor to achieve the 95 percent level of confidence,
r = the predicted or anticipated prevalence (coverage rate) for the key indicator, in this case the proportion of children sleeping under LLIN the night before survey which was estimated at 7.8% in the MIS 2005.
1.1 = the factor necessary to raise the sample size by 10 percent for non-response,
f = the design effect *(deff)*, 1.5 was selected for the purposes of this survey
e = the margin of error to be tolerated (0.12 as advised in the MIS sampling manual)
p = the proportion of the total population that the smallest group comprises (15% of the population were children under the age of five years from the 2008 national census)
n_h = the average household size (this was 5.9 from the 2008 national census)

Based on this sampling approach, a total of 5,800 households were required to provide precise estimates of the key indicator at the national and state levels and for urban and rural

populations. At an average of 20 households per cluster, therefore, 290 clusters were required for the 2009 northern states of Sudan survey which was increased to 300 clusters or 6000 households (Appendix A).

These clusters were then allocated into urban and rural categories proportionately within each state according to the 2008 national census. Once the clusters are classified into urban and rural, a list of Popular Administrative Units (PAUs) provided by the National Statistics and Census Office, were used to determine those PAUs in which survey clusters will be located. The PAUs in each state were selected according to probability proportional to size method. Then within each PAU, a cluster will be selected also using probability proportional to size method.

Because the selection of the PAUs and the clusters was done probability proportional to size, sample weighting was implemented only at the household level and weights were derived as the inversed of the probability of selecting a household within a cluster.

1.5.2 Development of survey questionnaires and manuals

The process of the development of the survey questionnaires and manuals began in July 2009 and continued through to the week before survey. Three survey questionnaires were developed first in English and then translated to Arabic and checked by several independent persons conversant in both English and Arabic, using the templates developed by the RBM-MERG as a basis (RBM-MERG 2007) with modifications to capture information on all ages. These questionnaires are: a household questionnaire; a household members questionnaires; a women's questionnaire.

The household questionnaire captured information on all usual members and visitors of the selected households. For each household member the following data were collected: age, sex, education, and relationship to the head of the household. The household questionnaire also recorded data on household head's education level and household assets to assess household socio-economic status. Information on the household ownership of mosquito nets and their use by household members was recorded. Data on household exposure to indoor insecticide spraying (IRS) and information-education-communication (IEC) activities were collected (Appendix B).

The household members' questionnaire recorded information on all household members on whether they had fever in the last 14 days and whether they sought treatment for the fever in that time; sources of treatment and drugs used. The questionnaire also had a section detailing recent travel history and net use while travelling and the final section captured information on malaria infection status for each assenting individual who were examined for parasitaemia first using RDTs; thick and thin blood smears.

The women's questionnaire was administered to consenting women aged 15-49 years who have ever been married and collected data on background characteristics, brief reproductive history, and use of ANC and IPTp services in most recent pregnancy and any preceding pregnancy that resulted in a delivery within the last 12 months (Appendix B).

1.5.3 Training and Pre-test activities

In July 2009, after the development of the draft set of survey tools, 15 coordinators selected at the national level to lead the survey in each of the 15 states and an additional 15 representatives from the states were trained in Khartoum for a period of one week. Training was undertaken on general interviewing skills, administration of consent forms, filling of questionnaires, collection of blood samples and the appropriate treatment of individuals found positive for malaria. Team members were also trained in the use of global positioning systems for mapping of clusters. A set of clusters in Khartoum, which were subsequently excluded from the actual surveys, were selected for testing of the survey tools. All filled questionnaires were then evaluated again and correction of mistakes and clarifications were made during pre-testing and any necessary adjustments to the survey tools resulting from the pre-test were then be undertaken.

A second more intensive training was then held on 29th September – 4th October in Khartoum in which dummy interviews and a pilot of tools was done. The trained state coordinators acted as trainers of field workers and this process, supervised and facilitated by the NMCP, run concurrently for a period of one week in each state. Each state then piloted the questionnaires in the state capital. The training in the states was held from 5th to 7th October. Training in the use of global positioning systems (GPS) for mapping of the households was also undertaken at this time. Laboratory technicians who undertook the reading of slides were trained on the 1st to 3rd October 2009.

1.5.4 Administrative preparation and community sensitization

A community sensitization exercise was undertaken a few weeks before and through the survey period in the print, radio and television media by the NMCP of the FMoH. A detailed kit of media materials was prepared to aid with this community sensitization. The sensitization message covered the risk malaria poses to population health, the efforts the government is undertaking to fight malaria, the need for information on the burden of the disease and hence the importance of the malaria indicator survey. Listeners were encouraged to support and participate in the survey and will be assured that those who were found to have malaria will be treated with effective drugs. Local administration, health NGOs and women associations were engaged to spread by word of mouth the impending malaria survey and to drum up support in their local communities. From past experience in Sudan, most people tend to be away from home in the early part of the day and often many household members are absent. To minimize this all community elders in

the selected clusters were contacted before the survey and were asked to mobilize members of the village to be present during the day of survey.

1.5.5 Composition and responsibilities of survey management and field team

Overall, the survey management team was composed of an international consultant designated by the WHO; a national consultant; 5 national coordinators; 15 state coordinators selected at the national level; 15 state coordinators selected at the state level; and 196 field team members from 28 teams of 7 individuals each.

The role of the international consultant was, in collaboration with the national malaria programme and national consultant, be responsible for general survey oversight; develop a scientifically sound survey protocol; design the survey sample; develop survey tools; field manuals; budget; electronic data entry forms; provide training to trainers of trainees; supervise data entry; undertake data analysis and writing of survey report. The national consultant work closely with international consultant to achieve the aforementioned tasks; ensure of overall successful implementation of survey; facilitate the local review and ethical approval of the survey protocol and participate in data analysis and report writing.

The national coordinators were drawn primarily from the NMCP national office and assisted the consultants in all aspects of survey preparation and management; were in charge of making sure that the survey is going to cover the targeted malaria indicators and objectives taking in consideration the special Sudanese situation; the actual survey implementation; management of survey budget; hiring of survey teams; procurement of survey materials; storage of survey questionnaires and samples; management of data entry; and participated review of survey report. The dissemination of survey results was primarily the responsibility of the national coordinators, headed by the Director of the NMCP. The overall survey coordinator was assigned from the NMCP to, in addition to the tasks mentioned for the national coordinators, coordinate and actively participate in the whole survey steps and process, facilitate development of survey methodologies to the full survey proposal, help in survey tools development, support survey process and implementation, contribute to survey data management and report development and writing till final approval and submission, and monitoring and supervision of survey steps and process.

The state coordinators selected at the national level acted as trainers of the survey field teams and in collaboration with the state coordinators selected at the state level and were in-charge of day to day management of the survey in their respective states. They also acted as the bridge between the field teams and the national level management team. They were responsible for daily checking of questionnaires and proper storage of survey materials; briefing of survey teams each day prior to start of survey and ensured appropriate inventory and registration of survey questionnaires; RDTs (First Response Malaria Ag (pLDH/HRP2) COMBO, Premier Medical Corporation Ltd); and slides before they handed over to the relevant teams for analysis. The state coordinators selected at the state level were responsible for the identification and hiring of field surveyors with the help of national-level state coordinators, organized and participated in training of survey team at state level, ensured all relevant state level departments are on-board, and in collaboration with national-level state coordinator were responsible for day to day management of survey and daily checking of questionnaires and proper storage of survey materials and maintaining daily contact with national level state coordinators.

Each survey field team consisted of 7 persons comprising 1 supervisor; 2 interviewers; 2 nurses or equivalent; and 2 laboratory technicians resulting in 28 field teams. Survey teams visited a selected cluster a day and equally divided the 20 households targeted per cluster. The supervisor then ensured that all survey procedures were followed and field teams conducted household interviews appropriately. The supervisor also checked that all questionnaires were correctly coded and filled before departing the cluster. The supervisor was also responsible for ensuring that call-backs were attended to and was the custodian of the survey questionnaires and other materials until they were handed over to the state coordinators. A complete registry of these materials was maintained by the supervisor; the state coordinators and the national coordinators.

1.5.6 Field work and quality control

The survey began on the 17th October 2009 and continued for a period of 10 days. For some of the large and sparsely populated states extra survey days were allocated and such that surveys in these states continued to the 5th November 2009.

Each survey team visited a cluster per day. At the end of each survey day, all questionnaires, RDTs, and blood slides were submitted to the state coordinators for review and storage. The state coordinators then reviewed the survey team's daily submissions and suggested corrections where necessary. The national consultant and NMCP national coordinators had also visited the states to review survey progress. At the end of every five days, the state coordinators submitted completed questionnaires to the NMCP office in Khartoum where a central data entry system was established. The slides were retained at the state for initial analysis and by 5th November 2009 were submitted to the national level for a second reading and a final reading for quality assurance at the Sennar reference lab.

1.5.7 Malaria testing

To avoid or minimize the inconvenience and pain caused during the collection of blood samples, only a single finger prick was used for the collection of the different blood samples. The first drop was wiped off from the finger using a swab dipped in methylated spirit, the second drop was applied to the RDT First Response Malaria Ag (pLDH/HRP2) COMBO, Premier Medical Corporation Ltd); and the subsequent sets of drops were used to prepare a thick and thin blood films . All leftover materials used

for the collection of blood samples, such as lancets and swabs were carried from the household in a special biohazard box and appropriately disposed of at the end of the survey day.

1.5.8 Data entry and analysis

Twenty trained data entry personnel were used to capture information from the survey questionnaires using customized data entry screens developed in Microsoft Access 2007. Data entry of the data was undertaken in a central place at the NMCP offices in Khartoum. The 20 data clerks were divided into equal groups each led by a data manager. Once entered data were checked for consistencies by the data manager and necessary corrections were made. Data were then submitted to the NMCP M&E officer who then sent the data to the international consultant for further cleaning and analysis. The results of the blood slides were recorded in customized forms in the laboratory. Cleaning and analysis of the survey data were undertaken by the international consultant in December and January and a final report will be published by the year 2010.

1.5.9 Ethical considerations and ethical review

Ethical clearance and consent to conduct interviews were obtained from the National Research Ethics Committee of the Federal Ministry of Health (letter no: **fmoh/rd/SEC/09, date: 7/9/2009**). Measures were taken to ensure the respect, dignity and freedom of each individual participating in the study. During training of the interviewers, emphasis was placed on the importance of obtaining signed informed consent and the avoidance of any kind of coercion. Where children below 15 years are involved, an informed consent was obtained from the household head; the mother or other guardians. To ensure confidentiality, all household members were identified by a unique code and personal data was only be accessed by the main investigators. the state, or national coordinators. The respondent was informed about all relevant aspects of the study including its aim, procedures attendant risk and hazards and the potential and that their participation was strictly on a voluntary basis. Those seen positive for malaria using the RDT were treated on the spot using nationally recommended antimalarial drugs.

CHAPTER 2: CHARACTERISTICS OF HOUSEHOLDS AND RESPONDENTS

A household was defined as a person or group of persons, related or not, living together in the same dwelling unit, under one household head, sharing a common source of food. The household questionnaire collected basic demographic and socio-economic characteristics for each person who spent the night preceding the survey in the sampled household, including usual residents and visitors, as well as information on their household characteristics. This chapter describes the demographic characteristics of household populations and distribution of household assets that have been used in defining household socio-economic status in subsequent chapters. The survey enumerated all de jure (persons usually resident in the selected households) and de facto (populations' resident on the night prior to survey). The difference between these two populations is small and unless otherwise specified all tables in this chapter refer to the de facto population.

2.1 Household population

Table 2.1 Household population by age, sex and residence

Percent distribution of de facto household population by age, sex and residence, Sudan northern states MIS 2009

	Rural			Urban			Total		
Age (years)	Male	Female	Total	Male	Female	Total	Male	Female	Total
0-4	22.2	18.0	20.0	15.3	13.6	14.4	19.6	16.5	17.9
5-9	17.9	14.9	16.3	14.4	11.5	12.9	16.6	13.7	15.1
10-14	11.8	11.7	11.8	12.3	11.1	11.7	12.0	11.5	11.7
15-19	7.4	9.2	8.4	9.2	10.8	10.0	8.1	9.8	9.0
20-24	5.0	8.8	7.0	7.6	9.5	8.6	6.0	9.1	7.6
25-29	4.5	9.3	7.1	5.8	9.6	7.8	5.0	9.4	7.3
30-34	4.8	5.5	5.2	5.7	6.8	6.2	5.1	6.0	5.6
35-39	5.5	6.4	6.0	5.2	7.2	6.2	5.4	6.7	6.1
40-44	4.3	3.7	4.0	5.3	4.8	5.1	4.7	4.1	4.4
45-49	3.6	2.4	3.0	4.5	3.8	4.1	3.9	2.9	3.4
50-54	3.3	3.9	3.6	4.3	4.6	4.5	3.7	4.2	3.9
55-59	2.1	1.7	1.9	2.6	1.8	2.2	2.3	1.8	2.0
60-64	2.5	1.5	1.9	2.8	1.9	2.3	2.6	1.6	2.1
65-69	1.6	0.9	1.2	1.7	1.1	1.4	1.6	1.0	1.3
70-74	1.4	1.0	1.2	1.6	0.8	1.2	1.5	0.9	1.2
75-79	0.8	0.4	0.6	0.7	0.4	0.5	0.8	0.4	0.6
80+	1.1	0.4	0.7	0.9	0.6	0.7	1.0	0.5	0.7
Don't know/missing	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number	8,998	10,342	19,240	5,368	5,796	11,164	14,366	16,138	30,504

Table 2.1 shows the distribution of de facto household population by age, sex and residence. A total of 30,504 individuals were enumerated with marginally more female (52.9%) than male members with the difference greater in rural areas compared to urban. 53.7% of the sampled

population were below the age of 20 years and only 13.5% of the male and 10.4% of the female household population was aged 50 or more years.

Table 2.2 Household composition

Percent distribution of household by head and de jure household population by residence and mean household size, Sudan northern states MIS 2009

	Urban	Rural	Total
Gender of household head			
Male	86.9	84.5	85.3
Female	13.1	15.5	14.7
Number of Usual members			
1	3.41	3.45	3.43
2	6.38	8.49	7.76
3	12.18	13.50	13.05
4	17.35	16.90	17.05
5	16.03	16.41	16.28
6	11.45	14.17	13.23
7	12.04	10.31	10.91
8	7.85	6.97	7.27
9+	13.30	9.80	11.01
Mean household size	5.5	5.2	5.3
Number of households	2,092	3,888	5,980

Table 2.2 shows the composition of over 5,980 sampled households. Over 85% of all households were headed by men. Average household size was 5.3 and was marginally smaller in rural areas. Almost 45% of urban households and 43% of rural households had more members than the national average of 5.0 persons per household.

2.2 Household characteristics

2.2.1 Drinking water and sanitation

Table 2.3 shows the distribution of household source of drinking water. In urban areas, almost 67% of the population had access to piped water: 56.5% piped into the dwelling; 6.5% into the compound; and 4.5% from a public tap. The second most common source of water (22.2%) in urban areas was delivery by a cart with small tanks mounted. In rural areas, however, 31.8% of the households accessed water through piped system, 29.1% from wells and boreholes and 12.4% through delivery by a cart with small tanks mounted.

With regard to household sanitation, Table 2.3 shows that only 21.2% of urban households used a flush toilet or flush latrine but the majority (70.6%) used pit latrines. In rural areas, about 3% of the households had access to a flush toilet or latrine, the majority (57.6%) used pit latrines while

a considerable number (38.6%) did not have access to a toilet or latrine and instead used bushes and fields.

Table 2.3 Household drinking water

Percent distribution of households by source of drinking water, according to urban-rural residence, Sudan northern states MIS 2009

	Urban	Rural	Total
Household drinking water			
Piped water into dwelling	56.5	11.5	27.0
Piped water in yard/plot	6.5	13.7	11.2
Piped water from public tap	4.5	6.6	5.8
Tube well or borehole	0.7	4.0	2.9
Protected well	2.1	13.9	9.9
Unprotected well	2.5	11.2	8.2
Protected spring	0.0	0.5	0.4
Unprotected spring	0.0	3.0	2.0
Rainwater	0.0	0.2	0.2
Tanker Truck	2.4	4.2	3.6
Cart with small tank	22.2	12.4	15.8
Rivers/streams/lakes/dams	0.6	5.5	3.8
Pond	0.5	4.7	3.2
Bottled water	0.0	0.3	0.2
Canal/irrigation channel	0.2	2.2	1.5
Other	1.2	6.1	4.4
Household sanitation			
Flush to piped sewer system	1.5	0.3	0.7
Flush to septic tank	13.2	0.6	4.9
Flush to pit latrine	6.5	2.3	3.8
Ventilated Improved Pit latrine	11.3	2.6	5.6
Pit latrine with slab	29.0	28.8	28.9
Pit latrine without slab/Open pit	30.3	26.2	27.6
Composing toilet	1.3	0.2	0.6
Bucket toilet	0.1	0.1	0.1
No toilet/use bushes	6.7	38.6	27.6
Other	0.2	0.1	0.2

2.2.2 Housing characteristics

Table 2.4 summarizes information on housing characteristics. Overall, 41% of households had access to electricity comprising 68% of urban households and only 27% of rural households. In urban areas, natural gas was the predominant cooking fuel following by charcoal. In rural areas, however, firewood (56%) was the main source of cooking fuel followed by natural gas (29%) and charcoal (14%). 71% of urban and 94% of rural households had earth/sand floor while 25% of urban households had either cement or ceramic tile floors.

Table 2.4 Housing characteristics

Percent distribution of households by housing characteristics, according to urban-rural residence, Sudan northern states MIS 2009

	Urban	Rural	Total
Electricity			
Yes	67.8	26.9	41.0
No	32.2	73.1	59.0
Cooking Fuel			
Electricity	0.3	0.2	0.2
LPG/Natural gas	63.2	29.0	40.8
Kerosene	0.1	0.0	0.1
Charcoal	27.8	13.9	18.7
Firewood	8.5	56.0	39.6
Dung	0.0	0.4	0.3
Other	0.0	0.4	0.3
Type of floor			
Earth/Sand	70.8	94.4	86.3
Dung	0.0	0.5	0.3
Wood planks	0.5	0.8	0.7
Vinyl/Asphalt strips	0.2	0.1	0.1
Ceramic tiles	13.5	1.5	5.6
Cement	11.5	2.3	5.5
Carpet	3.2	0.2	1.2
Other	0.3	0.2	0.3

2.2.3 Household possessions

Table 2.5 Household durable goods and means of transportation

Percent distribution of households by type of durable goods and means of transportation according to urban-rural residence, Sudan northern states MIS 2009

	Urban	Rural	Total
Household effects			
Radio	74.5	52.5	61.6
Television	69.7	23.8	42.7
Telephone	80.9	42.5	58.3
Refrigerator	49.5	13.4	28.3
Means of transport			
Bicycle	13.7	9.6	11.3
Motorcycle	6.9	2.0	4.0
Car/Truck	18.2	6.2	11.2
Cart	7.4	18.8	14.1
Camel/Donkey/Horse	8.9	44.3	29.7

Overall 62% of households owned a radio; 43% owned a television set; 58% owned a telephone and 28% owned a refrigerator. Ownership of all these assets was considerably higher in urban households compared to rural. The main mode of transport used or owned by households in urban areas was a car or truck followed by bicycles while in rural areas was a camel, donkey or horse (Table 2.5).

2.3 Construction of household wealth index from household assets

Using the household asset indicators described in section 2.2, principal component analysis (PCA) which is a data reduction techniques was used to construct weights, representing the importance and direction of each asset indicator's contribution to household wealth, was implemented. These weights were then applied to each household to compute a composite wealth index which was then used to rank households from the highest (1) to the lowest (5) wealth quintiles. See Appendix C for details of the PCA weights.

2.4 Characteristics of women respondents

Table 2.6 shows that almost 45% of all women respondents (ages 15-49 years) were below 30 years of age. Almost 37% of women between 15-49 years of age have not obtained any formal education; 34% had primary level education and 19% had secondary or higher level of education while10% had obtained religious education.

Table 2.6 Characteristics of women respondents

Percent distribution of women aged 15-49 by age, residence and education, Sudan northern states MIS 2009

	Percent	Number
Age (years		
15 - 19	5.8	292
20 - 24	15.5	785
25 - 29	23.2	1,175
30 - 34	16.0	807
35 - 39	19.4	979
40+	20.1	1,016
Residence		
Urban	34.9	1,766
Rural	65.1	3,288
Education		
No formal education	36.9	1,866
Religious	10.0	507
Primary	33.8	1,710
Secondary and higher	19.2	971
Total		**5,054**

CHAPTER 3: COVERAGE OF KEY MALARIA INTERVENTIONS

3.1 Household ownership of mosquito nets

During the survey all sampled households were asked whether they owned any nets; how many nets they owned; where the nets were obtained from; the net brand; whether nets were ever treated and whether they were treated in last six months or the net was an LLIN. Where households consented, interviewers observed each net owned by the household. For the purpose of this survey, an insecticide treated net (ITN) was defined as: 1) a factory-treated net that does not require any treatment, i.e. LLIN; 2) a pretreated net obtained within the last 6 months but might require re-treatment; or 3) a net that has been soaked with insecticide within the past 6 months.

Table 3.1 Household ownership of any nets; an insecticide-treated nets (ITN) ; and long lasting insecticidal nets (LLINs), Sudan northern states MIS 2009

	Any type of mosquito net			ITN			LLIN			
	%with at least one net	%with more than one net	Average number of nets per household	%with at least one net	%with more than one net	Average number of nets per household	%with at least one net	%with more than one net	Average number of nets per household	Number of Households surveyed
Residence										
Urban	50.2	34.6	1.1	36.8	22.2	0.7	35.3	21.1	0.7	2,092
Rural	58.3	36.1	1.2	44.7	23.6	0.8	43.7	22.8	0.8	3,888
Region										
Blue Nile	69.8	56.6	1.7	51.4	41.4	1.2	51.4	41.4	1.2	239
Gedarif	73.7	45.6	1.4	64.6	35.0	1.2	58.5	30.9	1.1	279
Gezira	69.7	34.3	1.2	48.0	20.9	0.8	47.4	19.7	0.7	640
Kassala	50.3	35.3	1.0	33.1	24.3	0.6	32.3	24.3	0.6	338
Khartoum	30.7	17.2	0.6	23.7	11.5	0.4	23.4	11.3	0.4	1,054
North Darfur	56.5	36.4	1.1	48.9	27.3	0.9	45.8	25.9	0.8	357
North Kordofan	56.8	39.7	1.2	44.3	25.4	0.8	42.7	23.4	0.8	578
Northern	49.4	21.7	0.8	36.1	9.3	0.5	36.1	9.3	0.5	218
Red Sea	35.4	23.4	0.8	27.6	14.4	0.5	26.3	14.1	0.5	239
River Nile	71.2	42.3	1.6	64.6	29.2	1.1	63.8	29.2	1.1	239
Sennar	54.1	34.7	1.0	46.1	24.7	0.8	42.4	19.9	0.7	279
South Darfur	66.0	49.5	1.7	43.1	27.8	1.0	42.6	27.4	0.9	600
South Kordofan	67.8	49.5	1.6	54.2	32.4	1.0	53.1	31.4	1.0	279
West Darfur	60.6	37.2	1.2	39.4	19.7	0.7	38.7	19.4	0.7	280
White Nile	75.9	56.8	1.8	54.2	36.6	1.1	53.2	35.7	1.1	360
Wealth quintile										
Highest	48.5	31.5	1.1	36.7	20.4	0.7	35.2	18.8	0.6	1,199
Fourth	61.5	40.5	1.4	47.0	26.5	0.9	45.7	25.1	0.8	1,197
Middle	60.2	41.4	1.3	44.8	26.4	0.8	43.6	25.8	0.8	1,193
Second	57.4	37.0	1.2	42.9	24.1	0.8	41.9	23.4	0.8	1,193
Lowest	47.5	27.1	0.9	36.0	17.8	0.6	35.1	17.3	0.6	1,198
Total	**55.0**	**35.5**	**1.1**	**41.4**	**23.0**	**0.8**	**40.3**	**22.1**	**0.7**	**5,980**

Table 3.1 summarizes household net ownership. Overall 55% of households (50% urban and 58% rural) owned at least one net while 36% (35% urban and 36% rural) owned more than 1 net. Households in seven states (Blue Nile, Gedarif, Gezira, River Nile, South Darfur, South Kordofan and White Nile) had more than 66% of the households owning at least one net. The lowest household net ownership was reported in the states of Khartoum (31%) and Red Sea. Household ownership of at least one or more than one ITN (41% and 23%) or one LLIN (40% and 22%) followed the same pattern of as ownership of any net by residence, state or wealth index. Interestingly, there were no significant differences between ownership of nets/ITNs/LLINs between the poorest and the wealthiest households. 65% and 63% of all nets in the households were ITNs and LLINs respectively while 97% of all ITNs were LLINs. Overall mean nets, ITNs and LLINs per household were 1.1, 0.8, and 0.7 respectively with minimal differences between urban and rural or by wealth status. Household ownership of at least one LLIN was >40% in Blue Nile, Gedarif, Gezira, North Darfur, North Kordofan, River Nile, Sennar, South Darfur, South Kordofan and White Nile. Two states, Khartoum and Red Sea, reported household ownership of at least one LLIN of less than 30%. Only Blue Nile state, however, had 40% or more of households reporting ownership of two or more LLINs.

3.2 Use of mosquito nets

Although the national mosquito bed net strategy targets children under the age of five years and pregnant women, information on net use by all age groups was collected to assess overall net use. This information is important because the northern states of the Sudan are generally a low malaria transmission area and because of the very low exposure the population is not equipped with functional immunity against malaria. As a result, the clinical consequences of infection are equivalent in children and adults and all should ideally be equally protected with a treated mosquito net. Recent RBM-WHO recommendations indeed require universal coverage with treated mosquito nets and the Sudan is planning to adopt this strategy starting 2010.

Table 3.2 shows that 15% of household members slept under any mosquito net the night prior to survey with 11% sleeping under an LLIN. There were no major differences in LLIN use by gender, residence although proportionately more individuals below the age of five years slept under an LLIN (21%) compared to older age groups. Although overall LLIN use was low, eight states (Blue Nile, Gedarif, North Darfur, South Darfur, South Kordofan, West Darfur and White Nile) reported LLIN use among all household members of 20% to 35%.

When use of mosquito nets was assessed only among individual who were from household that owned at least one net/ITN/LLIN (Table 3.3), the proportrion of household members sleeping under any net increased to 25.9%; 25.4% ITN; and 25.0% LLIN. The pattern of net, ITN and LLIN use across residence, age, gender, state and wealth quintile remained similar to the results observed in Table 3.2.

Among children under the age of five years (Table 3.4) overall use of ITN and LLIN was 16.1% and 15.5% respectively. There were significant variations, however, between states with the Blue Nile, Gedarif, Gezira, North Darfur, South Darfur, West Darfur and White all reporting ITN use of greater than 20% among children under the age of five years, over 97% of these ITNs being LLINs. ITNs and LLINs use was below 10% in Khartoum, North Kordofan, Northern and Red Sea states. There were no major different in net/ITN/LLIN use by residence or between the poorest and richest households.

Table 3.2 Use of mosquito nets by household members

Percentage of the sample population who slept under any nets; an insecticide-treated nets (ITN) ; and a long lasting insecticidal nets (LLINs) the night before survey by sex, residence, region and wealth quintile, Sudan northern states MIS 2009

	Percentage who slept under			
	Any net	ITN	LLIN	Number of individuals
Sex				
Male	14.1	10.4	10.3	13,718
Female	15.4	11.5	11.1	15,876
Residence				
Urban	14.0	10.6	10.0	10,844
Rural	15.4	11.7	11.4	18,750
Age*				
0-4	21.3	16.3	15.7	5,415
5-19	13.2	9.8	9.4	10,607
20-44	14.0	10.8	10.5	9,087
>44	12.4	9.6	9.3	4,431
Region				
Blue Nile	30.9	22.7	22.5	1,112
Gedarif	20.1	18.0	15.2	1,318
Gezira	17.7	13.7	13.4	3,355
Kassala	10.2	8.1	7.9	2,084
Khartoum	3.7	3.1	3.1	5,565
North Darfur	21.1	18.0	16.9	1,514
North Kordofan	8.5	5.8	5.3	3,251
Northern	9.3	0.8	0.8	918
Red Sea	4.8	2.6	2.4	915
River Nile	10.7	6.9	7.0	1,325
Sennar	17.6	15.2	13.3	1,226
South Darfur	28.1	21.3	20.4	2,885
South Kordofan	21.4	17.3	17.1	1,214
West Darfur	27.2	16.1	15.1	1,170
White Nile	34.5	24.6	22.6	1,742
Wealth quintile				
Highest	9.9	7.6	6.9	6,459
Fourth	15.2	11.6	11.3	6,494
Middle	18.5	14.4	14.0	5,746
Second	17.6	12.7	12.4	5,507
Lowest	14.2	11.1	10.7	5,387
Total	**14.8**	**11.2**	**10.8**	**29,594**

*54 individuals had missing age data.

Although generally household members' use of nets/ITNs/LLINs correlated with household ownership of the nets/ITNs/LLINs, there were some states where the ratio of net/ITN/LLIN use and household ownership of the same was below the average national ratio of 0.27. These states were Gedarif, Kassala, Khartoum, North Kordofan, Northern, Red Sea and River Nile. Table 3.4 shows the use of nets/ITN/LLIN among children under the age of five years in households where there was at list one net/ITN/LLIN. Approximately 35%, 34% and 34% slept under any mosquito net, an ITN or an LLIN the night prior to the survey respectively. These

estimates were considerably higher than those presented in Table 3.3 when all children under five were used as the denominator regardless of whether or not they lived in a household with a net/ITN/LLIN.

Table 3.3 Use of mosquito nets by members in households that owned at least one net/ITN/LLIN

Percentage of the sample population who slept under any nets; an insecticide-treated nets (ITN) ; and an long lasting insecticidal nets (LLINs) the night before survey by sex, residence, region and wealth quintile, Sudan northern states MIS 2009

	Any net	ITN	LLIN	Any net	ITN	LLIN
Sex						
Male	24.8	24.4	23.9	7,885	5,914	5,767
Female	26.8	26.4	26.0	9,202	6,928	6,775
Residence						
Urban	26.3	26.5	25.9	5,812	4,309	4,166
Rural	25.6	24.7	24.5	11,275	8,533	8,376
Age*						
0-4	34.9	34.5	34.1	3,315	2,517	2,450
5-19	22.5	21.5	21.0	6,297	4,746	4,647
20-44	25.4	25.4	25.1	5,063	3,785	3,694
>44	23.7	23.6	23.4	2,381	1,773	1,730
Region						
Blue Nile	42.9	42.6	42.4	773	590	590
Gedarif	26.2	25.9	23.9	1,036	945	878
Gezira	24.7	28.0	27.8	2,338	1,485	1,467
Kassala	19.5	23.7	23.5	1,065	690	677
Khartoum	11.8	12.9	13.0	1,797	1,390	1,374
North Darfur	37.3	36.9	37.0	871	746	700
North Kordofan	14.7	12.7	11.9	1,814	1,441	1,392
Northern	1.9	1.7	1.7	497	363	363
Red Sea	11.2	7.9	7.3	378	310	303
River Nile	14.6	10.5	10.7	879	801	788
Sennar	31.1	30.9	28.9	706	598	569
South Darfur	39.8	43.7	43.6	1985	1,311	1,303
South Kordofan	29.1	26.4	26.4	867	699	686
West Darfur	41.9	36.5	36.2	761	472	463
White Nile	43.7	39.3	37.9	1,320	1,001	989
Wealth quintile						
Highest	20.5	20.6	19.5	3,263	2,390	2,303
Fourth	23.8	23.0	22.9	4,177	3,154	3,083
Middle	28.6	28.8	28.4	3,594	2,743	2,690
Second	29.5	27.6	27.3	3,311	2,485	2,437
Lowest	28.7	29.0	28.6	2,742	2,070	2,029
Total	**25.9**	**25.4**	**25.0**	**17,087**	**12,842**	**12,542**

Table 3.4 Use of mosquito nets by children under the age of five years

Percentage of the sample under five population who slept under any nets; an insecticide-treated nets (ITN) ; and a long lasting insecticidal nets (LLINs) the night before survey by sex, residence, region and wealth quintile, Sudan northern states MIS 2009

	Percentage who slept under			
	Any net	ITN	LLIN	Number of individuals
Sex				
Male	21.7	16.2	15.5	2,784
Female	20.8	16.0	15.4	2,631
Residence				
Urban	20.5	15.1	14.3	1,596
Rural	21.7	16.7	16.1	3,819
Region				
Blue Nile	30.3	21.8	21.8	277
Gedarif	23.1	20.5	17.8	285
Gezira	28.4	23.3	22.9	542
Kassala	14.2	11.3	10.6	363
Khartoum	7.2	5.7	5.7	767
North Darfur	30.2	25.5	23.4	337
North Kordofan	12.6	9.1	8.4	664
Northern	2.5	2.5	2.5	99
Red Sea	9.3	5.7	5.1	125
River Nile	15.2	10.4	10.4	205
Sennar	23.5	19.8	16.2	168
South Darfur	32.3	23.7	23.3	629
South Kordofan	23.5	17.6	17.6	289
West Darfur	34.2	20.7	20.4	308
White Nile	41.2	30.0	28.8	357
Wealth quintile				
Highest	16.6	13.0	11.8	849
Fourth	23.5	17.5	17.1	953
Middle	23.6	18.6	18.0	1,153
Second	23.4	16.8	16.2	1,279
Lowest	18.8	14.3	13.7	1,181
Total	**21.3**	**16.1**	**15.5**	**5,415**

A total of 643/5,054 pregnant women were seen during the survey as shown in Table 3.4. Of these, 21.3% slept under a mosquito net the night before survey, 16.4% under an ITN and 16.1% under LLIN (Table 3.6). Women between the ages 25-34 reported higher rates of nets/ITNs/LLINs use compared to younger or older women while there was little difference in use by urban rural. However, a considerably higher proportion of women in the poorest households reported use of nets/ITNs/LLINs compared to those from the wealthiest households. Surprisingly, no pregnant woman reported to be using any type of net in Northern state, while use of any type of net was below 10% in Khartoum, North Kordofan, Read Sea and Sennar.

Among pregnant women who lived in households with at least one net/ITN/LLIN, however, the proportions of those sleeping under a mosquito net were higher than the overall estimates (Table 3.7). Overall about 36% of pregnant women slept under a net/ITN/LLIN in households

that had at least one of these types of mosquito nets In the states of Blue Nile, South Darfur and West Darfur, from 50% to over 70% of pregnant women who lived in households with at least one net/ITN/LLIN slept under mosquito nets. Similar to the pattern observed among all pregnant women, a higher proportion of those from the poorest households slept under mosquito in households with at least one net/ITN/LLIN

Table 3.5 Use of mosquito nets by children under the age of five years in households with at one net, an insecticide treated nets (ITN) or a long lasting insecticidal net (LLIN)

Percentage of the sample under five population who slept under any nets; ITNs; or LLINs the night before survey by sex, residence, region and wealth quintile, Sudan northern states MIS 2009

	Percentage who slept under			Number of children under the age of five years in households with		
	Any net	ITN	LLIN	Any net	ITN	LLIN
Sex						
Male	35.4	34.9	34.6	1,716	1,286	1,248
Female	33.6	33.3	32.8	1,637	1,258	1,229
Residence	35.6	35.7	35.3	947	687	655
Urban	34.2	33.4	32.9	2,406	1,857	1,822
Rural						
Region						
Blue Nile	39.7	38.7	38.7	200	152	152
Gedarif	28.9	27.8	26.1	235	217	206
Gezira	39.8	46.4	46.1	368	242	239
Kassala	27.1	33.2	32.5	180	119	115
Khartoum	19.1	19.8	19.9	295	229	228
North Darfur	47.3	4.5	44.9	217	190	177
North Kordofan	20.9	18.6	17.7	391	324	312
Northern	4.8	4.1	4.1	56	43	43
Red Sea	22.2	19.7	17.9	53	40	39
River Nile	21.6	16.4	16.8	127	116	112
Sennar	38.1	37.5	35.5	104	85	77
South Darfur	45.8	50.7	50.5	434	280	277
South Kordofan	31.5	27.5	27.7	199	160	159
West Darfur	50.6	44.8	44.8	211	138	135
White Nile	50.9	50.3	49.4	283	209	206
Wealth quintile						
Highest	31.3	31.8	31.0	468	354	332
Fourth	34.0	32.7	32.9	653	493	480
Middle	34.7	36.2	35.8	760	587	573
Second	36.9	34.7	34.0	816	622	610
Lowest	34.7	34.6	33.8	656	488	482
Total	**34.5**	**34.1**	**33.7**	**3,353**	**2,544**	**2,477**

Table 3.6 Use of mosquito nets by pregnant women

Percentage of the sample population of pregnant women who slept under any nets; an insecticide-treated nets (ITN); and a long lasting insecticidal nets (LLINs) the night before survey by age, residence, region and wealth quintile, Sudan northern states MIS 2009

	Percentage who slept under			
	Any net	ITN	LLIN	Number of pregnant women
Residence				
Urban	20.5	16.5	15.5	188
Rural	21.8	16.4	16.4	455
Age				
15-19	15.9	13.5	13.5	57
20-24	15.7	12.5	12.5	163
25-29	27.6	18.9	18.6	187
30-34	26.8	22.9	21.7	129
35-39	14.4	11.6	11.6	81
>=40	12.3	7.3	7.3	26
Region				
Blue Nile	43.2	33.9	33.9	26
Gedarif	30.4	22.1	22.1	27
Gezira	21.3	17.9	17.9	47
Kassala	12.7	11.8	11.8	47
Khartoum	8.5	8.5	8.5	84
North Darfur	30.0	27.8	27.8	41
North Kordofan	6.7	4.2	2.2	87
Northern	0.0	0.0	0.0	16
Red Sea	4.6	4.6	4.6	18
River Nile	11.4	11.4	11.4	25
Sennar	8.4	3.9	3.9	27
South Darfur	37.0	26.7	26.7	80
South Kordofan	22.0	18.0	18.0	41
West Darfur	55.1	36.4	34.3	35
White Nile	42.9	27.2	27.2	42
Wealth quintile				
Highest	11.1	7.8	7.8	90
Fourth	17.7	15.9	14.7	118
Middle	27.6	20.3	20.4	147
Second	23.4	17.7	17.3	155
Lowest	22.3	16.9	16.9	133
Total	**21.3**	**16.4**	**16.1**	**643**

Table 3.7 Use of mosquito nets by pregnant women in households with any nets, an insecticide treated nets (ITN) or a long lasting insecticidal net (LLIN)

Percentage of the sample under five population who slept under any nets; ITNs; or LLINs the night before survey by residence, age, region and wealth quintile, Sudan northern states MIS 2009

	Percentage who slept under			Number of pregnant women in households with		
	Any net	ITN	LLIN	Any net	ITN	LLIN
Residence						
Urban	35.8	38.2	38.3	109	82	77
Rural	36.1	34.2	35.1	270	208	203
Age						
15-19	31.9	31.8	31.8	29	24	24
20-24	27.1	29.3	31.6	95	68	65
25-29	43.8	39.7	39.8	116	87	85
30-34	42.9	43.5	43.0	80	65	62
35-39	26.1	26.8	28.4	45	35	33
>=40	21.5	16.6	16.6	14	11	11
Region						
Blue Nile	59.2	74.5	74.5	18	12	12
Gedarif	39.9	32.1	35.3	21	19	18
Gezira	29.7	42.7	42.6	33	18	18
Kassala	23.4	30.0	31.9	23	17	16
Khartoum	25.3	28.6	30.2	29	26	25
North Darfur	49.3	49.3	52.0	24	22	21
North Kordofan	12.7	09.3	5.2	46	40	37
Northern	-	-	-	9	8	8
Red Sea	15.5	15.5	15.5	7	7	7
River Nile	14.9	15.7	16.3	18	17	16
Sennar	17.4	12.5	14.6	12	8	7
South Darfur	54.8	56.9	56.9	50	34	34
South Kordofan	34.2	34.8	34.8	26	17	17
West Darfur	72.3	71.5	70.3	27	17	16
White Nile	48.5	39.4	39.4	36	28	28
Wealth quintile						
Highest	21.0	11.1	20.6	49	34	31
Fourth	28.6	17.7	32.6	75	59	56
Middle	40.9	27.6	37.6	93	73	70
Second	40.4	23.4	39.0	90	69	68
Lowest	42.2	22.3	41.0	72	55	55
Total	**36.0**	**35.5**	**36.1**	379	290	280

3.3 Insecticide spraying

Indoor residual spraying (IRS), as a vector control strategy, had been implemented in a number of northern states of the Sudan by the time of the survey primarily by the NMCP. Table 3.8 shows summary of households' exposure to insecticide spraying by residence. Overall, only 192 households had reported exposure to IRS and these represented 2.4% of urban households and 3.4% of rural households. About 21% of the 192 households were in Kassala state; 15% in Sennar; 11% in South Kordofan; 10% in Northern; 7% in North Kordofan; 6% each in Gezira and South Darfur while the remaining states all contributed less than 5% of all households that were sprayed.

However, the IRS presented here should be interpreted with caution. The current IRS strategy in the country is such that only communities settled within large irrigated schemes in the states of Gezira, Kassala and River Nile and those in the Northern state which are part of the *gambiae* project, a collaboration between the governments of Sudan and Egypt, are targeted for spraying. Consequently, the IRS information captured during the MIS 2009 is unlikely to be representative of the actual coverage in target areas and the coverage information presented here most likely represents a significant underestimate.

Table 3.8 Insecticide residual spraying of households, Sudan northern states MIS 2009

	No households sprayed	% of households sprayed
Residence		
Urban	61	2.4
Rural	131	3.4
Total	**192**	**2.9**

CHAPTER 4: FEVER AND TREATMENT SEEKING

4.1 Fever prevalence, diagnosis and treatment

Table 4.1 Prevalence and prompt treatment of fever

Percentage of persons who reported to have fever the two weeks before by sex, residence, age, region, and wealth quintile and when action to treat fever was taken, Sudan northern states MIS 2009

	Overall			Those who had fever			
	% with fever in the two weeks preceding the survey	% with fever on the day of survey	Number of persons	% who took action	% who took action within 48 hours	% who took action within 24 hours	Number of persons with fever
Sex							
Male	16.7	7.2	11,720	42.7	30.2	18.6	2,076
Female	20.9	9.1	14,751	36.8	22.9	13.5	3,223
Residence							
Urban	16.2	6.9	9,459	46.1	33.6	21.0	1,553
Rural	21.3	9.4	17,012	35.0	21.3	12.3	3,746
Age (years)*							
0-4	22.8	8.6	5,140	44.3	31.3	20.0	1,196
5-19	15.2	6.4	9,589	38.4	27.6	18.2	1,542
20-44	19.3	9.3	7,905	37.7	21.7	11.6	1,599
>44	23.4	10.6	3,794	35.7	22.4	11.8	948
Region							
Blue Nile	34.0	12.3	1,072	45.4	35.6	24.0	406
Gedarif	17.5	4.5	1,189	40.5	26.4	10.2	214
Gezira	18.4	6.5	3,130	41.7	32.4	23.4	549
Kassala	20.2	4.8	1,001	56.6	34.0	18.5	203
Khartoum	12.2	3.0	4,738	48.7	36.4	24.3	571
North Darfur	19.2	8.8	1,489	29.2	8.3	5.1	284
North Kordofan	20.6	11.5	3,050	29.6	19.8	10.6	631
Northern	8.2	10.6	895	43.3	29.9	20.0	74
Red Sea	1.9	12.8	899	38.0	37.9	31.9	15
River Nile	13.2	2.5	1,287	43.4	31.6	21.1	197
Sennar	29.2	12.5	1,121	43.6	28.3	13.3	319
South Darfur	25.8	16.9	2,718	29.9	14.8	7.1	715
South Kordofan	32.2	14.8	1,171	33.6	25.8	15.8	377
West Darfur	32.9	19.8	1,085	41.7	17.0	8.9	367
White Nile	23.9	13.4	1,626	34.6	26.8	16.3	377
Wealth quintile							
Highest	13.6	4.3	5,649	53.0	40.2	25.5	771
Fourth	14.9	6.0	5,776	44.2	31.5	20.9	886
Middle	21.4	9.9	5,183	40.6	27.4	16.6	1,104
Second	22.5	11.0	5,006	34.5	20.0	10.7	1,210
Lowest	26.5	12.8	4,857	27.2	14.1	7.1	1,328
Total	**19.1**	**8.3**	**26,471**	**39.1**	**25.8**	**15.5**	**5,299**

*43 individuals did not have age data

Of the 26,471 individuals who were interviewed, 19% reported to have fever during the two weeks preceding the survey with the prevalence of reported fever higher among rural household members compared to urban and among those below the age of five years or older than 44 years compared to other age groups. Fever prevalence among individuals living in the poorest households was almost twice as high as those living in the wealthiest households (Table 4.1). Fever prevalence was highest in the states of Blue Nile, West Darfur, South Kordofan and Sennar and lowest in Red Sea, Northern and Khartoum. Of those who reported having a fever during the two weeks prior to the survey, 39% took some action to treat the fever, with 26% and 16% taking action within 48 and 24 hours after onset of fever. Treatment seeking was highest among male household members compared to female; urban members compared to rural, among children under the age of five years compared to other age groups; while twice as many members in the wealthiest households sought treatment compared to those in the poorest households. Treatment seeking was highest in Kassala State (57%) followed by Khartoum (49%), while in the states of Blue Nile, Gedarif, Gezira, Northern, Red Sea, River Nile, Sennar and West Darfur, treatment seeking for fever was also above the national mean of 39%. Treatment seeking in the remaining states was all below the national mean. Treatment seeking in 48 and 24 hours was significantly lower in North, South and West Darfur compared to all other states. More than half of all fevers in the last two weeks had resolved by the day of survey.

4.2 Source of treatment for fever

Among those took action to treat fever, 53% reported that they were tested for malaria (Table 4.2). The main source of treatment for fever was the government health sector with almost equal number of people going to hospitals (29%) and health centres (30%) and about 11% using basic health units. About 7% were treated by community health workers and of the 23% of people who sought treatment from the private sector, 16% used private health facilities/pharmacies/drug stores; 6% used shops and the remainder used other private sources (Table 4.2). There were significant differences in the use of the government health sector by gender or age although rural household members and those in the poorest households tended to use basic health units more than those in urban areas or those from the wealthiest households. A higher proportion of urban and wealthier households used the private sector compared to rural and those in poorest households. Forty percent or more of the febrile individuals in Gedarif, North Darfur, River Nile and Sennar sought treatment from government hospitals while in Gezira, Kassala, Khartoum, Northern and White Nile most patients used government health centres. Interestingly, a majority of patients (40%) in Blue Nile state used Basic Health Units for the treatment of fevers.

4.3 Type of drugs used for treatment of fever

About 55% of fevers were treated with drugs which were not antimalarials while 45% were treated with antimalarials (Table 4.3). Majority of those not treated for malaria were treated using painkillers. Of those cases treated as uncomplicated malaria (Table 4.4), 44% were treated using the nationally recommended drug AS+SP, 13% with replaced monotherapies chloroquine or SP, while worryingly 34% were treated using arthemeter injections, a monotherapy which is regarded as the second-line treatment for severe malaria in Sudan and which has implications for possible emergence of resistance to artemisinins. This finding compares to the 17% of patients of uncomplicated malaria treated with arthemeter injection observed at health facilities in a national quality of care survey undertaken a month after the

MIS (unpublished data). Although not shown in Table 4.4 , about 77% of individuals who used AS+SP, 57% of those who used SP or chloroquine, 85% of those who used quinine and 78% of those who used Arthemeter obtained these medications from a government hospital, health centre or basic health unit.

Table 4.2 Source of treatment for fever

Percentage of persons who reported to have fever the two weeks and took action by source of treatment, residence, age, region, wealth quintile, Sudan northern states MIS 2009

	% tested for malaria	Government			Other public	Private		
		Hospital	Health centre	Basic Health unit	Community health worker	Health facility/pharmacy/drug store	Shop	other
Sex								
Male	52.0	29.8	28.0	10.0	7.1	17.8	6.0	1.4
Female	53.5	28.0	31.5	12.5	6.5	14.2	5.4	1.8
Residence								
Urban	66.9	28.2	33.1	4.5	4.7	24.2	3.5	1.9
Rural	42.1	29.2	27.6	16.7	8.3	9.3	7.4	1.5
Age								
0-4	47.8	32.6	25.9	11.5	7.4	14.4	6.3	2.0
5-19	52.8	26.9	32.1	11.5	5.2	16.5	5.8	2.1
20-44	55.4	26.6	33.3	12.2	6.5	14.7	5.8	1.0
>44	56.9	30.8	26.8	9.2	8.7	18.5	4.5	1.6
Region								
Blue Nile	35.5	18.6	22.0	40.4	8.5	8.5	1.1	0.9
Gedarif	53.9	42.2	23.1	31.7	0.0	3.0	0.0	0.0
Gezira	68.6	34.0	36.9	15.0	2.5	8.5	2.6	0.6
Kassala	62.8	21.5	50.1	5.7	11.0	10.7	0.6	0.4
Khartoum	67.3	25.4	34.8	3.8	4.0	25.4	2.7	3.9
North Darfur	48.1	54.7	18.0	5.8	9.3	9.9	2.2	0.0
North Kordofan	44.6	19.5	24.8	16.9	2.7	24.0	11.1	1.1
Northern	54.7	17.8	58.5	2.7	0.0	17.7	3.4	0.0
Red Sea	35.7	12.6	0.0	12.6	0.0	74.7	0.0	0.0
River Nile	54.7	40.0	32.2	1.3	1.1	11.1	11.8	2.5
Sennar	72.3	58.3	14.0	9.8	3.4	7.7	6.4	0.4
South Darfur	35.3	24.8	20.2	8.9	9.0	19.8	14.4	2.8
South Kordofan	44.0	25.8	23.0	11.8	2.8	31.2	2.0	3.3
West Darfur	18.9	16.1	22.8	4.3	3.4	5.9	15.7	0.8
White Nile	59.3	19.5	53.6	7.2	3.6	14.7		1.4
Wealth quintile								
Highest	74.6	25.5	37.3	3.8	2.2	26.5	3.3	1.5
Fourth	68.5	37.0	38.0	5.6	2.7	12.7	2.0	2.0
Middle	50.3	33.4	24.2	11.5	6.7	16.9	6.1	1.1
Second	30.1	24.8	23.0	18.5	13.9	10.1	7.7	2.1
Lowest	30.7	21.3	25.3	21.7	10.6	8.4	10.8	1.9
Total	**52.8**	**28.8**	**30.0**	**11.4**	**6.8**	**15.7**	**5.7**	**1.7**

*almost 8% of all individuals with fever did not know if they were parasitologically diagnosed for malaria using RDTs or microscopy.

A higher proportion of individuals from the poorest households (10.4%) used chloroquine or SP compared to those from the wealthiest households (2.9%). The states with highest use of AS+SP were Kassala, Blue Nile, North Kordofan, Northern, and Gezira while highest use of SP/chloroquine was in West Darfur, North Kordofan, South Darfur, White Nile and South Kordofan. Majority of patients in Red Sea, Gezira and White Nile were treated with arthemeter injections. Majority of those who were treated with AS+SP were children and adults were the predominant recipient of arthemeter injections.

Table 4.3 Type of drug used for treatment for fever

Percentage of persons who reported to have fever the two weeks and took action by type of drug, residence, age, region, wealth quintile, Sudan northern states MIS 2009

	ANTIMALARIALS					OTHERS	
	AS+SP	SP/ CHLOROQUINE	QUININE	ARTHEMETER	OTHER	ANTIPYRETICS	OTHER
Sex							
Male	21.2	6.1	1.8	12.4	2.4	46.3	9.9
Female	18.3	5.9	2.2	17.0	1.8	44.0	10.8
Residence							
Urban	18.4	4.7	1.5	13.7	2.6	48.6	10.4
Rural	20.4	6.9	2.4	16.1	1.6	42.1	10.4
Age							
0-4	15.9	3.0	1.6	7.3	2.0	5.9	10.7
5-19	23.3	6.4	2.4	12.6	2.1	4.3	10.0
20-44	17.4	7.1	2.7	21.0	2.1	3.8	11.3
>44	22.2	8.0	0.7	20.4	2.0	3.8	8.3
Region							
Blue Nile	32.0	2.3	3.3	16.3	1.5	40.1	4.6
Gedarif	18.4	0.4	5.1	14.9	0.0	58.6	2.6
Gezira	25.0	2.8	2.5	29.8	3.5	21.6	14.8
Kassala	38.8	5.6	5.5	16.9	0.0	30.5	2.7
Khartoum	11.4	1.5	0.0	10.1	1.8	62.7	12.5
North Darfur	21.4	1.8	1.4	2.9	0.0	46.4	26.1
North Kordofan	28.4	11.3	2.7	18.1	3.4	34.0	2.1
Northern	25.9	0.0	0.0	3.1	0.0	52.6	18.4
Red Sea	15.9	0.0	0.0	35.7	0.0	48.4	0.0
River Nile	12.8	0.0	0.0	13.8	0.0	69.6	3.7
Sennar	14.8	7.9	6.6	17.7	2.9	47.1	3.0
South Darfur	9.6	11.2	0.2	5.9	4.1	45.6	23.3
South Kordofan	21.0	8.9	0.7	17.3	3.0	28.2	20.9
West Darfur	10.3	15.6	0.7	6.4	0.8	54.7	11.6
White Nile	19.5	9.2	0.6	24.2	2.2	41.6	2.8
Wealth quintile							
Highest	18.5	2.9	1.4	14.8	3.0	49.9	9.5
Fourth	24.8	3.9	1.6	18.7	1.8	40.5	8.8
Middle	16.3	4.5	3.2	17.4	2.7	44.9	11.0
Second	18.2	10.5	1.8	11.2	0.0	48.9	9.2
Lowest	20.7	10.4	1.9	11.6	2.4	38.8	14.3
Total	**19.5**	**6.0**	**2.0**	**15.0**	**2.1**	**45.0**	**10.4**

	Table 4.4 Those who were treated with antimalarials					
	Percentage of persons who were given antimalarials for fever in the last two weeks by type of drug, residence, age, region, wealth quintile, Sudan northern states MIS 2009					
	AS+SP	SP/ CHLOROQUINE	QUININE	ARTHEMETER	OTHER	Number of persons treated with antimalarials
Sex						
Male	48.6	13.8	4.0	28.2	5.4	376
Female	40.4	13.1	4.8	37.6	4.0	499
Residence						
Urban	45.2	11.5	3.7	33.3	6.4	290
Rural	43.0	14.6	5.0	33.9	3.4	585
Age*						
0-4	53.3	10.1	5.2	24.6	6.8	145
5-19	50.1	13.5	5.2	26.7	4.5	267
20-44	34.6	14.1	5.5	41.7	4.1	291
>44	41.7	15.1	1.3	38.2	3.7	169
Region						
Blue Nile	58.0	4.1	5.9	29.4	2.6	106
Gedarif	47.5	1.1	13.1	38.3	0.0	34
Gezira	39.2	4.4	4.0	46.9	5.5	151
Kassala	58.0	8.4	8.2	25.4	0.0	61
Khartoum	45.8	6.1	0.0	40.8	7.3	64
North Darfur	77.8	6.7	4.9	10.5	0.0	19
North Kordofan	44.4	17.6	4.3	28.3	5.3	109
Northern	89.3	0.0	0.0	10.7	0.0	8
Red Sea	30.7	0.0	0.0	69.3	0.0	3
River Nile	48.1	0.0	0.0	51.9	0.0	22
Sennar	31.3	15.5	12.9	34.7	5.7	70
South Darfur	30.8	36.2	0.8	19.1	13.2	68
South Kordofan	40.9	17.4	1.4	34.6	5.7	45
West Darfur	30.5	46.2	2.0	19.0	2.3	47
White Nile	35.0	16.6	1.1	43.4	3.9	68
Wealth quintile						
Highest	45.5	7.2	3.5	36.4	7.4	164
Fourth	49.2	7.6	3.1	36.5	3.5	195
Middle	37.0	10.1	7.3	39.5	6.1	195
Second	43.4	25.1	4.4	27.1	0.0	166
Lowest	44.1	22.1	4.0	24.8	5.0	155
Total	**43.9**	**13.4**	**4.4**	**33.7**	**4.6**	**875**

*3 individuals did not have age data

CHAPTER 5: MALARIA PARASITE PREVALENCE

5.1 Prevalence of malaria parasites

There are a number of techniques to identify *Plasmodium sp*. in circulating peripheral blood. Perhaps the most common and widely used is microscopy. Microscopy however is only as good (sensitive/specific) as the quality of the blood slide preparation, the skill of the microscopist and the numbers of high powered fields examined (WHO, 2000; O'Meara *et al.*, 2006; Drakeley & Reyburn, 2009). In addition, for the purposes of large scale community surveillance involving thousands of study participant's expert, double reading with quality assurance of slide reading is exceptionally expensive.

In recent years there has been a proliferation in the numbers and improvement in the sensitivity/specificity of immunochromatic diagnostics tests, collectively known as Rapid Diagnostic Tests (RDTs) that detect different parasite protein products and divided into those based on detection of *P. falciparum*-specific histadine-rich protein (HRP), for example ParaCheck and ParaHIT, or species-specific isotypes of lactate dehydrogenase (LDH) or adolase, for example OptiMAL (Murray *et al*., 2008). When used properly RDTs can have an accuracy that exceeds 95% sensitivity and 90% specificity for *P. falciparum*.

In recent times there have been no widely accepted sensitive multi-parasite species RDTs. Now there are several HRP-2 tests available that appear to have better performance than earlier products against *P. falciparum* and *P. vivax*, based on detection of the antigens HRP-2 (for *P. falciparum*) and aldolase (for generic *Plasmodium*). Notable is CareStart Malaria HRP2/pLDH (Pf/Pv) COMBO (Access Bio, Inc) and First Response Malaria Ag (pLDH/HRP2) COMBO (Premier Medical Corporation Ltd.) which in a recent review by WHO and PATH was reported to have the highest detection rates (WHO, 2009). Due to ease of procurement, however First Response Malaria Ag COMBO was used in the Northern states of Sudan 2009 MIS. Although a pan-species test, the test only gave results on whether infection was due to Pf or mixed species and cannot distinguish between *Pf* and *Pv*.

All RDT positive cases detected during the household survey were given, by a qualified nurse or equivalent, an appropriate age specific treatment course of AS+SP as per national standard treatment guidelines and a referral note if their condition does not improve to the nearest health centre. All sampled individuals were also asked to provide a thick and thin blood smear prepared and examined from the same finger stick blood sample for an independent assessment of infection. The smears were stained in 4% Giemsa solution for 30 minutes and labeled slides transported to each state headquarters. Thick blood films were read using a light microscope with x 100 oil-immersion lens and x 10 eyepiece. One hundred high power fields were examined before a slide was considered negative. For all positive blood slides, the asexual stage of *Plasmodium* parasites were counted against 200 leukocytes and expressed as parasites/µl of blood by multiplying this number by a factor of 40 assuming a mean white blood cell count of 8000 cells/µl. Slides were read by independent microscopists at the state level and then centrally in Khartoum for a second reading. Finally, all RDT positive slides and a randomly selected 10% of the negatives were read by Prof. Elgadal National Institute for Malaria Sciences and Research in Sennar state.

Figure 5.1 Map showing the distribution of clusters where malaria infection was reported (red) and those where no cases were found (green)

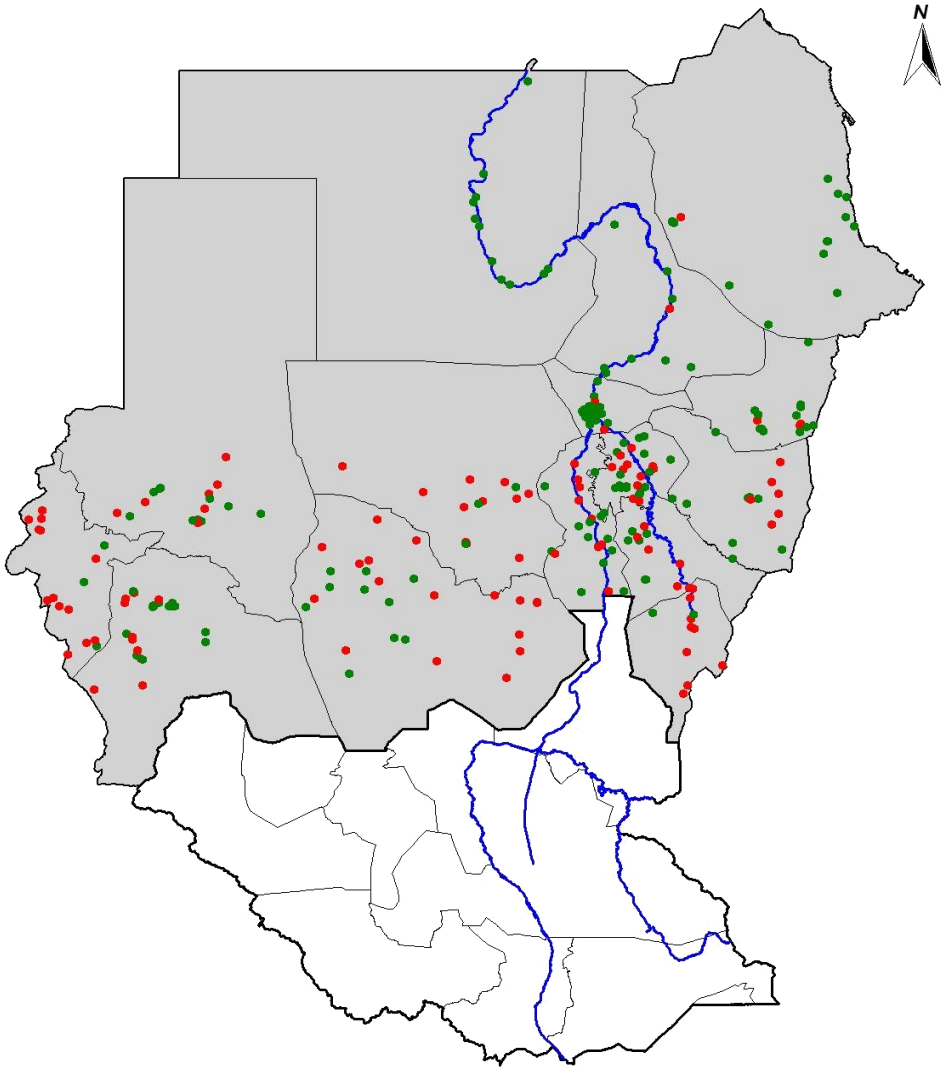


Figure 5.1 shows the distribution of the (117/300, 39%) clusters (in red) where at least one individual was found positive for malaria infection using the RDT. Overall, infection prevalence as measured by RDT was very low (1.8%) in the northern states of the Sudan (Table 5.1). Infection was marginally higher among male compared to female members of the household and almost three times higher in rural areas compared to urban. All states except Blue Nile (12.5%) and West Darfur (7.1%) reported prevalence of less than 3%. There were only marginal differences in infection prevalence by age. However, infection prevalence among individuals in the lowest wealth quintile was almost 7 times higher than those in the wealthiest quintile. No infections were reported in the Red Sea and Northern states.

Table 5.1 Summary of parasite prevalence using RDT and microscopy results Sudan northern states MIS 2009		
	% who were RDT positive	**Number of persons**
Sex		
Male	2.1	9,402
Female	1.5	12,586
Residence		
Urban	0.8	7,160
Rural	2.4	14,828
Age*		
0-4	2.0	4,106
5-19	2.5	7,974
20-44	1.1	6,686
>44	1.2	3,186
Region		
Blue Nile	12.5	1,018
Gedarif	1.6	1,098
Gezira	1.2	2,991
Kassala	1.1	919
Khartoum	0.1	3,214
North Darfur	1.1	1,159
North Kordofan	2.6	2,295
Northern	0.0	804
Red Sea	0.0	302
River Nile	0.5	1,063
Sennar	1.1	1,072
South Darfur	1.2	2,521
South Kordofan	2.1	1,134
West Darfur	7.1	1,025
White Nile	1.8	1,373
Wealth quintile		
Highest	0.4	4,331
Fourth	1.1	4,806
Middle	1.8	4,361
Second	3.3	4,290
Lowest	2.7	4,200
Total	**1.8**	**21,988**

*36 persons had missing age information

When parasitaemia only among individuals who reported to have had fever within the two weeks prior to survey were considered (Table 5.2), the proportion of individuals who were positive for malaria using RDTs almost doubled overall and by residence, gender, age, state or wealth quintile. Over 20% in Blue Nile and 9% in White Nile of individuals who reported fever in the last two weeks were found positive for malaria infection. Overall infection prevalence among febrile individuals, however, remained below 5% across all other states. The pattern of infection among febrile individuals by residence, gender, age and wealth quintile remained the same as that of the overall population.

Table 5.2 Summary of parasite prevalence using RDT among individuals who reported to have had fever in the two weeks prior to survey, Sudan northern states MIS 2009

	RDT positive	Number of persons with fever in last two week*
Sex		
Male	4.7	1,879
Female	3.5	2,993
Residence		
Urban	2.0	1,360
Rural	5.1	3,512
Age		
0-4	4.2	1,048
5-19	7.1	1,394
20-44	1.8	1,520
>44	2.6	900
Region		
Blue Nile	20.3	392
Gedarif	4.3	205
Gezira	2.1	540
Kassala	2.2	188
Khartoum	0.3	447
North Darfur	2.7	248
North Kordofan	4.6	540
Northern	0.0	70
Red Sea	0.0	12
River Nile	2.0	169
Sennar	1.7	311
South Darfur	1.9	692
South Kordofan	4.2	369
West Darfur	9.2	356
White Nile	3.4	333
Wealth quintile		
Highest	1.2	659
Fourth	2.8	806
Middle	4.0	1,020
Second	6.4	1,125
Lowest	4.7	1,262
Total	**4.0**	**4,872**

*427 individuals who reported fever in the last two weeks refused to be tested for malaria

Analysis of the blood slides for all individuals who had an RDT test revealed that a total 113 individuals were positive for malaria leading to a national prevalence of 0.5%. These individuals who were positive by microscopy included 22 who were reported negative for RDTs. The positive microscopy results were distributed by state as follows: Blue Nile (n=59); Gedaruf (n=2); Gezira (n=5); Khartoum (n=1); North Darfur (n=1); North Kordofan (n=8); Sennar (n=8); South Darfur (n=8); South Kordofan (n=4); West Darfur (n=15); and White Nile (n=2). However, there were a number of issues that rendered the microscopic results unreliable. A large number of slides were of poor quality, including all of those from the Northern state. Over 500 hundred slides, including for those of RDT positive individuals were destroyed during four repeat cross checking. In addition, there were significant discrepancies between readings by different microscopists during crosschecking process. Because of the generally poor quality of slides and microscopy results, it is advised here that RDT results are used for estimation of prevalence in the Sudan MIS 2009.

CHAPTER 6: ANC SERVICES AND IPTp

Currently the NMCP has targeted 8/15 states for IPTp, of which 4 (Blue Nile, Gezira, Sennar and South Kordofan) are wholly targeted while in partial targeting has been implemented in Gedarif, Kassala, South Darfur and White Nile.

Table 6.1 nonetheless summarizes the use of IPTp in all 15 states. Of the 5,054 women between the ages 15-49 years who were enumerated, 38% reported to have given birth in the last twelve months or were currently pregnant. 29% of these visited ANC services during their previous or current pregnancy with no significant difference by urban or rural although a significantly higher proportion of women from poorer households had either given birth in the 12 months prior to survey or were currently pregnant. Of these 57% visited a doctor, 2% visited a nurse, 24% visited a midwife whole 15% were attended to by a health visitor. Use of doctors was significantly in favour of women who were urban, from the wealthiest households or those with higher education. Midwives and health visitors were predominantly used rural women or those from poorer households. Interestingly, only 4% of women who were seen in West Darfur reported to have visited a doctor for ANC. ANC visits were lowest in North Darfur and Red Sea states although only North Kordofan and West Darfur reported ANC visits of ≥40%. Up to 55% of the women who used ANC services started within the first trimester, 34% in the second trimester and 11% in the third trimester. On average, women visited ANC clinics 4 times during their pregnancy with no major difference between urban or rural households.

The proportion of women who visited ANC clinics and were given at least a single dose of IPTp in the second or third trimester (any visit where 3 tablets of SP was given to the woman for malaria prevention i.e. IPTp1) was 7.4%. Overall usage of IPTp1 was highest (12%) in the 8 target states and 7.3% in the other states excluding Northern, Red Sea and River Nile where no woman reported usage of IPTp. Usage of the two required doses of SP for IPTp (IPTp2) was only 1.7% overall and 2.5% in the targeted states while surprisingly no woman was reported to have been provided with IPTp2 in Blue Nile, the state which reported the highest usage (29%) of IPTp1. There were no major differences in IPTp usage by urban-rural or by wealth quintile (Table 6.1).

Table 6.1 Use of ANC and IPTp services by women aged 15-49

Percentage of women who gave birth in the last twelve months or were currently pregnant by ANC visit and IPTp by residence, age, region, mother's education and wealth quintile, Sudan northern states MIS 2009

	All women 15-49 years	Those who visited an ANC clinic									
			Source of ANC services				Trimester of ANC visit					
	% who gave birth in last 12 months or are currently pregnant	% who visited ANC services	Doctor	Nurse	Midwife	Health visitor	First	Second	Third	Mean number of times of ANC visit	IPTp1	IPTp2
Residence												
Urban	34.0	29.5	62.8	1.0	23.5	12.4	61.4	31.7	6.9	4.1	7.0	1.6
Rural	40.9	28.8	53.1	3.2	24.4	16.5	50.3	36.1	13.6	3.6	7.6	1.7
Age												
15-19	54.3	39.4	58.7	2.3	25.2	12.9	58.8	28.7	12.5	3.5	5.6	1.0
20-24	57.2	45.1	54.2	2.9	26.6	15.2	55.9	33.5	10.6	3.9	7.4	0.9
25-29	50.2	39.3	56.6	2.4	20.1	19.1	56.1	33.5	10.4	4.0	6.8	0.8
30-34	43.9	32.7	64.7	1.2	20.8	11.3	54.3	34.5	11.3	3.8	7.9	1.8
35-39	30.7	23.5	53.7	2.0	30.1	10.7	51.9	38.3	9.9	3.9	8.3	2.2
>40	8.9	6.3	57.3	3.1	25.9	13.7	51.1	36.6	12.3	3.1	8.2	2.8
Region												
Blue Nile	42.4	26.9	37.0	1.1	47.7	14.2	59.1	31.4	9.5	3.6	29.4	0.0
Gedarif	42.1	35.4	49.2	4.0	36.2	10.5	75.6	20.2	4.2	3.6	5.5	1.0
Gezira	35.3	24.8	71.6	0.0	17.7	7.5	49.5	41.0	9.4	3.5	17.5	2.4
Kassala	37.0	27.0	67.9	4.7	14.1	9.6	53.2	33.2	13.6	3.2	7.8	3.6
Khartoum	27.5	23.7	74.5	0.4	13.6	10.8	64.4	31.1	4.4	4.4	3.0	0.6
North Darfur	30.4	19.4	51.9	5.5	21.2	18.1	64.7	26.3	9.0	3.7	11.2	3.1
North Kordofan	54.6	44.2	56.5	3.5	5.9	33.3	56.4	30.7	12.9	3.9	2.0	0.8
Northern	29.8	24.5	94.3	0.0	0.0	2.8	74.1	22.9	3.0	5.1	0.0	0.0
Red Sea	24.1	16.8	82.4	0.0	17.5	0.0	30.9	49.7	19.4	2.0	0.0	0.0
River Nile	34.5	29.5	94.5	0.0	2.0	0.0	45.4	32.6	22.0	3.2	0.0	0.0
Sennar	39.6	28.1	41.3	4.2	41.3	13.1	50.8	40.3	8.8	4.1	13.2	4.6
South Darfur	46.0	35.9	31.9	2.7	49.8	15.0	48.5	42.3	9.2	4.1	8.7	2.6
South Kordofan	44.8	29.2	46.5	3.1	35.5	12.1	51.5	29.7	18.8	3.8	2.0	2.0
West Darfur	55.3	41.3	4.0	4.2	59.0	28.1	45.0	40.4	14.5	3.8	13.1	3.9
White Nile	41.4	29.9	66.3	1.5	17.0	12.2	49.0	36.6	14.4	3.5	11.4	1.3
Mother's education												
No formal education	37.7	26.3	43.1	3.9	32.1	19.4	49.6	34.9	15.5	3.5	7.7	1.5

Religion	36.4	27.9	42.3	4.2	35.4	16.1	51.7	34.5	13.8	3.5	7.8	2.9
Primary	40.0	31.3	59.4	1.1	22.0	14.9	52.2	38.1	9.7	3.9	8.0	1.3
Secondary	36.9	32.1	75.5	16.7	14.2	8.7	64.9	28.7	6.5	4.3	6.9	2.6
Above	34.5	28.6	90.5	0.0	4.0	4.6	77.2	22.8		4.7	2.8	1.0
Wealth quintile												
Highest	27.9	24.8	85.8	0.9	8.5	4.1	72.1	25.8	2.1	4.2	7.1	1.2
Fourth	35.2	28.4	68.1	0.0	18.3	12.7	57.9	33.9	8.2	4.3	7.9	1.0
Middle	42.0	33.2	54.0	1.9	25.9	16.7	47.6	41.7	10.6	4.0	6.4	1.8
Second	47.1	35.1	41.7	3.1	32.3	20.9	47.9	34.9	17.1	3.5	9.3	3.0
Lowest	40.6	25.0	33.3	6.4	36.7	19.4	50.4	33.5	16.1	3.1	5.6	1.0
Total	**38.0**	**29.1**	**57.2**	**2.2**	**24.0**	**14.8**	**55.0**	**34.2**	**10.8**	**3.8**	**7.4**	**1.7**

CHAPTER 7: GENERAL MALARIA KNOWLEDGE

During the household interview, the household heads or respondents was asked whether there any household members who were involved in a discussion or attended a public meeting where malaria-related issues were discussed in the last 12 months; if any household members had come across printed materials or sign boards regarding malaria prevention and control. The household main respondent was asked if he/she had received any information through listening to radio, watching television, reading newspapers or through any other channels. The respondent was further asked the radio channel they most frequently listened to.

Table 7.1 shows that overall only 4% of households had a member who attended a malaria-related formal or informal meeting over the last 12 months, with the proportion of households in urban areas twice as high as those in rural areas. Kassala and Northern states reported the highest proportion (>10%) of households members attending such meeting while in Blue Nile, Gedarif, North Kordofan, Red Sea, River Nile, South Darfur and West Darfur this was less than 3% of households. Almost five times as many households in the wealthiest quintile attended such meetings compared to those in the poorest quintile.

With regard to accessing malaria information, 19% of all households (26% urban and 14% rural) have come across printed materials or sign boards related to malaria prevention and control. Blue Nile reported a significantly large proportion (62%) of household members who have come across malaria-related materials while all other states reported rates of 9% to 24%. 54% of household accessed malaria information through radio, TV or newspapers. Household members reported that the main medium for accessing malaria related information was the radio as reported by 32.2% of all households (33% urban, 32% rural). This was followed by the television (7.3%) used predominantly by urban households. Less than 5% of households reported to access malaria information through reading newspapers. Access to all media was significantly in favour of the households in the wealthiest quintile (Table 7.1).

Table 7.2 shows that 32.2% of all households (33% urban and 32% rural) used the radio as a source of information with households in North Darfur and White Nile reporting rates of 50% or more. Majority of households listened to the National Radio channel (70%), followed by state specific radio channels (15%) and FM 100 (7%). Except for the state specific radio channels, use of the other main radio channels was in favour of the wealthier households.

	Table 7.1 Knowledge of malaria acquired through public meetings and other media					
	All households		Source of malaria information			
	Attended malaria meeting	Seen printed malaria information	Source TV	Source Radio	Source Newspaper	Source other media
Residence						
Urban	6.1	25.6	26.0	32.8	4.7	2.1
Rural	3.3	13.7	11.2	31.9	1.5	0.6
Region						
Blue Nile	2.7	62.1	19.9	53.4	2.9	0.0
Gedarif	1.5	11.3	12.5	36.8	0.0	0.2
Gezira	4.0	14.1	29.3	37.7	0.6	0.6
Kassala	10.7	16.7	6.3	29.1	1.9	2.3
Khartoum	5.8	23.5	30.6	21.2	6.0	3.1
North Darfur	3.3	17.0	10.5	47.1	1.5	0.0
North Kordofan	2.6	11.0	6.0	31.0	1.6	0.0
Northern	10.6	23.7	36.4	31.1	6.5	0.0
Red Sea	2.3	15.1	7.0	14.7	2.2	0.6
River Nile	2.1	14.0	22.4	39.3	2.3	0.3
Sennar	6.3	20.7	20.7	38.3	6.7	2.1
South Darfur	1.3	13.9	6.9	31.9	0.5	0.7
South Kordofan	4.8	9.0	12.3	34.0	1.9	1.2
West Darfur	2.1	13.0	2.4	27.1	1.3	0.0
White Nile	6.3	24.4	12.6	48.3	2.7	1.0
Wealth quintile						
Highest	9.3	33.2	41.5	35.3	8.0	2.2
Fourth	5.0	20.6	28.4	36.7	2.6	1.5
Middle	3.4	17.4	8.7	36.6	1.4	1.0
Second	2.0	12.7	1.7	30.7	0.7	0.0
Lowest	1.7	6.0	0.7	20.5	0.5	1.0
Total	**4.4**	**18.6**	**17.3**	**32.2**	**2.8**	**1.2**

	Table 7.2 Household radio listening patterns and frequently listened to stations											
	Listen to Radio	National Radio	FM 100	Police Voice	Military Voice	KRT FM	Station 4	FM 96 (Mango)	Medical station	State specific station	Sport Station	Other
Residence												
Urban	33.2	64.2	13.1	0.2	0.5	0.9	2.7	0.6	0.6	13.0	1.1	3.0
Rural	31.5	73.8	2.9	0.08	0.0	1.0	0.3	0.06	0.2	16.1	0.1	5.5
Region												
Blue Nile	43.6	73.6	3.5	0.0	0.0	0.0	0.0	0.0	0.0	22.8	0.0	0.0
Gedarif	36.3	50.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0	48.2	0.0	0.0
Gezira	37.9	68.5	3.7	0.4	0.0	0.0	0.0	0.0	0.0	12.5	0.6	14.4
Kassala	31.1	41.7	2.7	0.0	0.0	0.0	0.0	0.0	0.0	49.1	0.0	6.5
Khartoum	20.9	47.4	21.3	0.6	1.3	4.6	9.6	2.1	2.7	2.5	2.7	5.5
North Darfur	50.0	78.8	3.3	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	6.0
North Kordofan	29.5	80.4	9.6	0.0	0.5	0.0	0.0	0.0	0.0	7.2	0.0	2.4
Northern	31.1	69.6	14.4	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0
Red Sea	14.9	53.7	14.7	0.0	0.0	0.0	0.0	0.0	0.0	27.4	4.2	0.0
River Nile	37.7	64.1	1.1	0.0	0.0	3.7	0.0	0.0	0.0	29.2	0.0	1.9
Sennar	39.9	90.4	8.3	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0
South Darfur	33.2	71.4	11.3	0.0	0.0	0.4	0.0	0.0	0.0	16.0	0.0	1.0
South Kordofan	35.5	98.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1
West Darfur	25.9	88.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	8.9
White Nile	50.1	92.5	0.0	0.0	0.0	1.0	0.0	0.0	0.0	3.0	0.0	3.5
Wealth quintile												
Highest	34.9	59.3	14.8	0.3	0.5	2.0	3.7	1.1	1.0	10.5	1.6	5.1
Fourth	37.6	67.1	8.0	0.0	0.4	1.2	0.9	0.0	0.5	16.9	0.5	4.5
Middle	37.2	75.4	4.6	0.2	0.0	0.5	0.9	0.0	0.0	14.7	0.1	3.5
Second	29.7	78.6	3.2	0.0	0.0	0.1	0.0	0.0	0.0	14.1	0.0	3.9
Lowest	20.3	72.2	1.3	0.0	0.0	0.4	0.0	0.0	0.0	20.7	0.0	5.3
Total	**32.2**	**69.7**	**7.3**	**0.1**	**0.2**	**1.0**	**1.3**	**0.2**	**0.4**	**14.8**	**0.5**	**4.4**

CHAPTER 8: LESSONS LEARNED

8.1 Planning and time frame

The planning for the survey began in June 2009, 4 months prior to start of survey and most of the technical issues around the survey were resolved two weeks before survey. However, there were difficulties in procurement of key survey materials. The request for materials was done by the NMCP via the International Health Office of the FMoH which then passed the request on to the WHO-Sudan which is the sub-recipient of GFATM money for the northern states. These three tier channel resulted in delays which led to rescheduling of survey by a week. More importantly, initial plans to examine anaemia among pregnant women in the IPTp states were dropped because of delays in procurement of Hemocues and other materials required for testing for anaemia. All stakeholders in planning national malaria surveys and particularly for procurement must consider simplifying and streamlining the requisition and procurement process.

8.2 Questionnaire design

Design of survey questionnaires for malaria indicator surveys have been simplified by the availability of RBM-MERG standard questionnaires which were modified in many sections for the Sudan MIS. However, given that the Sudan is an Arab speaking country, a detailed process of translating these questionnaires into Arabic was undertaken. Several additional adjustments were also made in order to capture intervention coverage, treatment seeking and parasiteamia among all age groups. The translation of the questionnaires was done by a qualified and experienced translator and was then checked by several individuals at the NMCP and the national consultant. Further improvements in the translation were done during training through contributions by the trainees.

8.3 Training, survey and data entry

The NMCP provided commendable facilitation of training including adequate training venue; selection of high quality surveyors; the translation of questionnaires; and piloting of survey tools. Because the NMCP had overall control of hiring field workers it was possible, in consultation with national and international consultants, to select only those that passed the rigorous training process. During survey, extensive checks of survey questionnaires were undertake at the state and national levels to ensure quality. Data entry was done at a central place in Khartoum. The data entry screens were in English and one of the main consequences was that during data entry household or individual IDs in Arabic format (right to left) as opposed to the required English format (left to right) necessitating extensive cleaning of data. Future surveys should take this into consideration. Garmin *etrex* handheld GPS units were used for field survey without too many problems. There were very few cases where individuals changes the settings of the GPS units but this were rectified immediately. Signal acquisition by this model of GPS was sufficiently quick.

8.4 Logistics

Logistical support was primarily done by the NMCP with funding via the WHO. Apart from some delays in procurement, there were no significant problems in providing adequate logistics to undertake the survey.

8.5 Challenges during sample selection

A few clusters (n=6) in the three Darfur states of the North, South and West were dropped from the sampling frame because they were inaccessible due to security reasons. This, however,

was unlikely to have major implications for the balance of the sample and the survey results given only very few clusters dropped.

8.6 Undertaking survey of all ages

There are a number of challenges that need consideration when undertaking a MIS covering all ages. First, there are difficulties in capturing the working members of the household, especially in urban areas and farming communities where individuals leave the house early in the morning and return in the evening. Although efforts to capture these individuals were made through call backs there was a still a considerable number who were missed. Second, school age children (5-19 years) are often away from home during school days. Although efforts were made to ensure school children participated in the surveys, this still remained a challenge. Finally, several individuals refused to participate in the testing of malaria. Future surveys should explore undertaking call backs during the evenings, implementing surveys during school holidays and implementing an intensive sensitization progamme to ensure most people provide blood samples for malaria testing.

CHAPTER 9: DISCUSSION AND RECCOMENDATIONS

9.1 Progress in key malaria control indicators

The results of the survey show that significant progress has been made in the last five years in key malaria indicators in the northern states of the Sudan. Household ownership of LLIN has significantly increased; proportion of individuals sleeping under an LLIN and the treatment of fevers with recommended ACTs have almost doubled and overall infection rates appear to have declined, albeit marginally. These results, although representing considerable achievements are well below the target set by the NMCP for 2010 in line with RBM recommendations. Further strategic efforts and investments are required to achieve these targets.

There is need to revisit the malaria control strategies in low transmission areas. Currently, most of the strategies recommended for malaria control in the low transmission northern states of the Sudan do not necessarily depart from those implemented in the higher transmission southern states or the rest of the malaria endemic sub-Saharan Africa (SSA). LLINs remain the bedrock of malaria control, IRS and IPTp are recommended in selected states but their scale-up is very low and there remains a wide disparity in household LLIN ownership (40%) to LLIN use by household members (10%). When data from those households with ITNs was analysed, this only increased to 18.6%. This disparity appears to be much larger than that reported in many malaria endemic settings in SSA and might be something driven by the low transmission ecology in the northern states where exposure to the mosquito nuisance is minimal for a considerable period of the year and it is both difficult to build a net use culture and the overall gains accrued from high coverage of LLINs would probably be low given the extremely low transmission. Investing in IRS for control of focal transmission and engendering the culture of malaria diagnosis and appropriate case management at health facilities might be a more efficient use of funds.

9.2 Use of artemisinin monotherapy for treatment of uncomplicated malaria

In the northern states of the Sudan, the first line recommended treatment is *artesunate-sulphadoxine pyremathamine* (AS+SP). In case of treatment failure with AS+SP, the recommended second-line therapy is *artemether-lumefantrine* (AL) and the third-line therapy is quinine (FMoH 2004). In severe malaria, the first-line therapy is quinine and arthemeter is used as an alternative. The result of the survey, however, show that only 20% of all fevers were treated with AS+SP and 15% were treated with arthemeter injections, making these drugs the two most commonly used antimalarials. Although still considered an effective anti-malarial, the use of an artemesinin monotherapy such as arthemeter for routine treatment of fever has some serious negative implications as it could lead to the rapid emergence of artemesinin resistance rendering ACTs, which are the remaining effective first-line therapy in all malaria endemic countries, ineffective. It is particularly worrying that almost 80% of all individuals who were treated with arthemeter received the treatment at a government health facility.

9.3 Capturing school children urban work-force and rural farmer populations during survey

A major challenge during the survey has been capturing a proportion of those urban individuals who often leave the house for work early in the morning and return home at the end of the day. In addition, in those states where farming was a key activity, the same problem was encountered. Although call-backs were undertaken, there remained a considerable number of individuals in Khratoum and other urban setting and the farming states along the Nile for whom

the member's questionnaire was not filled and who were not tested for malaria infection/exposure. Future survey should device ways this individuals can be captured either by undertaking survey in the evening where feasible or extending the call-back period.

9.4 Refusals to provide blood samples for malaria testing

Over 4,000 individuals representing approximately 13% of all individuals refused to provide blood samples for testing malaria parasite prevalence and exposure. This is a significant loss of sample size, although only 3% above the 10% non-response allowance built into the sample design. The predominant refusals were in urban areas and main reason for refusal appeared to be fear of being tested for HIV. Although the NMCP implemented extensive sensitization exercise, there still need for further effort in this area to minimize the level of refusals.

9.5 Pre-elimination

Given the low malaria transmission in the country, some of the northern states of the Sudan should be preparing for transition to pre-elimination control. However, this requires substantial investment in the health system surveillance with the capacity for prompt case-detection, follow up and highly focal targeting of malaria control interventions to achieve the pre-elimination status by the next five years. Investment is required in diagnostics tools in all health facilities, implementation of active case detection particularly for areas with low access, health workers training in diagnostics and case-management, a detailed and efficient health information system, understanding of the effect of human mobility and adopting control mechanisms to combat focal and highly seasonal transmission.

9.6 Health facility audits and fever case management studies

The survey has shown that a generally low treatment seeking behavior for fevers of around 40%. Of these, however, more than 70% used government health facilities indicating a high usage of this sector for treatment of fever. The results also show a low prescription of antimalarials in general, and the recommended national first-line drug and in particular the inappropriate use of arthemeter injection for treatment of uncomplicated malaria. It is particularly surprising that almost 80% of individuals treated for arthemeter injection received them from government health facilities. This point to serious failings in malaria case-management and it is not clear whether these are because of drug shortages or health worker practices in malaria case-management. The health facility audit undertaken in the 15 states in December 2009 should be used to provide useful information to help understand the MIS results on the treatment of fevers.

References

1. Abdalla SI, Malik EM, Ali KM (2007). The burden of malaria in Sudan: incidence, mortality and disability – adjusted life – years. *Malaria Journal,* **6**: 97
2. Abdel-Hameed AA, El-Jak IE, Faragalla IA (2001). Sentinel posts for monitoring therapeutic efficacy of antimalarial drugs against *Plasmodium falciparum* infections in the Sudan. *African Journal of Medical Science*, **30**: 1-5.
3. Abdel-Hameed AA (2001). Malaria case management at the community level in Gezera, Sudan. *African Journal of Medical Science*, **30** Suppl: 43-6
4. Adam I, Osman ME, Elghzali G, Ahmed GI, Gustafssons LL, Elbashir MI (2004). Efficacies of chloroquine, sulfadoxine-pyrimethamine and quinine in the treatment of uncomplicated, *Plasmodium falciparum* malaria in eastern Sudan. *Annals of Tropical Medicine & Parasitology*, **98**: 661-666
5. Adam I, A-Elbasit IE, Idris SM, Malik EM, Elbashir MI (2005). A comparison of the efficacy of artesunate plus sulfadoxine-pyrimethamine with that of sulfadoxine-pyrimethamine alone, in the treatment of uncomplicated, *Plasmodium falciparum* malaria in eastern Sudan. *Annals of Tropical Medicine & Parasitology*, **99**: 449-455
6. Bell DR, Wilson DW, Martin LB (2005). False-positive results of a *Plasmodium falciparum* histidine-rich protein 2 –detecting malaria rapid diagnostic test due to high sensitivity in a community with fluctuating low parasite density. *American Journal of Tropical Medicine & Hygiene,* **73**: 199-203
7. Bell D & Perkins MD (2008). Making malaria testing relevant: beyond test purchase. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* **102**: 1067-1066
8. Chaloner K & Verdinelli I (1995). Bayesian Experimental Design: A Review. *Statistical Science*, **10**: 273-304
9. Chiodini PL, Bowers K, Jorgensen P, Barnwell JW, Grady KK, Luchavez J, Moody AH, Cenizal A, Bell D (2007). The heat stability of *Plasmodium* lactate dehydrogenase-based and histidine-rich protein 2-based malaria rapid diagnostic tests. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* **101**: 331-337
10. Corran PH, Coleman P, Riley EM, Drakeley CI (2007). Serology: a robust indicator of malaria transmission intensity? *Trends in Parasitology***, 23:** 575-582.
11. Corran PH, Cook J, Lynch C, Leendertse H, Alphaxard M, Griffin J, Cox J, Abeku T, Bousema T, Ghani AC, Drakeley C, Riley E (2008). Dried blood spots as a source of anti-malarial antibodies for epidemiological studies. *Malaria Journal,* **7**: 195.
12. Dafalla SE, El-Agib FH, Bushra GO (2003). Maternal mortality in a teaching hospital in Sudan. *Saudi Medical Journal*, **24**: 369-72
13. Diggle PJ, Tawn JA, Moyeed RA (1998). Model-based geostatistics. *Journal of the Royal Statistical Society C: Applications*, **47**: 299-326
14. Drakeley CJ, Corran PH, Coleman PG, Tongren JE, McDonald SL, Carneiro I, Malima R, Lusingu J, Manjurano A, Nkya WM, Lemnge MM, Cox J, Reyburn H, Riley EM (2005). Estimating medium- and long-term trends in malaria transmission by using serological markers of malaria exposure. *Proceedings of National. Academy of Science, U S A* **102**: 5108-5113
15. Drakely CJ & Reyburn H (2009). Out with the old, in with the new: the utility of rapid diagnostic tests for malaria diagnosis in Africa. *Transactions of the Royal Society of Tropical Medicine & Hygiene,* **103**: 333-337.
16. Druilhe P, Pradier O, Marc JP, Miltgen F, Mazier D, Parent G (1986). Levels of antibodies to *Plasmodium falciparum* sporozoite surface antigens reflect malaria transmission rates and are persistent in the absence of re-infection. *Infection & Immunity*, **53**: 393-397.
17. El Gaddal AA (1985). Malaria in the Sudan. *Proceedings of the conference on malaria in Africa. Practical considerations on malaria vaccine and clinical trials. Washington, D.C., U.S.A, December 1-4,* pgs 156-159.
18. El Khalifa SM, Mustafan IO, Wais M, Malik EM (2008). Malaria control in an urban area; a successful story from Khartoum, 1995-2004. *La Revue de Santé de la Méditerranée Orientale*, **14**: 206-215.
19. El Sayed BB, Arnot DE, Mukhtar MM, Baraka OZ, Dafalla AA, Elnaiem DE, Nugud AH (2000). A study of the urban malaria transmission problem in Sudan. *Acta Tropica*, **75**: 163-171.

20. Federal Ministry of Health, Central Bureau of Statistics, UNFPA (2001). Safe motherhood survey: National Report 1999. Sudan. September 2001.
21. Federal Ministry of Health/National Malaria Control Programme (2005). Malaria prevalence and coverage indicators survey Sudan – October 2005. Final Report – December 2005.
22. Federal Ministry of Health/National Malaria Control Programme (2006). National malaria strategic plan 2007-2012. Khartoum, 2006.
23. Hay SI, Guerra CA, Gething PW, Patil AP, Tatem AJ, Noor AM, Kabaria CW, Manh BH, Elyazar IRF, Brooker S, Smith DL, Moyeed RA, Snow RW (2009). A world malaria map: *Plasmodium falciparum* endemicity in 2007. *PLoS Medicine, 6: 100048.*
24. Guerra CA, Gikandi PW, Tatem AJ, Noor AM, Smith DL, Hay SI, Snow RW (2008). The limits and intensity of Plasmodium falciparum transmission: Implications for malaria control and elimination worldwide*. PLoS Medicine,* 5: e38.
25. Lee N, Baker J, Andrews KT, Gatton ML, Bell D, Cheng Q, McCarthy J (2006). Effect of sequence variation in *Plasmodium falciparum* histidine-rich protein 2 on binding of specific monoclonal antibodies: implications for rapid diagnostic tests for malaria. *Journal of Clinical Microbiology,* **44**: 2773-2778
26. Macro International Inc (1996). *Sampling Manual.* DHS-III Basic Documentation No 6. Calverton, Maryland.
27. Malik EM, Ahmed ES, Elkhalifa SM, Hussein MA, Suleiman AMN (2003). Stratification of Khartoum urban area by the risk of malaria transmission. *Eastern Mediterranean Health Journal,* **9**: 559-569.
28. Malik EM, Atta HY, Weis M, Lang A, Puta C, Lettenmaier C, Bell A (2004). *Sudan Roll Back Malaria consultative mission: essential actions to support the attainment of the Abuja targets*. EARN Reaping Mission Final report, April 2004.
29. Malik EM, Eltahir HG, Ahmed ES (2005). Clinical and laboratory aspects of malaria among children with fever in a low transmission area of Sudan. *Eastern Mediterranean Health Journal,* **11**: 753-761.
30. Malik EM, Mohamed TA, Elmardi KA, Mowien RM, Elhassan AH, Elamin SB, Mannan AA, Ahmed ES (2006). From chloroquine to artemisinin-based combination therapy: the Sudanese experience. *Malaria Journal,* **5**: 65.
31. Malik EM, Hanafi K, Ali SH, Ahmed ES, Mohamed KA (2006). Treatment-seeking behavior for malaria in children under five years of age: implementation for home management in rural areas with high seasonal transmission in Sudan. *Malaria Journal,* **5**: 60
32. Murray CK, Gasser RA, Magill AJ, Miller RS (2008). Update on rapid diagnostic testing for malaria. *Clinical Microbiological Reviews*, **21**: 91-110
33. National Malaria Control Program/Federal Ministry of Health (2003). Roll Back Malaria Progress in Sudan. Final Report 2003
34. National Malaria Control Program/Federal Ministry of Health (2006). National Strategic Plan for RBM 2007-2012. Khartoum, 2006.
35. O'Hagan A & Stevens JW (2001). Bayesian assessment of sample size for clinical trials of cost-effectiveness. *Medical Decision Making*, **21**: 219-230
36. O'Meara WP, Barcus M, Wongsrichanalai C, Muth S, Maguire JD, Jordan RG, Prescott WR, McKenzie FE (2006). Reader technique as a source of variability in determining malaria parasite density by microscopy. *Malaria Journal*, **5**: 118
37. Onwujekwe O, Malik EF, Mustafa SH, Mnzavaa A (2005). Do malaria preventive interventions reach the poor? Socioeconomic inequities in expenditure on and use of mosquito control tools in Sudan. *Health Policy and Planning,* **21**: 10-16
38. Ramasamy R, Nagendran K, Ramasamy MS (1994). Antibodies to epitopes on merozoite and sporozoite surface antigens as serologic markers of malaria transmission: studies at a site in the dry zone of Sri Lanka. *American Journal of Tropical Medicine & Hygiene,* **50**: 537-547
39. Salah MT, Mohammed MM, Himeidan YE, Malik EM, Elbashir MI, Adam I (2005). A randomized comparison of sulphadoxine-pyrimethamine and combination of sulphadoxine pyrimethamine with chloroquine in the treatment of uncomplicated falciparum malaria in Eastern Sudan. *Saudi Medical Journal*, **26**: 147-148

40. UNICEF (2007) Malaria and Children. Progress in Intervention Coverage. New York: The United Nations Children's Fund (UNICEF): http://www.unicef.org/health/files/ Malaria_Oct6_for_web(1).pdf, Accessed: 28th January 2008.
41. van den Broek IV, Gatkoi T, Lowoko B, Nzila A, Ochong E, Keus K (2003). Chloroquine, sulfadoxine-pyrimethamine and amodiaquine efficacy for the treatment of uncomplicated *Plasmodium falciparum* malaria in Upper Nile, south Sudan. *Transactions of Royal Society of Tropical Medicine & Hygiene*, **97**: 229-235
42. Weatherall DJ (2004). JBS Haldane and the malaria hypothesis. In *Infectious disease and host-pathogen evolution* (ed. Dronamraju, K.R.) 18-36 (Cambridge University Press, Cambridge, 2004)
43. Webster HK, Gingrich JB, Wongsrichanalai C, Tulyayon S, Suvarnamani A, Sookto P, Permpanich B (1992). Circumsporozoite antibody as a serologic marker of *Plasmodium falciparum* transmission. *American Journal of Tropical Medicine & Hygiene,* **47**: 489-497
44. WHO (2000). *New perspectives in malaria diagnosis*. Geneva: World Health Organization, *WHO/CDS/RBM/2000.14*
45. WHO (2008). *World Malaria Report.* World Health Organization, Geneva, 2008.
46. WHO (2009). *Malaria rapid diagnostic test performance: results of WHO product testing of malaria RDTs: round 1 (2008)*. World Health Organization Special Programme for Tropical Diseases, 2009.

APPENDIX A: Sample distribution and weighting

Table 1: Summary of sample design and sample size based on estimates from the 2008 national census

State	Total households	Proportion households urban	Proportion households rural	Proportion of households	Number of sample households	No of final sample of clusters	Sample clusters Urban	Sample clusters Rural
Blue Nile	141,506	0.25	0.75	0.03	240	12	3	9
Gedarif	235,980	0.27	0.73	0.05	280	14	4	10
Gezira	536,989	0.1	0.9	0.11	640	32	3	29
Kassala	286,573	0.3	0.7	0.06	340	17	5	12
Khartoum	871,140	0.8	0.2	0.18	1,060	53	42	11
North Darfur	298,409	0.2	0.8	0.06	360	18	4	14
North Kordofan	470,385	0.2	0.8	0.10	580	29	6	23
Northern	114,779	0.17	0.83	0.02	220	11	2	9
Red Sea	190,250	0.46	0.54	0.04	240	12	5	7
River Nile	194,501	0.28	0.72	0.04	240	12	3	9
Sennar	216,722	0.22	0.78	0.05	280	14	3	11
South Darfur	495,851	0.29	0.71	0.10	600	30	9	21
South Kordofan	212,186	0.25	0.75	0.04	280	14	4	10
West Darfur	222,503	0.19	0.81	0.05	280	14	3	11
White Nile	293,403	0.32	0.68	0.06	360	18	6	12
Total	**4,781,177**	**0.34**	**0.66**	**1.00**	**6,000**	**300**	**102**	**198**

Sampling weights

Because a probability proportional to size was used in distribitnng the clusters by state and PAU, sampling weights were developed for each cluster from the selection probability of the household was calculated as follows:

$$P_h = n_h / N_h$$

where n_h is the number of households selected from a cluster h and N_h is the total number of households in the same cluster h. weights were then computed as the inverse of the probability of selection of a household in a cluster.

Appendix B Questionnaires (Arabic and English)

Appendix C PCA scoring coefficients (weights) used in developing wealth index

Variable	Weight
No Formal Education	-0.1644
Religious (Khalwa Or equivalent)	-0.0896
Partial Primary/Intermediate/Basic Level	0.0096
Complete Primary/Intermediate/Basic Level	0.0715
Partial Secondary Level	0.0329
Complete Secondary Level	0.1164
Above Secondary	0.1614
Piped Water Into Dwelling, Piped Water In Yard/Plot, Piped Water From Public Tap	0.2963
Tube Well Or Borehole, Protected Well, Unprotected Well, Protected Spring, Unprotected Spring	-0.1882
Rainwater, Tanker Truck, Cart With Small Tank	-0.0521
Rivers/Streams/Lakes/Dams, Pond, Bottled Water, Canal Irrigation Channel, Other	-0.1388
Flush To Piped Sewer System, Flush To Septic Tank, Flush To Pit Latrine	0.1676
Ventilated Improved Pit Latrine, Pit Latrine With Slab, Pit Latrine Without Slab/Open Pit	0.1116
Composing Toilet, Bucket Toilet	0.0133
No Toilet/Use Bushes, Other	-0.2322
Electricity	0.3285
Television	0.3289
Telephone	0.2737
Electricity, LPG/Natural Gas, Kerosene	0.3276
Charcoal	-0.0378
Firewood, Dung, Other	-0.2987
Earth/Sand	-0.2429
Dung, Wood planks, Vinyl/Asphalt Strips	-0.008
Ceramic Tiles	0.1731
Cement	0.1541
Carpet, Other	0.0781
Bicycle	0.0318
Motorcycle	0.0551
Cartruck	0.1616
Cart	-0.0806
Donkey	-0.1938

Appendix D: Standard errors and confidence intervals by state of the key indicators

	Table Source of treatment for fever, Sudan northern states MIS 2009													
	Government						Other public		Private					
	Hospital		**Health centre**		**Basic Health unit**		**Community health worker**		**Health facility/pharmacy/drug store**		**Shop**		**other**	
	Std error	95% conf interval	Std error	95% conf interval	Std error	95% conf interval	Std error	95% conf interval	Std error	95% conf interval	Std error	95% conf interval	Std error	95% conf interval
Region														
Blue Nile	7.0	4.8-32.3	8.0	6.3-37.7	13.0	14.7-66.1	6.0	-3.3-20.2	3.0	2.3-14.7	8.0	-0.4-2.9	1.0	-0.8-2.6
Gedarif	12.0	18.0-66.4	8.0	7.1-39.1	13.0	6.5-56.9	0.0	0.0	2.0	-1.1-7.1	0.0	0.0	0.0	0.0
Gezira	8.0	18.1-50.0	7.0	23.6-50.2	6.0	2.7-27.3	2.0	-0.1-5.0	2.0	4.0-12.9	1.0	0.2-5.1	0.0	-0.3-1.5
Kassala	4.0	14.5-28.6	8.0	33.5-66.7	4.0	-1.6-13.1	8.0	-4.3-26.2	3.0	4.5-16.9	1.0	-0.6-1.8	0.0	-0.5-1.3
Khartoum	3.0	18.8-32.1	5.0	25.1-44.4	2.0	0.5-7.1	1.0	1.5-6.4	4.0	17.3-33.3	1.0	0.7-4.7	1.0	1.5-6.4
North Darfur	9.0	36.7-72.8	6.0	5.2-30.7	3.0	0.7-11.0	7.0	-4.2-22.9	4.0	3.0-16.9	2.0	-0.9-5.3	0.0	0.0
North Kordofan	4.0	11.5-27.5	0.06	12.9-36.6	6.0	5.4-28.4	2.0	-0.4-5.8	4.0	16.8-31.1	3.0	4.5-17.7	1.0	-0.2-2.4
Northern	7.0	3.8-31.8	12.0	34.0-83.1	3.0	-2.9-8.2	0.0	0.0	8.0	2.5-32.9	3.0	-2.7-9.4	0.0	0.0
Red Sea	12.0	11.4-36.7	0.0	0.0	12.0	-11.4-36.7	0.0	0.0	24.0	26.5-122.9	0.0	0.0	0.0	0.0
River Nile	9.0	22.1-57.8	8.0	17.2-47.2	1.0	-1.2-3.8	1.0	-1.1-3.4	4.0	3.9-18.2	4.0	3.1-20.5	2.0	-0.5-5.5
Sennar	1.0	39.1-77.4	9.0	-2.9-30.8	5.0	0.06-19.6	2.0	-0.9-7.8	2.0	3.9-11.5	3.0	0.4-12.4	0.0	-0.4-1.1
South Darfur	5.0	14.3-35.3	5.0	11.2-29.3	2.0	4.0-13.7	3.0	4.0-14.2	4.0	12.3-27.2	4.0	6.0-22.9	2.0	-0.5-6.0
South Kordofan	6.0	13.2-38.4	5.0	11.5-34.5	3.0	5.2-18.5	1.0	0.2-5.4	7.0	17.6-44.8	1.0	-0.5-4.5	2.0	-0.1-6.8
West Darfur	4.0	7.5-24.6	5.0	12.7-33.0	2.0	0.2-8.4	9.0	15.8-53.0	3.0	-0.3-12.1	5.0	6.5-24.9	1.0	-0.8-2.3
White Nile	4.0	11.9-27.1	6.0	41.4-65.7	3.0	0.3-14.1	1.0	0.7-6.5	7.0	0.8-28.7	0.0	0.0	1.0	-1.1-3.8

	Use of mosquito nets by pregnant women, Sudan northern states MIS 2009					
	Any net		ITN		LLIN1	
	Std error	95% conf interval	Std error	95% conf interval	Std error	95% conf interval
Region						
Blue Nile	14.0	16.0-70.4	12.0	9.9-57.8	12.0	9.7-57.8
Gedarif	12.0	6.8-53.9	11.0	1.3-43.0	10.0	1.3-43.0
Gezira	7.0	8.0-34.6	6.0	5.6-30.1	6.0	5.6-30.1
Kassala	6.0	1.5-23.8	6.0	0.5-23.1	6.0	0.5-23.1
Khartoum	3.0	2.4-14.5	3.0	2.4-14.5	3.0	2.4-14.5
North Darfur	8.0	13.4-46.7	9.0	10.3-45.2	9.0	10.3-45.3
North Kordofan	3.0	1.2-12.3	2.0	-0.7-9.1	2.0	-0.9-5.2
Northern	-	-	-	-	-	-
Red Sea	4.0	-3.8-12.9	4.0	-3.8-12.9	4.0	-3.8-12.9
River Nile	7.0	3.2-26.0	7.0	-3.2-26.0	7.0	-3.2-26.0
Sennar	5.0	-1.9-18.7	4.0	-4.0-11.8	4.0	-4.0-11.8
South Darfur	9.0	19.5-54.5	7.0	13.6-40.0	7.0	13.6-40.0
South Kordofan	6.0	10.1-33.9	5.0	8.7-27.2	5.0	8.7-27.2
West Darfur	11.0	33.4-76.8	6.0	24.4-48.3	6.0	23.1-45.5
White Nile	7.0	28.3-57.4	7.0	13.5-41.0	7.0	13.5-41.0

	Use of mosquito nets by children under the age of five years, Sudan northern states MIS 2009					
	Any net		ITN		LLIN1	
	Std error	95% conf interval	Std error	95% conf interval	Std error	95% conf interval
Region						
Blue Nile	8.0	15.5-45.1	7.0	8.8-34.8	7.8	8.8-34.8
Gedarif	4.0	15.2-30.9	4.0	13.1-27.9	4.0	10.2-25.5
Gezira	4.0	19.6-37.1	4.0	15.3-31.4	4.0	14.9-30.8
Kassala	4.0	7.1-21.2	4.0	4.2-18.4	4.0	3.4-17.9
Khartoum	2.0	3.3-11.1	2.0	2.0-9.5	2.0	2.0-9.5
North Darfur	7.0	17.2-43.3	7.0	12.5-38.5	7.0	10.5-36.3
North Kordofan	3.0	7.6-17.6	2.0	4.6-13.7	2.0	4.2-12.5
Northern	3.0	-2.7-7.7	3.0	-2.7-7.7	3.0	-2.7-7.7
Red Sea	6.0	-2.2-20.8	4.0	-1.4-12.9	4.0	-1.8-12.0
River Nile	6.0	2.6-27.9	5.0	1.1-19.8	5.0	1.1-19.8
Sennar	7.0	10.1-37.1	7.0	5.6-34.0	7.0	3.3-29.1
South Darfur	5.0	22.2-42.3	4.0	14.9-32.4	4.0	14.5-32.1
South Kordofan	4.0	15.4-31.5	3.0	12.2-23.0	3.0	12.2-23.0
West Darfur	9.0	16.5-51.9	6.0	8.4-32.9	6.0	8.2-32.6
White Nile	5.0	30.6-51.9	5.0	20.5-39.3	5.0	19.5-38.2

Table Prevalence and prompt treatment of fever
Percentage of children under the age of five years who reported to have fever the two weeks before by survey residence, region, mother's education, wealth quintile and when action to treat fever was taken, Sudan northern states MIS 2009

	Overall		Those who had fever					
	Percentage with fever in the two weeks preceding the survey		Percentage who took action		Percentage who took action within 48 hours		Percentage who took action within 24 hours	
	Std error	95% conf interval	Std error	95% conf interval	Std error	95% conf interval	Std error	95% conf interval
Region								
Blue Nile	4.0	26.0-42.0	3.0	38.7-52.1	3.0	28.8-42.5	3.0	18.3-29.7
Gedarif	3.0	11.5-23.5	7.0	26.7-54.2	5.0	16.2-36.6	3.0	5.2-15.1
Gezira	1.0	16.1-20.6	4.0	34.3-49.1	3.0	26.0-39.1	2.0	18.6-28.3
Kassala	2.0	16.4-23.9	7.0	42.8-70.8	6.0	22.3-45.8	3.0	12.3-24.8
Khartoum	1.0	10.0-14.3	3.0	42.1-55.3	3.0	30.7-42.1	3.0	18.8-29.8
North Darfur	3.0	14.6-23.8	3.0	22.6-35.9	2.0	4.3-12.3	2.0	1.5-8.6
North Kordofan	1.0	17.8-23.3	3.0	23.0-36.5	3.0	14.4-25.2	2.0	6.6-14.7
Northern	1.0	5.4-11.0	5.0	33.0-53.6	5.0	20.7-39.1	6.0	8.9-31.1
Red Sea	1.0	0.1-3.6	7.0	23.4-52.4	7.0	23.4-52.4	7.0	18.1-45.8
River Nile	2.0	9.2-17.3	4.0	34.9-51.9	4.0	22.9-40.2	4.0	13.4-28.9
Sennar	4.0	22.2-36.0	8.0	28.3-59.0	7.0	15.3-41.4	4.0	5.0-21.7
South Darfur	2.0	21.5-30.0	2.0	25.1-34.6	2.0	11.0-18.5	1.0	4.5-9.7
South Kordofan	5.0	23.3-41.1	6.0	21.8-45.3	5.0	15.2-36.3	4.0	8.1-23.5
West Darfur	3.0	27.8-38.0	6.0	29.6-53.8	3.0	11.8-22.3	2.0	5.5-12.2
White Nile	2.0	20.0-28.2	5.0	25.4-43.8	4.0	19.1-34.4	3.0	10.3-22.3

Appendix E: Persons involved in the Sudan northern states 2009 national malaria indicator survey

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