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# Evaluation of the Impact of the Scale-up of Malaria Control Interventions on All-Cause Mortality in Children under Five Years of Age in Senegal, 2005–2010

## Senegal Malaria Impact Evaluation Group

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PRESIDENT'S MALARIA INITIATIVE



## Acronyms

<b>ACT</b>	Artemisinin-based combination therapies
<b>ADB</b>	African Development Bank
<b>ANC</b>	Antenatal care
<b>ANACIM</b>	<i>Agence Nationale de l'Aviation Civile du Sénégal</i> (national civil aviation agency of Senegal)
<b>ANSD</b>	<i>Agence Nationale de la Statistique et de la Démographie</i> (national bureau of statistics)
<b>AQ</b>	Amodiaquine
<b>BCC</b>	Behavior change communication
<b>CBO</b>	Community-based organization
<b>CDC</b>	Centers for Disease Control and Prevention
<b>CSE</b>	<i>Centre de Suivi Ecologique</i> (center for ecological monitoring)
<b>CDMO</b>	Chief District Medical Officer
<b>CDSMT</b>	<i>Cadre de dépenses sectoriel en moyenne terme</i> (Framework for medium term sectorial spending)
<b>CHW</b>	Community health worker
<b>CRMO</b>	Chief Regional Medical Officer
<b>DHMT</b>	District Health Management Team
<b>DHS</b>	Demographic and Health Surveys
<b>DOT</b>	Directly observed treatment
<b>DPM</b>	Division of Preventive Medicine
<b>DRH</b>	Division of Reproductive Health
<b>EPI</b>	Expanded Program on Immunization
<b>Global Fund</b>	Global Fund to Fight AIDS, Tuberculosis and Malaria
<b>GMAP</b>	Global Malaria Action Plan
<b>HC</b>	Health Center
<b>HCP</b>	Home care provider
<b>HMM</b>	Home management of Malaria
<b>ICP</b>	<i>Infirmier Chef de Poste</i> (Chief Nurse)

<b>IDB</b>	Islamic Development Bank
<b>IMCI</b>	Integrated Management of Child Illnesses
<b>IPD</b>	<i>Institut Pasteur Dakar</i>
<b>IPTp</b>	Intermittent preventive treatment in pregnancy
<b>IRD</b>	<i>Institut de Recherche pour le Développement</i>
<b>IRS</b>	Indoor residual spraying
<b>ISED</b>	<i>Institut de Santé et Développement</i>
<b>ITN</b>	Insecticide-treated net
<b>JICA</b>	Japan International Cooperation Agency
<b>LC</b>	Larval control
<b>LLIN</b>	Long-lasting insecticide-treated net
<b>LEVP</b>	Laboratory of Vector Ecology and Parasitology
<b>M&amp;E</b>	Monitoring and evaluation
<b>MACEPA</b>	Malaria Control and Evaluation Partnership in Africa
<b>MDG</b>	Millennium Development Goals
<b>MERG</b>	Monitoring and Evaluation Reference Group
<b>MHSW</b>	Ministry of Health and Social Welfare
<b>MICS</b>	Multiple Indicator Cluster Survey
<b>MIM</b>	Multilateral Initiative on Malaria
<b>MPA</b>	Minimum package of activities
<b>MPL</b>	Medical parasitology laboratory
<b>NCAA</b>	National Civil Aviation Agency of Senegal
<b>NGO</b>	Non-governmental organization
<b>NHIS</b>	National Health Information System
<b>NMCP</b>	National Malaria Control Program
<b>NMSS</b>	National Malaria Survey in Senegal
<b>NSHDP</b>	National Strategic Health Development Plan
<b>PNA</b>	<i>Pharmacie Nationale d'Approvisionnement</i> (National Supply Pharmacy)
<b>OMVS</b>	<i>Organisation pour la Mise en Valeur du Fleuve Sénégal</i> (Organization for the Development of the Senegal River)

<b>PHC</b>	Primary health care
<b>PMI</b>	President's Malaria Initiative
<b>PRSD</b>	Poverty Reduction Strategy Document
<b>RBM</b>	Roll Back Malaria
<b>RBMME</b>	Roll Back Malaria Monitoring and Evaluation (NMCP routine malaria database)
<b>RDT</b>	Rapid diagnostic test
<b>RHMT</b>	Regional Health Management Team
<b>SLAP</b>	<i>Section de Lutte Anti-parasitaire</i> (antiparasitic disease section)
<b>SP</b>	Sulfadoxine pyrimethamine
<b>TBA</b>	Traditional birth attendant
<b>UC</b>	Universal coverage
<b>UCAD</b>	<i>Université Cheikh Anta Diop</i> (University of Dakar)
<b>UNDP</b>	United Nations Development Programme
<b>UNICEF</b>	United Nations Children's Fund
<b>USAID</b>	United States Agency for International Development
<b>USD</b>	United States dollar
<b>VC</b>	Vector control
<b>WAMA</b>	West African Monetary Agency (UEMOA)
<b>WB</b>	World Bank
<b>WHO</b>	World Health Organization

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## Executive Summary

Malaria remains a major public health problem in many endemic countries where nearly 2 billion people are at risk. According to the World Health Organization (WHO), approximately 40% of the population at risk of malaria lives in the poorest countries of the world.

Senegal is one of the 43 malaria endemic countries in sub Saharan Africa (SSA), and malaria is a leading cause of morbidity and mortality at the clinics. The Demographic and Health Survey (DHS) conducted during 2010–2011 showed approximately 50% reduction in parasite prevalence from 2008–2009 and a 40% decline in all-cause mortality among children under 5 years of age from 2005 to 2010. If this trend continues, Senegal is likely to meet targets set by the Roll Back Malaria (RBM) partnership for 2015. Despite these encouraging results, malaria remains an important public health problem in Senegal. Malaria control still face many challenges, especially in universal access to major interventions, such as rapid diagnostic tests (RDT) and treatment with artemisinin-based combination therapy (ACT) at community level.

Since 2007, the National Malaria Control Program (NMCP) has received support from the U.S. President's Malaria Initiative (PMI). This initiative is part of the efforts of the international community in agreement with the RBM Partnership to combat malaria. The objectives of the RBM Partnership are in line with those of the NMCP and PMI, with a 50% targeted reduction of malaria mortality in 2010 in reference to 2000 as a baseline. The year 2011 marks the beginning of the second decade of organized and coordinated efforts for malaria control in Senegal and the implementation of the third National Strategic Plan for Malaria Control, which covers the period 2011–2015.

In this context, the Ministry of Health decided to assess the impact of malaria control efforts in Senegal over the period 2005–2010, which marks the beginning of the scale-up of most control interventions. The specific objectives were to measure all-cause child mortality during the deployment of malaria interventions and to determine if malaria control interventions have contributed to a significant reduction in all-cause mortality in children under 5 years of age.

The methodology used for the evaluation is in line with the recommendation of the RBM Monitoring and Evaluation Reference Group (MERG). We compared the periods before and after interventions. The pre-intervention period (before 2005) defines the period before the scale-up of malaria control interventions. For this period, baseline data on mortality in children under 5 years of age are available from the fourth DHS (DHS-IV), conducted in 2005, which collected mortality data for the last 5 years (2000–2005). The post-intervention period defines the period from 2006 onward. Data on mortality in children under 5 years of age during the intervention period are obtained from the fifth DHS (DHS-V), conducted in 2010–2011. The main sources of data for this assessment, therefore, are databases from DHS and MIS (Malaria Indicator Survey).

Malaria transmission in Senegal is characterized by very low transmission in the north, low transmission in the center, and high transmission in the south. In the capital, Dakar, malaria transmission is very heterogeneous, representing a separate transmission zone. Therefore, for this evaluation, Senegal is split into four epidemiological zones based on parasite prevalence. These zones are Dakar, the north, the center, and the south.

In the past 5 years, the vector control strategy relied on promoting the use of insecticide-treated mosquito nets (ITNs) and indoor residual spraying (IRS). Efforts in vector control led to an increase in the availability of resources, and substantial improvement in intervention coverage. Household ownership of ITNs increased significantly from 20% in 2005 to 63% in 2010 ( $p < 0.001$ ). Implementation of IRS started in 2007, and by 2010 coverage increased significantly. The proportion of households protected by ITNs or IRS rose from 37% in 2006 to 66% in 2010, a percentage point change of 28%. The increase in vector control coverage was accompanied by a significant improvement in ITN use. The proportion of children under 5 years of age sleeping under an ITN increased by 26 percentage points ( $p < 0.001$ ), rising from 7% in 2005 to 35% in 2010. The largest increases in ownership and use of ITNs were observed among populations most at risk of malaria, namely populations living in rural areas, those from the two poorest wealth quintiles, and those from the center and southern parts of the country where malaria transmission is the highest. Coverage of intermittent preventive treatment in pregnancy (IPTp) improved substantially in 2010 (39%) compared to 2005 (12%) ( $p < 0.001$ ); however, IPTp coverage had a slight decline from 2008 to 2010. The use of ITNs among pregnant women increased significantly ( $p < 0.001$ ) from 2005 (9%) to 2010 (36%).

For malaria case management, the proportion of children under 5 years of age with fever within the last 2 weeks who sought care in 2005 (41%) remained similar in 2010 (44%). The proportion of suspected malaria episodes that received malaria diagnostic testing, either by microscopy or RDT, doubled from 2008 to 2010, increasing from 5%–10%. The proportion of children who received treatment with any antimalarial declined to 8% in 2010, compared to 27% in 2005, the period before the scale-up of interventions. In 2010, the proportion of children who received antimalarial treatment as recommended by national guidelines decreased to 5.3%. These results suggest a net decrease in the use of antimalarials, which is most likely the result of a decreased incidence of malaria and improved access to and use of malaria diagnostic tools.

Overall, the results showed a significant decline in severe anemia. The proportion of children aged 6–59 months with severe anemia in 2005 and 2010 were 20% and 14% ( $p < 0.001$ ), respectively. Parasite prevalence decreased significantly from 6% in 2008 to 3% in 2010 ( $p < 0.001$ ). The prevalence of anemia decreased significantly in children ages 12–23 months, the age group in which a significant decline of parasite prevalence was observed. The greatest reductions in anemia and parasitaemia were observed in populations from rural areas, the poorest populations, and populations from the central

and southern epidemiological zones, who also displayed the highest increase in ownership and use of ITNs. The prevalence of anemia and malaria are related to socioeconomic status. These indicators decreased from the poorest to the richest quintile of the population in all surveys. Significant decreases in malaria were observed only among the poorest. Anemia declined significantly in children aged 12–23 months, the most vulnerable population, in the northern, central, and southern epidemiological zones, suggesting that the reduced burden of malaria may have contributed to the decline of anemia.

The change in environmental factors, mostly rainfall, from 2005 to 2010 could have contributed to sustaining or even increasing the burden of malaria; however, we observed a decrease in the prevalence of malaria during this period. Over this period, sociodemographic and economic status of households improved, possibly contributing to improved maternal and child health as attested by improved coverage of antenatal care (ANC) and immunization among children. While nutritional indicators have not changed favorably during this period, it is worth noting that acute respiratory infections (ARI) in children under 5 years of age in Senegal decreased significantly. Thus, the favorable trend of certain contextual factors may contribute to the reduction of malaria morbidity and all-cause mortality.

All-cause child mortality (ACCM) declined significantly (40%) during the period, with mortality rates estimated at 121 and 72 per 1,000 live births, respectively, in 2005 and 2010. Further analysis showed a significant reduction in all-cause mortality among all age groups. The decline in mortality among children under 5 years was noticeable across all wealth quintiles, from the poorest to the richest, and in all transmission zones, except in the region of Dakar. The largest reductions were observed in populations where ownership and use of ITNs was the highest, and the decrease in parasite prevalence and anemia was the largest. These were populations from rural areas, those belonging to the poorest quintiles, and populations from the central and southern transmission zones.

These results are consistent with those derived from routine data. Until mid-2007, malaria morbidity was based on the number of clinically diagnosed or suspected cases and treated as such; however, this has changed with the introduction of RDTs for systematic confirmation of all malaria cases. From 2001 and 2009, the proportional morbidity and mortality recorded in health facilities during the period declined from 36% to 3% and from 30% to 4%, respectively. During the same period, malaria deaths dropped from 6% to 3%. The decline in malaria observed in health facilities could be explained partially by the introduction of RDTs, which improved malaria case definition; however, it should be stressed that morbidity and mortality continued to decline after the introduction of RDTs.

Kaplan-Meier survival analysis showed better child survival over the period 2005–2010 compared to 2000–2005. Except for the region of Dakar, child survival estimates were higher in areas with the lowest prevalence of malaria. In addition, a Poisson regression

model revealed that compared to the reference period, all-cause mortality in children under 5 years was significantly lower after the scale-up of malaria control measures (OR = 0.63; 95% CI: 0.46–0.86). Children under 5 years of age from regions where ownership of at least one ITN per household was less than 30% (OR = 0.66; 95% CI: 0.46–0.93) had higher mortality than children from region where ITN ownership was more than 30%.

Using the LiST model, we estimated that after 5 years of scale-up of ITN ownership and use, approximately 5,774 deaths among children aged 1–59 months were averted. A significant increase in the number of lives saved was observed in 2009, corresponding to the intensification of malaria control interventions. Overall, all-cause mortality in children under 5 years of age declined significantly over the period 2005–2010. Malaria control interventions, such as access to malaria diagnostic testing with the introduction of RDTs, treatment of malaria episodes with ACTs, and the scale-up of ITNs and IRS for vector control, are likely to have played a part in the decline of malaria over these 5 years. It is important, however, to note that deaths among children 5 years and under may result from numerous causes. Along with the large-scale deployment of malaria interventions, great success has been achieved by other programs that promote child survival. It is conceivable that the observed reduction in deaths among children under 5 years of age between the two periods is the result of an overall improvement in child survival in Senegal. Better wealth, education, and maternal and child health may have contributed to the decline in all-cause child mortality. However, the reduction in malaria morbidity after the scale-up of malaria interventions has played a determinant role in the reduction of all-cause infant and child mortality.

# Background and Context

## Background

### *Rationale*

Malaria remains a major public health problem in many endemic countries where nearly 2 billion people are at risk. According to the World Health Organization (WHO), approximately 40% of the population at risk of malaria lives in the poorest countries of the world.

Senegal is one of the 43 malaria endemic countries in sub Saharan Africa (SSA), and malaria is a leading cause of morbidity and mortality at the clinics. In 2005, the proportion of outpatient visits as a result of malaria was 32%, and the proportion of hospital deaths associated with malaria was estimated at 21%.

The evaluation of the first phase of Round 4 of the Global Fund to fight against AIDS, Tuberculosis and Malaria (Global Fund) in 2006 showed progress in malaria control in Senegal, including effective treatment of nearly 80% of malaria episodes in public health facilities. The implementation of the 2006–2010 Strategic Plan was essential for national scale-up of key interventions, which contributed to substantial improvements in the coverage of malaria interventions.

Over the period 2007–2008, with the start of the second phase of Round 4 and the first phase of Round 7 of the Global Fund grants, the National Malaria Control Program (NMCP) strengthened efforts to scale-up malaria control interventions, such as long-lasting insecticide-treated nets (LLINs), intermittent preventive treatment in pregnancy (IPTp), and malaria case management using artemisinin-based combination therapy (ACT) after biological diagnosis by rapid diagnostic testing (RDT).

Until mid 2007, malaria morbidity estimates were obtained from clinically diagnosed or suspected cases and treated as such. Malaria case definition has changed since the introduction of RDTs to require systematic confirmation of all cases. Malaria data collected by the NMCP in the RBMME database indicate that from 2001 to 2009, the proportional morbidity and mortality at health facilities declined from 36% to 3% and 30% to 4%, respectively. During the same period, case fatality rate of malaria declined from 6% to 3%. The 2010–2011 Demographic Health Survey (DHS) showed a decline in parasite prevalence from 6% in 2008 to 3% in 2010 and 40% decrease in all-cause mortality among children under 5 years of age from 2005 to 2010. If this trend is sustained, Senegal is likely to be among the countries that will meet the objectives set by RBM for 2015.

Despite these encouraging results, malaria remains a public health problem in Senegal, compounded by the population's poor access to health services. Malaria control still faces many challenges, particularly in universal access to major interventions, such as

access to RDTs and treatment with ACT at the community level, limited human resources, and effective supply chain management. The monitoring and evaluation system also presents many challenges in providing high-quality data.

Since 2007, the NMCP has received support from the U.S. President's Malaria Initiative (PMI), which is part of the international community's efforts under the Roll Back Malaria (RBM) Partnership agreement to combat malaria. The objectives of the RBM Partnership are in line with those of the Senegal NMCP and PMI, with a targeted 50% reduction of malaria mortality in 2010, referenced to mortality levels in 2000. At the United Nations General Assembly, held in November 2011 in New York, the heads-of-states of malaria endemic countries that subscribed to the RBM Partnership, including Senegal, presented their country progress reports on malaria control.

The year 2011 marked the beginning of the second decade of organized and coordinated efforts for malaria control in Senegal and the implementation of the third National Strategic Plan for Malaria Control 2011–2015, which signaled it was time to assess the impact of malaria control efforts in the country. This assessment represents an opportunity for Senegal to show how much progress has been made after the national scale-up of key malaria intervention implementations in the past 5 years. This assessment will be of interest to policy makers, researchers, financial partners, and national and international health professionals to inform strategic decisions. Data generated will support advocacy for strengthening the local expertise needed to achieve the Millennium Development Goals (MDGs) and sustain national and international financial support. The aim of this evaluation is to assess the impact of malaria control interventions over the period from 2005 to 2010, corresponding to the period of national scale-up of malaria control interventions in Senegal. The assessment methodology for this evaluation is recommended by the RBM Monitoring and Evaluation Reference Group (MERG).

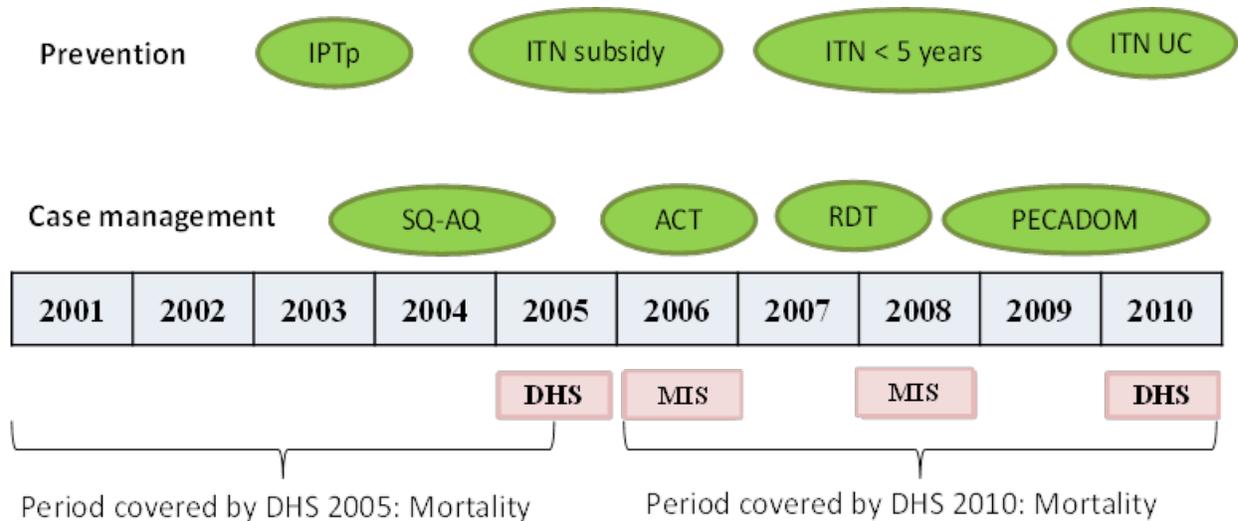
### ***Evaluation Design***

The overall objective of this evaluation is to assess the impact of all malaria control interventions from 2005 to 2010. The evaluation has these specific objectives:

- To measure all-cause child mortality during the intensification of malaria control interventions.
- To demonstrate that malaria control efforts have contributed to the reduction of all-cause child mortality.

The evaluation compared pre- and post-intervention periods. The pre-intervention period (before 2005) defines the period before the scale-up of malaria control interventions. Pre-intervention data on all-cause mortality among children under age 5 years were obtained from the fourth DHS, DHS-IV, conducted in 2005, which collected mortality data for the period 2000–2005 (Figure 1).

**Figure 1: Schematic presentation of the evaluation period**



**Note:** ACT=Artemisinin-based combination therapy; ITN=insecticide-treated nets; IPTp=intermittent preventive treatment in pregnancy; MIS=Malaria Indicator Survey; RDT=rapid diagnostic test, PECADOM= home-based treatment of malaria; UC=universal coverage; SP/AQ=sulfadoxine pyrimethamine/amodiaquine.

The post-intervention period defines the period starting in 2006, corresponding to the beginning of intensification of malaria control interventions, and ending in 2010. Data on mortality among children under 5 years of age were obtained from DHS-V, conducted in 2010–2011. Malaria Indicator Surveys (MIS) conducted in 2006 and 2008 provided data to compare changes in morbidity and mortality between the baseline (before 2006) and the period of national scale-up of malaria interventions.

Malaria transmission in Senegal is heterogeneous, consisting of several transmission zones. These zones are very low transmission in the north, low transmission in the center, and high transmission in the south. In Dakar, the capital city, malaria transmission is highly heterogeneous, and it represents a separate epidemiological zone. This analysis divides the country to fit these epidemiological zones, which are based on parasite prevalence.

### **Institutional Context**

The evaluation was funded by PMI and conducted under the leadership of the NMCP, with support from malaria control partners in Senegal and MEASURE Evaluation. The evaluation was based primarily on the review of DHS and MIS data and routine data from health facilities. We also reviewed reports from various studies on malaria conducted in Senegal and documents on the sources and levels of funding for malaria control activities.

The Ministry of Health set up a steering committee to coordinate the evaluation in 2012. The main objective of the committee was to facilitate the involvement of malaria control

stakeholders in Senegal. Throughout the evaluation process, the committee was able to create and maintain an enabling environment for good collaboration among technical departments of the government, academia, and other research institutions. Regular meetings were held at NMCP to monitor activities and approve all documents prepared by a team of consultants before any dissemination.

### **Evaluation Indicators**

The recommendations of RBM’s MERG guided the selection and definition of indicators used in this evaluation (Table 1).

**Table 1: Roll Back Malaria core population-based indicators used in this evaluation**

<b>Intervention</b>	<b>Description of indicator</b>
Vector control using insecticide-treated nets and long lasting insecticide-treated nets and indoor residual spraying	Proportion of households with at least one ITN/LLIN
	Proportion of the population with access to an ITN/LLIN within their household
	Proportion of the population that slept under an ITN/LLIN the previous night, in households owning at least one ITN*
	Proportion of children under 5 years old who slept under an ITN/LLIN the previous night
	Households covered by vector control: Proportion of households with at least one ITN/LLIN and/or sprayed by IRS in the last 12 months
Prevention and control of malaria in pregnant women	Proportion of women who received at least two doses of intermittent preventive treatment (IPTp) for malaria during ANC visits during their last pregnancy
	Proportion of pregnant women who slept under an ITN the previous night
Case management	Proportion of children under 5 years old with fever in the last 2 weeks for whom advice or treatment was sought
	Proportion of children under 5 years old with fever in the last 2 weeks who had blood taken from a finger or heel prick for malaria diagnosis
	Proportion of children under 5 years with fever in last 2 weeks who received any antimalarial treatment*
	Proportion of children under 5 years with fever in last 2 weeks who received first-line treatment according to national policy within 24 hours from onset of fever*
Mortality	All-cause under 5 years mortality rate
Morbidity	Parasite prevalence: proportion of children aged 6–59 months with malaria infection
	Prevalence of severe anemia: proportion of children aged 6–59 months with hemoglobin concentration <8 g/dL
	Prevalence of severe anemia and parasitemia: proportion of children aged 6–59 months with hemoglobin concentration <8 g/dL and malaria infection*
	Prevalence of fever and parasitemia: proportion of children aged 6–59 months with fever and malaria infection*

**Note:** \*These indicators are no longer recommended by the Roll Back Malaria Monitoring and Evaluation Reference Group, but are included here because they are still used to track National Malaria Control Program targets and Millennium Development Goals. ANC= Antenatal care, ITN=insecticide-treated nets; IPTp=intermittent preventive treatment, IRS=Indoor residual spraying

### **Insecticide-treated Nets**

ITNs are one of the major strategies for malaria control. The RBM ITN indicators report on both ownership and use of ITNs. ITN ownership is a household-level indicator, whereas use is measured for individuals. Use and access at the population level are measured, as is use by target populations that historically are at greatest risk of malaria morbidity and mortality: children under 5 years and pregnant women.

## **Intermittent Preventive Treatment in Pregnancy**

IPTp is another key strategy for malaria control, thus IPTp coverage is part of the RBM's MERG population-based indicators. WHO recommends IPTp in moderate-to-high malaria transmission areas. Until October 2012, IPTp strategy recommended the administration of at least two doses of sulfadoxine pyrimethamine (SP) starting from the second trimester of pregnancy, with at least 1 month interval between doses; however, the revised policy now recommends at least three doses.<sup>(1)</sup> For this evaluation, we report on IPTp coverage based on at least two doses of SP, in keeping with the policy that was in place during the period covered by this evaluation.

## **Malaria Case Management**

Proper diagnosis and effective treatment of malaria cases is another essential component of malaria control strategy. RBM's MERG population-based indicators recommend the estimation of the levels of access to biological diagnosis and effective treatment of malaria with effective antimalarial drugs. Facility-based data are often better suited for monitoring trends in malaria case management, and we include them in this report where relevant. Population-based surveys do not typically contain data on outpatients' visits to health facilities. Consequently, the proportion of children with fever who received a biological diagnosis of malaria is measured by a proxy indicator based on receiving a finger or heel prick, or not.

## **Parasite and Severe Anemia Prevalence**

The prevalence of severe anemia (hemoglobin level <8 g/dL) and malaria infection in children 6–59 months are two outcomes this evaluation examined that lie on the causal pathway between malaria control and child mortality. Severe anemia is a potential impact measure for total malaria-related disease burden, measurable at the population level with less seasonality than parasite prevalence.<sup>(2-4)</sup> Parasite prevalence is perhaps the most direct measure of malaria burden; however, the use of national estimates to measure success of programs is challenged because malaria transmission is heterogeneous; therefore, morbidity analyses were supplemented by longitudinal facility-based data on malaria cases, where possible.

## **All Cause Child Mortality**

The primary endpoint for this evaluation is to assess the impact of malaria interventions on all-cause mortality among children under 5 years of age. The mortality rate is expressed as the number of deaths among children aged 0–59 months per 1,000 live births. In line with the RBM's MERG guidelines, all-cause child mortality is the primary indicator for measuring impact. All-cause mortality is preferable to malaria-attributable mortality for a number of reasons, including lack of national-level malaria-specific mortality data, concerns about the sensitivity and specificity of verbal autopsy to determine malaria-specific deaths, and because malaria may have an indirect

contribution to under-5-years child mortality, estimated at 50% to 100% of the mortality that can be directly attributed to malaria.

### **Sources of Data for This Evaluation**

Data for this assessment were obtained mainly from the DHS and MIS databases, which are kept by the national bureau of statistics (“*Agence Nationale de la Statistique et de la Démographie*” - ANSD) with a copy of the census database, which is split into enumeration areas to address the general population and housing census sampling needs. Enumeration areas (“*districts de recensement*”) are well characterized by geographical boundaries and number of households by region, department, and council, as well as area of residence (urban and rural). In addition to measuring the key indicators, these databases also accounted for contextual factors. We also used meteorological data from the national civil aviation agency of Senegal (“*Agence Nationale de l’Aviation Civile du Sénégal* - ANACIM) in collaboration with the Center for Ecological Monitoring (“*Centre de Suivi Ecologique*” - CSE).

### **Malaria Indicator Surveys and Demographic and Health Surveys Data**

Mortality data collected during DHS-IV, conducted in 2005 (baseline mortality and morbidity before the scale-up of interventions, are compared with mortality and morbidity data collected during DHS-V, conducted in 2010–2011. These two databases can reliably inform on the level of reduction in mortality achieved post-intervention. Compared to other sources of data, such as those used by UNICEF, DHS data allow for data to be disaggregated by epidemiological zone and age group. Malaria Indicator Survey (MIS) data offer an opportunity to assess the trend of impact indicators (mortality, morbidity) between the two evaluation periods (2000-2005 and 2006-2010) and also to capture immediate changes in intervention coverage and some contextual factors. A more detailed description of DHS and MIS, with focus on survey methodology, sample size estimation, and other statistical parameters, is provided in Appendix A.

### **Routine Data from the National Malaria Control Program**

The NMCP database, or Roll Back Malaria Monitoring and Evaluation (RBMME), established to support RBM progress-monitoring activities, provided information on hospital mortality among children under 5 years, and on malaria morbidity before and after the scale-up of malaria control interventions. This database is updated regularly using data sent quarterly by health officers from districts and hospitals. Data include mortality, morbidity, IPTp, LLIN distribution, and ACT and RDT stock management. Members of district health management teams gather quarterly with NMCP members to submit, review, and validate routine data. During quarterly reviews, data are submitted from all levels of the health system pyramid. On-site data consistency checks are performed to check for discrepancies among information in the records of health facilities and information in reports submitted to the intermediate and central levels.

In addition, data from studies conducted by academic and research institutions have provided case studies to better support analysis and interpretation of the evaluation results.

## ***Data Management and Analysis***

### **Univariate Analysis**

After extraction of relevant information from different databases, data were analyzed using STATA software ([www.stata.com](http://www.stata.com)) and R<sup>TM</sup>. Mortality in children under 5 years was estimated and expressed as a percentage, and 95% confidence intervals (95% CI) were calculated. Crude mortality rates were compared to assess change over time between pre- and post-scale-up periods. Stratified analyses were then conducted by age group, sex, area of residence (urban or rural), epidemiological zone (Dakar, Centre, North, and South), household wealth quintiles, household size, and education of the mother. Contingency tables were also constructed and analyzed using the Pearson's chi-square test. Risk difference was estimated using the 2005 and 2010 data, and the 95% CI was calculated. Significance level of tests was set at 5% for one-sided test.

The same approach was used to assess the impact of interventions on morbidity (prevalence of malaria infection and anemia).

### **Multivariate Analysis**

This evaluation used the Kaplan-Meier conditional survival model to estimate overall child survival in 2005 and 2010, but it also stratified by epidemiological zones. This evaluation also used a multivariate Poisson regression model fitted to examine mortality risk between pre- and post-scale-up periods. The model controlled for confounding factors including ITN ownership and other relevant contextual factors that may influence child survival. Odds ratios (OR) were estimated using residuals derived from the Poisson regression model.

## **Country Profile**

### ***Presentation of Senegal***

#### **Location**

Senegal is in West Africa between 12° and 16° N, and 11° and 17°W, covering an area of 196,712 km<sup>2</sup>. The population was estimated at 12, 855,153 inhabitants in 2011, with a population density of 65.3 per km<sup>2</sup>. Senegal is bordered to the north by Mauritania, to the east by Mali, to the south by Guinea and Guinea Bissau, and to the west by more than 700 km of coastal line along the Atlantic Ocean. Gambia juts into the central part of Senegal, creating an enclave of more than 300 km. The Cape Verde Islands are 560 km off the Senegalese coast. The landscape is generally flat, with only a few areas of elevation in the southern part of the country.

## **Climate**

The climate is characteristic of the Sudanese savannah with a dry season from November–May and a rainy season from June–October. The average annual rainfall is higher in the South (1,250 mm) and decrease gradually from south to north, reaching as low as 300 mm in the north, with year–to-year variations. The rainfall patterns correspond to three well-defined climatic zones; a forest area in the south, a savannah area in the center and a semi-desert zone in the north.

## **Hydrography**

Apart from the Atlantic Ocean, which defines the coast of Senegal, surface water resources consist mainly of four rivers and stream tributaries, and some temporary streams. The lower reaches of the Senegal River and the middle reaches of the Gambia River are the two major systems that cross Senegal. The Sine and Saloum are inlets, while the Casamance River is a small coastal water course. Other rivers and valleys complement the hydrological landscape. Large dams built at Diama and Manantialia which are shared with Mali and Mauritania through the Organization for the Development of the Senegal River (OMVS), contributes to water resource control and thus, to the development of agriculture, animal husbandry, navigation, improved access to drinking water and energy for the population.

## **Administrative**

Senegal is a secular democratic and social republic, which ensures the equality of all citizens before the law, without distinction of origin, race, sex, or religion, and it respects all beliefs. In 2008, following the modification of the February 1972 law on administrative divisions, three new regions were formed to increase the total number of regions to 14. Senegal is divided into 45 administrative departments, which are subdivided into 121 arrondissements. These are further sub-divided into 113 boroughs and 370 rural communes. Large towns (Dakar, Rufisque, Pikine Guédiawaye, and Thies) are then subdivided into 46 communes d'arrondissement (communities).

The territorial administrative management system is characterized by two co-existing modes, a devolved mode whereby the local authority is exerted by State agents, and a decentralized mode whereby local authority is exerted by elected bodies. In the devolved mode, the region is under the authority of a Governor, the department is under the authority of a Prefect and the District is managed by a Sub-Prefect. In the decentralized mode, the region as a local community is managed by a regional council, the municipality by the municipal council and the rural community by the rural council. On top of these authorities who enjoy a favorable framework for development at the grass roots level, sit the elected councilors vested with power transferred in nine areas, including health care.

## **Socioeconomic Data**

The Government of Senegal has implemented economic growth and poverty reduction strategies (Poverty Reduction Strategy Plan PRSP1: 2003–2005; PRSP2 2006–2010; Economic and Social Policy DPES: 2011–2015) since 2001 with a target growth rate of 7 to 8% to halve poverty by 20 15 and achieve the MDGs. Significant economic and financial results were observed in recent years. The true annual economic growth was around 5% on average in a context of low inflation and other economic fundamentals. For the period 2003–2005 the decrease in the incidence of poverty was more pronounced in urban areas. The proportion of households living below the poverty line decreased from 48% in 2002 to 43% in 2005. Despite these results, the Senegalese economy remains vulnerable to external factors, including rainfall deficit, rising oil prices and food prices and the persistent effects of the international financial crisis in 2008.

## Health System

### Health Pyramid

The health system in Senegal is pyramidal with three levels including the Central level, the Intermediate and Regional level, and Operational level (Figure 2).

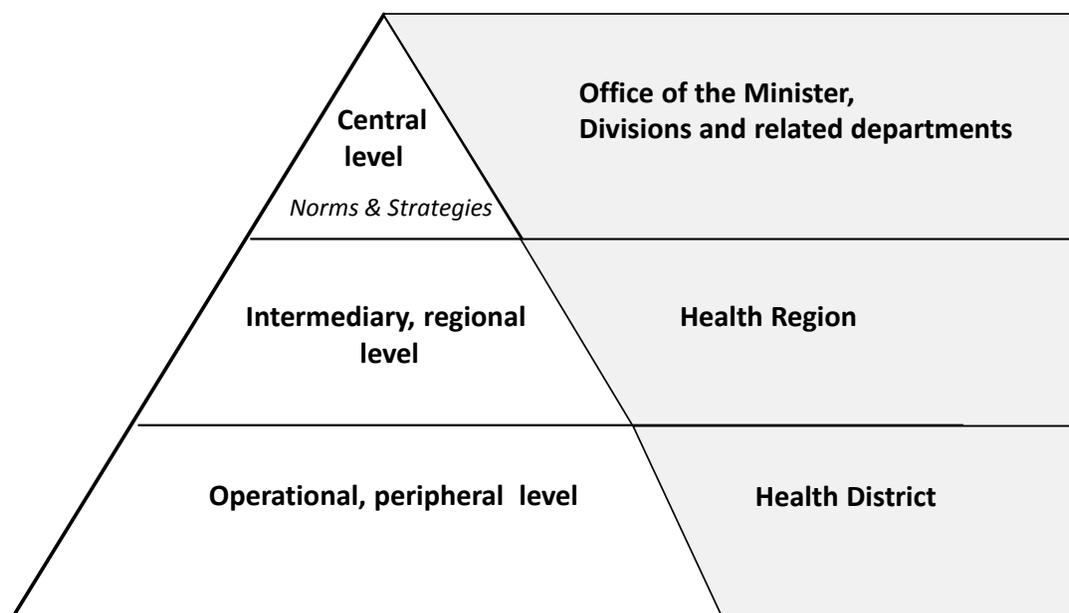
The **Central level** includes the Minister's office, divisions, and related offices. This level defines general guidance and priorities for health.

The **Intermediate and Regional level** includes the Health Region which corresponds to the administrative region. The regional level is headed by a Chief Regional Medical Officer (CRMO or *Médecin-Chef de Région, MCR*) who manages the senior regional health team comprised of supervisors of various health programs.

The **Operational level** corresponds to the Health District which may match exactly the entire administrative department or part of it. A Health District comprises at least one health center and a number of health posts. The operational level is managed by a Chief District Medical Officer (CDMO, locally known as *Médecin Chef de District, MCD*) who leads the district senior management team. The District represents the operational level of the health system where health programs are implemented.

It is noteworthy that medicines and hospital supplies are supplied at the regional level by the regional supply pharmacy, which receives its supplies from the National Supply Pharmacy (NSP) at the central level.

**Figure 2: National health pyramid**



## Health Infrastructures

Senegal has four types of health facilities:

**The Health Post** (*Poste de Santé, PS*) is the first level of contact patients have with the public health care structure. A health post is led by a state-certified nurse who occupies the function of Chief Nurse (known locally as *infirmier chef de poste*, or ICP). Health posts are located in major rural communities or in villages with relatively large populations and provide basic health care, as well as supervision and a referral center for the community level structures which include health huts (*case de santé*), rural maternities that are managed by community health workers (CHWs) or traditional birth attendants (TBA), and home-based care providers (DSDOMs).

**The Health Center** (*Centre de Santé, CS*) is the second tier in the structure of public health facilities, and a referral center for health posts. Health centers are located in towns or townships. A health center oversees a set of health posts and is led by a Chief Medical Officer.

**The Regional Hospital** (*Centre Hospitalier Régional, CHR*) is the third level, from bottom to top, of the public health care system and referral center for health centers. Regional hospitals are autonomous in their management; depending on their location they could play a role at the communal, departmental or regional level, providing services for internal medicine, obstetrics and gynecology, pediatrics and surgery, and sometimes in other areas of medical or surgical needs. The current national standard for coverage is one regional hospital for 150,000 inhabitants.

**The National Hospital** (*Centre Hospitalier National, CHN*) is the last tier of the public health care system, the top of the health care system pyramid and the last resort for health care. National Hospitals provide health care for the entire population because they have highly specialized technical resources and offer various health care services. Seven national hospitals are located in the capital city, Dakar.

In addition to formal health facilities, community health programs contribute to provide health care in Senegal. The community level had more than 2,000 functional health huts (*case de santé*) in 2010. These are run by community volunteers (CHWs or TBA) who provide malaria prevention and case management and other child survival interventions. In villages without health hut or health post, the NMCP has trained volunteers to provide malaria care at home (Dispensateurs de Soins à Domicile, or DSDOM) or home management of malaria (HMM). In 2010, Senegal had 861 DSDOM for HMM.

In 2010, according to CDSMT (*Cadre de dépenses sectoriel en moyenne terme*, or Framework for medium term sectorial spending) report, the health care system in Senegal included the following public facilities: 14 medical regions, 25 hospitals of which 23 were functional, 76 health districts, 89 health centers of which 20 are actually

health posts serving as health centers and 11 upgraded as first level public health institutions (*Etablissement publique de Santé niveau 1, EPS1*), 1,247 health posts of which 1,214 were functional, 129 maternities, 2,098 health huts; and 06 public health institutions with no hospitalization services. In addition to these public health infrastructures, the health system includes 555 private medical offices, 37 private clinics, 570 private paramedical facilities, 23 corporate health facilities and 77 private health posts. (CDSMT 2010 Report on Performance). The CDSMT report also indicated that the private sector, including the private for-profit and the private not-for-profit (faith based sector), plays an important role in the health care system, but is not adequately used for the implementation of malaria control interventions. Among children under 5 years with fever or cough in the previous 2 weeks, 16% sought care from the private sector.

To facilitate patients' care, a referral and counter-referral system was established based on the health care system structure for the referral of patients and transfer of health information from the peripheral level (health post and health center) to the hospital level; however, Senegal has not met the standards recommended by WHO for health infrastructure coverage.

### ***Malaria in Senegal***

Malaria transmission is linked to rainfall patterns and usually occurs during the rainy season and the beginning of the dry season. This period has a high density of malaria vectors. In general, the rains begin in June or July, earlier in the south than the north, and continue until October. The highest malaria transmission occurs in October and November. The main malaria species in Senegal is *Plasmodium falciparum*, which is responsible for 99% of malaria infections. *Plasmodium malariae* and *Plasmodium ovale* account for the remainder (about 10%) of the malaria infections in Senegal.

### **Stratification of the Risk of Malaria**

There is no malaria free zone in Senegal; therefore, the entire population is at risk. Depending on the climatic conditions and environmental factors that drive transmission, two main epidemiological strata characterize malaria transmission in Senegal, the tropical and Sahelian transmission strata.

**Tropical transmission stratum:** It covers south of a straight line between Mbour and Kidira corresponding to moist Sudanese and Guinea savannah zones. The annual rainfall varies from 800–1,500 mm. These areas are characterized by a long transmission season of 4–6 months covering the rainy season and the beginning of the dry season. The transmission level is fairly high (20 to 100 infective bites/person/year) and malaria morbidity high, especially during the high transmission period. Malaria transmission is stable, from holo- to meso-endemic. The main vectors include *Anopheles gambiae*, *An. arabiensis*, *An. funestus* and *An. nili*. This stratum is mostly found in the southern regions (Ziguinchor, Kolda, Tambacounda and Kédougou) in

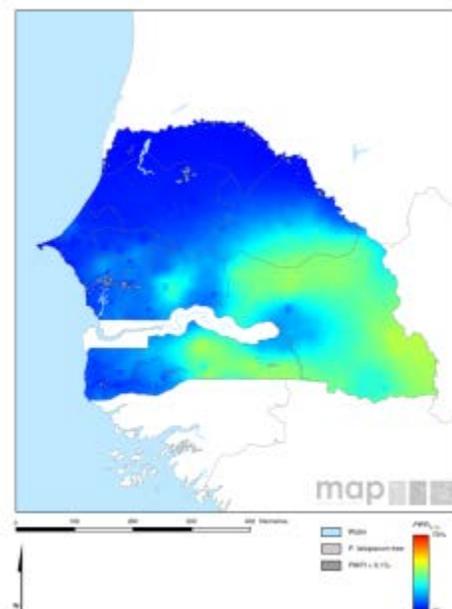
Sudanese and Guinea Savannah where the average annual rainfall is estimated at 1250 mm. Most transmission occurs from July–December.

**The Sahelian transmission feature:** This covers the areas north of the straight line between Mbour and Kidira and is marked by a short seasonal transmission (less than 4 months) and low malaria transmission (0–20 infective bites/person/year). Malaria is meso- to hypo-endemic, ranging from moderately stable to unstable. The main vectors are *An. gambiae*, *An. arabiensis*, *An. funestus*, *An. melas* and *An. pharoensis*. Malaria morbidity is generally low, however, sharp increases of cases, suggesting an epidemic, can be observed during years of particularly heavy rainfall. This stratum is found mainly in the northern parts of the central regions (Kaolack, Fatick, Diourbel, Dakar and Thies) and the North (Louga, St. Louis and Matam). Regions belonging to the Sahelian zone are characterized by 2–3 months of rainfall between July and October, with average annual rainfall of less than 500 mm.

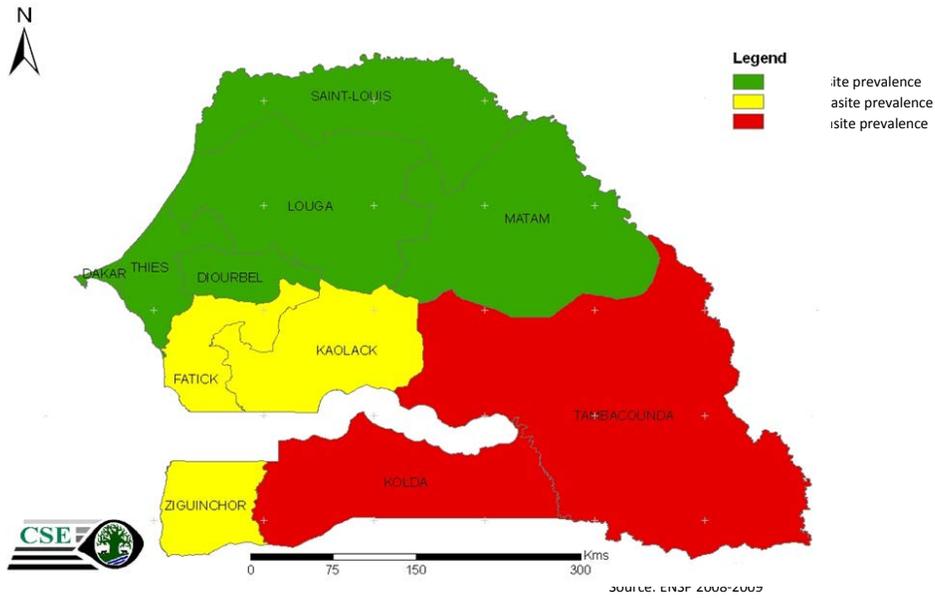
In each of these transmission risk zones, there may be local changes due to natural or anthropogenic factors that affect small scale variations. The intensity of transmission can vary considerably from one region to another, from one locality to another within the same region depending on environmental conditions, and from one year to another depending on climatic conditions.

The Malaria Atlas Project (Figure 3), the stratification generated by the first MIS which took into account the parasite prevalence (Figure 4), and malaria incidence calculated using 2009 routine data (the latest year when complete data were available) (Figure 5) are all in agreement. Malaria transmission in Senegal is high in the South and the East of Senegal, and lower in the North and the Center as well as in the Ziguinchor region, which is a coastal area dominated by mangroves and the presence of *An melas* vector.

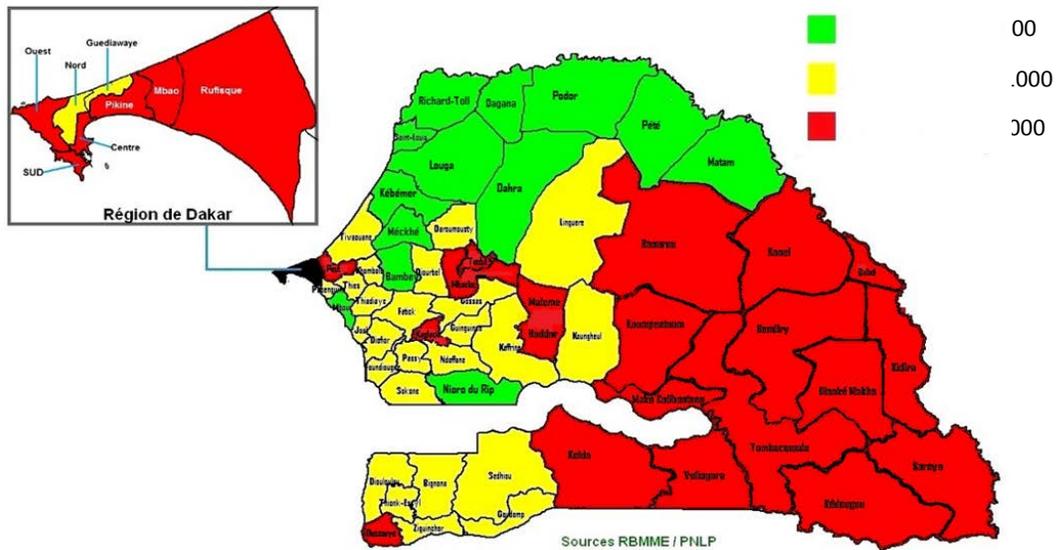
**Figure 3: Malaria Atlas Project: Estimated percentage of children 2–10 years with parasitemia in 2010.**



**Figure 4: Stratification based on parasite prevalence according to the Malaria Indicator Survey (MIS) in 2008-2009**



**Figure 5: Stratification based on the incidence (per 1000) of malaria using routine health facility data, 2009**



## **Overview on Climate, Vectors, and Malaria Transmission**

Ndiaye et al (2001)<sup>5</sup> studied how the climate influences spatial distribution and epidemiology of malaria. Climate influences the transmission of malaria through three partially related mechanisms (Lindsay et al, 1996); (i) the distribution and abundance of *Anopheles* vectors, (ii) the possibility and success of sporogonic development of the parasite within the vector and (iii) the modulation of human-vector contact.

Temperature, rainfall, relative humidity, and wind are four climate elements particularly involved in these processes.

**Temperature** influences the duration of the sporogonic development of the parasite, the duration of pre-imaginal development of the vector and the survival of adult mosquitoes. Above 35 °C and below 18 °C, the sporogonic development of *P. falciparum* is interrupted; at temperatures of 20, 24, and 30 °C, the sporogonic development takes 20, 11, and 9 days respectively. The pre-imaginal development of *Anopheles* occurs in water. At 25 °C, it takes about 10 days for *An. gambiae* and 20 days for *An. funestus*. The duration of pre-imaginal development increases when temperature decreases (up to 3 weeks for *gambiae*) and shortens when temperature increases (5 days at 30 °C for *An. gambiae*).<sup>(5)</sup>

**Rainfall** influences the availability and quality of mosquito breeding sites. In Sahelian Savannah, Mouchet et al (1996)<sup>(6)</sup> showed that droughts reduce the duration of the period during which breeding sites effectively contained water and intensity of malaria transmission, to a point that “a shrinking of malaria endemicity” was observed.<sup>5</sup> On the other hand, unusual rains, followed by floods, led to a significant increase in malaria cases in Asia and Kenya.<sup>(7-8)</sup> Finally, the impact of raindrops on *Anopheline* larvae does not appear to affect larval survival<sup>(9)</sup>; however, it is well established that heavy rains can cause significant mortality through the leaching of larval habitats, leading to aquatic stages being swept away and destroyed during floods.

The relative **humidity**, in turn, affects the survival of adult mosquitoes. As an example, usually a relative humidity of 80%, favorable to the survival of *Anopheles* is maintained in insectaries. Even small deviations of around  $\pm 5\%$  have a strong negative impact on survival.

Finally, wind influences the movement of adult vectors. Depending on the direction and speed, wind can play a positive or negative role in the dispersal of mosquitoes, including *Anopheles* vectors. It has been reported that *An. pharoensis*, a potential malaria vector in Egypt, usually has a dispersion from breeding sites on the order of 6 km. Occasionally, using winds from the northwest, *An. pharoensis* can move long distances. The presence of vectors was observed more than 100 km from the Nile Delta on several

occasions and more than 280 km once. Strong winds also can oppose the usual movement of mosquitoes looking for a blood meal.

In the framework of the Quantifying Weather and Climate Impacts on Health in Developing Countries (QWeCI) project, Diouf et al (2013)<sup>(10)</sup> showed the usefulness of new tools, such as climate models for the modeling of malaria<sup>(11-14)</sup>.

### **The Role of Malaria Control in the National Development Priorities**

Senegal has placed malaria control among national priorities defined in health policy. The country also clearly laid out technical guidelines for the implementation of strategies to control malaria in line with WHO recommendations. Malaria control is among the high priority programs, both in the second PRSP2 and in the National Strategic Health Development Plan (NSHDP) I and II. The political will of national authorities has been demonstrated many times, first by an effective commitment of the President of Senegal to attending national events on malaria, secondly through increased national funding with the allocation of a specific budget line for malaria control in the budget.

### **Organizational Structure of Malaria Control**

The NMCP is a national program attached to the Division of Disease Control within the Ministry of Health. The NMCP has a multidisciplinary team with diverse expertise, with the oversight of a steering committee consisting of representatives of partners, representatives of different public departments, research and academic institutions, as well as health professionals. In the regions and districts, coordination and implementation of malaria control activities is under the responsibility of regional and district senior management teams with the oversight of Regional Development Committees (chaired by a Governor), and Departmental Development Committees (chaired by a *Prefet*).

### **Key Strategies for Malaria Control**

Malaria control strategies are drawn from the declaration of national policy to control malaria. Strategies have been regularly updated in accordance with the WHO recommended guidelines, following these definitions:

- Vector control: This is selective strategy based on the use of ITNs, the use of repellent insecticides for IRS and chemical treatment of breeding sites
- Prevention and treatment of malaria in pregnant women at health facilities through case management and prevention by IPTp and LLIN
- Diagnosis and effective treatment of malaria cases at health facility and community level (home management of malaria, or HMM)
- Prevention and early response to malaria epidemics and emergencies; through integration of the HMIS and establishment sentinel surveillance sites.

To accelerate the implementation of malaria control programs, support strategies such as community-based interventions, strengthening the management of NMCP, capacity building of staff, devising a communication plan, strengthening operational research, and monitoring and evaluation also have been developed.

### **Key Players in Malaria Control**

Over the last 10 years, in the context of the RBM partnership, Senegal has developed a partnership that has contributed to mobilize resources and implement major control interventions. Malaria advocacy is carried out continuously to diversify activities and areas of intervention of partners.

Many technical and financial partners are involved in the financing and implementing malaria control interventions (Table 2). These include departments within the Ministry of Health, departments from other ministries, the agencies of the United Nations (WHO, UNICEF, UNDP), World Bank, the Organization for the Development of the Senegal River (OMVS), PMI, the Global Fund, the RBM Partnership, the Islamic Development Bank, the African Development Bank, the Japanese International Cooperation Agency (JICA), the Chinese Cooperation, academic and research institutes (University Cheikh Anta Diop, the Institute for Research and Development, Pasteur Institute), civil society, decentralized collectivities and communities (NGOs, community based-organizations[CBOs]) and community support networks for malaria control.

**Table 2: Area of intervention by partner**

Partners	Intervention area									
	LLIN	IRS	IPTp	RDT	ACT	BCC	Epidemic	M&E	PM	OR
Government MHSW	X		X	X	X	X	X	X	X	
Global Fund	X			X	X	X	x	X	X	
USAID–PMI	X	X	X	X	X	X	x	X		x
World Bank Booster	X					X				
UNICEF	X					X				
OMS			X		X		X	X	X	
FIND Diagnosis Foundation				x						
IDB	X			X		X			X	
Chinese Cooperation					x					x
ISED/UCAD									X	X
IRD										X
IPD										X
Private Sector						X			X	

**Note:** ACT=Artemisinin-based combination therapy, LLINs= Long lasting insecticide-treated nets, OR = Operations research, PM = Program management, RDT=Rapid diagnostic test, M&E=Monitoring and evaluation, BCC=Behavior change communication, IPTp=Intermittent preventive treatment

Source: NMCP

## Evolution of Malaria Control Policy and Strategy in Senegal

Key milestones of malaria control in Senegal are:

**Before 1994**, malaria control was integrated in the national policy of primary health care adopted since 1978 by Senegal. The actions taken were limited to the management of cases at health facilities in the context of a minimum package of activities (MPA).

**In 1995**, the NMCP was created and a scientific committee for malaria control was established. This group has actively participated in the development of the first national malaria control program (1995–2000).

**In 1997**, Senegal hosted the first meeting of the Multilateral Initiative on Malaria in Africa (MIM). The same year, along with 21 other African countries, Senegal was granted financial resources by WHO to implement an “accelerated malaria control program,” which was implemented in 12 health districts.

**In June 1999**, Senegal hosted a meeting to be part of the Roll Back Malaria initiative and joined the Health for Peace initiative, along with Guinea Bissau, Guinea Conakry, and Gambia. Senegal adopted an integrated strategy for malaria control.

**In 2000**, Senegal strengthened its commitment to malaria control following the Summit of Heads of State and Government on Malaria, held in April 2000, which adopted the Abuja Declaration and Plan of Action.

**In 2001**, as part of the adoption of the MDGs by the Secretary General of the United Nations, Senegal endorsed and implemented strategic adjustments needed to accelerate the achievement of Goal 6, which relates to malaria, HIV/AIDS, and tuberculosis.

**In 2002**, with the launch of the Global Fund to against HIV/AIDS, Tuberculosis and Malaria, the NMCP received the first grant of Global Fund Round 1 which helped accelerate the scale-up of malaria prevention and case management interventions.

**In 2003**, with the failing efficacy of conventional monotherapies (chloroquine, SP, amodiaquine), Senegal revised its policy for the management of uncomplicated malaria. The amodiaquine-sulfadoxine-pyrimethamine combination (AQ-SP) was used transiently from 2003–2006 for malaria treatment. The decision to adopt ACTs was made in 2004.

**In 2006**, ACTs were introduced in Senegal for the treatment of uncomplicated malaria. ACTs were made available to all health facilities, from hospitals to community health huts. Severe cases continued to be treated at referral health facilities with parenteral quinine. All malaria cases diagnosed among pregnant women were considered serious and treated as such. In the same year, distribution of subsidized LLINs through community-based organizations and in health facilities began.

**In 2007**, the introduction of rapid diagnostic tests by the NMCP marked a turning point in the history of malaria control in Senegal, with a change in case definition to include only cases confirmed by parasitologic diagnosis. IRS was also introduced in 2007 implemented in three pilot districts (Richard Toll, and Nioro Vélingara).

**In 2008**, the strategy of HMM based on the use of ACTs and RDTs by CHW was piloted in 20 villages to improve community access to malaria treatment. The first campaigns of mass distribution of LLINs to children under 5 years of age at sub-national level were also conducted in 2008.

**In 2009**, HMM was extended to 408 additional villages. The first nation-wide campaign of mass distribution of LLINs targeting children under 5 years of age was conducted.

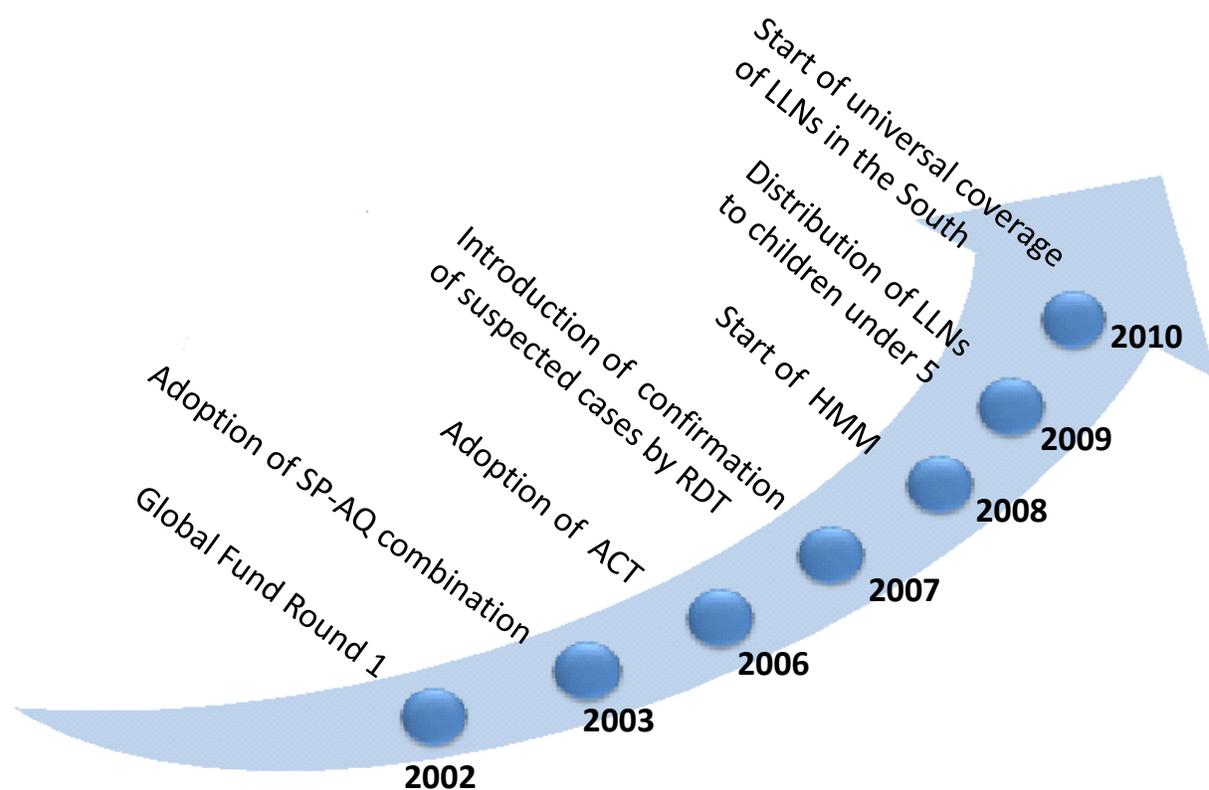
**In 2010**, HMM was further extended to cover 861 villages. The distribution of LLINs for universal coverage (targeting each sleeping place) was conducted in 4 regions in the Southeast, where transmission is highest, and IRS was introduced in three additional districts.

Senegal has adhered to all major international initiatives pertaining to malaria control and has built an effective partnership supported by a strong political commitment. This

enabled the mobilization of substantial resources from the Government and development partners.

To date, significant achievements have been made in the implementation of numerous components of the NMCP. At the operational level, activities have led to improved access and quality of treatment, as well as the acceptance of ITNs as a useful tool for malaria prevention.

**Figure 6: Key milestones of malaria control from 2002–2010 in Senegal**



**Note:** ACT=Artemisinin-based combination therapy, LLNs= Long lasting insecticide-treated nets, RDT=Rapid diagnostic test, HMM: Home based management of malaria, SP/AQ= Sulfadoxine Pyrimethamine/Amodiaquine

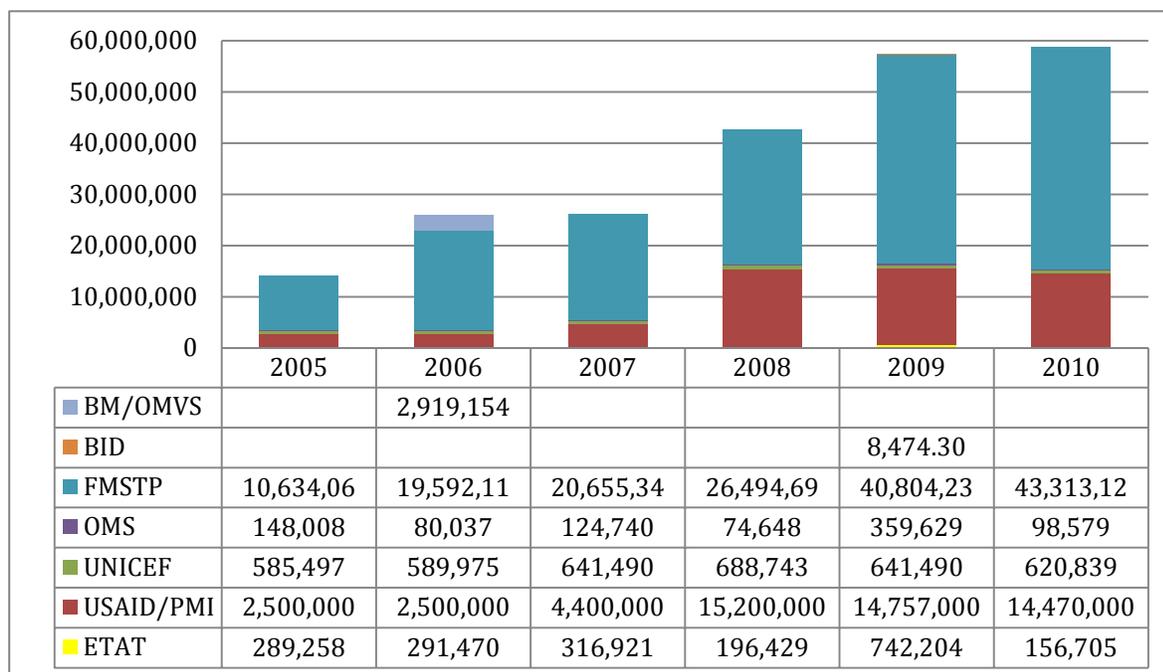
### ***Evolution of Financial Resources for Malaria Control***

Since 2005, Senegal has established an effective malaria control program, based on enhanced management capacities and well-defined plans. Implementing good operational and programmatic practices has helped increase external financial resources. The fruitful partnership developed from 2005 to 2010 was instrumental in mobilizing substantial resources from the Government and development partners. These funds have helped accelerate the implementation of activities defined in the two strategic plans that were rolled out during this period.

Funding for malaria control quadrupled from USD \$14,156,825 in 2005 to USD \$58,459,248 in 2010, for a total amount of USD \$224,894,859 over 6 years. The

increase in resources allowed the NMCP to intensify activities and expand the coverage of key malaria control interventions (ITNs, IRS, IPTp, RDT, and ACTs). Malaria control interventions were made accessible to all people, including to people living in remote areas. This achievement derives, to some extent, from the HMM program, which trained volunteers to visit patients at home, conduct RDTs to diagnose malaria, and administer treatment, if necessary, at no cost to patients.

**Figure 7: Financial contributions of the key partners from 2005 to 2010 in USD**



**Source:** NMCP, the amount corresponding to the Global fund to Fight AIDS, Tuberculosis, and Malaria disbursements.

BM/OMVS: World Bank / Organization for the Development of the Senegal River; BID: Islamic Development Bank; FMSTP: Global Fund to fight AIDS, Tuberculosis, and Malaria; OMS: World Health Organization; USAID/PMI: United States Agency for International Development / President's Malaria Initiative



## Scaleup of Malaria Interventions 2005–2010

### Vector Control with ITNs and IRS

**Context:** Vector control is a key element in the prevention of malaria. Before the development of the first insecticide in the 1940s, malaria control relied on treating mosquito breeding sites to eliminate larvae and reduce the population of adult mosquitoes. The development of insecticides suited for use in vector control has improved significantly malaria control. ITNs and IRS have become the pillars of malaria prevention efforts.

#### *Insecticide-Treated Nets*

ITNs are the cornerstone of malaria prevention. The use of nets for protection against mosquitoes has a long history; however it is only after the 1970s that the use of nets treated with insecticides to prevent malaria began.

In the early 1990s, a trial on treated mosquito nets in The Gambia showed a 40% reduction in all-cause mortality among children 1–4 years.<sup>(15)</sup> Thereafter, several other trials have confirmed the efficacy of ITNs, as reported by a systematic review that showed a 17% reduction in all-cause child mortality and a reduction in clinical malaria of approximately 50%.<sup>(16)</sup> In addition, a significant reduction of vector density was observed in communities where ITN coverage was sufficiently high, with a protective effect in the community even to people who do not sleep under an ITN; they benefit from the community protection.<sup>(17-18)</sup> A new approach for manufacturing ITNs based on the incorporation of an insecticide chemical in the fibers of the net has led to the development of a new generation of ITNs, long-lasting insecticide-treated nets (LLINs).

Initially, the use of ITNs was aimed primarily at children under 5 years and pregnant women, the most at-risk groups that available evidence indicated a benefit in reducing morbidity or mortality. With malaria elimination now a target and increasing levels of funding, endemic countries have adopted universal coverage with ITNs to ensure optimal access to ITNs in the general population and achieve the optimal level of community protection.

#### *Indoor Residual Spraying*

IRS consists of spraying the interior walls of homes with residual insecticides. This strategy is particularly effective against indoor-resting (endophilic) and indoor-biting (endophagic) mosquitoes. *Anopheles* mosquitoes usually rest indoors after a blood meal, and spraying the walls with insecticides prevents *Anopheles* from taking an additional blood meal or reaching maturation and laying mosquito eggs, and therefore, IRS reduces transmission. A systematic review showed that the effectiveness of IRS is

variable, but IRS decreases the incidence of malaria by 6%–88% and the prevalence of malaria infection by 26%–76%.<sup>(19)</sup>

## Implementation of Vector Control

### *Insecticide-Treated Nets*

The NMCP and its partners have supported various approaches to distribute ITNs, including (i) free distribution through periodic mass campaigns, (ii) distribution of subsidized ITNs targeted at vulnerable groups, (iii) non-targeted distribution of ITNs through health facilities and community-based organizations (CBOs), and (iv) commercial sales. From 2006 to 2009, NMCP supported the sale of nets to the general population in health facility pharmacies and through CBOs at a subsidized price of 1,000 CFA (USD 2), with a fraction of the sale price going to health districts and CBOs. From 2007–2009, PMI supported health facility sales of subsidized ITNs to pregnant women and children under 5 years, with beneficiaries contributing 1,000 to 1,500 cfa (USD 2-3) per net, depending on the net size. In 2008, the NMCP began working with PMI and other partners for large-scale distribution of ITNs to children under 5 years through mass campaigns, with a subnational campaign. In 2009, a national campaign of LLIN distribution, combined with vitamin A supplementation, administration of mebendazole, and vaccination against measles, distributed 2,305,456 LLINs. In 2010, the NMCP started implementing the policy of universal coverage of ITNs with the aim of providing one net per sleeping space. This was implemented through pilot distributions to the districts of Saraya and Vélingara in collaboration with the Peace Corps and World Vision (117,060 LLINs), and then expanded to four high-transmission regions: Sédhiou, Kolda, Tambacounda, and Kédougou (621,481 nets) (Table 3).

Three major manufacturers also have provided LLINs for sale in the private sector at a cost of 3,000 to 7,500 CFA (USD \$7.15 to \$17.90) per net.

**Table 3: Number of ITNs distributed by strategy**

	2005	2006	2007	2008	2009	2010	Total
<b>Subsidize routine system (USD)</b>	392,706	838,477	660,864	216,671	171,592	6,440	<b>2,286,750</b>
<b>Mass campaigns</b>			193,851	1,290,000	2,305,456	1,216,723	<b>5,006,030</b>
<b>Others (CBO pharmacies, private donors)</b>			2,121	79,851	54,970	35,500	<b>172,442</b>
<b>During net retreatment</b>	206,983	11,411	219,305				<b>437,699</b>
<b>Total</b>	<b>599,689</b>	<b>849,888</b>	<b>1,076,141</b>	<b>1,586,522</b>	<b>2,532,018</b>	<b>1,258,663</b>	<b>7,902,921</b>

Source: NMCP

### **Indoor Residual Spraying**

Nioro, Richard Toll, and Vélingara were selected as pilot districts to benefit from IRS when the intervention started in 2007. In 2010, IRS was expanded to the districts of Guinguiné, Malème Hodar, and Koumpentoum, which allowed for a substantial increase in the population covered by IRS (Table 4). Implementation of IRS in these districts was accompanied by regular monitoring of the effectiveness of the spraying and mosquito susceptibility to the insecticide (Table 5).

**Table 4: Evolution of the population covered by IRS**

	2007	2008	2009	2010
Number of districts	3	3	3	6
Targeted structures	*	162,439	200,761	259,967
Sprayed structures	*	153,942	176,279	254,559
Coverage	*	95%	88%	98%
Potentially protected population	678,971	645,346	661,814	959,727

**Note:** In 2007, data were collected on numbers of households, not numbers of structures.

**Source:** National Malaria Control Program.

**Table 5: Evolution of IRS and vector susceptibility to insecticide from 2007–2010**

	2007	2008	2009	2010
<b>Insecticide sprayed by district</b>				
Nioro	lambda-cyhalothrin	lambda-cyhalothrin	lambda-cyhalothrin	deltamethrin
Richard Toll	lambda-cyhalothrin	lambda-cyhalothrin	lambda-cyhalothrin	lambda-cyhalothrin
Velingara	lambda-cyhalothrin	lambda-cyhalothrin	lambda-cyhalothrin	deltamethrin
Guinguineo	---	---	---	deltamethrin
Koumpentoum	---	---	---	deltamethrin
Malem Hoddar	---	---	---	deltamethrin
<b>Mosquito sensitivity to pyrethroids: deltamethrin, lambda-cyhalothrin, permethrin</b>				
Nioro	---	95%, 95%, 85%	98%, 75%, 70%	67%, 39%, 56%
Richard Toll	---	99%, 95%, 100%		43%, 48%, 18%
Velingara	---	92%, 80%, 58%	82%, 90%, 55%	58%, 88%, 50%
Guinguineo	---	---	---	41%, 51%, 15%
Koumpentoum	---	---	---	68%, 63%, 57%
Malem Hoddar	---	---	---	49%, 36%, 17%

Source: National Malaria Control Program.

## Vector Control Coverage

**Question:** *Have vector control coverage indicators shown a significant increase in Senegal from 2005 to 2010?*

To answer this question, we examined the trends of the following indicators:

- ITN ownership at the household level
- Households protected by an ITN or IRS, or both
- Access to a net by people at the household level
- Use of ITNs among the general population in households owning at least one ITN
- Use of ITNs among children under 5 years

In 2011, RBM MERG recommended that the proportion of the population that has access to a mosquito net be used as an indicator of ITN use, with the assumption that a net is used by two people. For each household, the number of ITNs is multiplied by two, and the result is divided by the number of people who stayed in the household the previous night (maximum = 1). The number of people who slept under a net was divided by the number of people who have access to a net as a measure of use/access ratio.

## ITN Ownership at the Household Level

Ownership of ITNs at the household level in Senegal was 20% in 2005, 36% in 2006, and 60% in 2009, compared to 63% in 2010. Overall, ownership of ITNs at the household level has increased significantly from 2005 to 2010 ( $p<0.001$ ) Figure 8.

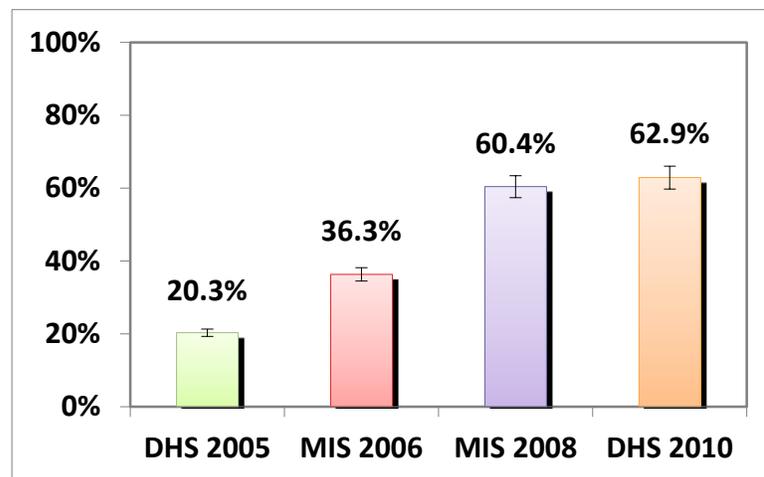
Table 6 shows the trend of ITN ownership by sociodemographic characteristics of the population from 2005 to 2010

according to the national surveys. Ownership of ITNs in rural areas increased from 22% in 2005 to 73% in 2010 ( $p<0.001$ ). In urban areas, a percentage point increase of 34% of ITN ownership by households was observed from 2005 to 2010 ( $p<0.001$ ).

ITN coverage increased significantly in different epidemiological zones from 2005 to 2010. The greatest percentage point increases were seen in the southern and central regions, with increases of 57% (32% to 88%) and 58% (21% to 80%) respectively. Smaller increases were seen in the north and in Dakar, with percentage point increases of 41% (24% to 66%) and 24% (13% to 37%) respectively.

In 2005, all quintiles of wealth had almost the same level of ITN ownership (18%–20%). The delivery strategies implemented through various interventions were key for the observed increase in ITN ownership, enabling the poorest segment of the population to have good access to ITNs in 2010, with ITN ownership reaching 75% in the poorest quintile, compared to 42% for the least poor households.

**Figure 8: Ownership of ITNs at the household level from 2005–2010, Senegal**



Note: DHS=Demographic and Health survey, MIS = Malaria Indicator Survey

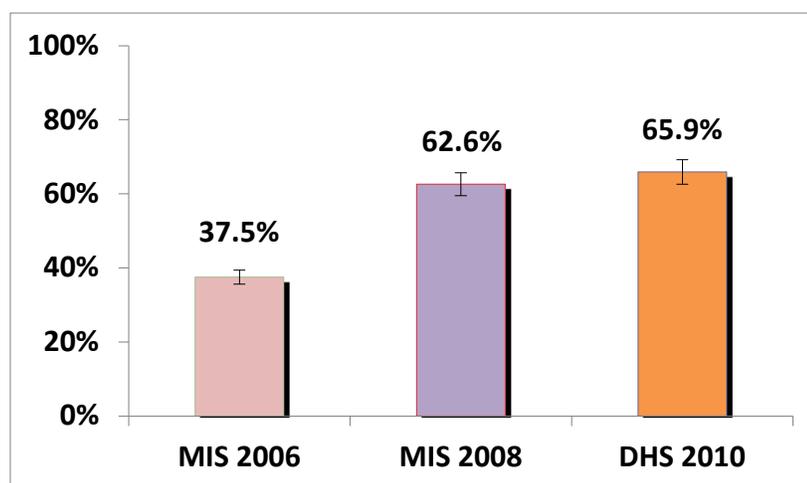
**Table 6: Household ownership of ITNs from 2005 to 2010 in Senegal**

<b>Indicator: Percentage of households with at least one ITN among all surveyed households by demographic characteristic</b>										
<b>Background characteristics</b>	DHS 2005		MIS 2006		MIS 2008		DHS 2010		Percentage point change (95%CI) *	p-value**
	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N		
<b>Total</b>	20.3 (18.8-21.9)	7412	36.3(32.9-39.9)	3063	60.4(57.4-63.3)	9291	62.9(59.7-66.1)	7902	42.6 (39.1-46.1)	<0.001
<b>Place of Residence</b>										
<i>Rural</i>	22.4 (20.1-24.9)	3,822	38.4(34.2-42.9)	1638	69.9(67.2-72.4)	4,874	73.2(70.2-76.1)	4,038	50.8 (47.0-54.6)	<0.001
<i>Urban</i>	18.1 (16.2-20.2)	3,590	33.9(28.5-39.9)	1425	49.9(44.1-55.7)	4,417	52.2(46.6-57.6)	3,864	34.1 (28.3-39.9)	<0.001
<b>Epidemiological Zone</b>										
<i>Dakar</i>	13.1 (10.7-15.9)	2,111	27.8(19.6-37.7)	832	36.5(28.7-45.1)	2,539	37.0(29.3-45.6)	2,112	23.9 (15.3-32.5)	<0.001
<i>North</i>	24.3 (22.7-25.9)	2,820	30.7(28.1-33.5)	1181	61.0(59.4-62.6)	3,764	65.6(63.9-67.2)	3,147	41.3 (39.0-43.6)	<0.001
<i>Center</i>	21.4 (19.4-23.6)	1,504	40.5(36.5-44.4)	618	83.0(81.2-84.7)	1,820	79.1(77.0-81.1)	1,599	57.7 (54.8-60.6)	<0.001
<i>South</i>	31.7 (28.8-34.8)	977	52.0(47.3-56.9)	432	52.0(49.1-54.9)	1,167	88.3(86.1-90.2)	1,023	56.6 (53.1-60.1)	<0.001
<b>Wealth quintile</b>										
<i>Poorest</i>	20.7 (17.7-24.0)	1,260	36.5(28.3-45.5)	552	66.8(63.0-70.5)	1,690	75.0(71.2-78.5)	1,600	54.3 (49.4-59.2)	<0.001
<i>Second poorest</i>	20.5 (17.9-23.5)	1,444	39.4(35.1-43.8)	599	70.3(66.8-73.6)	1,844	75.5(71.8-78.8)	1,584	55.0 (50.5-59.5)	<0.001
<i>Medium</i>	23.3 (20.4-26.4)	1,559	37.2(32.3-42.3)	629	73.6(69.1-77.8)	1,688	69.1(64.5-73.4)	1,490	45.8 (40.6-51.0)	<0.001
<i>Fourth</i>	18.8 (16.3-21.6)	1,656	33.2(27.0-40.1)	674	53.4(48.3-58.4)	2,068	53.8(47.9-59.5)	1,574	35.0 (28.5-41.5)	<0.001
<i>Richest</i>	18.4 (15.5-21.8)	1,494	35.9(15.5-21.8)	609	41.8(34.6-49.4)	2,001	42.4(35.4-49.6)	1,653	24.0 (16.3-31.7)	<0.001
<p><b>Note:</b> n = number of households (denominator); Insecticide-treated nets are nets that have been impregnated industrially by the manufacturer and do not require additional treatment (long-lasting insecticide-treated) or an pre-impregnated net obtained less than 12 months ago, or<sup>(20)</sup> a net that has been dipped in an insecticide less than 12 months ago. * The level of variation is calculated in absolute terms from 2005 to 2010. ** Pearson <math>\chi^2</math> one-sided test</p>										
<b>Source:</b> DHS 2005, 2010, MIS 2006, 2008.										

## Households Protected by ITNs and IRS

The proportion of households protected by ITNs or IRS, or both, was 38% in 2006, 63% in 2009, and 66% in 2010. Overall, an increase of 28 percentage points was seen in the proportion of households protected by ITNs or IRS, or both, from 2006–2010 (Figure 9).

**Figure 9: Households protected by ITNs or IRS, or both, in Senegal from 2005 to 2010**



In rural areas, the estimates of the proportion of households protected by ITNs or IRS, or both, were 39% in 2006 and 75% in 2010 ( $p<0.001$ ), while in urban areas, the coverage of ITNs or IRS, or both, increased from 35% in 2006 to 55% in 2010 ( $p<0.001$ ) (Table 7).

**Note:** DHS =Demographic and Health Surveys, MIS = Malaria Indicator Survey

**Table 7: Households protected by ITNs or IRS, or both, in Senegal 2005–2010**

<b>Indicator: Percentage of households with at least one ITN or receiving IRS in the last 12 months, or both, among surveyed households by demographic characteristics</b>								
<b>Background characteristics</b>	<b>MIS 2006</b>		<b>MIS 2008</b>		<b>DHS 2010</b>		Percentage point change (95%CI) *	<i>p</i> -value**
	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N		
<b>Total</b>	37.5 (34.2-41.0)	3063	62.6 (59.4-65.6)	9291	65.6 (62.4-68.6)	7902	28.1 (23.5-32.7)	<0.001
<b>Place of Residence</b>								
<i>Rural</i>	39.5(35.2-43.9)	1638	71.8(69.1-74.4)	4874	75.2(72.1-78.0)	4038	35.7 (30.5-40.9)	<0.001
<i>Urban</i>	35.3(30.0-41.0)	1425	52.3(46.2-58.4)	4417	55.5(50.2-60.7)	3864	20.2 (12.6-27.8)	<0.001
<b>Epidemiological Zone</b>								
<i>Dakar</i>	28.7(25.7-31.9)	832	38.9(37.0-40.8)	2539	41.6(39.5-43.8)	2112	12.9 (9.2-16.6)	<0.001
<i>North</i>	32.3(29.6-35.0)	1181	63.0(61.4-64.5)	3764	67.1(65.4-68.7)	3167	34.8 (31.7-37.9)	<0.001
<i>Center</i>	41.6(37.6-45.6)	618	84.1(82.4-85.8)	1820	80.3(78.3-82.2)	1599	38.7 (34.4-43.0)	<0.001
<i>South</i>	53.2(48.5-57.9)	432	60.0(57.2-62.8)	1167	92.6(90.9-94.2)	1023	39.4 (34.4-44.4)	<0.001
<b>Wealth Quintiles</b>								
<i>Poorest</i>	36.8(28.6-45.8)	552	68.6(64.6-72.3)	1690	77.6(73.7-81.0)	1600	40.8 (31.4-50.2)	<0.001
<i>Second</i>	39.6(35.2-44.1)	599	72.3(68.7-75.6)	1844	77.4(73.7-80.8)	1584	37.8 (32.1-43.5)	<0.001
<i>Middle</i>	38.2(33.4-43.3)	629	75.9(71.4-79.9)	1688	71.7(67.4-75.7)	1490	33.5 (27.1-39.9)	<0.001
<i>Fourth</i>	34.6(28.2-41.7)	674	56.4(50.7-62.0)	2068	55.6(49.9-61.1)	1574	21.0 (12.2-29.8)	<0.001
<i>Richest</i>	38.7(32.3-45.5)	609	43.6(36.2-51.3)	2001	46.5(39.8-53.4)	1653	7.8 (-1.8-17.4)	0.0005

**Notes:** n = number of households (denominator); Insecticide-treated nets are nets that have been impregnated industrially by the manufacturer and do not require additional treatment (long-lasting insecticide-treated nets) or pre-impregnated nets obtained less than 12 months ago, or<sup>(20)</sup> nets that has been dipped in insecticide less than 12 months ago.

\* The level of variation is calculated in absolute terms from 2006 to 2010. \*\* Pearson  $\chi^2$  one-sided test

**Source:** DHS 2010, MIS 2006, 2008.

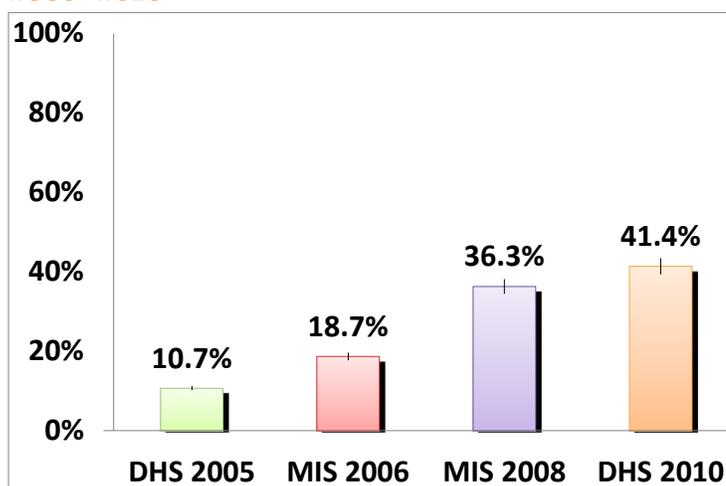
## Access to ITNs at the Household Level

The percentage of the population with access to ITNs at the household level is a new indicator that is calculated by assuming that on average two people sleep under each net.

Access to ITNs increased significantly from 11% in 2005 to 41% in 2010 ( $p < 0.001$ ) (Figure 10). Access by rural and urban populations and wealth quintiles showed similar trends to ownership of ITNs.

Household access to ITNs improved from 2005 to 2010 in urban and rural areas, in the different epidemiological zones, and in all quintiles of wealth. The largest increases were observed in rural areas among the poorest two quintiles, and in south and central epidemiological zones. In the southern epidemiological zone, household access to ITNs reached 70% in 2010 after the campaign for universal coverage (Table 8).

**Figure 10: Household access to ITNs in Senegal, 2005–2010**



**Note:** DHS = Demographic and Health Surveys, MIS = Malaria Indicator Survey

**Table 8: Access to ITNs at the household level in Senegal, 2005–2010**

<b>Indicator: Percentage of the household population with access to ITNs among all surveyed households by demographic characteristics</b>										
<b>Background Characteristics</b>	<b>DHS 2005</b>		<b>MIS 2006</b>		<b>MIS 2008</b>		<b>DHS 2010</b>		<b>Percentage point change (95%CI) *</b>	<b>p-value** one-sided</b>
	<b>% (95%CI)</b>	<b>N</b>								
<b>Total</b>	10.7 (9.7-11.7)	7412	18.7(16.6-20.7)	3063	36.3(34.3-38.4)	9291	41.4(39.1-43.7)	7902	30.7 (29.4-32.0)	<0.001
<b>Place of Residence</b>										
<i>Rural</i>	11.3 (9.8-12.8)	3822	19.4(14.8-21.3)	1638	30.5(26.5-34.5)	4874	49.6(46.9-52.2)	4038	38.3 (36.5-40.1)	<0.001
<i>Urban</i>	10.1 (8.7-11.5)	3590	18.0(16.0-22.3)	1425	41.5(39.3-43.8)	4417	32.8(29.1-36.5)	3864	22.7 (20.9-24.5)	<0.001
<b>Epidemiological zone</b>										
<i>Dakar</i>	7.8 (5.9-9.7)	2111	15.8(10.6-20.9)	832	19.9(14.8-23.0)	2539	19.8(15.0-24.6)	2112	12.0 (9.9-14.0)	<0.001
<i>North</i>	10.9 (9.2-12.6)	2820	14.7(12.4-17.1)	1181	32.0(28.7-35.3)	3764	56.2(52.5-59.9)	3147	45.3 (43.2-47.4)	<0.001
<i>Center</i>	9.9 (8.5-11.4)	1504	20.1(16.7-23.5)	618	48.4(46.2-50.7)	1820	39.2(36.4-41.9)	1599	29.3 (26.4-32.1)	<0.001
<i>South</i>	17.9 (14.8-20.6)	977	33.4(26.0-40.7)	432	43.7(39.0-48.5)	1167	69.6(66.6-72.6)	1023	51.7 (47.9-55.4)	<0.001
<b>Wealth quintile</b>										
<i>Poorest</i>	9.7 (8.1-11.8)	1260	19.0(12.9-25.1)	552	39.0(36.2-41.8)	1690	52.2(48.8-55.6)	1600	42.5 (39.5-45.4)	<0.001
<i>Second</i>	10.2 (8.6-11.8)	1444	20.1(17.5-21.7)	599	44.6(41.8-47.4)	1844	52.1(48.8-55.4)	1584	41.9 (38.9-44.8)	<0.001
<i>Middle</i>	13.1 (11.2-14.9)	1559	18.6(15.6-21.6)	629	44.1(40.9-47.4)	1688	45.6(42.3-49.0)	1490	32.5 (29.4-35.5)	<0.001
<i>Fourth</i>	10.4(8.7-12.1)	1656	16.7(12.8-20.6)	674	32.4(28.8-36.1)	2068	33.1(29.0-37.3)	1574	22.7 (19.9-25.4)	<0.001
<i>Richest</i>	10.1(8.0-12.1)	1494	19.5(15.0-24.0)	609	23.8(19.4-28.2)	2001	24.7(20.6-28.8)	1653	14.6(12.0-17.2)	<0.001

**Note:** n = number of households (denominator); insecticide-treated nets are nets that have been impregnated industrially by the manufacturer and do not require additional treatment (long-lasting insecticide-treated nets) or pre-impregnated nets obtained less than 12 months ago, or<sup>(20)</sup> nets that have been dipped in an insecticide less than 12 months ago.

\* The level of variation is calculated in absolute terms from 2006 to 2010. \*\* Pearson  $\chi^2$  one-sided test

**Source:** DHS 2005, 2010, MIS 2006 and 2008.

## Use of ITNs at Household Level from 2005 to 2010

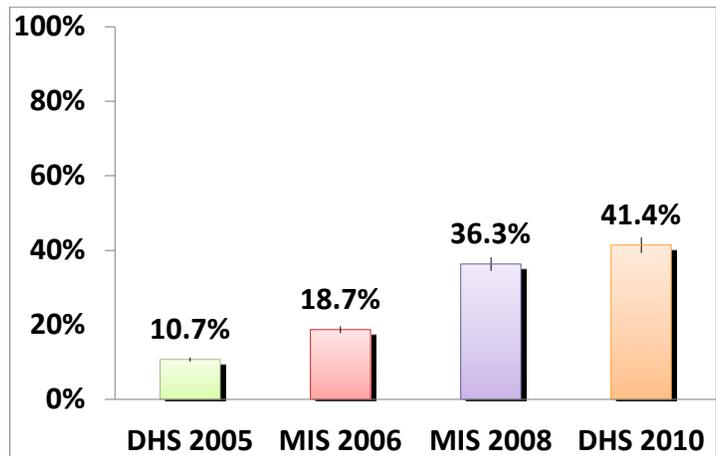
In 2005, among people living in households that owned an ITN, 10% slept under a net. In 2006, the proportion of people who slept under an ITN was 17%, compared to 35% and 38%, respectively in 2008 and 2010 in Senegal. This suggests a significant increase of 28 percentage points from 2005 to 2010 ( $p < 0.001$ ) (Figure 11).

In urban areas, 9% of individuals living in households with ITNs used them in 2005. This increased significantly to 30% by 2010 ( $p < 0.0001$ ). In rural areas, a significant increase also was observed, with 11% of people who used an ITN in households owning at least one ITN in 2005 and 45% in 2010 ( $p < 0.0001$ ).

The substantial increase in the proportion of people who slept under ITNs was observed across all epidemiological zones. The largest increases occurred in the central and southern epidemiological zones. The absolute increase in ITN use in the moderate transmission zone (center) was 43 percentage points ( $p < 0.001$ ), increasing from 9% in 2005 to 52% in 2010. The corresponding estimates for the southern epidemiological zone were 17% in 2005 and 62% in 2010 ( $p < 0.001$ ).

In terms of equity, similar levels were observed for ITN possession and access at the household level. A substantial improvement was observed among individuals belonging to the two poorest wealth quintiles compared to those from other wealth quintiles. Use of ITNs increased significantly from 9% at baseline (2005) to 49% post-intervention in 2010 ( $p < 0.001$ ) in the poorest wealth quintile. In the second poorest wealth quintile, ITN use increased from 10% in 2005 to 48% in 2010 ( $p < 0.001$ ), compared to an increase of 14 percentage points in the poorest quintile (8% to 22%). (Table 9).

**Figure 11: ITN use among people living in households with at least one ITN in Senegal, 2005–2010.**



**Note:** DHS = Demographic and Health Surveys, MIS = Malaria Indicator Survey

**Table 9: Use of ITNs among people living in households with at least one ITN in Senegal, 2005–2010**

<b>Indicator: Percentage of surveyed population living in households with at least one ITN who slept under an ITN the night before the survey</b>										
<b>Background characteristics</b>	DHS 2005		MIS 2006		MIS 2008		DHS 2010		Percentage point change (95%CI) *	<i>p</i> -value**
	% (95%CI)	N								
<b>Total</b>	9.8(8.9-10.8)	63494	17.5(15.5-19.6)	28167	34.9(33.1-36.8)	84480	38.1(36.0-40.2)	73365	28.3 (27.9-28.7)	<0.001
<b>Place of Residence</b>										
<i>Rural</i>	8.6(7.5-9.8)	27957	16.9(14.2-19.6)	11544	29.5(25.8-33.2)	35177	30.1(26.7-33.5)	32901	21.5 (20.9-22.1)	<0.001
<i>Urban</i>	10.7(9.3-12.2)	35538	18.0(14.9-21.1)	16623	38.8(36.6-41.1)	49303	44.6(41.9-47.3)	40464	33.9 (33.3-34.5)	<0.001
<b>Epidemiological Zone</b>										
<i>Dakar</i>	5.9(4.4-7.4)	14728	14.4(10.0-18.9)	5994	17.8(13.1-22.5)	19245	18.1(13.8-22.4)	17028	12.2 (11.5-12.9)	<0.001
<i>North</i>	12.3(11.9-12.7)	25856	12.3(11.7-12.9)	11787	32.9(32.4-33.4)	36729	35.7(35.2-36.2)	30565	23.4 (22.7-24.1)	<0.001
<i>Center</i>	9.4(8.9-9.9)	13629	19.2(18.2-20.2)	5772	54.2(53.5-54.9)	17090	51.7(50.9-52.5)	15464	42.3 (41.4-43.2)	<0.001
<i>South</i>	16.8(16.0-17.6)	9281	29.2(27.9-30.5)	4614	35.4(34.5-36.3)	11417	61.6(60.7-62.5)	10307	44.8 (43.6-46.0)	<0.001
<b>Wealth Quintile</b>										
<i>Poorest</i>	9.4(7.7-11.2)	12501	20.0(12.9-27.2)	5664	38.2(35.5-40.8)	16786	48.6(45.2-51.9)	14615	39.2 (38.2-40.1)	<0.001
<i>Second</i>	10.1(8.4-11.7)	12580	18.8(16.2-21.5)	5568	42.5(39.8-45.2)	16846	47.6(44.4-50.9)	14630	37.5 (36.5-38.5)	<0.001
<i>Middle</i>	12.8(10.8-14.7)	12697	17.1(14.2-19.9)	5557	40.6(37.1-44.1)	17018	41.3(38.1-44.5)	14642	28.5 (27.5-29.5)	<0.001
<i>Fourth</i>	8.8(7.2-10.4)	12811	15.7(12.8-18.6)	5721	30.9(27.7-34.2)	16892	30.8(26.6-34.9)	14735	22.0 (21.8-23.6)	<0.001
<i>Richest</i>	8.1(6.4-9.7)	12904	16.1(12.5-19.7)	5657	22.5(18.5-26.5)	16937	22.4(18.9-25.9)	14743	14.3 (13.5-15.1)	<0.001

**Note:** n = number of respondents interviewed (denominator); Insecticide-treated nets are nets that have been impregnated industrially by the manufacturer and do not require additional treatment (long-lasting insecticide-treated nets) or pre-impregnated nets obtained less than 12 months ago, or nets that have been dipped in an insecticide less than 12 months ago. \* The percentage change from 2005 to 2010 is calculated in absolute terms. \*\* \*\*\* Pearson  $\chi^2$  one-sided test

**Source:** DHS 2005, 2010, MIS 2006, 2008.

## Use of ITNs Among Children Under 5 Years

In 2005, 7% of children under 5 years of age were sleeping under an ITN, compared to 20% in 2006, 32% in 2009 and 35% in 2010. Overall, the use of ITNs among children under 5 years has increased significantly from 2005 to 2010 ( $p<0.001$ ) (Figure 12).

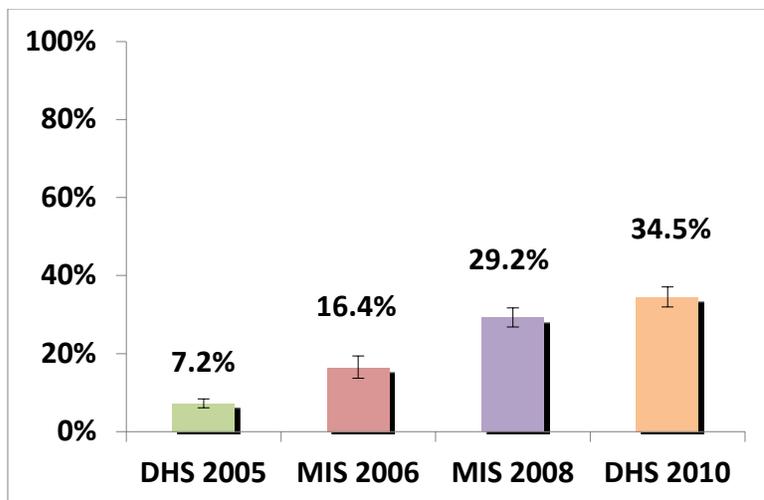
Analysis of ITN use by age band showed a significant increase from 2005–2010. In children younger than 12 months, use of ITNs increased from 9% in 2005 to 35% in 2010 ( $p<0.001$ ). Among

children aged 11–23 months, the proportion that used ITNs increased from 7% in 2005 to 37% in 2010, suggesting an absolute increase of 30 percentage points between the two periods ( $p<0.001$ ). Substantial increases in the use of ITNs also were observed in older children (ages 24, 36, and 48 months) from 2005 to 2010 (Table 10:).

In urban settings, 7% of children under 5 years slept under an ITN in 2005, compared to 31% in 2010, indicating an absolute increase of 24 percentage points ( $p<0.001$ ). In 2005, 7% of children under 5 years living in rural areas slept under an ITN. This proportion increased significantly in 2010, reaching 36% in children under 5 years living in rural areas ( $p<0.001$ ).

Marked increases in ITN use also were achieved in all malaria epidemiological zones over the specified period; however, the southern epidemiological zone displayed the greatest increase in ITN use compared to the other epidemiological zones with an increase from 8% to 50%. The second largest increase was found in the center, which increased from 7% to 40% (with a peak of 48% in 2008). In wealth quintiles, the sharpest increases were observed in children under 5 years from the two poorest wealth quintiles, with an increase from 4% to 38% in the poorest quintile, and from 7% to 41% in the second quintile.

**Figure 12: Use of ITNs among children under 5 years of age in Senegal, 2005–2010**



**Note:** DHS = Demographic and Health Surveys, MIS = Malaria Indicator Survey

**Table 10: Use of ITNs among children under 5 years in Senegal, 2005–2010**

<b>Indicator: Percentage of children under 5 years who slept under an ITN the night before the survey, by sociodemographic characteristic</b>										
<b>Background characteristics</b>	<b>DHS 2005</b>		<b>MIS 2006</b>		<b>MIS 2008</b>		<b>DHS 2010</b>		<b>Percentage point change (95%CI) *</b>	<b>p-value**</b>
	<b>% (95%CI)</b>	<b>N</b>								
<b>Total</b>	7.2(6.1-8.4)	10452	16.4(13.7-19.4)	4685	29.2(26.8-31.7)	14368	34.5(32.0-37.1)	12395	27.3 (24.5-30.1)	<0.001
<b>Age (in months)</b>										
<12	8.9(7.4-10.7)	2388	19.6(16.2-23.6)	995	31.8(28.6-35.0)	2915	35.3(32.2-38.5)	2505	26.4 (22.9-29.9)	<0.001
12-23	6.9(5.5-8.6)	2121	18.7(14.9-23.2)	995	30.8(27.4-34.4)	2720	36.9(33.5-40.6)	2397	30.0 (26.1-33.9)	<0.001
24-35	7.0(5.7-8.7)	1999	15.1(12.0-18.8)	886	29.6(26.9-32.5)	2811	34.4(31.3-37.6)	2524	27.4 (23.9-30.9)	<0.001
36-47	6.5(5.2-8.2)	2041	15.2(12.2-18.7)	929	27.0(24.4-29.7)	2933	32.8(29.7-36.1)	2596	26.3 (22.8-29.8)	<0.001
48-59	6.1(4.8-7.7)	1903	12.7(9.6-16.5)	880	27.0(24.0-30.2)	2989	33.1(30.3-36.1)	2373	27.0 (23.8-30.2)	<0.001
<b>Sex</b>										
Male	7.5(6.2-9.0)	5335	16.0(13.4-19.0)	2396	29.4(26.8-32.0)	7306	34.2(31.5-36.9)	6340	26.7 (23.6-29.8)	<0.001
Female	6.9(5.8-8.1)	5117	16.8(13.8-20.3)	2289	29.0(26.4-31.8)	7063	34.9(32.1-37.8)	6054	28.0 (25.0-31.0)	<0.001
<b>Place of Residence</b>										
Rural	7.3(5.8-9.2)	3783	15.0(11.8-19.0)	1599	29.3(25.0-34.0)	5212	31.3(26.8-36.1)	4648	24.0 (19.0-29.0)	<0.001
Urban	7.1(5.7-8.8)	6669	17.1(13.4-21.5)	3086	29.1(26.4-32.1)	9157	36.4(33.4-39.6)	7746	29.3 (25.8-32.8)	<0.001
<b>Epidemiological Zone</b>										
Dakar	4.9(2.9-8.8)	1811	10.8(5.9-19.0)	753	20.6(15.4-27.0)	2753	17.5(12.2-24.4)	2372	12.6 (10.8-14.4)	<0.001
North	11.2(10.3-12.1)	4557	10.8(9.5-12.2)	2058	23.8(22.8-24.9)	6425	34.9(33.6-36.2)	5249	23.7 (22.1-25.3)	<0.001
Center	6.8(5.8-7.8)	2404	18.3(15.9-20.9)	957	47.7(45.9-49.5)	3016	40.3(38.5-42.1)	2814	33.5 (31.4-35.6)	<0.001
South	7.7(6.5-9.1)	1680	26.4(23.6-29.4)	917	28.7(26.8-30.6)	2175	50.3(48.1-52.5)	1960	42.6 (40.0-45.2)	<0.001
<b>Wealth Quintile</b>										
Poorest	3.7(2.6-5.2)	2422	20.1(12.8-30.2)	1112	29.1(25.8-32.8)	3314	38.2(34.3-42.2)	2904	34.5 (30.4-38.6)	<0.001
Second	7.3(5.5-9.6)	2325	18.6(14.8-23.1)	998	32.0(28.5-35.6)	3116	40.6(36.8-44.6)	2785	33.3 (28.9-37.7)	<0.001
Middle	11.0(8.8-13.7)	2176	16.1(12.9-19.9)	961	30.2(25.0-35.9)	2960	39.7(35.3-44.3)	2408	28.7 (23.6-33.8)	<0.001
Fourth	8.4(6.4-11.1)	1906	14.7(10.8-19.7)	868	30.0(25.7-34.6)	2611	28.6(23.8-34.0)	2295	20.2 (14.6-25.8)	<0.001
Richest	5.6(3.7-8.3)	1625	10.2(6.1-16.5)	746	23.5(18.5-29.3)	2367	21.1(16.8-26.1)	2002	15.5 (10.3-20.7)	<0.001

Remark: n = number of children under 5 years (denominator); insecticide-treated nets are nets that have been impregnated industrially by the manufacturer and do not require additional treatment (long-lasting insecticide-treated nets), pre-impregnated insecticide-treated nets obtained less than 12 months ago, or nets that have been dipped in an insecticide less than 12 months ago. \* The percentage change is calculated in absolute terms from 2005 to 2010. \*\* Pearson  $\chi^2$  one-sided test

**Source:** DHS 2005, 2010, MIS 2006, 2008.

### Summary: Vector Control

Over the past 5 years, vector control relied on two key elements, promoting the use of ITNs and IRS. Efforts deployed in vector control led to a substantial increase in resources, which contributed significantly to the improvement of coverage indicators. Initially, the promotion of ITNs targeted the most vulnerable groups of the population, such as children under 5 years and pregnant women. Lately, as part of universal coverage of ITNs, the target was extended to the whole Senegalese population. This has contributed to an increase in household ownership of ITNs from 20% in 2005 to 36% in 2006, 60% in 2009, and 63% in 2010. Comparison of the baseline (2005) and the end of the intervention (2010) periods showed a marked increase in ITN ownership at the household level ( $p < 0.001$ ). Disaggregated data by demographic and socioeconomic characteristics of the population also showed consistent increases in ITN coverage in households. The highest increases were observed in populations living in high malaria transmission areas, including rural areas, and in populations from the poorest wealth quintiles (corresponding to the most at-risk populations). In such circumstances, a significant impact on malaria is likely.

The implementation of IRS started in 2007 and resulted in improved coverage from 2006 to 2010. The proportion of households protected by ITNs and IRS increased from 37% in 2006 (baseline) to 63% in 2009, and reached 66% in 2010, indicating a significant increase compared to the baseline period (2006).

An increase in the coverage of vector control measures was accompanied by a significant improvement in ITN use. The ratio of users to people who have access gives an indication of the percentage of the population using ITNs among all people with access to them. From 2005 to 2010, the use of ITNs increased among people who have access to ITNs, as indicated by 61% of the population with access to ITNs that had slept under an ITN in 2005, compared with 76% in 2010 (Table 11).

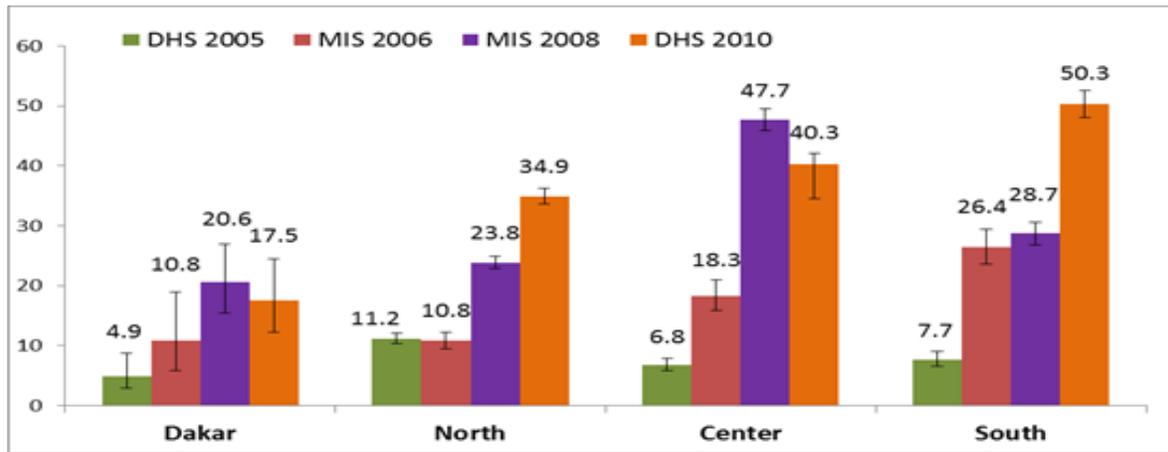
**Table 11: ITN use and access ratio among people living in households with at least one ITN in Senegal, 2005–2010**

Year and Type of Survey	Percentage of households with at least one ITN	Percentage of population who slept under an ITN the previous night	Average percentage of population with access to an ITN in the household	Ratio Use/Access
DHS 2005	20.3	5.8	9.8	0.61
MIS 2006	36.6	12.2	17.5	0.69
MIS 2008	60.4	22.9	34.9	0.66
DHS 2010	66.2	28.9	38.1	0.76

Among children under 5 years, the proportion who slept under an ITN increased from 7% in 2005 to 20% in 2006, 32% in 2009, and 35% in 2010. This indicated a significant

increase ( $p < 0.001$ ) in ITN use in children under 5 years from 2005 to 2010. The largest increases were observed in the south and center epidemiological zones, where the risk of malaria is highest (Figure 13).

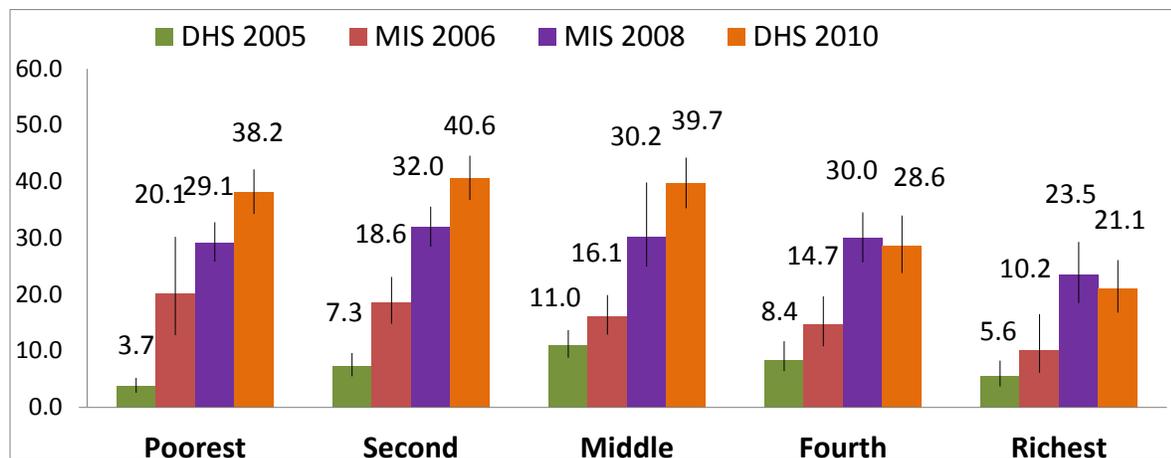
**Figure 13: ITN use among children under 5 years by epidemiological zone in Senegal, 2005–2010**



**Note:** ESD (DHS)=Demographic and Health Surveys, MIS = Malaria Indicator Survey

The greatest increases in ITN use among children under 5 years post-intervention were observed in the two poorest wealth quintiles; however, the proportion of users was similar across the three least wealthy quintiles in 2010 (Figure 14).

**Figure 14: Use of ITNs among children under 5 years by wealth quintile, Senegal 2005 to 2010**



**Note:** ESD (DHS)=Demographic and Health Surveys, MIS = Malaria Indicator Survey

Vector control interventions, especially ITNs, were made available to populations living in areas of high transmission. Data from cross-sectional surveys showed substantial

improvements in ITN ownership and use of ITNs achieved in these areas; however, reaching vulnerable and less accessible populations remains a challenge. The encouraging results in ITN coverage and use in these populations is testimony to the success of mass distribution campaigns to ensure access to malaria preventive measures for the poorest.

## Prevention of Malaria in Pregnancy

### Context

High risk is associated with malaria in pregnancy, especially primigravidae during the second and third trimester and HIV-positive pregnant women. Malaria significantly increases the risk of severe disease in pregnant women and their babies, and the disease can cause serious adverse effects, including anemia, abortion, delayed intrauterine growth, prematurity, and low birthweight.<sup>(22-23)</sup> In areas of high transmission, malaria indirectly contributes to maternal mortality.<sup>(2)</sup> Malaria during pregnancy increases the risk of neonatal mortality associated with low birthweight and anemia in newborns.<sup>(3-4)</sup>

In 2002, WHO recommended IPTp with SP as a strategy for malaria prevention in pregnancy in endemic countries.<sup>(24)</sup> The recommended dosage is at least two doses of SP (three tablets, each containing 500 mg of sulfadoxine and 25 mg of pyrimethamine) during ANC visits, starting from the second trimester quarter of the pregnancy, with at least a 4-week interval between doses.

ITN use is another important strategy for preventing malaria during pregnancy. A study on ITN use by pregnant women in areas of high transmission showed a 47% reduction in the incidence of severe anemia in pregnancy, a 35% reduction in the prevalence of placental parasitaemia, and a 28% reduction in low birthweight.<sup>(25)</sup> Analysis that included databases from 25 African countries showed that protecting a woman during pregnancy with either ITNs or IPTp reduces neonatal mortality by 18% and low birthweight by 21%.<sup>(26)</sup>

### Implementation

IPTp with SP for malaria prevention in pregnancy was adopted by the NMCP in 2003 as a strategy for malaria control in Senegal. The national policy recommends the administration of at least two doses of SP as a directly observed treatment (DOT) to all pregnant women during the second and third trimesters of pregnancy, with at least a 1-month interval between doses.

The Ministry of Health has instructed all districts to maintain stocks of SP for administration to pregnant women free of charge. As part of the decentralization, the Ministry of Economy and Finance allocates funds to local administrative authorities to be managed in concert with health districts for the purchase of medications, including SP. Allocation of these funds is intended to make SP permanently available at the peripheral level for free-of-charge administration to pregnant women that attend ANC visits. In addition, vouchers for subsidized ITNs are distributed to pregnant women during ANC visits (Table 12).

**Table 12: Distribution of sulfadoxine-pyrimethamine in public health facilities in Senegal from 2005 to 2010**

	2005	2006	2007	2008	2009	2010
Total ANC population (expected pregnancies)	433,438	432,022	442,390	453,008	463,879	488,150
Total number of SP doses distributed (number of blisters of 3 tablets)	na	na	na	500,000	0	351,973

**Source:** PNA Senegal.

**Note:** na = data not available; SP was not purchased in 2009.

### Prevention of Malaria in Pregnant Women

#### Questions:

- *Did IPTp coverage for malaria prevention in pregnant women in Senegal increase significantly from 2005 to 2010?*
- *Did ITN use among pregnant women in Senegal increase significantly from 2005 to 2010?*

To address these questions, we analyzed the trends of the following indicators:

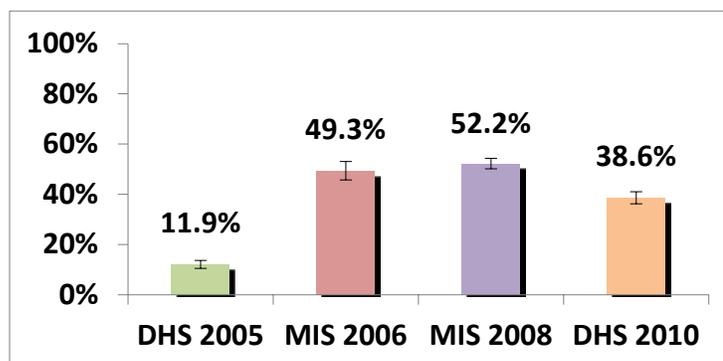
- Use of IPTp among pregnant women
- Use of ITNs among pregnant women

#### IPTp coverage

Overall, IPTp coverage among pregnant women was 12% in 2005, 49% in 2006, 52% in 2008, and 39% in 2010, indicating a significant increase in coverage from 2005 to 2010 ( $p < 0.001$ ), although there was a decline in 2010, compared with 2006 and 2008 (Figure 15).

Table 13 presents the trend in the use of IPTp in pregnancy from 2005 to 2010, according to various background

**Figure 15: Use of intermittent preventive treatment in pregnancy in Senegal, 2005-2010**



**Note:** ESD (DHS)=Demographic and Health Surveys, MIS = Malaria Indicator Survey

characteristics. The use of IPTp in urban areas increased significantly from 15% in 2005 to 45% in 2010 ( $p<0.001$ ). A substantial increase also was observed in rural areas, with 10% and 34% ( $p<0.001$ ) of pregnant women having received IPTp in 2005 and 2010, respectively.

In the epidemiological zone of Dakar, a significant increase in the use of IPTp was observed in 2010 (41%), compared to 2005 (9%) ( $p<0.001$ ). Similar trends were observed in the central epidemiological zone, with IPTp use of 11% in 2005 and 40% in 2010 ( $p<0.001$ ). In the northern epidemiological zone, IPTp use more than doubled from 2005 (15%) to 2010 (37%). A significant increase also was observed in the southern epidemiological zone, with IPTp use increasing from 5% in 2005 to 33% in 2010 ( $p<0.001$ ). Despite the high level of transmission in the south, IPTp coverage remains lower than in the remainder of the country.

Analysis by socioeconomic status showed that IPTp coverage was only 8% in 2005 among the poorest and 17% in the wealthy households. IPTp coverage improved from 2005 to 2010 among the poorest quintile of population, but the level of coverage achieved in 2010 in this group is much lower than in the least poor quintile (26% compared with 48%). Stratified analysis by parity indicated that IPTp increased significantly from 2005 to 2010 among primigravidae ( $p<0.001$ ) and among multigravidae ( $p<0.001$ ).

Pregnant women who had their first ANC visit within the first 3 months of pregnancy showed a significant increase in IPTp use from 2005 to 2010, with 14% and 42% ( $p<0.001$ ), respectively, having received IPTp. A similar level of increase in the use of IPTp was observed from 2005 to 2010 among women who had their first ANC visit during the fourth month of pregnancy. Comparing the use of IPTp in 2005 with use in 2010, data showed significant increases in pregnant women who had their first ANC visit at the gestational ages of 5, 6, and 7 months and more, with 10%, 8%, and 2%, respectively, in 2005 and 39%, 33%, and 17%, respectively, in 2010.

**Table 13: Use of intermittent preventive treatment among pregnant women in Senegal, 2005–2010**

<b>Indicator: Percentage of women ages 15–49 years who gave birth to a live child in the 2 years preceding the survey who received IPTp with 2 or more doses of SP during ANC during last pregnancy, according to demographic characteristics</b>										
<b>Background Characteristics</b>	DHS 2005		MIS 2006		MIS 2008		DHS 2010		Percentage point change*	<i>p</i> -value**
	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N	% (95%CI)	
<b>Total</b>	11.9(10.4-13.6)	4391	49.3 (45.7-53.0)	1906	52.2(50.1-54.3)	5406	38.6(36.2-41.0)	4516	26.7 (23.9-29.5)	<0.001
<b>Place of Residence</b>										
<i>Urban</i>	14.9(11.8-18.7)	1608	54.9 (48.0-61.6)	681	51.6 (48.0-55.2)	2079	45.5(40.9-50.2)	1702	30.6 (24.7-36.5)	<0.001
<i>Rural</i>	10.1(8.7-11.8)	2783	46.2 (42.0-50.4)	1225	52.6 (50.0-55.2)	3328	34.4(31.5-37.4)	2814	24.3 (21.0-27.6)	<0.001
<b>Epidemiological Zone</b>										
<i>Dakar</i>	9.7(5.8-15.8)	790	61.2 (49.4-71.9)	326	50.8 (45.2-55.6)	1105	41.2(34.1-48.7)	831	31.5 (27.6-35.4)	<0.001
<i>North</i>	15.0(13.4-16.7)	1880	45.9 (42.5-49.4)	821	52.6 (50.6-54.7)	2323	37.4(35.2-39.6)	1928	22.4 (19.7-25.1)	<0.001
<i>Center</i>	11.0(9.1-13.1)	981	42.1 (37.1-47)	393	54.4 (51.5-57.3)	1165	40.0(36.9-43.0)	1048	29.0 (25.4-32.6)	<0.001
<i>South</i>	5.2(3.6-7.0)	739	46.0 (42.5-49.3)	366	51.4 (47.9-54.8)	816	33.3(29.8-36.8)	708	28.1 (24.3-31.9)	<0.001
<b>Wealth Quintile</b>										
<i>Poorest</i>	7.7(6.1-9.8)	1023	37.5 (30.8-44.7)	439	46.4 (42.9-50.0)	1217	26.2(23.0-29.8)	1061	18.5 (14.7-22.3)	<0.001
<i>Second</i>	8.7(7.0-10.8)	967	46.5 (41.6-51.6)	398	51.0 (46.9-55.1)	1189	35.8(31.3-40.6)	1020	27.1 (22.0-32.2)	<0.001
<i>Medium</i>	13.9(11.3-17.0)	936	46.6 (39.6-53.8)	395	53.8 (49.8-55.7)	1101	44.6(39.5-49.9)	865	30.7 (24.7-36.7)	<0.001
<i>Fourth</i>	14(10.3-18.8)	812	57.1 (50.2-63.9)	364	58.0 (53.0-62.7)	977	43.1(36.0-50.4)	882	29.1 (20.8-37.4)	<0.001
<i>Richest</i>	17.5(13.0-23.1)	653	64.0 (55.0-72.0)	311	53.5(47.7-59.2)	923	48.4(42.8-50.4)	688	30.9 (23.4-38.4)	<0.001
<b>Parity</b>										
<i>1</i>	12.4(10-15.2)	925	na	na	51.2(47.1-55.3)	1186	40.1(35.1-45.3)	1009	27.7 (22.0-33.4)	<0.001
<i>2+</i>	11.8(10.2-13.5)	3466	na	na	52.5(50.3-54.8)	4220	38.2(35.8-40.6)	3507	26.4 (23.6-29.2)	<0.001
<b>Age of pregnancy at the time of the first ANC visit</b>										
<i>&lt;3</i>	14.4(12.3-16.7)	2408	na	na	na	na	42.5(39.6-45.6)	2575	28.1 (24.5-31.7)	<0.001
<i>4</i>	14.1(11.2-17.5)	652	na	na	na	na	43.1(38.5-47.9)	702	29.0 (23.3-34.7)	<0.001
<i>5</i>	10.4(7.9-13.5)	486	na	na	na	na	39.0(33.3-45.1)	427	28.6 (22.1-35.1)	<0.001
<i>6</i>	8.2(5.2-12.5)	284	na	na	na	na	32.9(26.3-40.4)	252	24.7 (16.8-32.6)	<0.001
<i>7+</i>	1.9(1.1-3.3)	560	na	na	na	na	17.0(12.5-22.6)	559	15.1 (10.1-20.1)	<0.001
<b>Note:</b> n = number of surveyed women (denominator). * The level of variation is calculated in absolute terms from 2005 to 2010. ** Pearson $\chi^2$ one-sided test										
<b>Source:</b> DHS 2005, 2010, MIS 2006, 2008.										

### **ITN Use Among Pregnant Women in Senegal**

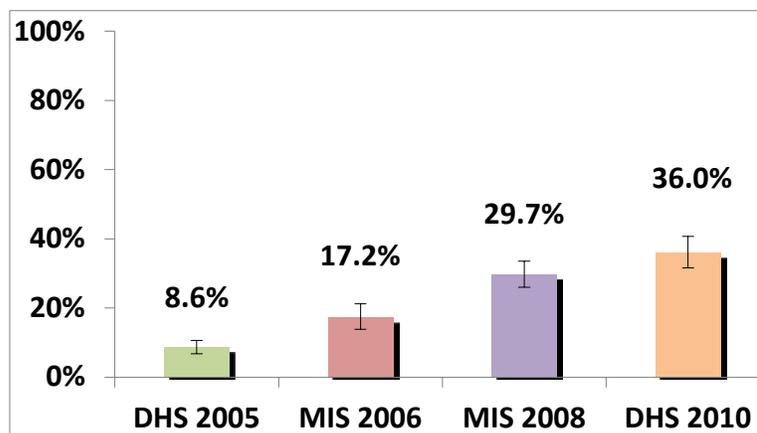
The use of ITNs by pregnant women in Senegal was 9% in 2005, 17% in 2006, 30% in 2009, and 36% in 2010, indicating a significant increase from 2005 to 2010 ( $p<0.001$ ) (Figure 16).

In urban areas, 10% and 32% of pregnant women used ITNs in 2005 and 2010, respectively, an increase of 22 percentage points ( $p<0.001$ ).

The corresponding estimates in rural areas were 8% in 2005

and 38% in 2010, a significant improvement in ITN use among pregnant women between these periods ( $p<0.001$ ). A trend similar to that of ITN use in children under 5 years was found when analyses were performed by wealth quintile. Higher proportions of women from the southern regions and the poorest households used ITNs than women from other epidemiological zones or the poorest households (Table 14).

**Figure 16: ITN use among pregnant women in Senegal, 2005–2010**



**Note:** ESD (DHS)=Demographic and Health Surveys, MIS = Malaria Indicator Survey

**Table 14: Use of ITNs among pregnant women in Senegal, 2005–2010**

<b>Indicator: Percentage of pregnant women who slept under an ITN the night preceding the survey, by demographic characteristics</b>										
<b>Background characteristics</b>	DHS 2005		MIS 2006		MIS 2008		DHS 2010		Percentage point change* % (95%CI)	p-value**
	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N		
<b>Total</b>	8.6(6.8-10.7)	1215	17.2(13.9-21.2)	470	29.7(26.0-33.6)	1429	36.0(31.6-40.7)	1279	27.4(22.5-32.3)	<0.001
<b>Place of Residence</b>										
<i>Rural</i>	10.0(7.0-14.1)	423	11.6(7.1-18.2)	137	26.7(19.5-35.4)	469	32.2(23.8-41.8)	485	22.2 (12.5-31.9)	<0.001
<i>Urban</i>	7.8(5.7-10.5)	792	19.6(15.2-24.8)	333	31.1(27.1-35.4)	960	38.4(34.0-42.9)	793	30.6 (25.5-35.7)	<0.001
<b>Epidemiological Zone</b>										
<i>Dakar</i>	3.8(1.0-13.9)	166	00	52	20.3(15.7-25.6)	265	14.7(7.5-26.6)	277	10.9 (0.2-21.6)	<0.001
<i>North</i>	13.6(10.8-18.7)	544	11.4(7.3-16.5)	203	25(21.7-28.6)	627	39.7(35.5-44.3)	495	26.1 (20.9-31.3)	<0.001
<i>Center</i>	8.0(5.1-11.9)	275	5.2(1.6-11.3)	100	26.1(20.9-31.9)	260	29.3(23.0-34.9)	277	21.3 (15.1-27.5)	<0.001
<i>South</i>	6.8(4.0-11.1)	229	22.8(15.3-31.3)	115	28.7(23.2-34.2)	277	55.5(48.5-61.9)	231	48.7 (41.5-55.9)	<0.001
<b>Wealth Quintile</b>										
<i>Poorest</i>	3.0(1.7-5.5)	302	17.5(11.9-25.0)	116	31.3(25.9-37.2)	375	41.0(34.6-47.8)	329	38.0 (31.1-44.9)	<0.001
<i>Second</i>	7.7(5.0-11.7)	283	23.5(16.8-31.7)	130	28.6(23.0-35.0)	328	45.0(38.0-52.2)	262	37.3 (29.5-45.1)	<0.001
<i>Middle</i>	13.7(9.8-18.9)	258	18.9(12.8-27.1)	97	33.9(25.8-43.0)	233	42.9(35.2-50.9)	233	29.2 (20.2-38.2)	<0.001
<i>Fourth</i>	12.1(7.9-18.1)	198	12.7(6.7-22.8)	91	27.3(19.8-36.2)	295	31.5(21.9-43.2)	217	19.4 (7.6-31.2)	<0.001
<i>Richest</i>	7.9(3.8-15.5)	174	1.2(0.2-8.4)	37	26.8(17.3-39.2)	198	16.4(9.6-26.7)	237	08.5 (-1.6-18.6)	0.005

**Note:** n = number of households (denominator); insecticide-treated nets are nets that have been impregnated industrially by the manufacturer and do not require additional treatment (long-lasting insecticide treated nets) or pre-impregnated nets obtained less than 12 months ago, or<sup>(21)</sup> nets that have been dipped in an insecticide less than 12 months ago. \* The level of variation is calculated in absolute terms from 2005 to 2010. \*\* Pearson  $\chi^2$  one-sided test

**Source:** DHS 2005, 2010, MIS 2006, 2008.

### ***Summary: Prevention of Malaria in Pregnant Women***

Analysis of the trend of malaria prevention in pregnant women in Senegal was based on two key indicators: (1) the use of IPTp and (2) the use of ITNs during pregnancy.

Overall, prevention of malaria in pregnancy has improved considerably over the last 5 years. IPTp coverage increased from 12% in 2005 to 49% in 2006, 52% in 2009, and 39% in 2010, indicating a significant increase from 2005 to 2010 ( $p<0.001$ ). A steep decline was apparent between 2008 and 2010, and may be explained by stockouts of SP at the National Supply Pharmacy in 2009.

Significant progress was made in the use of ITNs among pregnant women in Senegal from 2005 to 2010. At the baseline in 2005, the use of ITNs was 9%, and increased to 17% in 2006, 30% in 2009, and 36% in 2010, indicating a significant increase from 2005 to 2010 ( $p<0.001$ ). Greater increases in the use of ITNs among pregnant women were observed in women who are at higher risk of malaria (women from the southern epidemiological zone and the poorest households). In contrast, IPTp coverage was lower among these women, which may reduce the expected impact of the overall improvement in IPTp coverage on malaria in pregnancy.

## Case Management of Malaria

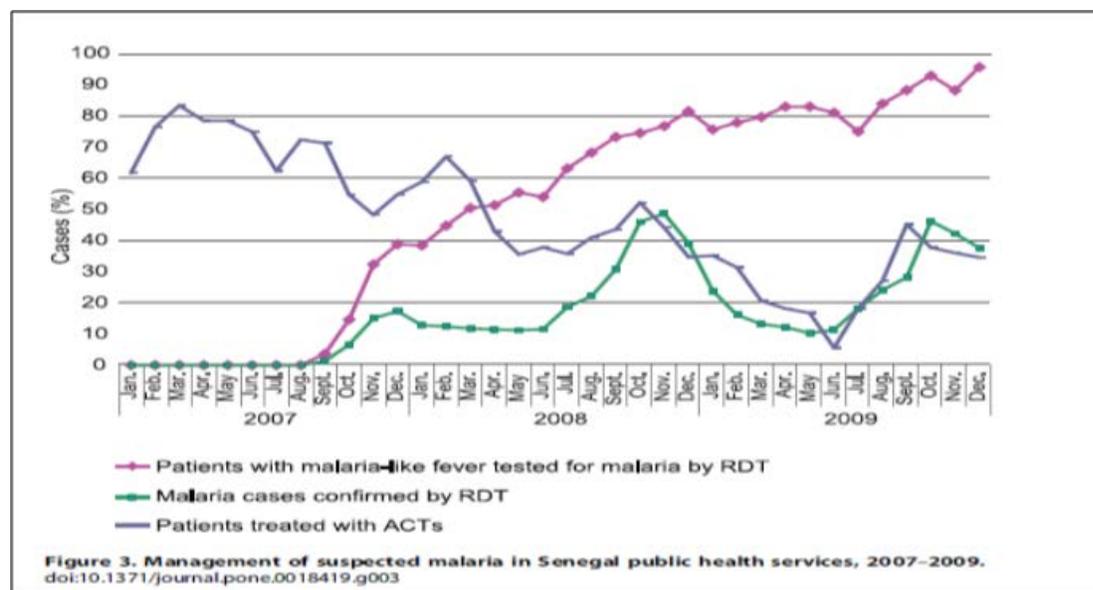
### Context

WHO recommends universal access to biological diagnosis of malaria by microscopy or RDTs and treatment of patients with confirmed uncomplicated malaria with ACTs. A systematic review found that the protective efficacy of early treatment of uncomplicated malaria with ACTs (compared to no treatment) was 99% in children under 2 years and 97% in children aged 2–5 years.<sup>(27)</sup>

### Implementation

**Diagnosis with RDT and Treatment with ACT:** Senegal adopted ACTs for the treatment of uncomplicated malaria in 2004, and recommended that SP-AQ combination be used for treatment until artesunate-amodiaquine (AS-AQ) was introduced in 2006. Treatment with ACTs was scaled-up in public health facilities in 2006 and introduced in health huts at the community level in 2008. RDTs were piloted in 2006, introduced in late 2007 and deployed widely in 2008, enabling the confirmation of 86% of suspected malaria cases in 2009. This rapid increase in the use of RDTs drastically decreased the over-use of ACTs.<sup>(28)</sup> (Figure 17).

**Figure 17: Impact of the introduction of RDTs on the use of ACTs**



Along with the introduction of RDTs, the NMCP developed a flow chart for case management to promote rational use of RDTs. This chart states that patients with signs of febrile illness other than malaria (cough, sputum, sore throat, rash, or otitis) should not be tested for malaria, but should be treated for other conditions. Patients are advised to return within 48 hours to be tested for malaria if their condition does not

improve. Thus, with the introduction of RDTs, the definition of a malaria episode, previously based only on clinical signs, was amended to include confirmation by laboratory diagnostic testing. The definition of a suspected case also changed to exclude febrile illness presenting signs or symptoms suggestive of other illnesses than malaria.

When ACTs were first introduced, the cost per treatment course was set at approximately USD \$ 0.75 for children under 5 years and USD \$ 1.50 for patients ages 5 years and older. In 2008, on the World Malaria Day, the Government of Senegal reduced the cost per treatment by 50%, and on the same occasion in 2010, declared that treatment with ACTs should be free of charge. Malaria diagnosis with RDTs has been free of charge since it was introduced.

After the first distribution of 2,281,609 treatment courses of ACTs in 2006 to meet the country's needs, the NMCP sustained regular acquisition of ACTs by ordering more than 800,000 doses on average per year from 2007 to 2010 (Table 15).

**Table 15: Distribution of ACTs in public health facilities in Senegal, 2005–2010**

	2005	2006	2007	2008	2009	2010
<b>Doses of ACT distributed</b>	0	2,281,609	990,141	743,611	704,367	961,884

**Source:** NMCP Senegal.

Regular monitoring and supervision of ordering and consumption of stocks of ACT at the peripheral health facility level with the support of technical and financial partners was key to ensuring no stockouts of ACTs in more than 90% of health facilities, except in 2009, when 14% of health facilities experienced stockouts for more than 7 days (Table 16).

**Table 16: Proportion of health facilities with no stockout of ACTs for more than 7 days in Senegal, 2005–2010**

	2005	2006	2007	2008	2009	2010
<b>Total</b>	—	100%	97%	98%	86%	93%

**Source:** NMCP Senegal.

Since the introduction of RDTs in 2007 and the development of a flow chart for malaria case management, the use of RDTs has increased steadily year after year (Table 17), and these commodities are available in all public health facilities (Table 18).

**Table 17: Evolution of the number of RDTs distributed to public health facilities in Senegal, 2005–2010**

	2005	2006	2007	2008	2009	2010
<b>Number of RDTs purchased</b>	0	148,000	374,225	625,775	1,041,925	1,252,900

Source: NMCP Senegal

**Table 18: Proportion of public health facilities that reported no stockout of RDTs for more than 7 days within the last 3 months in Senegal, 2005–2010**

	2005	2006	2007	2008	2009	2010
<b>Total</b>	–	–	–	100%	100%	100%

Source: NMCP Senegal.

Note: Indicator: number of public health facilities that did not experience a stockout of more than 7 days in the last 3 months.

**Home Management of Malaria:** In 2008, NMCP started a pilot project of home management of malaria (HMM), known locally as PECADOM, which rested on using RDT for diagnosis and ACTs for treatment at home. This approach expanded rapidly, from 20 pilot villages in 2008 to 408 villages in 25 districts and 7 regions of high transmission in 2009. The number of localities was further increased to 861 villages in 32 districts across 9 regions of high transmission in 2010.<sup>(29)</sup> A village must be at least 5 km from the nearest health facility to be eligible for HMM and have volunteers selected by village community members to support the implementation of the project. In 2009 and the first half of 2010, respectively, 6,198 and 5,474 cases of malaria were diagnosed and treated at home as the result of the implementation of HMM at the community level (Table 19).

**Table 19: Home management of malaria in Senegal, 2005–2010**

	2005	2006	2007	2008	2009	2010*
Number of villages involved in HMM	0	0	0	20	408	861
Number of DSDOM (home care providers, HCP) trained in HMM	0	0	0	20	408	861
Number of malaria cases diagnosed by RDTs and treated in the context of HMM	0	0	0	822	6,198	5,474

Note: HMM began in 2008; \*The 2010 data cover the period from January–May 2010. HMM=home management of malaria; ; RDTs=rapid diagnostic test.

Source: NMCP Senegal

## ***Trend of Coverage of Malaria Case Management***

### **Questions:**

- *Did the proportion of children under 5 with fever who received an effective malaria treatment in Senegal increase significantly from 2005 to 2010?*
- *Did the proportion of children under 5 years with fever who received laboratory confirmation of malaria increase significantly from 2005 to 2010?*

To answer these questions, we examined trends for the following indicators:

- Children under 5 years with fever in the last 2 weeks for whom advice or treatment was sought with a conventional health service
- Proportion of children under 5 years old with fever in the last 2 weeks who had blood taken from a finger or heel prick for malaria diagnosis
- Children under 5 years who received any antimalarial treatment among all children of the same age group who presented with fever
- Children under 5 years with fever who received antimalarial treatment recommended by NMCP within 24 hours

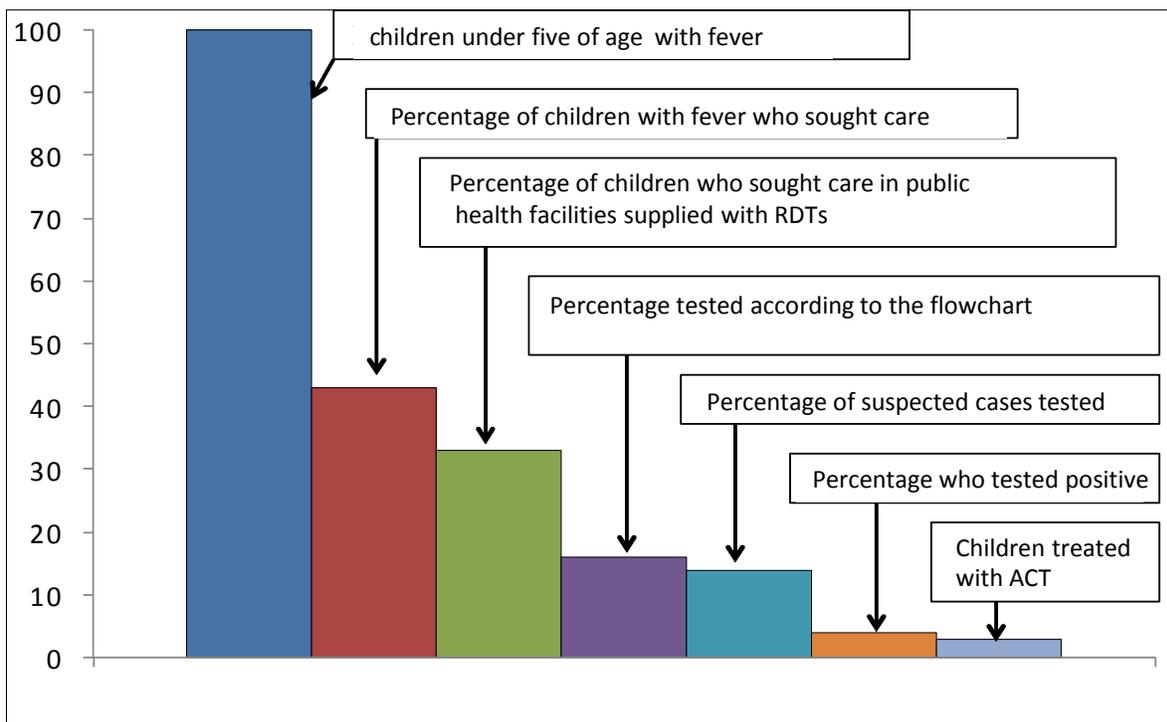
In the context of the scale-up of biological confirmation of malaria and the use of the flowchart to support case management in Senegal, standard indicators of malaria case management are difficult to interpret.

Numerous factors impact the proportion of children under 5 years with fever who received ACTs: the proportion of children seeking care, the proportion of children who are eligible for RDT, the proportion of suspected cases tested, the positivity rate and the percentage of positive cases treated with ACTs. Through surveys, it is possible to measure the percentage of children who sought care, the percentage of children tested, and the percentage of children treated, but it is not possible to assess whether malaria cases have been correctly managed according to flowchart instructions. In addition, measuring the percentage of children tested or the percentage of positive cases treated is not straightforward. The use of routine data through the RBM database at the NMCP can mitigate deficiencies associated with measuring these indicators during surveys.

Under a high biological confirmation rate, a decrease in the proportion of children treated with ACTs is anticipated if the proportion of children tested for malaria increases and the burden of malaria decreases. We used information from the 2010-2011 DHS, routine data, and evaluation of the case management algorithm to demonstrate factors that result in the low proportion of children with fever who receive

an ACT in the context of universal diagnosis and declining malaria incidence (Figure 18).

**Figure 18: Factors explaining the low proportion of children receiving ACTs in the context of universal diagnosis**



### Care Seeking in Case of Fever in Children Under 5 Years from 2005 to 2010

Table 20 shows the trend of care seeking among children under 5 years with fever from 2005 to 2010. The proportion who sought care for malaria among this group of children was 41% in 2005 and 44% in 2010. The proportion of children with fever who attended public health facilities for care increased marginally from 2005 to 2010 ( $p=0.011$ ).

In urban areas, the percentage of children under 5 years seen for care in public health facilities remained the same from 2005 (49.5%) to 2010 (49.6%). In rural areas, care seeking among children was 34% in 2005 and 37% in 2010. The corresponding estimates for the epidemiological zone of Dakar were 51% in 2005 and 52% in 2010. The percentage of children who sought care remained steady (38%–39%) from 2005 to 2010 in the northern, central, and southern epidemiological zones.

Children from the wealthiest households are more likely to seek care, with 53% and 55%, respectively, in 2005 and 2010. Nevertheless, a significant increase in care seeking at public health facilities was observed in children from the middle wealth quintile,

rising from 37% in 2005 to 47% in 2010 ( $p < 0.001$ ). The poorest quintile displayed a low frequency of care seeking. It is worth noting that among the poorest quintile of the population, health care seeking remained constant at 30% in 2005 and 2010.

**Table 20: Care seeking with a conventional health service in children under 5 years in Senegal, 2005 to 2010**

<b>Indicator: Percentage of children under 5 years with a fever in the two weeks preceding the survey for whom care was sought with a conventional health service</b>						
<b>Background characteristics</b>	DHS 2005		DHS 2010		Percentage point change	<i>p</i> -value**
	% (95%CI)	N	% (95%CI)	N	% (95%CI)*	
<b>Total</b>	40.6(38.9-42.3)	3304	43.6(41.4-45.5)	2463	3.0(0.4-5.5)	0.011
<b>Age (in months)</b>						
<12	46.5(43.4-49.5)	1005	39.3(35.4-43.1)	630	-7.2(-12.1-2.9)	0.002
12-23	39.9(36.6-43.2)	854	39.5(35.6-43.3)	620	-0.4(-5.4-4.6)	0.21
24-35	39.8(35.8-43.7)	597	40.5(36.6-44.8)	502	0.7(-5.1-6.6)	0.08
36-47	34.9(30.6-39.1)	486	46.9(42.1-51.6)	424	12(5.6-18.4)	<0.001
48-59	34.5(29.6-39.4)	362	42.1(36.3-47.8)	287	7.6(0.07-15.2)	0.02
<b>Gender</b>						
Male	42.9(20.5-45.6)	1753	43.8(41.1-46.4)	1332	0.9(-2.6-4.4)	0.3
Female	38.0(35.5-40.4)	1551	42.5(39.6-45.3)	1131	4.5(0.7-8.2)	0.009
<b>Place of Residence</b>						
Rural	34.4(32.3-36.4)	1992	37.0(34.3-39.7)	1252	2.6(-0.7-5.9)	0.06
Urban	49.5(46.8-52.2)	1312	49.6(46.7-53.4)	1211	0.1(-3.8-4.0)	0.06
<b>Epidemiological Zone</b>						
Dakar	50.6(47.0-54.2)	748	52.1(48.6-55.5)	800	1.5 (-3.4-6.4)	0.27
North	38.4(35.2-41.)	1311	38.3(35.3-41.3)	965	-0.1(-4.1-3.9)	0.48
Center	39.1(35.5-42.7)	709	39.2(34.4-44.0)	397	0.1(-5.8-6.1)	0.55
South	39.9(35.3-44.4)	452	38.8(33.2-44.3)	300	-1.1(-8.2-6.0)	0.38
<b>Wealth quintile</b>						
Poorest	30.1 (26.0-34.2)	711	30.0(26.6-33.3)	490	-0.1(-5.1-5.2)	0.5
Second	33.7(29.0-38.4)	724	39.5(35.9-43.1)	390	5.8(-0.02-11.7)	0.02
Middle	37.3(32.7-41.8)	651	47.1(43.2-50.9)	430	9.8(-3.8-15.7)	<0.001
Fourth	52.1(48.2-56.0)	665	42.9(39.1-46.2)	626	-9.2(-14.6-3.7)	0.005
(Richest)	53.2(48.9-57.4)	553	55.4(51.2-59.5)	528	2.2(-8 -3.7)	0.23

**Note:** n = number of children (denominator); Conventional health services for case management include public or private facilities and exclude traditional healers. \*The percentage change is calculated in absolute terms from 2005 to 2010. \*\* Pearson  $\chi^2$  one-sided test

**Source:** DHS 2005, 2010.

## Laboratory Confirmation of Malaria in Febrile Children

Biological confirmation with RDTs was adopted in 2007 and represents a key element in the management of malaria in Senegal. For this section, data for the periods 2008 and 2010 were compared. Only a small proportion of children received laboratory confirmation in 2008 (4.9%), but this proportion doubled in 2010 (9.7%). A significant increase was observed in all age groups ( $p < 0.005$ ). The increase was higher in rural areas (6.2%) than in urban areas (3.8%). A significant change was noted in all epidemiological zones, except for the central zone. The largest increase was observed in the epidemiological zone of Dakar where the proportion of confirmed cases increased from 4% in 2008 to 12% in 2010. Proportions of febrile children with laboratory confirmation of malaria were similar among the different wealth quintiles in 2008 and 2010 (except for wealthiest group in 2010). The greatest increases were found in the least poor quintiles (richest, from 4% to 14%, and fourth from 4% to 10%).

**Table 21: Biological confirmation of malaria cases in children under 5 years**

<b>Indicator: Percentage of children under 5 with fever in the two weeks preceding the survey who received a biological test for confirmation of malaria</b>						
<b>Background characteristic</b>	<b>MIS 2008</b>		<b>DHS 2010</b>		<b>Percentage point change* %(95%CI)</b>	<b>p-value**</b>
	<b>% (95% CI)</b>	<b>N</b>	<b>% (95%CI)</b>	<b>N</b>		
<b>Total</b>	4.9(4.0-5.9)	4123	9.7(8.0-11.8)	2463	4.8(-5.0-14.6)	<0.001
<b>Age (in months)</b>						
<12	3.3(2.1 - 5.1)	1,128	8.5(5.3-13.3)	630	5.2(1.0-9.4)	<0.001
12-23	3.8(2.6-5.4)	999	7.5(4.8-11.4)	620	3.7(0.3-7.1)	<0.001
24-35	8.0(5.8-11.0)	813	12.3(8.4-17.6)	502	4.3(-0.9-9.5)	0.005
36-47	3.3(3.3-2.1)	651	9.2(5.9-14.0)	424	5.9(1.7-10.1)	<0.001
47-59	7.3(4.5-11.6)	532	13.7(8.8-20.6)	287	6.4(-0.2-13.0)	<0.001
<b>Place of residence</b>						
Rural	4.2(3.0 - 5.8)	1,708	10.4(7.4-14.3)	1 211	6.2(2.6-9.8)	<0.001
Urban	5.3(4.2 - 6.7)	2,415	9.1(7.5-11.0)	1 252	3.8(1.7-5.9)	<0.001
<b>Epidemiological zone</b>						
Dakar	3.7(2.3-6.0)	1,116	12.0(7.8-17.9)	800	8.3(5.8-10.8)	<0.001
North	4.1(3.3-5.1)	1,613	7.4(5.7-9.0)	965	3.3(1.4-5.2)	<0.001
Center	7.9(5.7-10.1)	577	9.1(6.1-12.1)	353	1.2(-2.5;4.9)	0.26
South	5.7(4.1-7.2)	817	11.6(8.2-14.9)	344	5.9(2.2-9.6)	<0.001
<b>Wealth quintile</b>						
Poorest	5.0(3.7-6.7)	901	8.0(5.7-11.0)	490	3.0(0-6.0)	0.01
Second	5.3(3.8-7.4)	808	7.7(5.3-10.9)	390	2.4(-0.9-5.7)	0.05
Middle	5.3(3.6-7.7)	796	7.8(5.5-11.0)	430	2.5(-0.9-5.9)	0.04
Fourth	4.4(2.8-6.9)	825	9.9(7.1-13.8)	626	5.5(1.6-9.4)	<0.001
Richest	4.4(2.5-7.4)	793	14.2(8.8-22.2)	528	9.8(2.7-16.9)	<0.001

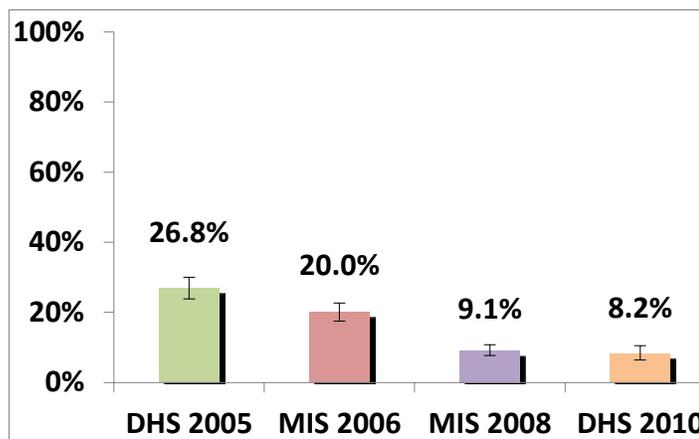
**Note:** N = Number of children (denominator); \*The level of variation is calculated in absolute terms from 2008 to 2010; \*\*Pearson  $\chi^2$  one-sided test.

**Source:** DHS 2010, MIS 2008.

### **Antimalarial Treatment (Any Antimalarial) in Children Under 5 years of age from 2005 to 2010**

In 2005, 27% of children younger than 5 years with fever received antimalarial treatment. This decreased to 8% in 2010, representing an absolute decrease of 19 percentage points ( $p < 0.001$ ). Since the introduction of RDTs in 2007, all fevers were no longer considered malaria cases at health care facilities (Figure 19).

**Figure 19: Antimalarial treatment (any antimalarial) in children under 5 years with fever in Senegal, 2005–2010**



**Note:** DHS = Demographic and Health Surveys, MIS = Malaria Indicator Survey

This downward trend was consistent across all age groups and was more marked in rural than urban areas. The epidemiological zones differed, with a greater decrease observed in the Dakar epidemiological zone (26 percentage points), followed by the central epidemiological zone (15 percentage points). Considering wealth quintiles, absolute decrease of 14 and 25 percentage points were observed respectively in the poorest and wealthiest households ( $p < 0.001$ ). The highest decreases in the proportion of children who received treatment were observed in Dakar and in the second poorest quintile. Despite the decreasing trend of antimalarial treatment, the use of antimalarial drugs remains relatively elevated in the epidemiological zone of Dakar and among the second poorest households (Table 22).

**Table 22: Antimalarial treatment (any antimalarial) in children under 5 years with fever in Senegal, 2005–2010**

Indicator: Percentage of children under 5 years who received antimalarial treatment among children under 5 years with fever in the 2 weeks preceding the survey										
Background Characteristics	DHS 2005		MIS 2006		MIS 2008		DHS 2010		Percentage point change* % (95%CI)	p-value**
	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N		
<b>Total</b>	26.8(23.-30.0)	2891	20.0(17.5-22.7)	1625	9.1(7.7-10.8)	4123	8.2(6.4-10.5)	2463	-18.6 (-22.3;-14.9)	<0.001
<b>Age (in months)</b>										
<12	26.1(20.9-32.0)	878	16.6(12.3-22.2)	433	7.1(5.1-9.7)	1 128	5.9(3.6-9.3)	630	-20.2(-26.5;-13.9)	<0.001
12-23	27.6(23.6-32.0)	760	21.9(17.9-26.6)	472	8.5(6.0-11.7)	999	6.8(4.5-10.2)	620	-20.8(-25.9;-15.7)	<0.001
24-35	29.2(24.2-34.8)	527	21.1(16.0-27.2)	302	10.7(7.9-14.4)	813	10.6(7.4-14.9)	502	-18.6(-25.1;-12.1)	<0.001
36-47	25.9(20.8-31.7)	409	20.6(15.5-26.9)	245	8.4(6.2-11.4)	651	11.6(7.0-18.7)	424	-14.3(-22.2;-6.4)	<0.001
47-59	24(18.9-30.0)	317	20.2(14.6-27.3)	173	13.2(8.9-19.2)	532	7.4(4.3-12.5)	287	-16.6(-23.3;-9.9)	<0.001
<b>Gender</b>										
Male	28.2(24.9-31.7)	1 521	19.8(16.7-23.4)	846	9.2(7.7-10.9)	2 150	9.3(7.1-12.1)	1 332	-18.9(-23.1;-14.7)	<0.001
Female	25.3(21.5-29.4)	1 370	20.1(16.9-23.8)	779	9.1(6.9-11.8)	1 973	7.0(4.9-9.8)	1 131	-18.3(-22.9;-13.7)	<0.001
<b>Place of residence</b>										
Rural	34.1(28.5-40.2)	1 097	16.3(12.6-20.9)	503	10.3(7.5-14.1)	1 708	10.2(6.8-14.8)	1 211	-23.9(-31.0;-16.8)	<0.001
Urban	22.3(19.4-25.5)	1 794	21.6(18.6-25.0)	1 122	8.3(7.0-9.9)	2 415	6.3(4.9-8.1)	1 252	-16.0(-19.5;-12.5)	<0.001
<b>Epidemiological zone</b>										
Dakar	37.6(29.9-45.9)	622	16.3(10.0-25.4)	241	12.4(8.5-17.7)	1116	11.9(7.1-19.3)	800	-25.7(-35.8;-15.6)	<0.001
North	22.5(20.1-24.9)	1149	11.7(9.2-14.1)	661	4.6(3.6-5.6)	1613	5.8(4.3-7.3)	965	-16.7(-19.5;-13.8)	<0.001
Center	18.3(15.2-21.4)	607	23.9(19.1-28.7)	303	8.7(6.3-11.0)	557	3.7(1.7-5.6)	353	-14.6(-18.2;-10.9)	<0.001
South	26.6(22.7-30.4)	512	29.5(25.1-33.8)	421	14.8(12.1-5.9)	687	9.6(6.5-12.7)	344	-17.0(-21.9;-12.0)	<0.001
<b>Wealth quintile</b>										
poorest	19.8(15.7-24.8)	647	22.4(17.9-27.8)	438	9.6(7.4-12.4)	901	5.5(4.0-7.5)	490	-14.3(-19.1;-9.5)	<0.001
Second	22.1(18.1-26.6)	659	25.0(20.2-30.4)	366	8.1(6.2-10.6)	808	7.3(5.0-10.7)	390	-14.8(-19.7;-9.9)	<0.001
Middle	25.9(21.3-31.0)	558	20.4(16.3-25.1)	308	6.0(4.3-8.4)	796	8.5(5.2-13.6)	430	-17.4(-23.8;-11.0)	<0.001
Fourth	33.3(27.2-40.0)	564	13.4(9.5-18.5)	292	11.7(7.6-17.4)	825	7.6(4.1-13.6)	626	-25.7(-33.4;-18.0)	<0.001
richest	36.4(28.0-45.6)	462	15.0(8.8-24.5)	221	10.1(7.5-13.4)	793	11.9(6.9-19.8)	528	-24.5(-35.3;-13.7)	<0.001

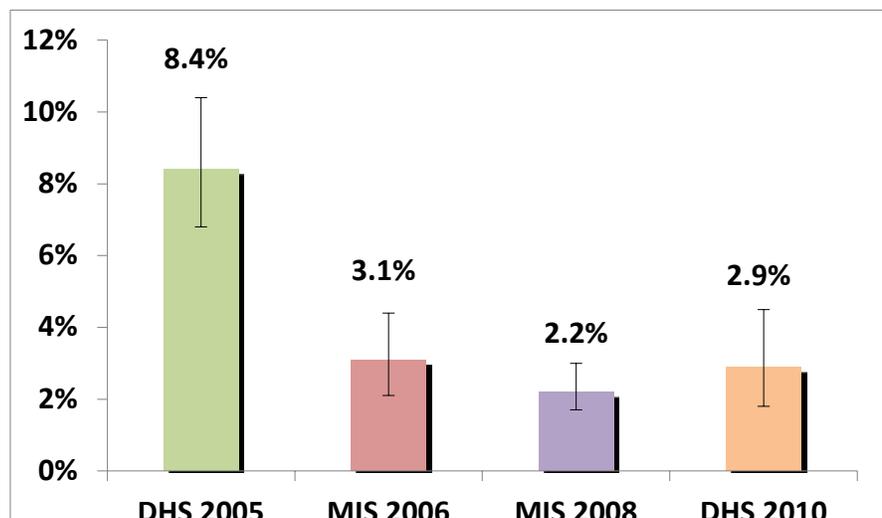
\* The level of variation is calculated in absolute terms from 2005 to 2010; \*\*Pearson  $\chi^2$  one-sided test.\*\*

Source: DHS 2005, 2010, MIS 2006, 2008.

## Antimalarial Treatment

Malaria treatment must comply with the NMCP guidelines. Overall, the results of different surveys showed a consistent decrease in the proportion of children under 5 years of age who received the recommended antimalarial treatment within 24 hours, from 2005 (8.4%) and 2010 (2.9%) (Figure 20).

**Figure 20: Malaria treatment with recommended antimalarials in febrile children under 5 years, in Senegal, 2005 to 2010**



Note: DHS =Demographic and Health Surveys, MIS = Malaria Indicator Survey

The decline was slightly greater in urban areas (7.1%) than in rural areas (5.2%). A similar trend was observed after age-specific analysis. Treatment with the recommended antimalarials was higher in the epidemiological zone of Dakar in both 2005 and 2010. As observed with the overall estimate, there was decline in the proportion of children with fever who received a recommended antimalarial in the different epidemiological zones of malaria in Senegal. The decline was more pronounced in Dakar, with a decrease from 14% to 5% ( $p<0.05$ ). The proportions of children with fever who received a recommended antimalarial within 24 hours increased from the poorest to the wealthiest household both in 2005 and 2010. This situation reflects the rational use of antimalarial over the past 5 years due to the introduction of RDTs and the development of a flowchart to support malaria case management (Table 23).

**Table 23: Malaria treatment in febrile children under 5 years within 24 hours of onset of fever using antimalarials recommended by the NMCP**

<b>Indicator: Percentage of children under 5 years who received antimalarial treatment in the 24 hours following the onset of fever according to national guidelines among children who had fever in the two weeks preceding the survey</b>										
<b>Background Characteristics</b>	DHS 2005		MIS 2006		MIS 2008		DHS 2010		Percentage point change* % (95%CI)	P-value **
	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N		
<b>Total</b>	8.4(6.8-10.4)	2,891	3.1(2.1-4.4)	1,625	2.2(1.7-3.0)	4,123	2.9(1.8-4.5)	2,463	-5.5(-7.7;-3.3)	<0.001
<b>Age (in months)</b>										
<12	7.4(5.5-10.0)	878	2.9(1.3-6.2)	433	1.4(0.6-3.3)	1128	2.1(0.8-5.6)	630	-5.3(-8.3;-2.3)	<0.001
12–23	8.3(5.9-11.5)	760	3.1(1.5-6.0)	472	2.1(1.3-3.3)	999	2.0(0.9-4.5)	620	-6.3(-9.5;-3.1)	<0.001
24–35	10.8(7.5-15.3)	527	3.3(1.6-6.7)	302	2.1(1.2-3.7)	813	2.6(1.3-5.1)	502	-8.2(-12.5;-3.9)	<0.001
36–47	7.8(4.8-12.4)	409	3.0(1.4-6.1)	245	2.8(1.7-4.6)	651	5.5(2.0-14.1)	424	-2.3(-8.8;4.2)	<0.090
47–59	8.2(5.2-12.9)	317	3.2(1.4-7.1)	173	4.0(2.2-7.1)	532	2.9(1.1-7.6)	287	-5.3(-9.9;-0.7)	0.002
<b>Sex</b>										
Male	7.7(6.2-9.6)	1,521	2.7(1.7-4.3)	846	2.1(1.5-3.0)	2,150	2.6(1.3-5.2)	1,332	-5.1(-7.6;-2.6)	<0.001
Female	9.2(6.7-12.4)	1,370	3.4(2.3-5.1)	779	2.4(1.6-3.5)	1,973	3.1(1.8-5.3)	1,131	-6.1(-9.3;-2.9)	<0.001
<b>Type of Residence</b>										
Rural	11.4(7.9-16.0)	1,097	2.0(0.9-4.2)	503	1.7(0.9-3.0)	1,708	4.3(2.3-7.9)	1,211	-7.1(-11.9;-2.3)	<0.001
Urban	6.6(5.3-8.2)	1,794	3.5(2.3-5.3)	1,122	2.6(1.9-3.7)	2,415	1.4(0.9-2.5)	1,252	-5.2(-6.8;-3.6)	<0.001
<b>Epidemiological zone</b>										
Dakar	14.4(9.1-22.0)	622	1.9(0.4-7.8)	241	1.8(0.8-3.9)	1,116	5.5(2.6-11.2)	800	-8.9(-16.6;-1.2)	<0.001
North	6.2(4.8-7.6)	1,149	1.0(0.2-1.7)	661	0.9(0.04-1.4)	1,613	1.1(0.4-1.7)	965	-5.1(-6.6;-3.5)	<0.001
Center	5.4(3.7-7.1)	683	3.6(1.6-5.5)	356	2.1(1.0-3.1)	707	1.0(0.0-1.9)	397	-4.4(-6.3;-2.2)	<0.001
South	8.9(6.2-11.6)	436	6.6(4.1-9.1)	368	4.9(3.3-6.5)	687	3.8(1.6-5.9)	300	-5.1(-8.5;-1.6)	0.003
<b>Wealth quintile</b>										
Poorest	3.9(2.4-6.3)	647	4.2(2.2-7.9)	438	3.7(2.3-5.8)	901	1.0(0.5-2.2)	490	-2.9 (-5.0;-0.8)	<0.001
Second	7.2(5.2-10.0)	659	4.1(2.1-8.0)	366	3.1(2.0-4.7)	808	1.3(0.5-3.2)	390	-5.9(-8.5;-3.3)	<0.001
Middle	9.6(7.1-12.8)	558	2.5(1.3-4.9)	308	0.8(0.4-1.7)	796	2.3(1.0-5.4)	430	-7.3(-10.7;-3.9)	<0.001
Fourth	12.3(8.3-18.0)	564	0.8(0.2-3.2)	292	1.6(0.6-4.0)	825	3.2(1.3-7.4)	626	-9.1(-14.5;-3.7)	<0.001
Richest	10.2(4.5-21.4)	462	2.6(0.8-8.1)	221	1.9(0.8-4.4)	793	5.7(2.2-13.9)	528	-4.5(-14.1;-5.1)	0.04

**Note:** n=number of children (denominator) ; Chloroquine (CQ) was the first line treatment in 2000, SP-AQ from 2004 to 2005, and ACT since 2006; \*The level of variation is calculated in absolute terms from 2005 to 2010, \*\*Pearson  $\chi^2$  one-sided test

**Source:** DHS 2005, 2010, MIS 2006, 2008.

### ***Summary: Malaria Case Management***

Management of malaria is a major strategy in the fight against malaria. Progress made in case management was assessed mainly using four indicators: (1) care seeking for fever, (2) laboratory confirmation of malaria by RDTs or microscopy (3) treatment with any antimalarial, and (4) treatment within 24 hours using the antimalarial medicine recommended by the NMCP.

The proportion of children under 5 years seeking care for malaria in Senegal was 41% in 2005, compared to 44% in 2010. A greater increase in the proportion of children seeking care was found among children from the second poorest and middle quintiles of wealth.

Overall, biological diagnosis of malaria was low, but the upward trend observed in 2010 (10%) illustrated some improvement over the last 2 years, considering that in 2008 only 5% of suspected malaria cases benefited from laboratory diagnosis. A significant increase was observed in all epidemiological zones, except the central zone.

Globally the proportion of children who received any antimalarial treatment declined from 27% in 2005 to 20% in 2006, and plateaued at around 8%–9% from 2008 to 2010. An absolute decline of 6 percentage points was observed from 2005 to 2010 among children who received treatment in accordance with national guidelines. A similar trend was confirmed in urban and rural areas and in the different epidemiological zones. These results reflect a net decrease in the use of antimalarials, which could be explained by improved access to biological diagnosis, and therefore, enabling better differential diagnosis of malaria from other illnesses, which leads to a rational use of antimalarials and a declining incidence of malaria.

Despite efforts to improve access to diagnosis and treatment to the poorest and less privileged fraction of the population, care seeking for fever and malaria and the proportion of children who received malaria diagnosis remained low in the poorest quintiles.

## Malaria Morbidity

### Questions:

- *Did the proportion of children under 5 years with severe anemia (hemoglobin less than 8 g/dL), decrease significantly from 2005 to 2010?*
- *Did the proportion of children under 5 years with positive parasitemia decrease significantly between 2005 and 2010?*

We analyzed the trend in the following indicators to address these categories:

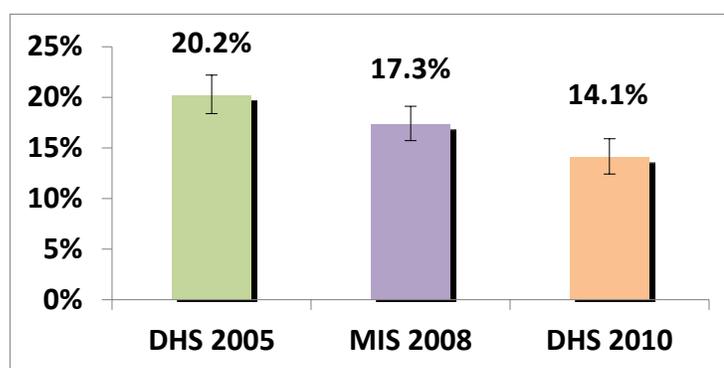
- Severe anemia (hemoglobin less than 8 g/dL) among children under 5 years
- Carriage of malaria infection, detected by microscopy
- Severe anemia and presence of malaria infection among children under 5 years
- Children under 5 years with fever associated with a positive smear

### Severe Anemia

Overall, the prevalence of severe anemia in children aged 6–59 months was 20% in 2005 and 14% in 2010, an absolute reduction of 6 percentage points ( $p<0.001$ ) (Figure 21).

The prevalence of anemia was higher in rural than in urban areas in both 2005 and 2010. In rural areas, anemia declined from 22% in 2005 to 16% ( $p<0.001$ ), while in urban areas it declined from 16% in 2005 to 13% in 2010,  $p<0.001$ . Between these periods, a significant decrease in the proportion of children with anemia was observed in all the epidemiological zones, except the southern zone. In Dakar, the prevalence of anemia remained unchanged from 2005 to 2008 (15%) and declined significantly in 2010 (9%). In the southern epidemiological zone, the prevalence of anemia fluctuated from 2005 to 2010, increasing from 21% in 2005 to 31% in 2008, before declining to 18% in 2010. It should be noted that droughts (as occurred in 2007) are often followed by periods of food insecurity, which may have contributed to the rise in the prevalence of anemia in 2008.

**Figure 21: Prevalence of severe anemia in children aged 6–59 months in Senegal 2005–2010**



**Note:** DHS = Demographic and Health Surveys, MIS = Malaria Indicator Survey

Anemia is linked to socioeconomic status, decreasing from the poorest to the wealthiest quintile consistently in all surveys. From 2005 to 2010, the prevalence of anemia decreased significantly and consistently in all wealth quintiles, with an absolute decline on the order of 6 percentage points in all the groups (Table 24).

Analysis by epidemiological zone and child's age showed a significant decrease in the epidemiological zone of Dakar among children 24–59 months from 2005 to 2010. The lower prevalence of anemia observed in the other age groups in 2010 compared to 2005 were not statistically significant ( $p>0.05$ ). In the north, central, and south epidemiological zones, anemia in children aged 12–23 months, the group most at risk of malaria, decreased significantly (Table 25).

**Table 24: Prevalence of severe anemia (hemoglobin <8g/dL) in children aged 6–59 months in Senegal, 2005 to 2010**

<b>Indicator: Percentage of children aged 6–59 months with a hemoglobin less than 8.0 g/dL by sociodemographic characteristics</b>								
	DHS 2005		MIS 2008		DHS 2010		Percentage point change* %(95%CI)	P-value**
	% (95%CI)	N	% (95%CI)	N	% (95%CI)	N		
<b>Total</b>	20.2(18.4-22.2)	2517	17.3(15.7-19.1)	3891	14.1(12.4-15.9)	3761	-6.1(-8.7;-3.5)	<0.001
<b>Age (in months)</b>								
6–11	13.4(9.7-18.3)	273	13.4(8.1-21.5)	342	8.5(6.0-11.9)	393	-4.9(-10.1;0.3)	0.02
12–23	28.7(24.5-	581	19.1(15.8-22.8)	884	19.4(15.9-23.5)	823	-9.3(-15.0;-3.6)	<0.001
24–59	18.3(16.2-20.7)	1663	17.2(15.7-18.6)	2664	13.2(11.8-14.5)	2541	-5.2(-8.0;-2.4)	<0.001
<b>Gender</b>								
Male	22.1(19.8-24.6)	1293	19.1(16.8-21.6)	1904	15.5(13.5-17.8)	1941	-6.6(-9.8;-3.4)	<0.001
Female	18.2(15.5-21.2)	1224	15.6(13.4-18.1)	1987	12.6(11.1-14.0)	1820	-5.6(-9.2;-2.0)	<0.001
<b>Place of Residence</b>								
Rural	15.9(12.8-19.7)	889	13.3(10.9-16.1)	1402	10.5(7.8-14.1)	1434	-5.4(-10.1;-0.7)	<0.001
Urban	22.5(20.4-24.9)	1628	19.6(17.4-21.9)	2489	16.3(14.4-18.4)	2327	-6.2(-9.3;-3.1)	<0.001
<b>Epidemiological Zone</b>								
Dakar	15.1(10.0-22.2)	387	15.0(11.4-19.5)	746	9.0(5.0-15.5)	766	-6.1(-10.0;-1.9)	<0.001
North	20.2(17.8-22.5)	1103	13.8(12.1-15.4)	1780	13.4(11.7-15.1)	1533	-6.8(-9.7;-3.8)	<0.001
Center	24.5(21.2-27.8)	624	15.3(12.9-17.6)	929	17.7(15.1-20.2)	860	-6.8(-11.3;-2.5)	<0.001
South	20.6(16.6-24.5)	403	30.9(27.1-34.7)	560	18.0(14.9-21.1)	600	-2.6(-7.6;2.4)	0.15
<b>Wealth quintile</b>								
Poorest	25.7(22.1-29.8)	629	25.3(21.8-29.1)	857	19.8(16.6-23.5)	852	-5.9(-11.0;-0.8)	0.003
Second	23.5(19.9-27.6)	534	20.0(16.8-	851	17.6(15.0-20.5)	815	-5.9(-10.7;-1.1)	0.002
Middle	18.3(15.1-22.1)	493	13.6(10.6-17.4)	831	11.7(9.3-14.5)	752	-6.6(-11.0;-2.2)	<0.001
Fourth	16.9(12.4-22.6)	410	14.2(10.2-19.4)	727	11.4(7.5-17.0)	749	-5.5(-12.4;1.4)	0.004
Richest	13.6(9.5-19.2)	450	11.1(7.7-15.7)	625	7.6(4.5-12.5)	593	-6.0(-12.3;0.3)	<0.001

**Note:** N = number of children (denominator); \*The degree of variation is calculated in absolute terms from 2005 to 2010; \*\*Pearson  $\chi^2$  one-sided test.

**Source:** DHS 2005, 2010, MIS 2008.

**Table 25: Evolution of the prevalence of anemia in children aged 6–59 months by age and epidemiological zone in Senegal, 2005–2010**

<b>Indicator: Percentage of children under 5 years with a hemoglobin level below 8g/dL by age and epidemiological zone</b>								
Characteristics	DHS 2005		MIS 2008		DHS 2010		Percentage point change* %(95%CI)	P-value**
	% (95% CI)	N	% (95% CI)	N	% (95% CI)	N		
<b>Dakar</b>								
<i>6–11 months</i>	5.1(-2.3 -12.5)	34	17.2(9.5-24.8)	93	1.1(-1.0 ;3.2)	91	-4.0(-11.7 ; 3.7)	0.08
<i>12–23 months</i>	19.1(9.7-28.4)	68	10.3(5.9-14.7)	184	15.0(9.1-20.9)	140	-4.1(-15.1 ; 6.9)	0.22
<i>24–59 months</i>	13.3(9.0-17.6)	240	15.0(11.7-18.4)	428	6.7(4.5-8.9)	448	-6.6(-11.4 ; -17.6)	<0.001
<b>North</b>								
<i>6–11 months</i>	14.5(8.4-20.5)	131	9.5(4.4-14.6)	127	12.9(7.4-18.3)	147	-1.6(-9.7 ; 6.5)	0.34
<i>12–23 months</i>	26.5(21.1-31.8)	260	17.6(13.7-21.4)	380	18.2(13.9-22.4)	318	-8.3(-15.1 ; -1.4)	0.008
<i>24–59 months</i>	18.3(15.2-21.3)	617	12.1(10.1-14.1)	1058	12.2(9.2-15.2)	863	-6.1(-10.4 ; -1.8)	0.003
<b>Center</b>								
<i>6–11 months</i>	16.4(7.6-25.1)	69	8.2(1.9-14.5)	73	7.1(1.6-12.5)	85	-9.3(-19.6;1.1)	0.03
<i>12–23 months</i>	35.7(27.6-43.7)	136	20.0(13.8-26.2)	160	20.8(14.7-26.8)	173	-14.9(-27.9;-4.8)	<0.001
<i>24–59 months</i>	25.7(20.9-30.5)	317	19.2(15.6-22.8)	464	17.0(13.5-20.4)	454	-8.7(-14.6 ; -2.7)	<0.001
<b>South</b>								
<i>6–11 months</i>	7.3(0.6-15.2)	41	23.9(11.6-36.2)	46	14.0(4.4-23.6)	50	6.7(-5.8 ; 19.1)	0.15
<i>12–23 months</i>	39.4(29.7-49.0)	99	32.8(24.3-41.4)	117	20.2(12.9-27.4)	119	-19.2(-31.2;-7.2)	0.009
<i>24–59 months</i>	16.8(12.0-21.5)	238	32.0(27.1-36.9)	347	19.2(14.8-23.5)	318	2.4(-0.4 ; 8.6)	0.23

\*The degree of variation is calculated in absolute terms from 2005 to 2010; \*\*Pearson  $\chi^2$  one-sided test.

**Source:** DHS 2005, 2010, MIS 2008.

## Parasitaemia

### Prevalence of Malaria

The MIS conducted in 2008 was the first survey that examined the prevalence of malaria infection. This survey compared parasite prevalence from 2008 to 2010.

Overall, the prevalence of malaria was estimated at 6% in 2008 and 3% in 2010 (Figure 22).

Tables 26 and 27 summarize parasite prevalence in children under 5 years from 2008 to 2010 by sociodemographic characteristics. Parasite prevalence decreased in all age groups except in children aged 6–11 months. No difference was

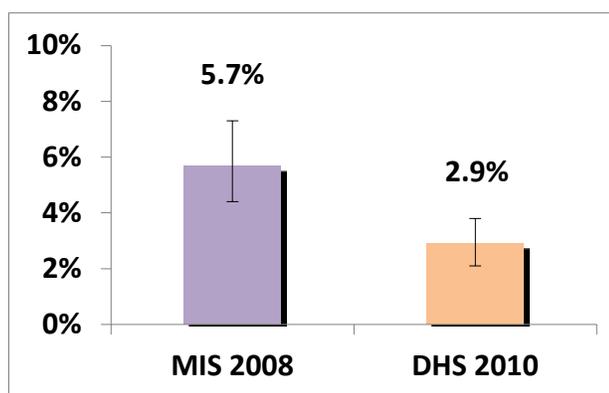
observed between boys and girls in 2008 (5.6% compared with 5.7%) and in 2010 (3.0% compared with 2.7%). Malaria infection was higher in rural areas than in urban areas. In rural areas, the prevalence of malaria infection decreased from 8% to 4%, while in urban areas there was no evidence of a significant difference, with 0.8% and 1.4%, respectively, in 2008 and 2010 ( $p=0.06$ ).

Analysis by epidemiological zone showed no significant difference in malaria infection from 2008 to 2010 ( $p=0.10$ ) in the epidemiological zone of Dakar. In the other zones, significant reductions of in parasite prevalence were observed. The reduction was greater in the Southern epidemiological zone where parasitemia decreased from 21% in 2008 to 8% in 2010 ( $p< 0.001$ ).

An inverse relationship existed between parasitaemia and the socioeconomic level. Significant reductions were observed in the poorest (9.6%) and second poorest quintiles (5.2%) of the population. Similar levels of infection were found in 2008 (1.4%) and 2010 (1.6%) ( $p= 0.86$ ) in the middle quintile. The fourth quintile showed no evidence of a difference between these periods ( $p>0.05$ ), while a marginal, but significant increase was detected in the wealthiest quintile, in which parasite prevalence was estimated at 0.7% in 2008 and 1.6% in 2010 ( $p<0.001$ ).

No evidence of a difference between age groups was observed in the region of Dakar. In the south the prevalence of malaria infection decreased significantly from 24% in 2008 to 9% in 2010 ( $p<0.001$ ) in children aged 24–59 months, and from 16% in 2008 to 5%

**Figure 22: Parasite prevalence among children 6–59 months in Senegal, 2008–2010**



**Note:** DHS =Demographic and Health Surveys, MIS = Malaria Indicator Survey

in 2010 ( $p<0.001$ ) in children aged 12–23 months ( $p<0.001$ ). In the central epidemiological zone, the prevalence of malaria in children aged 24–59 months in 2008 and 2010 was 7% and 4% ( $p=0.006$ ), respectively.

**Table 26: Parasite prevalence in children 6–59 months in Senegal, 2008-2010**

<b>Indicator: Percentage of children aged 6–59 months with a confirmed malaria infection by microscopy</b>						
<b>Background Characteristics</b>	<b>MIS 2008</b>		<b>DHS 2010</b>		<b>Percentage point change*</b> %(95%CI)	<b>p-value**</b>
	<b>% (95%CI)</b>	<b>N</b>	<b>% (95%CI)</b>	<b>N</b>		
<b>Total</b>	5.7(4.4-7.3)	3847	2.9(2.1-3.8)	3762	-2.8(-4.6;-1.0)	<0.001
<b>Age (in months)</b>						
6–11 months	2.4(1.3-4.6)	340	1.9 (0.9-3.8)	394	-0.5(-2.6;1.6)	0.32
12–23 months	3.5 (2.3-5.4)	863	1.4 (0.8-2.6)	813	-2.1(-3.9;-0.3)	0.002
24–59 months	6.8 (5.8-7.7)	2644	3.4 (2.6-4.1)	2553	-3.4(-4.5;-2.2)	<0.001
<b>Gender</b>						
Male	5.6(4.1-7.6)	1 874	3.0(2.1-4.3)	1 947	-2.6(-4.7;-0.5)	<0.001
Female	5.7(4.2-7.6)	1 973	2.7(1.9-3.9)	1 814	-3.0(-5.0;-1.0)	<0.001
<b>Place of Residence</b>						
Urban	0.8(0.4-1.8)	1 369	1.4(0.6-3.4)	1 440	0.6(-0.7;1.9)	<0.001
Rural	8.3(6.4-10.9)	2 478	3.8(2.8-5.0)	2 321	-4.5(-7.0;-2.0)	<0.001
<b>Epidemiological Zone</b>						
Dakar	0.8(0.2-3.2)	723	1.5(0.4-6.2)	761	0.7(-1.8;3.2)	0.10
North	2.4(1.6-3.1)	1769	1.1(0.6-1.6)	1528	-1.3(-2.1 ; -0.4)	0.002
Center	6.9(5.1-8.6)	803	3.7(2.4-4.9)	873	-3.2(-5.3;-10.4)	<0.001
South	20.6(17.2-23.9)	552	7.7(0.4-6.2)	600	-12.9(-16.9 ; -8.9)	<0.001
<b>Wealth Quintile</b>						
Poorest	15.8(12.1-20.4)	855	6.2(4.2-8.9)	849	-9.6(-14.3;-4.9)	<0.001
Second	7.3(04.7-11.4)	843	2.1(1.2-3.5)	817	-5.2(-8.7;-1.7)	<0.001
Middle	1.4(0.7-2.9)	825	1.6(0.8-3.3)	764	0.2(-1.3; 1.7)	0.86
Forth	0.7(0.2-2.1)	709	1.6(0.7-3.7)	734	0.9(-0.7;2.5)	<0.001
Richest	0.7(0.2-3.0)	615	2.3(0.7-7.3)	597	1.6(-1.3;4.5)	<0.001

**Note:** N = number of children (denominator). \*The degree of variation is calculated in absolute terms from 2008–2010.

\*\*Pearson  $\chi^2$  one-sided test

**Source:** DHS 2010, MIS 2008.

**Table 27: Parasite prevalence in children aged 6–59 months by age and epidemiological zone in Senegal in 2008 and 2010**

<b>Indicator: Percentage of children under 5 years with microscopically confirmed malaria parasite, by age and epidemiological zone</b>						
<b>Characteristics of Respondents</b>	<b>MIS 2008</b>		<b>DHS 2010</b>		<b>Percentage point change* %(95%CI)</b>	<b>p-value</b>
	<b>% (95%CI)</b>	<b>N</b>	<b>% (95%CI)</b>	<b>N</b>		
<b>Dakar</b>						
6–11 months	0	93	0	95	0	
12–23 months	0	169	0	157	0	
24–59 months	1.4(0.2-2.5)	420	2.3(1.1-3.6)	513	0.9(-0.8 ;2.6)	0.15
<b>North</b>						
6–11 months	0	126	0	156	0	0
12–23 months	1.8(0.4-3.1)	377	0	341	-1.8(-3.1 ; -0.4)	0.04
24–59 months	2.9(2.1-3.7)	1554	1.7(0.9-2.9)	1038	-1.2(-2.3; -0.0)	0.02
<b>Center</b>						
6–11 months	5.5(0.2-10.7)	72	5.4(0.8-9.9)	93	-0.1(-7.1; 6.9)	0.48
12–23 months	3.1(0.3-5.8)	150	2.6(0.3-4.8)	190	-0.5(-4.0; 3.0)	0.39
24–59 months	7.1(4.7-9.4)	462	3.7(2.2-5.2)	596	-3.4(-6.2; -0.6)	0.006
<b>South</b>						
6–11 months	8.9(5.8-17.2)	45	5.4(0.5-11.3)	56	-3.5(13.7 ; -6.7)	0.24
12–23 months	15.5(8.8-22.2)	113	4.5(0.9-8.0)	132	-11.0(-18.5 ; -3.4)	<0.001
24–59 months	24.5(19.9-29.0)	342	8.7 (5.9-11.4)	412	-15.8 (-21.1-10.5)	<0.001

\*The degree of variation is calculated in absolute terms from 2008–2010; \*\*Pearson  $\chi^2$  one-sided test.

**Source:** DHS 2010, MIS 2008.

### **Sensitivity Analysis**

The fact that the surveys were not conducted during the same months of the year may represent a major limitation to the validity of the results. The first survey took place from October 2008 to February 2009. The second survey took place from November 2010 to April 2011, and the period from February to June corresponds to the period of lowest transmission. In some regions, especially the southern epidemiological zone, where transmission is higher, the survey was not conducted during the same periods; therefore, sensitivity analyses were conducted to address this limitation.

First, we analyzed regions where at least 75% of the sample that were surveyed in 2010–2011, had been surveyed by February 2011 at the latest. These included the epidemiological zone of Dakar, the northern epidemiological zone, and the regions of Tambacounda and Kédougou in the south. We compared parasite prevalence among these regions using data generated by the 2008 and 2010 surveys. These analyses estimated the prevalence of malaria at 4% in 2008 and 2% in 2010 ( $p < 0.001$ ) (Table 28).

**Table 28: Parasite prevalence in children aged 6–59 months in 2008 and 2010 in regions surveyed by February 2011**

<b>Indicator: Percentage of children aged 6–59 months with a confirmed malaria parasite by microscopy</b>						
<b>Epidemiological Zone</b>	MIS 2008		DHS 2010		Percentage point change* %(95%CI)	<i>p</i> -value**
	% (95%CI)	N	% (95%CI)	N		
<b>Total</b>	3.5(2.9-4.3)	2699	1.8(1.3-2.3)	2528	-1.7(-2.1 ; -0.9)	0.001
Dakar	0.8(0.2-3.2)	723	1.5(0.4-6.2)	761	0.7(-0.3;1.7)	0.100
North	2.4(1.6-3.1)	1769	1.1(0.6-1.6)	1528	-1.3(-2.1 ; -0.4)	0.002
Tambacounda /Kedougou	23.3(17.5-20.0)	207	7.9(4.5-11.3)	239	-15.4(-22.1 ; -8.7)	0.001

Note N=number of children (denominator). \*The degree of variation is calculated in absolute terms from 2008 to 2010. \*\*Pearson  $\chi^2$  one-sided test.

**Source:** DHS 2010, MIS 2008

To add regions that were excluded in the previous analysis, we assumed that the level of variation in these regions is the same as the national variation. Our hypothesis is very restrictive because all of these regions had a higher prevalence than the national average; at equal transmission intensities, the level of reduction in the prevalence of malaria infection in these regions would be higher than national because of regression toward the mean. An estimation of the ratio of national prevalence from 2008 to 2010 (1.9%) allowed us to simulate the prevalence of infection in these regions. Based on this analysis, we estimated a national prevalence of 6% in 2008 and 3% in 2010 (Table 29).

**Table 29: Parasite prevalence in children 6–59 months in 2008 and 2010, simulated using all regions surveyed by February 2011**

<b>Indicator: Percentage of children aged 6–59 months with a confirmed malaria parasite by microscopy</b>						
<b>Epidemiological Zone</b>	MIS 2008		DHS 2010		Percentage point change* (95%CI)	<i>p</i> value**
	% (95%CI)	N	% (95%CI)	N		
<b>Total</b>	5.7(4.4-4.1)	3,847	3.3(2.7-3.8)	3762	-2.4(-3.3 ; -1.4)	<0.001
<i>Dakar</i>	0.8(0.2-3.2)	723	1.5(0.4-6.2)	761	0.7(-0.3;1.7)	0.100
<i>North</i>	2.4(1.6-3.1)	1,769	1.1(0.6-1.6)	1528	-1.3(-5.4 ; -1.1)	0.002
<i>Center</i>	6.9(5.1-8.6)	803	3.6(2.4-4.9)	873	-3.3(-5.3; -10.4)	<0.001
<i>South</i>	20.6(17.2-23.9)	552	10.7(8.2-13.2)	600	-9.9(-14.1 ; -54)	<0.001

Note: N=number of children (denominator). \*The degree of variation is calculated in absolute terms from 2008–2010. \*\*Pearson  $\chi^2$  one-sided test

**Source:** DHS 2010, MIS 2008.

The last scenario chose regions where at least 75% of the targeted sample of the population was surveyed between November 2010 and February 2011 (excluding Dakar) for both the 2008 and 2010 surveys. National prevalence was 5% in 2008 and 2% in 2010 ( $p<0.001$ ) (Table 30).

**Table 30: Parasite prevalence in children 6–59 months in 2009 using data from all regions surveyed from November to February in 2008 and 2010**

<b>Indicator: Percentage of children aged 6–59 months with a malaria infection confirmed by microscopy</b>						
<b>Epidemiological Zone</b>	MIS 2008		DHS 2010		Percentage point change %(95%CI)	<i>P</i> -value**
	% (95%CI)	N	% (95%CI)	N		
<b>Total</b>	4.6(3.6-5.5)	1976	2.0(1.3-2.6)	1767	-2.6(-3.7 ; -1.4)	0.001
North	2.4(1.6-3.1)	1769	1.1(0.6-1.6)	1528	-1.3(-2.1 ; -0.4)	0.002
Tambacounda	23.3(17.5-20.0)	207	7.9(4.5-11.3)	239	-15.4(-22.1 ; -8.7)	0.001

**Note:** N=number of children (denominator). \*The degree of variation is calculated in absolute terms from 2008–2010. \*\*Pearson  $\chi^2$  one-sided test

**Source:** DHS 2010, MIS 2008.

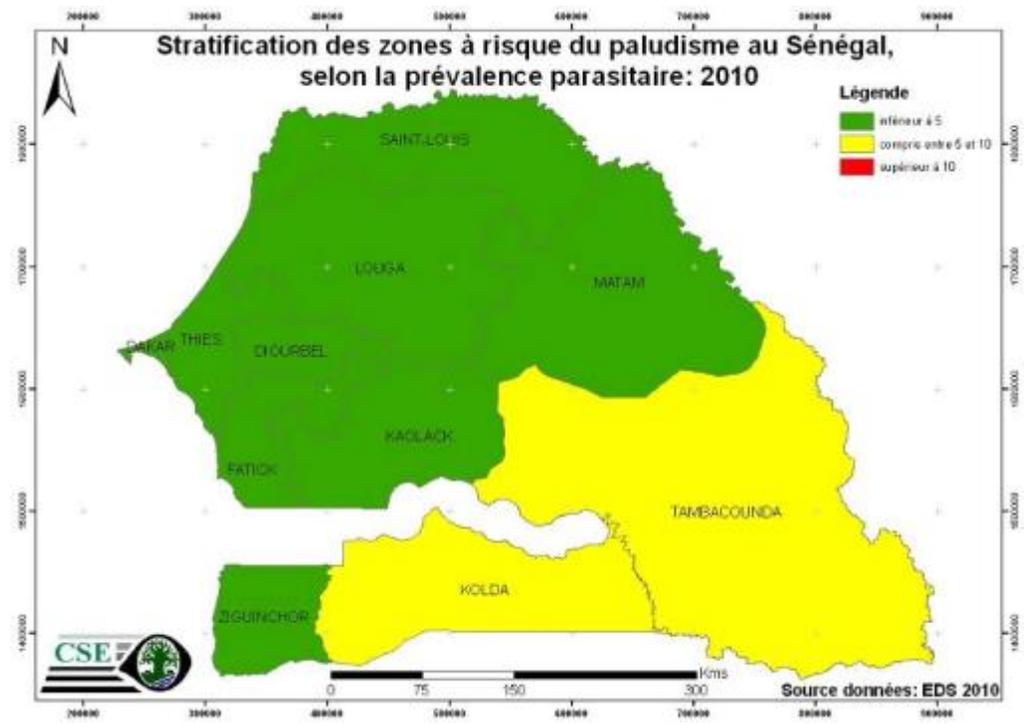
Crude analysis and analysis based on the different scenarios confirmed that the prevalence of malaria infection decreased significantly in Senegal from 2008 to 2010. These scenarios showed that most regions with a high prevalence of parasitemia were done during the low transmission season in the 2010 to 2011 DHS, which may result in an artificial decrease in parasite prevalence; however, it should be stressed that all scenarios demonstrated significant reduction.

The decrease in parasite prevalence at the national level was substantiated by a decrease in all the epidemiological zones. In 2010, no region had a greater than 10% parasite prevalence (Figure 23).

**Figure 23: Stratification of the risk of malaria by area according to parasite prevalence 2009**



**2010**



## Severe Anemia and Parasitemia

We examined the proportion of children with severe anemia and malaria infection, and found that overall, the prevalence of severe anemia associated with malaria infection as confirmed by microscopy was 3% in 2008 and 1% in 2010 ( $p < 0.001$ ) (Figure 24).

Table 31 presents the prevalence of severe anemia associated with parasitaemia in children under 5

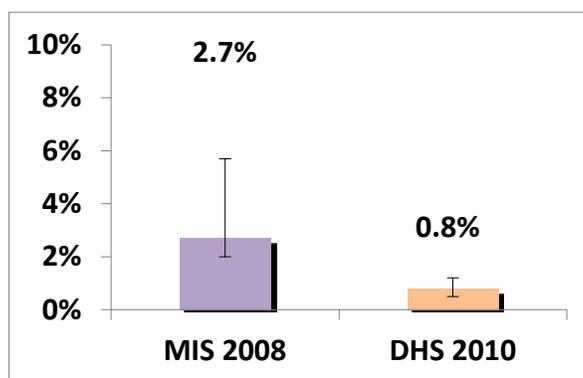
years by sociodemographic characteristics in 2008 and 2010. There was no evidence of a significant decrease in children under 12 months. Among children aged 12–23 months, the prevalence of malaria-associated severe anemia was 2% in 2008 and 0.4% in 2010, whereas among children 24–59 months, the prevalence declined from 3% in 2008 to 1% in 2010 ( $p < 0.05$ ).

A significant reduction was observed among both girls and boys. The reduction in the prevalence of malaria-associated anemia varied between rural and urban areas. In urban areas, no significant difference was noted between the two periods, while in rural areas, malaria-associated anemia prevalence decreased from 4% (2008) to 1% (2010).

The results also varied depending on the epidemiological zone. In Dakar, a slight and non-significant decline was observed. In the other epidemiological zones, different levels of reduction were observed, with the southern zone showing the highest reduction and the north zone the lowest.

The prevalence of malaria-associated anemia is related to socioeconomic status. The proportion of children with severe anemia and parasitemia was higher among the poorest households both in 2008 and in 2010 at 7.9% and 2.0%, respectively. The reduction in the prevalence of malaria-associated anemia between 2008 and 2010 was greater among children from the poorest and the second poorest households, with a decrease from 7.9% to 2%, respectively, and 3.2% to 0.6%, respectively. No evidence indicated a reduction among children belonging to the other wealth quintiles.

**Figure 24: Prevalence of malaria-associated anemia in children aged 6–59 months in Senegal, 2008**



**Note:** DHS = Demographic and Health Surveys, MIS = Malaria Indicator Survey

**Table 31: Prevalence of malaria-associated anemia among children aged 6–59 months in Senegal, 2008-2010**

<b>Indicator: Percentage of children aged 6–59 months with a hemoglobin less than 8.0 g/dL associated with malaria infection confirmed by microscopy</b>						
<b>Background Characteristics</b>	<b>MIS 2008</b>		<b>DHS 2010</b>		<b>Percentage point change %(95%CI)*</b>	<b>P-value**</b>
	<b>% (95%CI)</b>	<b>N</b>	<b>% (95%CI)</b>	<b>N</b>		
<b>Total</b>	2.7(2.0-5.7)	3843	0.8(0.5-1.2)	3762	-1.9(-2.8 ; -1.0)	<0.001
<b>Age (in months)</b>						
<i>6–11</i>	1.5(0.2-2.8)	336	0.7(0.1-1.5)	401	-0.8(-2.3 ; 0.7)	0.14
<i>11–23</i>	2.2(1.2-3.2)	818	0.4(0.0-0.8)	820	-1.8(-2.8 ; -0.7)	<0.001
<i>24–59</i>	3.4(2.6-4.1)	2273	0.9(0.5-1.2)	2561	-2.5(-3.3 ; -1.7)	<0.001
<b>Gender</b>						
<i>Male</i>	2.9(2.1-4.0)	1 872	0.8(0.5-1.3)	1 947	-2.1(-3.2; -1.0)	<0.001
<i>Female</i>	2.5(1.7-3.7)	1 971	0.7(0.4-1.4)	1 814	-1.8(-2.9; -0.7)	<0.001
<b>Place of Residence</b>						
<i>Urban</i>	0.3(0.1-0.8)	1 369	0.3(0.1-1.5)	1 440	0.0(-0.6; 0.6)	0.5
<i>Rural</i>	4.0(2.9-5.5)	2 474	1.0(0.6-1.7)	2 321	-3.0 (-4.5-1.5)	<0.001
<b>Epidemiological Zone</b>						
<i>Dakar</i>	0.1(0.0-1.0)	723	0.4(0.1-3.2)	761	0.3(-0.5 ; 1.1)	0.12
<i>North</i>	0.7(0.3 -1.1)	1768	0.2(0.0-0.4)	1528	-0.5(-0.9 ; -0.0)	0.02
<i>Center</i>	3.0(1.8-4.2)	801	0.8(0.3-1.4)	873	-2.2(-3.5 ; -0.8)	<0.001
<i>South</i>	11.5(8.8-14.2)	551	2.3(1.1-3.5)	600	-9.2(-12.1 ; -6.3)	<0.001
<b>Wealth Quintile</b>						
<i>Poorest</i>	7.9(5.5-11.2)	852	2.0(1.1-3.5)	849	-5.9(-8.9; -2.9)	<0.001
<i>Second</i>	3.2(2.1-4.8)	842	0.6(0.3-1.5)	817	-2.6(-4.1; -1.1)	<0.001
<i>Middle</i>	0.8(0.3-2.2)	824	0.3(0.1-0.9)	764	-0.5(-1.4; 0.4)	0.13
<i>Fourth</i>	0.4(0.1-1.2)	709	0.5(0.1-3.2)	734	0.1(-1.0; 1.2)	0.38
<i>Richest</i>	0.0	615	0.2(0.0-1.1)	597	0.2(-0.2; 0.6)	0.13

Remark: n=number of children (denominator). \*The degree of variation is calculated in absolute terms from 2005 to 2010. \*\*Pearson  $\chi^2$  one-sided test.

Source: DHS 2010, MIS 2008.

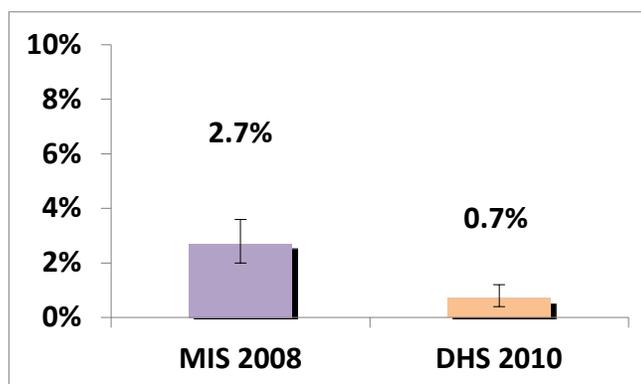
## Fever and Parasitaemia

Overall, the prevalence of fever associated with malaria during the last 2 weeks preceding the surveys decreased from 3% (2008) to 0.7% (2010) ( $p < 0.001$ ) (Figure 25).

Analysis by age group showed a reduction in the proportion of fever plus parasitemia in children older than 11 months, whereas in children younger than 11 months, no significant reduction was observed. Among girls, the prevalence of fever plus

parasitemia was 2% in 2008 and 0.6% in 2010, while among boys, it declined from 3.2% in 2008 to 0.8% in 2010. The prevalence of fever plus parasitemia was lower in 2010 in urban areas, but did not show a significant difference when compared to 2008 ( $p = 0.15$ ). In rural areas, fewer children experienced fever plus parasitemia in 2010 (0.6%) compared to 2008 (4%) ( $p < 0.001$ ). Analysis stratified by epidemiological zone indicated no significant decrease in the Dakar zone ( $p = 0.4$ ), unlike the southern epidemiological zone and, to a lesser extent, the central and northern epidemiological zones where significant decreases were apparent in the prevalence of fever plus parasitemia. Significant reductions also were observed among children belonging to households from the two poorest wealth quintiles, but not in the remaining wealth quintiles (Table 32).

**Figure 25: Prevalence of fever associated with parasitaemia among children in Senegal, 2008-2010**



**Note:** DHS = Demographic and Health Surveys, MIS = Malaria Indicator Survey

**Table 32: Prevalence of fever associated with parasitaemia among children in Senegal**

<b>Indicator: Percentage of children under 5 years with fever in the 2 weeks preceding the survey and confirmed malaria infection by microscopy</b>						
<b>Background Characteristics</b>	<b>MIS 2008</b>		<b>DHS 2010</b>		<b>Percentage point change % (95%CI)*</b>	<b>p-value**</b>
	<b>% (95%CI)</b>	<b>N</b>	<b>% (95%CI)</b>	<b>N</b>		
<b>Total</b>	2.7(2.0-3.6)	3423	0.7(0.4-1.2)	3258	-2.0(-2.6 ; -1.9)	<0.001
<b>Age (in months)</b>						
<i>6-11</i>	1.4(0.2-2.5)	342	0.8(0.1-1.5)	326	-0.6(-2.1 ; 0.5)	0.3
<i>11-23</i>	2.1(1.1-3.1)	809	0.3(0.0-0.7)	805	-1.8(-2.8 ; -0.7)	<0.003
<i>24-59</i>	3.0(2.1-4.1)	2272	0.9(5.2-1.6)	2127	-2.1(-2.9 ; -1.3)	<0.001
<b>Sex</b>						
<i>Male</i>	3.2(2.2-4.6)	1 673	0.8(0.4-1.6)	1 696	-2.4(-3.3; -1.4)	<0.001
<i>Female</i>	2.2(1.5-3.2)	1750	0.6(0.3-1.2)	1 563	-1.6(-2.3; -0.8)	<0.001
<b>Place of Residence</b>						
<i>Urban</i>	0.7(0.3-1.7)	1 227	0.4(0.1-1.9)	1 265	-0.3(-0.8; 0.2)	0.15
<i>Rural</i>	3.8(2.8-5.2)	2 196	0.9(0.5-1.4)	1 993	-2.9(-3.8; -1.9)	<0.001
<b>Epidemiological Zone</b>						
<i>Dakar</i>	0.7 (0.2-3.0)	664	0.6(0.1-4.0)	667	-0.1(-0.9 ; 0.7)	0.4
<i>North</i>	1.0(0.5-1.5)	1571	0.3(0.0-0.6)	1341	-0.7(-1.2 ; -0.1)	0.01
<i>Center</i>	2.3(1.2-3.4)	696	0.8(0.2-1.4)	753	-1.5(-2.7 ; -0.2)	<0.009
<i>South</i>	10.8(8.0-13.5)	493	1.2(0.4-2.0)	497	-9.6(-12.4 ; -6.7)	<0.001
<b>Wealth quintile</b>						
<i>Poorest</i>	6.9(4.8-9.7)	749	1.4(0.8-2.6)	722	-5.5(-7.5; -3.4)	<0.001
<i>Second</i>	3.9(2.3-6.3)	747	0.3(0.1-0.9)	704	-3.6(-5.0; -2.1)	<0.001
<i>Middle</i>	0.5(0.2-1.5)	744	0.2(0.0-0.7)	669	-0.3(-0.9; 0.3)	0.17
<i>Fourth</i>	0.4(0.1-1.4)	630	0.4(0; 1-1; 6)	640	0.0(-0.6; 0.6)	0.5
<i>Richest</i>	0.8(0.2-3.4)	552	1.3(0.4-4.5)	523	0.5(-0.7; 1.7)	0.21

Remark: n=number of children (denominator). \*The degree of variation is calculated in absolute terms from 2008–2010. \*\*Pearson  $\chi^2$  one-sided test

**Source:** DHS 2010, MIS 2008.

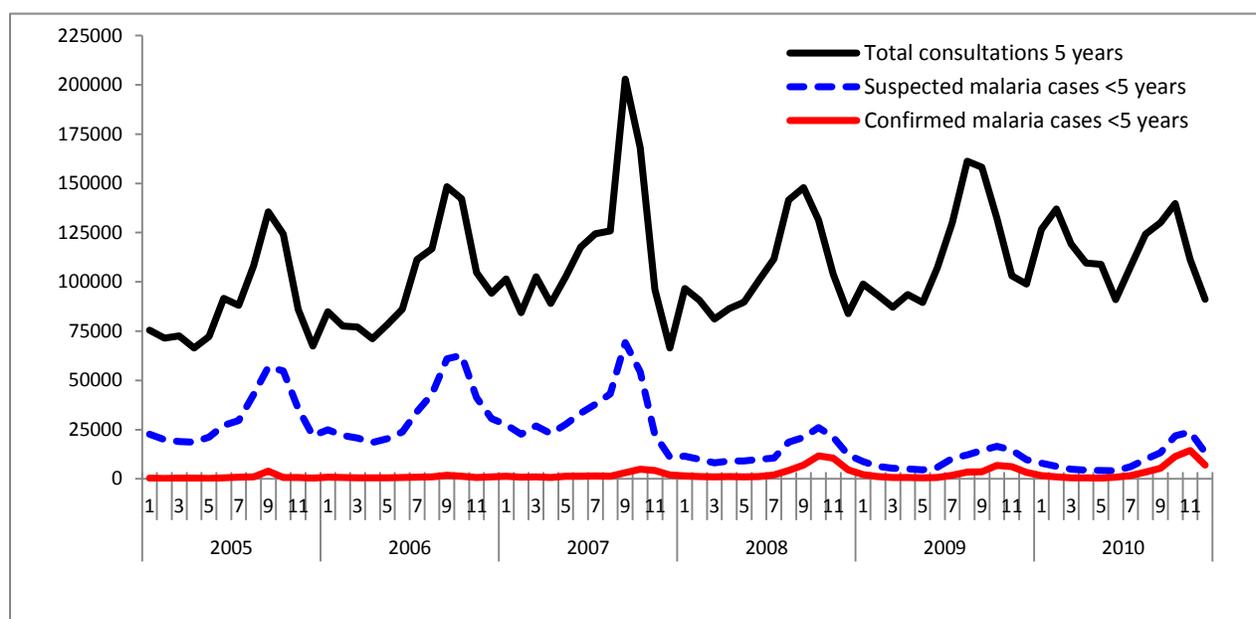
## Malaria Information System Data

Senegal has a structured routine information system that provides timely information for decision-making, the management of health programs, and the development of health systems. The NMCP information system is tied to the national Health Management Information Service (HMIS), enabling the collection of data on activities undertaken in the public, semi-public, and private sector, as well as in the community. Data collection is organized so that forms for the reporting of malaria cases, malaria

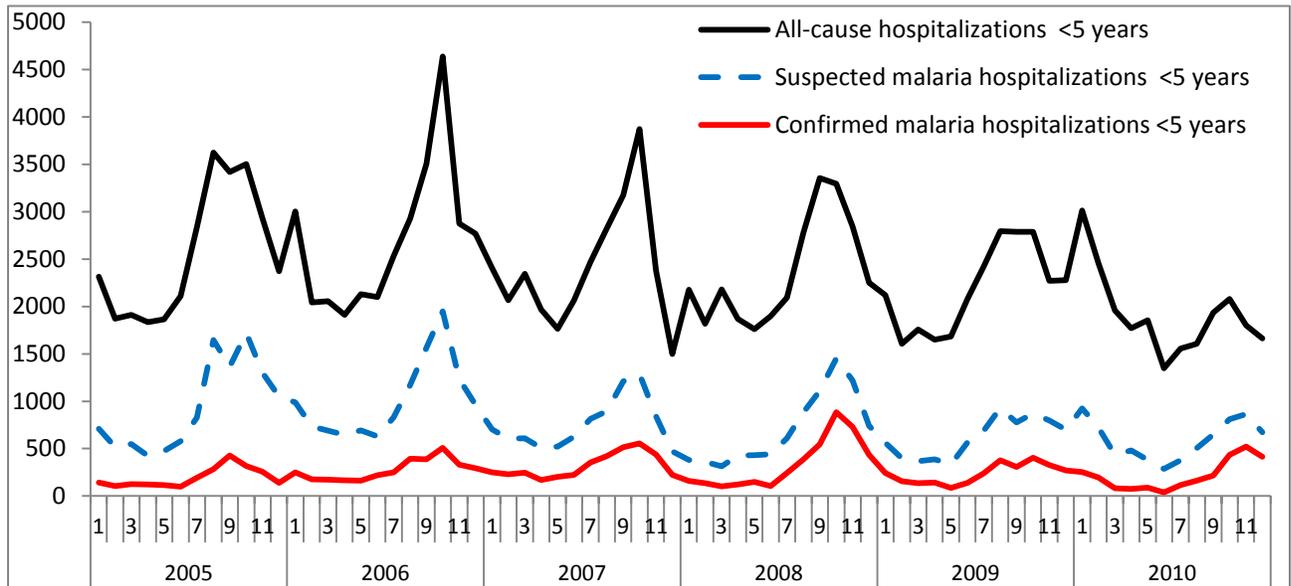
prevention, and case management activities are completed at the operational levels (districts). For information management, key players at each level of the health system structure are responsible for generating relevant local information based on the routinely collected data, including the recording of malaria cases, compiling data for office reports, preparing monthly or quarterly reports, conducting local investigation for diseases of special interest, processing data, and analyzing coverage indicators and the performance of health programs. A database supported by the RBM (RBMME) was set up in all health districts, hospitals, and military camps for better management of data collected at the operational level.

Before the introduction of RDTs and the case management flowchart, the number of suspected cases of malaria (diagnosis based on the presence of fever) increased gradually from 2005–2007 in relation to the number of consultations at health facilities. The peak of cases was observed during the rainy season in the different epidemiological zones. From 2008 to 2009, the number of suspected and confirmed cases decreased, with a slight increase in 2010, a spectacularly wet year (Figure 26). Over 80% of suspected malaria cases were tested for malaria in 2009, and a further increase was observed in 2010 (92%). Similar trends were observed in hospitalizations for severe malaria (Table 33).

**Figure 26: Evolution of consultations, suspected and confirmed malaria cases among children under 5 years, from 2005 to 2010**



**Figure 27: Evolution of all-cause hospitalizations, suspected and confirmed malaria cases**



**Table 33: Malaria morbidity in children under 5 years in public health facilities in Senegal 2005–2010**

		2005	2006	2007	2008	2009	2010
<b>Number of consultations</b>	<b>Total</b>	1,059,421	1,193,028	1,381,871	1,265,561	1,353,198	1,397,110
	<b>Dakar</b>	327,446	370,690	434,416	395,077	366,758	381,485
	<b>Center</b>	202,679	198,289	252,525	220,378	278,508	511,101
	<b>North</b>	350,382	431,362	489,089	446,777	490,439	296,428
	<b>South</b>	178,914	192,687	205,841	203,329	217,493	208,096
<b>Suspected cases of malaria</b>	<b>Total</b>	370,061	403,094	399,109	167,274	113,731	120,569
	<b>Dakar</b>	74,963	86,954	84,446	37,806	26,187	30,509
	<b>Center</b>	87,665	78,737	92,228	31,342	19,364	36,243
	<b>North</b>	121,900	152,033	136,464	45,019	30,418	25,888
	<b>South</b>	85,533	85,370	85,971	53,107	37,762	27,929
<b>Percentage of suspected cases tested:</b> <i>Proportion of suspected cases of malaria who had a biological diagnosis (RDT or microscopy) in children &lt; 5 years</i>	<b>Total</b>				62.6%	81.4%	92.4%
	<b>Dakar</b>				52.3%	75.9%	89.4%
	<b>Center</b>				75.2%	94.0%	89.4%
	<b>North</b>				63.4%	86.1%	98.4%
	<b>South</b>				61.8%	74.9%	94.2%
<b>Confirmed cases of malaria</b>	<b>Total</b>	9,642	10,687	23,356	46,725	30,800	48,168
	<b>Dakar</b>	5,370	4,067	6,381	6,036	6,148	8,793
	<b>Center</b>	1,296	2,527	5,661	9,688	4,212	14,165
	<b>North</b>	2,092	2,639	6,996	10,246	6,845	12,223
	<b>South</b>	884	1,454	4,318	20,755	13,595	12,987
<b>Positivity rate (%):</b> <i>Proportion of confirmed malaria cases among all suspected malaria cases that had a biological diagnosis by RDT or microscopy in</i>	<b>Total</b>				27.9%	27.1%	43.2%
	<b>Dakar</b>				16.0%	23.5%	32.2%
	<b>Center</b>				30.9%	21.8%	43.8%
	<b>North</b>				22.8%	22.5%	48.0%
	<b>South</b>				39.1%	36.0%	49.4%
<b>Incidence per thousand</b>	<b>Total</b>	4.47	4.97	10.61	20.74	13.35	19.84
	<b>Dakar</b>	11.79	8.36	12.82	11.86	11.82	17.49
	<b>Center</b>	2.95	5.71	12.60	21.23	9.09	26.15
	<b>North</b>	2.22	2.91	7.51	10.69	6.63	11.83
	<b>South</b>	2.79	4.62	13.40	62.88	40.20	37.03
<b>Proportional morbidity:</b> <i>Proportion of malaria cases among all children under 5 years who sought care at public health facilities (confirmed after 2007)</i>	<b>Total</b>	34.9%	33.8%	23.3%	3.7%	2.3%	3.5%
	<b>Dakar</b>	43.3%	39.7%	29.5%	4.4%	1.5%	2.3%
	<b>Center</b>	22.9%	23.5%	16.2%	1.5%	1.7%	2.8%
	<b>North</b>	34.8%	35.2%	22.5%	2.3%	1.4%	4.1%
	<b>South</b>	47.8%	44.3%	32.8%	10.2%	6.3%	6.2%

**Source:** Routine data, NMCP, Senegal.

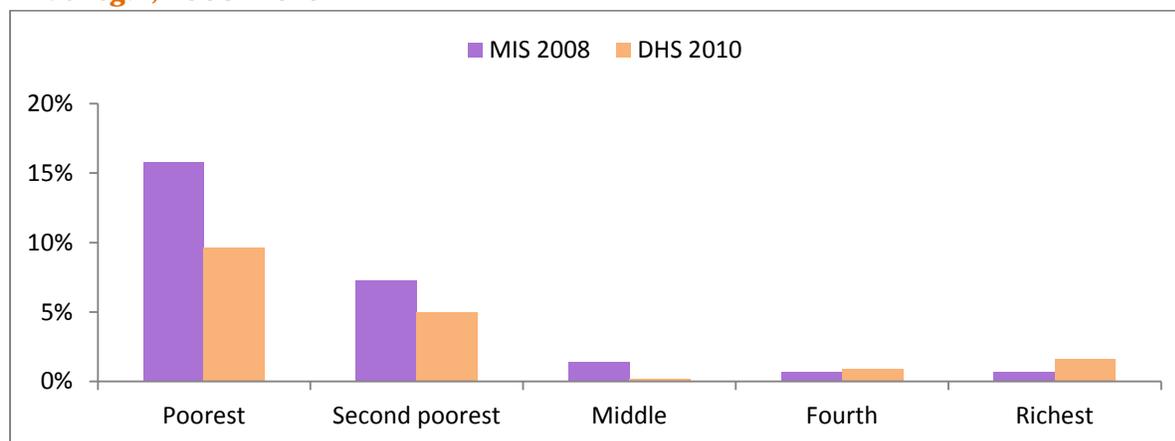
## Summary on Malaria Morbidity

We assessed two periods for the trend of malaria morbidity, from 2005 to 2010 and more specifically from 2008–2010, after the intensification of scale up. Overall, the trend showed a decline in malaria morbidity in the 5 year period. The prevalence of severe anemia was 20% in 2005 and 14% in 2010 ( $p<0.05$ ), while the overall parasite prevalence decreased from 6% in 2008 (the first year it was measured) to 3% in 2010 ( $p<0.05$ ). We observed a similar significant decrease in the proportion of children with malaria-associated anemia and malaria-associated fever.

The distributions of anemia and malaria were analyzed according to certain factors. Over the 5-year period, the prevalence of anemia and malaria was greater in rural than urban areas. In rural areas, evidence showed a decline in anemia and malaria, while in urban areas, it showed a significant decrease for anemia only.

The prevalence of anemia and malaria are related to socioeconomic status, decreasing from the poorest to the richest wealth quintiles consistently in all surveys. From 2005 to 2010, the prevalence of anemia decreased significantly among all children, regardless of the wealth quintile; however, statistically malaria had significant decreases among the two poorest quintiles only (Figure 28).

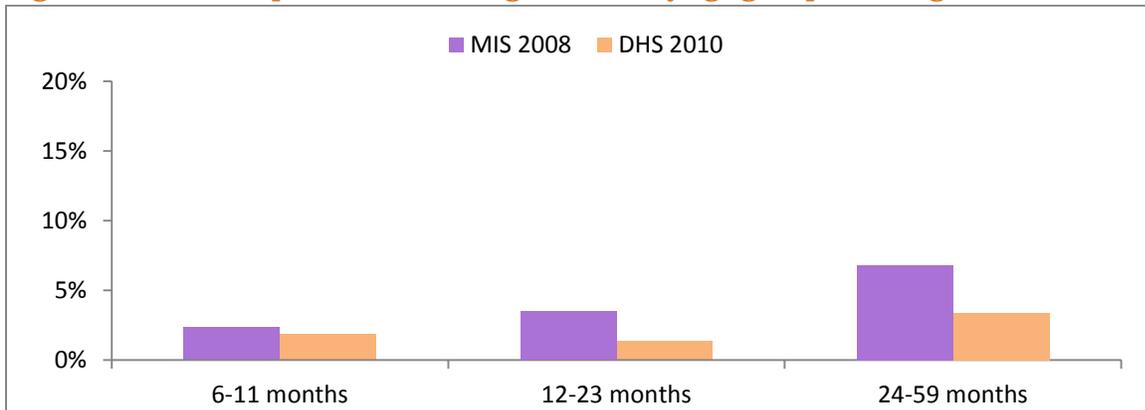
**Figure 28: Parasite prevalence among children under 5 years of age by wealth quintile in Senegal, 2008–2010**



DHS=Demographic and health survey, MIS=Malaria Indicator Survey

Analyses performed for the different epidemiological zones by age groups demonstrated no significant decrease in parasite prevalence in children 6–11 months, unlike in children aged 12–23 months, among whom significant decreases were observed in the northern and southern epidemiological zones. Parasite prevalence decreased in children aged 24–59 months in all but the Dakar epidemiological zone. Pooled analysis showed a reduction in parasite prevalence among children aged 12–59 months (Figure 29).

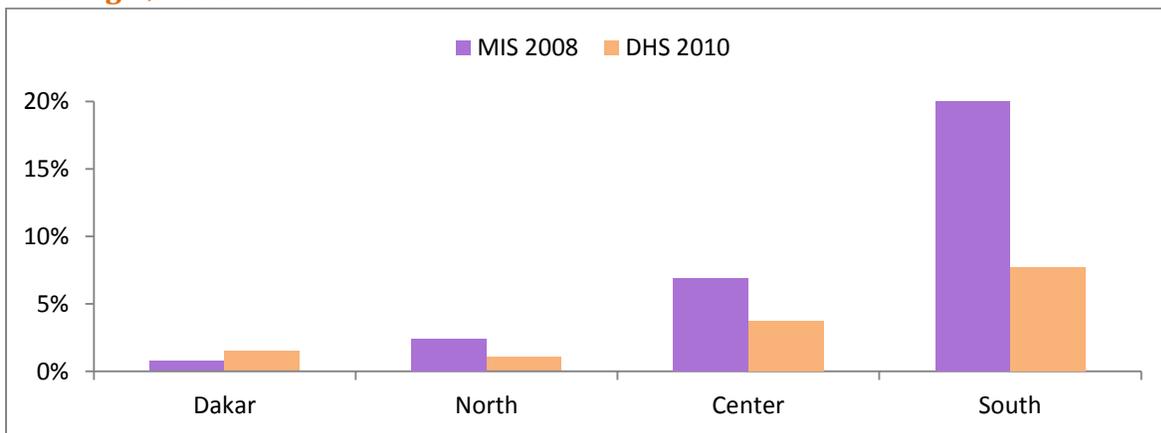
**Figure 29: Parasite prevalence among children by age group in Senegal, 2008–2010**



DHS =Demographic and Health Surveys, MIS = Malaria Indicator Survey

Anemia in children aged of 12–23 months, the group most at risk of malaria-related anemia, decreased significantly, in the northern, central, and southern epidemiological zones, suggesting that the decrease in anemia may be associated with the decline of malaria (Figure 30).

**Figure 30: Parasite prevalence among children under 5 years by epidemiological zone in Senegal, 2008–2010**



DHS =Demographic and Health Surveys, MIS = Malaria Indicator Survey

Parasite prevalence decreased more among populations with greater improvement in ITN coverage, including in populations from the central and southern epidemiological zones, populations belonging to the two poorest wealth quintiles, and those from rural areas.

It is not possible to make a valid comparison of routine data from 2005 to 2010 because RDTs and the flowchart were introduced in 2007 and scaled-up in 2008. Between 2007 and 2008, the number of suspected cases decreased significantly and the number of confirmed cases increased. Between 2008 and 2009, the proportion of suspected cases that were tested for malaria increased, but the number of suspected cases continued to decline, along with the number of confirmed cases. The same trends were observed in all epidemiological zones except Dakar, where the number of confirmed cases was on the rise. Similar trends were observed in hospitalized patients.

## All Cause Mortality among Children Under 5 Years

### Questions:

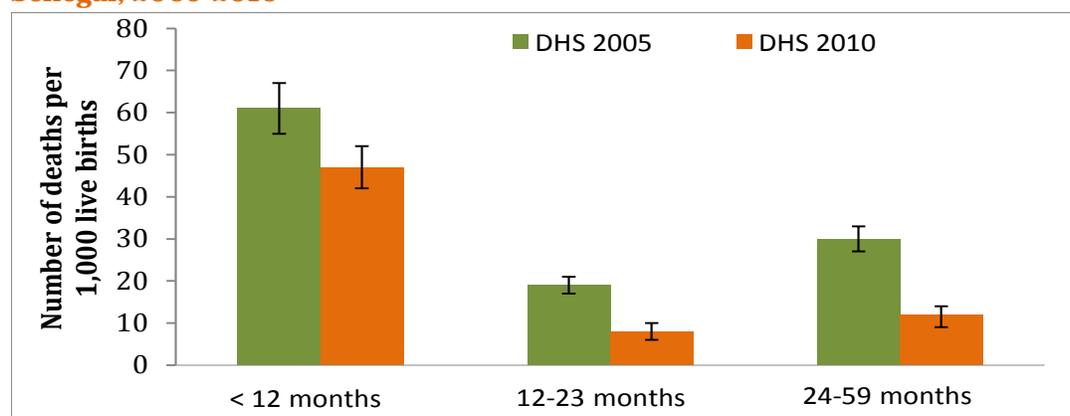
- *Did all-cause mortality in children under 5 years in Senegal decrease significantly from 2005 to 2010?*
- *How large was the decrease in mortality, if any, among the groups at risk of malaria?*

We examined the trends in mortality among children under 5 years of age using DHS data from 2005 and 2010 to address these questions.

### Trends in All-Cause Child Mortality

All-cause mortality in children under 5 years of age decreased significantly from 2005 to 2010. The estimated mortality rates were 121 and 72 per 1,000 live births, respectively, which was a relative decrease of 40%. Analysis by age showed significant decreases in all age groups, with a greater reduction of mortality in children aged 23–59 months (Figure 31 and Table 34).

**Figure 31: All-cause mortality in children under 5 years by age group in Senegal, 2005-2010**

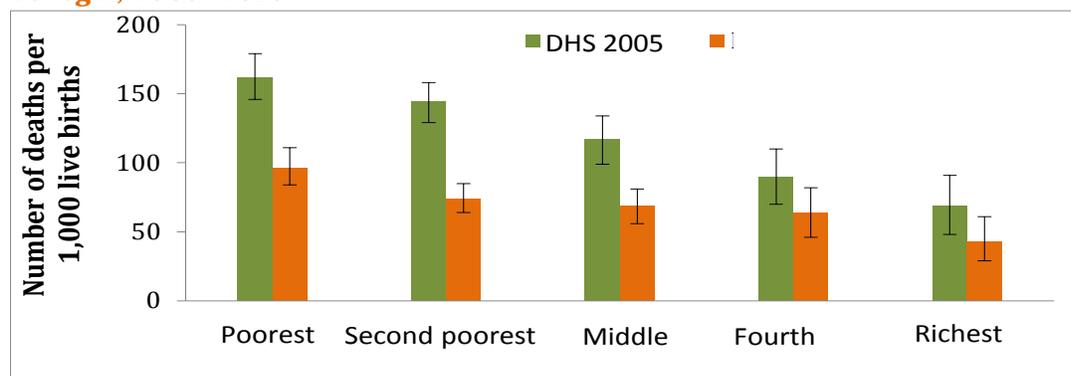


All-cause mortality among girls was significantly lower in 2010 than 2005 (67 per 1,000 live births compared with 116 per 1,000 live births), yielding a relative reduction of 42%. A similar decrease was observed in boys. In rural areas, all-cause mortality declined from 139 per 1,000 live births in 2005 to 84 per 1,000 live births in 2010, corresponding to a relative decrease of 40%, which was similar to the reduction observed in urban areas (39%) (Table 34).

Evidence also indicated that mortality among children was lower in 2010 than in 2005 in all wealth quintiles, from the poorest to the wealthiest, though the decrease was only significant in the poorest, second and middle quintiles. All-cause mortality was estimated at 162‰ in 2005 among the poorest quintile and 69‰ among the wealthiest quintile. In

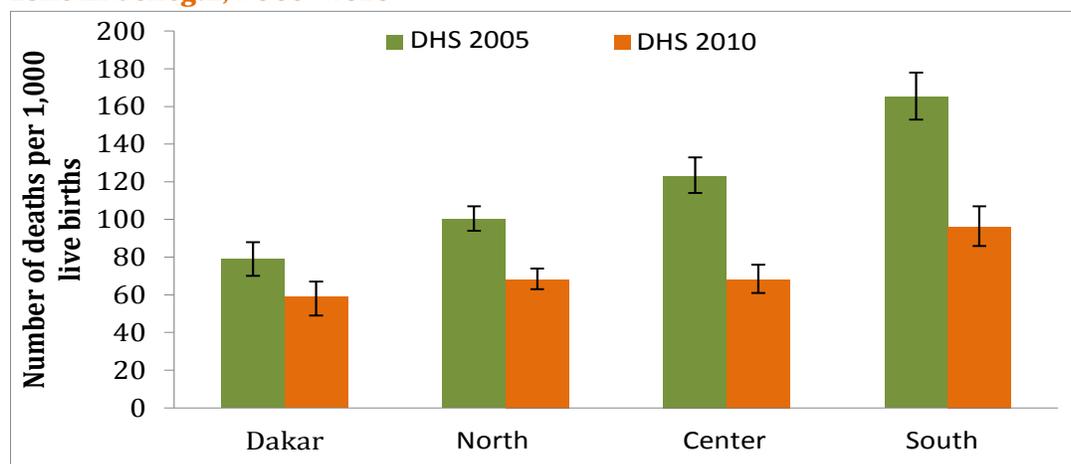
2010, these rates decreased to 96‰ and 43‰, respectively, of live births. The highest decrease was found in the second poorest quintile (48%) and the lowest in the fourth quintile (28%) (Figure 32 and Table 34).

**Figure 32: All-cause mortality in children under 5 years by wealth quintile in Senegal, 2005–2010**



Subsequent stratified analysis showed significant decreases in all epidemiological zones in the 2005–2010 period. All-cause mortality estimates for 2005 were 165‰ for the southern epidemiological zone and 79‰ for Dakar. The same trend was observed in 2010, with the lowest mortality in Dakar and the highest in the southern epidemiological zone. The greatest reduction occurred in the central zone (45%), followed by the southern epidemiological zone (42%) (Figure 33 and Table 35).

**Figure 33: All-cause mortality in children under 5 years by epidemiological zone in Senegal, 2005–2010**



**Table 34: All-cause mortality in children under 5 years in Senegal, 2005–2010**

<b>Indicator: All-cause mortality (per 1,000 live births) during the 5 years preceding the survey, by sociodemographic characteristics</b>						
<b>Background Characteristics</b>	DHS 2005		DHS 2010		Relative change (%)*	<i>p</i> value**
	%o (95%CI)	N	%o (95%CI)	N		
<b>Overall mortality in children under 5</b>	121.2(113.32-129.14)	19052	71.6(65.8-77.34)	19992	40.1	<0.001
<b>Age Group</b>						
<i>6-11 months</i>	13.7(11.9-15.3)	17,983	7.4(6.2-8.7)	19,116	46.0	<0.001
<i>12-23 months</i>	18.6(16.7-20.8)	17,770	8.1(6.4-9.5)	18,977	56.5	<0.001
<i>24-59 months</i>	30.0(27.5-32.7)	17,844	12.2(10.7-14.7)	18,823	59.3	<0.001
<i>Neo-natal (0-28 days)</i>	34.6(30.4-39.5)	19,052	29.2(25.48-33.4)	19,992	15.6	0.2
<i>Post- neo-natal (1-12 months)</i>	26.4(23.8-30.8)	18,295	17.5(15.1-21.0)	19,357	33.7	<0.001
<i>Infant (0-12 months)</i>	61.0(55.4-66.6)	19,052	46.7(41.9-51.5)	19,992	23.4	<0.001
<b>Gender</b>						
<i>Male</i>	126.2(114.9-137.3)	9,763	76.3(67.9-84.5)	10,226	39.6	<0.001
<i>Female</i>	116.0(105.6-126.3)	9,289	66.6(59.1-74.0)	9,767	42.6	<0.001
<b>Place of Residence</b>						
<i>Urban</i>	89.9(76.4-103.2)	6,834	51.2(41.2-61.1)	7,454	43.0	<0.001
<i>Rural</i>	139.2(129.4-148.9)	12,218	84.2(76.8-91.5)	12,538	39.5	<0.001
<b>Epidemiological Zone</b>						
<i>Dakar</i>	79(69.9-88.1)	3,374	55.0 (47.7-62.3)	3,770	30.4	<0.001
<i>Center</i>	123(113.2-132.7)	4,338	68.0 (60.6-75.3)	4,500	44.7	<0.001
<i>North</i>	100(93.4-106.5)	8,021	68.0 (62.6-73.4)	8,442	32.0	<0.001
<i>South</i>	165(152.4-177.6)	3,320	96.0 (85.9-52.8)	3,280	41.8	<0.001
<b>Wealth Quintile</b>						
<i>Poorest</i>	162.3(145.5-178.7)	4,501	96.2(84.4-100.7)	4,829	40.7	<0.001
<i>Second</i>	144.0(129.4-158.3)	4,328	74.2(63.7-84.7)	4,448	48.4	<0.001
<i>Middle</i>	117.2(99.5-134.5)	3,963	68.7(56.0-81.3)	3,868	41.3	<0.001
<i>Fourth</i>	89.9(69.7-109.6)	3,473	64.4(46.0-82.4)	3,802	28.3	0.08
<i>Richest</i>	68.8(48.0-91.0)	2,788	43.2(24.8-61.2)	3,006	37.2	0.06

**Note:** N= number of children (denominator). \*The degree of variation is calculated in relative terms from 2005 to 2010. \*\*Pearson  $\chi^2$  one-sided test

Further analyses were performed to examine mortality rate by epidemiological zone. Results showed similar trends to overall mortality at the national level. Mortality had significant decreases across age categories in the different epidemiological zones, except in the region of Dakar and the northern zone, where the reduction in neonatal mortality was statistically insignificant. In Dakar, the mortality decreased significantly in children aged 6–11 months and 24–59 months only. In the northern zone, neonatal mortality remained similar between 2005 and 2010 (37%o compared with 35%o). In the rest of the country, significant reduction in mortality were observed in all age categories, with the largest decrease in children aged 12–59 months (Table 35).

**Table 35: All-cause mortality in children under 5 years by epidemiological zone in Senegal, 2005–2010**

<b>Indicator: All-cause mortality (per 1,000 live births) stratified by age group and epidemiological zone in Senegal, 2005–2010</b>						
<b>Background Characteristics</b>	<b>DHS 2005</b>		<b>DHS 2010</b>		<b>Relative change (%)</b>	<b>p value</b>
	<b>%o (IC95%)</b>	<b>N</b>	<b>%o (IC95%)</b>	<b>N</b>		
<b>Dakar</b>						
<i>6–11 months</i>	10.0 (6.6-21.2)	3263	5.0 (2.7-7.3)	3634	50.0	0.007
<i>12–23 months</i>	8.0 (4.9-11.0)	3232	6.0 (3.5-8.5)	3615	25.0	0.159
<i>24–59 months</i>	22.0 (16.9-27.0)	3207	8.0 (5.1-10.9)	3592	63.6	0.001
<i>Neo-natal (0–28 days)</i>	29.0 (23.3-34.6)	3374	26.0 (20.6-31.4)	3770	10.3	0.225
<i>Post- neo-natal (1–12 months)</i>	13.0 (9.2-16.8)	3276	17.0 (12.8-21.2)	3670	30.7	0.16
<i>Infant (0–12 months)</i>	42.0 (35.2-48.7)	3374	43.0 (36.1-49.8)	3770	2.3	0.419
<i>Enfant (0–59 months)</i>	79.0 (69.9-88.1)	3374	59.0 (51.0-69.0)	3770	25.1	<0.001
<b>North</b>						
<i>6–11 months</i>	12.0 (9.5-14.4)	7605	8.0 (6.0-9.9)	8048	33.3	0.005
<i>12–23 months</i>	16.0 (13.1-18.8)	7512	6.0 (4.3-7.7)	7988	62.5	<0.001
<i>24–59 months</i>	24.0 (20.5-27.5)	7390	9.0 (6.9-21.2)	7941	62.5	<0.001
<i>Neo-natal (0–28 days)</i>	37.0 (12.8-21.2)	8021	35.0 (31.1-38.9)	8442	5.4	0.245
<i>Post- neo-natal (1–12 months)</i>	26.0 (22.4-29.5)	7727	19.0 (16.0-21.9)	8145	26.9	<0.001
<i>Infant (0–12 months)</i>	63.0 (57.7-68.3)	8021	54.0 (49.2-58.8)	8442	14.2	0.006
<i>Enfant (0–59 months)</i>	100.0 (93.4-106.5)	8021	68.0 (62.6-73.4)	8442	32.0	<0.001
<b>Center</b>						
<i>6–11 months</i>	16.0 (12.1-19.8)	4084	7.0 (4.5-9.5)	4316	56.2	<0.001
<i>12–23 months</i>	23.0 (18.3-27.6)	4018	8.0 (5.3-10.6)	4284	65.2	<0.001
<i>24–59 months</i>	32.0 (26.5-37.5)	3927	13.0 (9.5-16.4)	4249	59.3	<0.001
<i>Neo-natal (0–28 days)</i>	45.0 (38.8-51.2)	4338	30.0 (25.0-34.9)	4500	33.3	<0.001
<i>Post- neo-natal (1–12 months)</i>	29.0 (23.9-34.1)	4144	19.0 (14.9-23.0)	4366	34.5	<0.001
<i>Infant (0–12 months)</i>	74.0 (66.2-81.7)	4338	49.0 (42.7-55.3)	4500	33.8	<0.001
<i>Enfant (0–59 months)</i>	123.0(113.2-132.7)	4338	68.0 (60.6-75.3)	4500	44.7	<0.001
<b>South</b>						
<i>6–11 months</i>	19.0 (14.1-23.8)	3067	9.0 (5.7-12.3)	3118	52.6	
<i>12–23 months</i>	31.0 (24.8-37.2)	3008	16.0 (11.6-20.4)	3090	48.4	<0.001
<i>24–59 months</i>	49.0 (41.2-56.8)	2916	25.0 (19.4-30.5)	3041	48.9	<0.001
<i>Neo-natal (0–28 days)</i>	52.0 (44.4-59.5)	3320	32.0 (25.9-38.0)	3280	38.4	<0.001
<i>Post- neo-natal (1–12 months)</i>	42.0 (34.9-49.0)	3148	26.0 (20.4-31.5)	3176	38.1	<0.001
<i>Infant (0–12 months)</i>	94.0 (84.1-103.9)	3320	58.0 (50.0-65.9)	3280	38.3	<0.001
<i>Enfant (0–59 months)</i>	165(152.4-177.6)	3320	96.0(85.9-106.2)	3280	41.8	<0.001

**Note:** N=number of infants (denominator). \*The degree of variation is calculated in relative terms from 2008–2010. \*\*Pearson  $\chi^2$  one-sided test

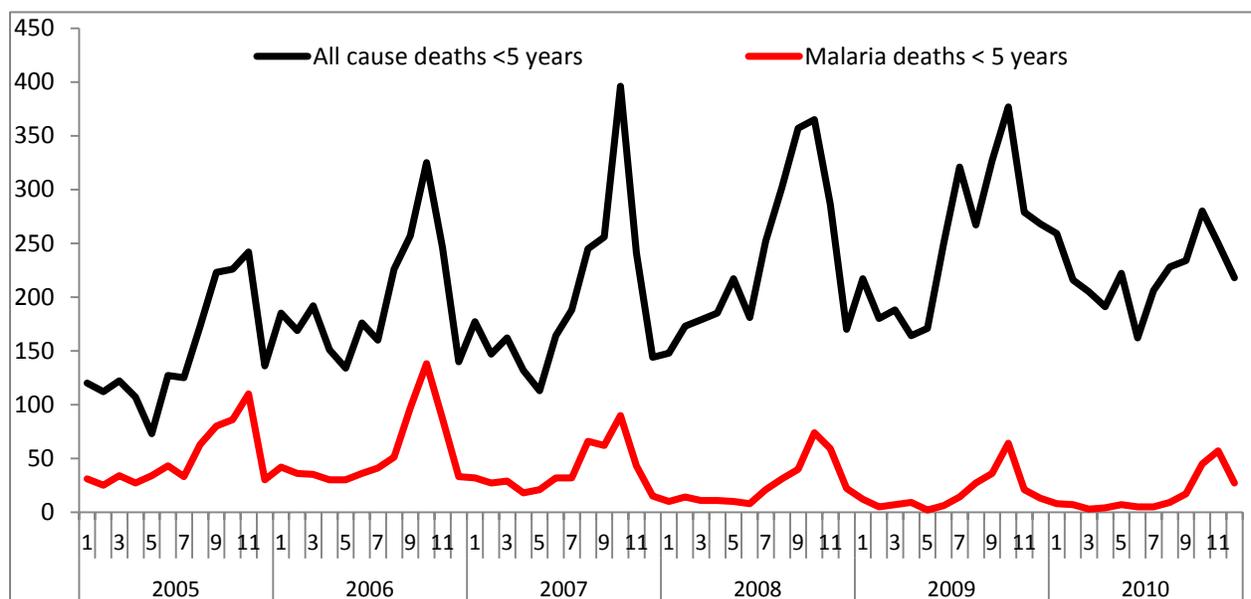
**Source:** DHS 2005–2010.

## Assessing Mortality Using Routine Data

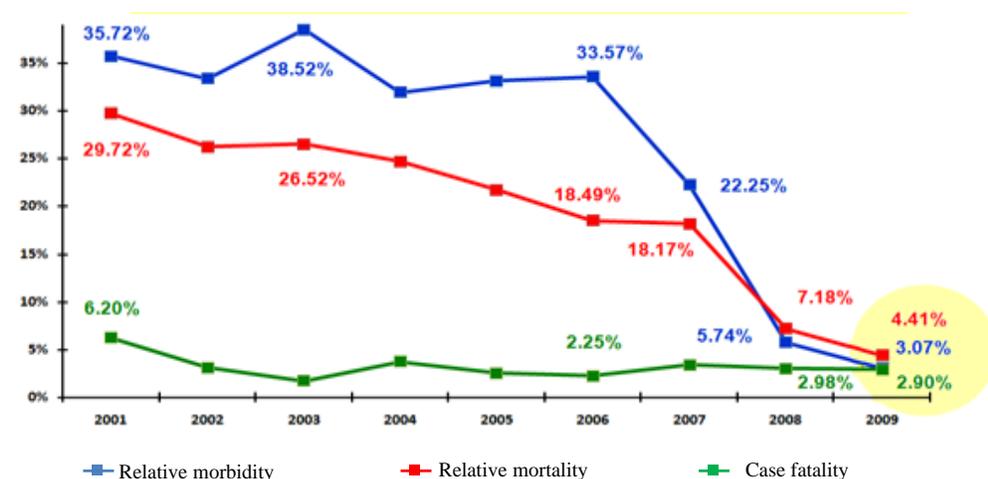
Until mid-2007, malaria morbidity of children under 5 years of age was estimated from the number of suspected clinical cases and treated as such. Proportional morbidity and mortality recorded in health facilities increased from 35.7% to 3.1%, respectively, and from 29.7% to 4.4%, respectively, from 2001–2009. During the same period, malaria

deaths decreased from 6.2% to 2.9%. It should be stressed that only deaths that occurred in health centers and hospitals were reported here (Figures 34 and 35).

**Figure 34: Trend of all-cause and malaria deaths (children under 5 years of age)**



**Figure 35: Trend of relative malaria morbidity, mortality, and case fatality rate among children under 5 years of age in health facilities in Senegal from 2001–2010.**



Routine data showed an increase in the number deaths among hospitalized children under 5 years of age from 2005–2010, even as all-cause under 5 mortality dropped (Table 36). The number of deaths resulting from malaria dropped substantially over the same period in all strata except Dakar (Table 37).

**Table 36: Number of deaths among children under 5 years recorded in public health facilities in Senegal, 2005–2010**

	2005	2006	2007	2008	2009	2010
<b>National</b>	1,786	2,361	2,365	2,815	2,638	2,671
<b>Dakar</b>	296	528	575	977	999	991
<b>North</b>	801	1065	1079	1096	1325	1059
<b>Center</b>	330	359	345	420	397	344
<b>South</b>	359	409	366	322	288	277

**Source:** Routine data, NMCP, Senegal. NA=not available.

**Table 37: Number of deaths due to malaria recorded in public health facilities among children under 5 years in Senegal, 2005–2010**

	2005	2006	2007	2008	2009	2010
<b>National</b>	596	656	467	311	218	194
<b>Dakar</b>	20	78	39	39	32	39
<b>North</b>	222	250	150	103	98	72
<b>Center</b>	159	137	108	80	26	53
<b>South</b>	195	191	170	89	60	30

**Source:** Data from routine NMCP Senegal. NA=not available.

## Summary on Mortality

Significant reductions in all-cause mortality in children under 5 years were achieved from 2005 to 2010. Mortality rates decreased from 121 per 1,000 live births in 2005 to 72 in 2010, resulting in a 40% relative reduction. Age-specific analysis showed significant decreases across all age categories. Overall, mortality decreased significantly in the different epidemiological zones. Evidence also indicated that mortality among children decreased from the poorest to the wealthiest households. The largest reductions in mortality were observed in children who experienced a significant reduction in parasite prevalence, such as children from the central and southern epidemiological zones, those belonging to the poorest quintiles, those living in rural areas, and those from 12–59 months age category.

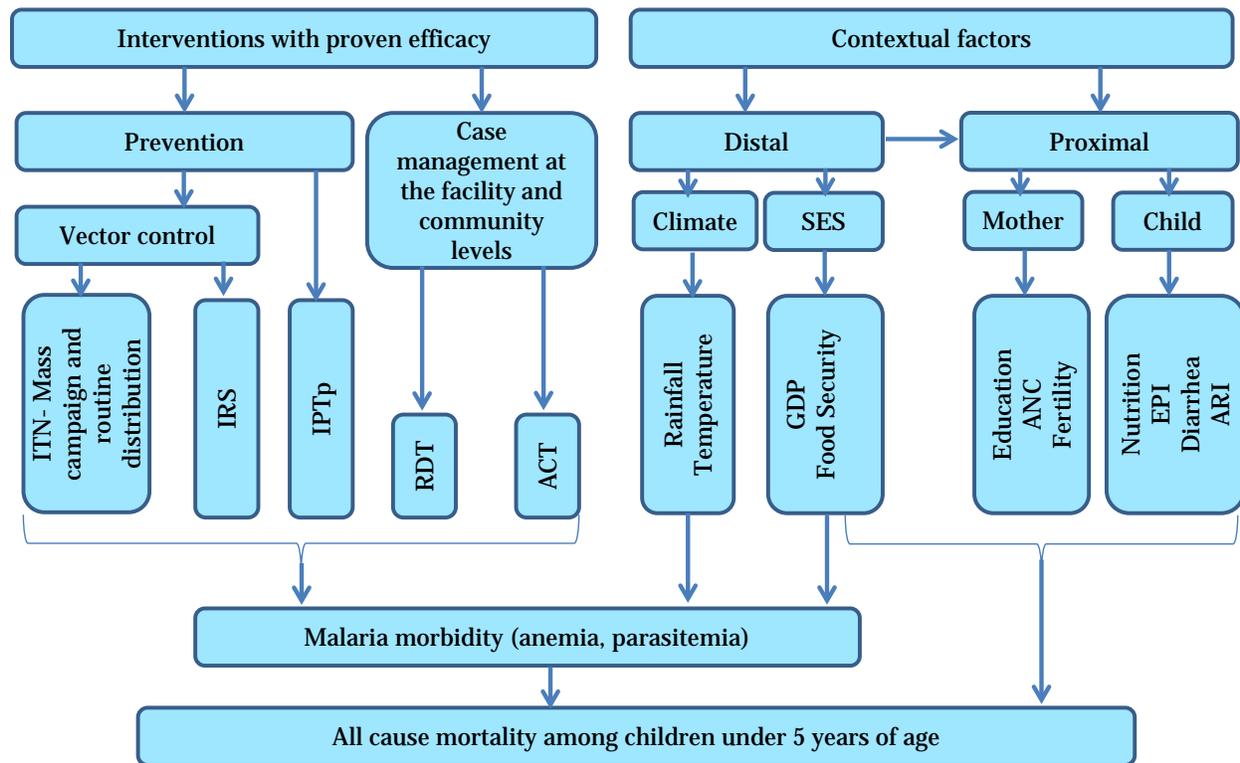
Detailed mortality analysis by epidemiological zone showed trends similar to the trend of overall mortality. Mortality had significant decreases across age categories in the different epidemiological zones, except in the region of Dakar. Analysis of malaria morbidity also showed no evidence of a decrease in Dakar.

# Contextual Factors: Other Interventions that may Contribute to Reducing Mortality in Children Under 5 Years

## Context

This assessment of the impact of the scale-up of malaria control interventions is based on a plausibility argument. Given that it is difficult to measure mortality resulting from malaria, the objective of the plausibility argument is to demonstrate the association between the scale-up of malaria interventions and the reduction of all-cause mortality in children under 5 years of age in Senegal. This exercise attempts to show that the scale-up of interventions was sufficient to have an impact that would decrease morbidity due to malaria and all-cause mortality. The plausibility argument requires taking into account the contextual factors because they also could contribute to the reduction of malaria morbidity and all-cause mortality. These contextual factors include distal factors (climate, socioeconomic), and proximal factors (education, reproductive health, and child survival) (Figure 36).

**Figure 36: Conceptual framework of impact assessment**



ANC= Antenatal care, ITN=insecticide-treated nets; IPTp=intermittent preventive treatment, IRS=Indoor residual spraying, EPI= Expanded program for immunization, GDP=Gross domestic product, SES= Socioeconomic status

## Question:

- *Was there a significant improvement in some key contextual factors that may lead to a reduction in all-cause mortality in children under 5 years in Senegal?*

For background factors, environmental changes were assessed using rainfall and temperature variation (ANACIM) data. Socioeconomic data were assessed by examining household characteristics and the evolution of gross domestic product (GDP) per capita.

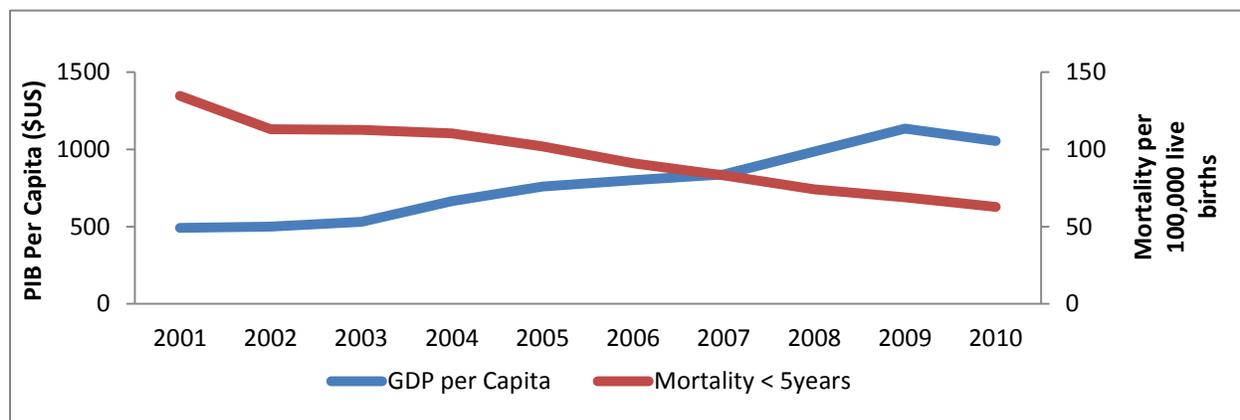
Data from national surveys conducted by the Senegalese health system were used to document the evolution of relevant contextual factors at the household level and individuals with potential to influence mortality. The term contextual factor refers to a set of data (or intervention) unrelated to malaria control that, to some extent, explains the observed changes in intensity of transmission, morbidity, and mortality. A trend analysis of these factors was undertaken to compare the frequency of these indicators during pre-intervention with their frequency post-intervention.

## Trend of Contextual Factors

### *Distal factors*

**Economic Factors:** GDP per capita in Senegal increased from UDS\$492 to USD\$1,055 over the past decade. During the period 2005–2010, the number of child deaths dropped by 40% (Figure 37).

**Figure 37: Evolution of gross domestic product per capita and mortality among children under 5 years in Senegal, 2001–2010**



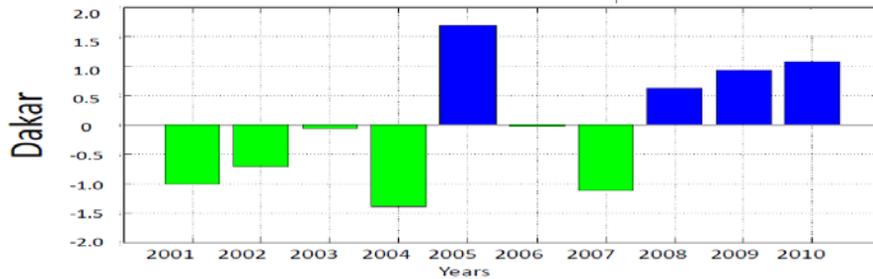
**Sources:** World Bank, WDI; DHS (2005–2010).

**Climate Factors:** Rainfall plays a role in the transmission of malaria. Dry periods generally are associated with a decrease in malaria transmission, while intense rainfalls have a positive effect. Data available for the period 2000–2005 suggest that this period was generally dry in most of Senegal, based on Lamb indices, compared to 2006 to 2010. Rainfall varied by region in 2006–2007. The driest period in most regions of

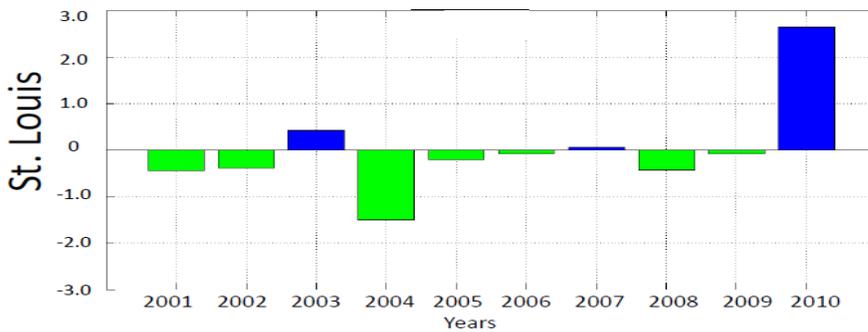
Senegal occurred in 2007, while the period 2008–2010 was marked by substantial rainfalls that exceeded national annual averages (Figure 38).

**Figure 38 : Abnormalities in rainfall in the different epidemiological zones in Senegal from 2001 - 2010**

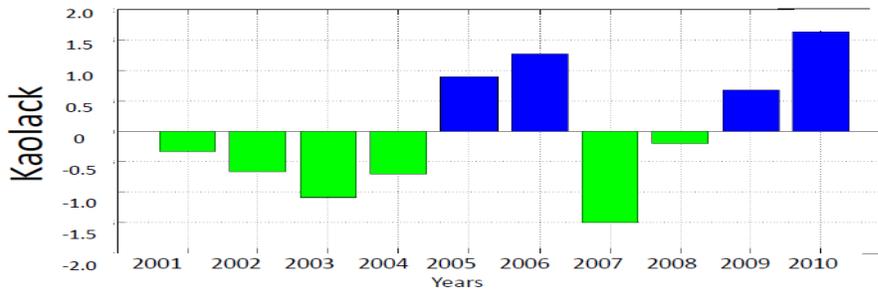
**a) Dakar**



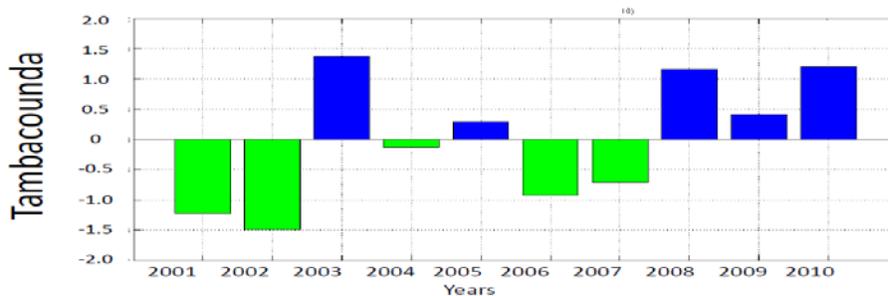
**b) North**



**c) Central**



**d) South**



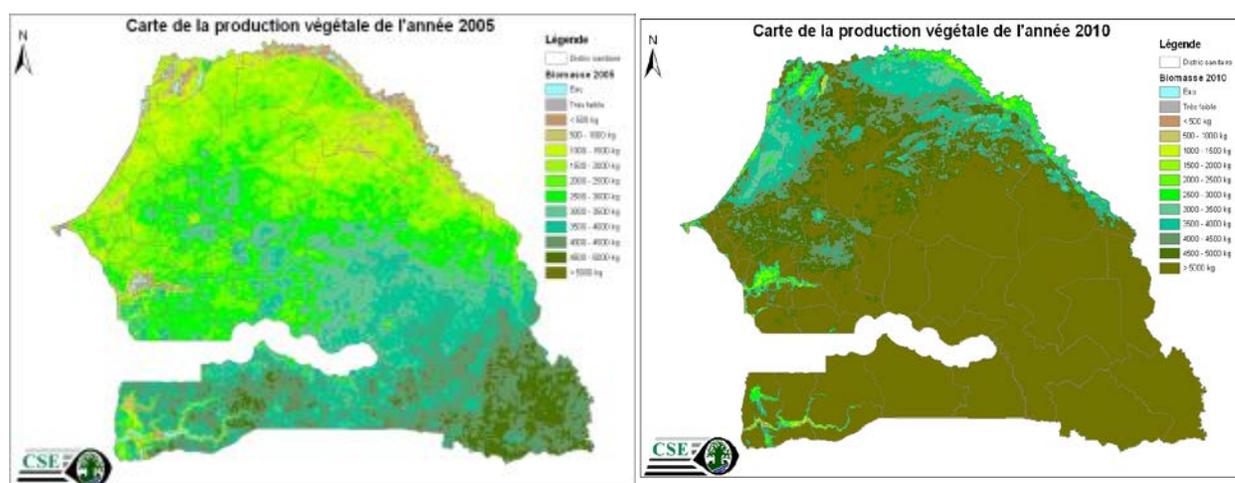
Since the 1950s, rainfall in Senegal has decreased by about 30% (CSE, 2010), with considerable year-to-year variations and variations from one region to another. For example, rainfall decreased by 50% in Dakar between 1950 and 2000, while in Kédougou a relatively marginal decrease of 7% was reported over the same period (CSE, 2010). At the same time, average temperatures are on the rise throughout the country, with an average increase of 1.6 °C over the specified period. The largest increase in average temperatures was observed in the north of Senegal (3.0 °C in Linguère), and the smallest increase was observed in the south (0.7 °C in Kédougou). This upward trend in average temperatures was corroborated by recent data covering the period 2001–2012.<sup>(30)</sup>

Since the early 2000s, however, rainfall appears to have increased significantly. The annual rainfall data for the period 2005–2010 shows a potential for a sustained favorable environmental for malaria transmission, notwithstanding the decreasing trend of malaria reported by NMCP. Positive rainfall anomalies (rainfall above the national average) were frequent during the period 2005–2010.

- In the area of low malaria prevalence (<5%), positive rainfall anomalies include approximately 300 mm of rainfall in St. Louis in 2010, while the average rainfall was from 20 to 150 mm in Matam from 2003–2010. In Diourbel, unusual positive rainfall anomalies were observed in 2001, 2005 (more than 180 mm), 2007, 2008, 2009, and 2010.
- In the area of moderate malaria parasite prevalence (5–10%), an area that includes Fatick, Kaffrine, Kaolack, and Ziguinchor, positive rainfall anomalies were observed. In Kaolack, for example, positive rainfall anomalies were observed in 2005 (+100 mm), 2006 (+145 mm), 2009 (about 80 mm), and 2010 (+190 mm). In Ziguinchor, in the south of Senegal, in 2005, 2006, and 2010, positive rainfall anomalies of 200 mm and more were recorded. In 2008, the positive anomaly exceeded 400 mm in Ziguinchor.
- In the area of high malaria prevalence (>10%), which comprises Sédhiou, Kolda, Tambacounda, and Kédougou, positive rainfall anomalies were also confirmed. In Tambacounda, positive anomalies of 80–300 mm were recorded in 2003, 2005, 2008, 2009, and 2010. In Kolda, positive anomalies of 50–500 mm were recorded in 2003, 2005, 2008, and 2010. In the region of Dakar, which remains a special case (high urbanization, recurrent floods in recent years) positive rainfall anomalies also have been recorded, with more than +240 mm in 2005, +80 mm in 2008, +120 in 2009, and +150 mm in 2010.

These positive rainfall anomalies are correlated to good conditions for vegetation production, particularly during the period 2007–2010 when malaria interventions were scaled-up, which would have an implication for malaria transmission. The changing environment in recent years in Senegal, therefore, is favorable for sustained or increased malaria transmission (Figure 39).

**Figure 23: Biomass production in Senegal in 2005 and 2010**



### Household Characteristics

Several household-related factors that may affect mortality in children under 5 years were analyzed in this report. Overall access to drinking water has improved significantly, rising from 70% to 79% from 2005–2009 ( $p<0.05$ ). Similar results were observed in access to improved toilets and houses with improved flooring with an increase of 12 and 20 percentage points ( $p<0.05$ ), respectively.

Under sociodemographic factors, the proportion of women of childbearing age that reached at least the primary school level increased marginally from 2005 (40%) to 2010 (42%) (Table 38).

**Table 38: Trend of contextual factors at household level in Senegal, 2005–2010.**

Parameters Studied	DHS 2005		DHS 2010		Percentage point change (95%CI)*	p value**
	% (95%CI)	N	% (95%CI)	N		
<b>Household Characteristics</b>						
Access to drinking water	70.0 (68.9-71.0)	7412	79(78.1-79.8)	7902	9.0(7.6-10.3)	<0.001
Access to improved toilet	47.9(46.7-70.0)	7412	59.9(58.8-60.9)	7902	12.0(10.4-13.5)	<0.001
House with improved flooring	69.0(67.9-69.3)	7412	89.1(88.4-89.7)	7902	20.1(18.4-21.5)	<0.001
Household with electricity	47.0(45.8-48.1)	7412	56.5(55.4-57.6)	7902	9.5(7.9-11.1)	<0.001
Households with telephone (landline or mobile)	16.2(15.3-17.0)	7412	88.4(87.7-89.1)	7902	72.2(71.1-73.2)	<0.001
<b>Sociodemographic Factors</b>						
Proportion of women ages 15–49 with at least primary school level education	40.4(39.6-41.2)	14602	42.1(41.3-42.8)	15688	1.7 (0.5-2.8)	<0.001
Proportion of women ages 15–49 never attended school	59.6(58.8-60.4)	14602	57.9(57.1-58.7)	15688	-1.7(-2.8;-0.6)	<0.001

**Note:** \* The degree of variation is calculated in absolute terms from 2005 to 2010. \*\*Pearson  $\chi^2$  one-sided test.

**Source:** DHS 2005, 2010

### ***Proximal Factors***

Many efforts were undertaken to improve maternal and child health. The priority underlined by the National Strategic Health Development Plan (NSHDP), is to reduce the burden of maternal and child morbidity and mortality. The various strategic plans developed by the reproductive health program are complementary to the national strategic plan for child survival (PNSE 2007–2015) for mother child and newborn for the short, medium, and long term, to mobilize policies and strategies for achieving health-related MDGs. The operational plan for scaling up high-impact interventions on infant and child mortality, the implementation plan for the treatment of diarrhea with oral rehydration salts (ORS) and zinc, the National Strategic Plan for Malaria Control, the Full Multiannual Plan for the Expanded Programme on Immunization (EPI), and the National Action Plan for Family Planning all fit into this framework. To strengthen surveillance with EPI, in 1998 Senegal adopted the global initiative of polio eradication by organizing two to three National Immunization Days using a door-to-door approach each year from February–March. At the same time, these immunization campaigns are being used for mass deworming and vitamin A supplementation for children. In the same framework, vaccination campaigns against measles are organized every three years. Scale-up of vaccination coverage is being pursued with the introduction of new vaccines, such as the vaccine against hepatitis B in 2003 and the pentavalent vaccine (diphtheria, tetanus, pertussis, polio, and hepatitis B) in 2005.

In general, maternal health indicators have improved over the period 2005–2010. Although the proportion of non-preventable risk deliveries has increased marginally from 2005 to 2010 (15.7% compared with 17%), those of multiple preventable risks have decreased ( $p < 0.05$ ). The observation holds also for birth intervals of less than 24 months. The proportion of women who received more than three ANC visits increased from 39.8% in 2005 to 50.0% in 2010. The proportion of women who delivered in health facilities has increased by 11 percentage points, and deliveries attended by qualified personnel by 12 percentage points ( $p < 0.05$ ) (Table 39) over the same period.

**Table 39: Trend of contextual factors in maternal health in Senegal, 2005 to 2010**

Parameters studied	DHS 2005		DHS 2010		Percentage point change (95%CI)*	p value**
	% (95%CI)	N	% (95%CI)	N		
<b>Risks related to fertility</b>						
Single high-risk birth *	37.9(36.9-38.8)	10534	39.0(38.1-39.9)	11503	1.1 (-0.2;2.3)	0.046
Multinle birth with nreventable risks	21.6(20.8-22.4)	10534	19.1(18.4-19.8)	11503	-2.5 (-3.5;-1.4)	0.001
Birth with non-preventable risks***	15.7(15.0-16.4)	10534	17.0(16.3-17.7)	11503	1.3 (0.3-2.3)	0.004
Birth interval <24 months	6.2 (5.7-6.6)	10534	17.9 (17.2-18.6)	11503	11.7 (10.8-12.5)	0.001
Birth order greater than or equal to 4	23.9(23.1-24.7)	10534	25.0(24.2-25.8)	11503	1.1 (0.0-2.2)	0.02
Mother age <18 or age >34 years	8.7 (8.1-9.2)	10534	7.1 (6.6-7.5)	11503	-1.6 (-2.3;-0.8)	0.001
<b>Antenatal care coverage</b>						
Antenatal care (ANC ≥4)	39.8(38.6-40.9)	6927	50.0(48.8-51.1)	7678	10.2 (8.6-11.8)	0.001
At least 2 doses of TT during	66.6 (65.4-67.7)	6927	57.4 (56.3-58.5)	7678	-9.2 (-9.2;-7.6)	0.001
Delivery in a health facility*	61.8 (60.6-62.9)	6927	72.8(71.8-73.7)	11479	11.0 (9.4-12.5)	0.001
Delivery attended by skilled personnel	52.0(50.8-53.2)	6927	64.1(63.0-65.2)	11479	12.1 (10.5-13.7)	0.001

\* The degree of variation is calculated in absolute terms from 2005 to 2010. \*The degree of variation is calculated in absolute terms from 2005 to 2010. \*\*Pearson  $\chi^2$  one-sided test.

**Source:** DHS 2005, 2010.

Care seeking coverage and services for children under 5 years also has improved between the two periods. The proportion of children who received ORS after an episode of diarrhea as part of Integrated Management of Childhood Illness (IMCI) increased from 15 to 22%. Immunization coverage by the different antigens increased significantly, except for polio 3 vaccine. Complete immunization coverage was 58% in 2005 and 64% in 2010 ( $p<0.001$ ). Early initiation of breastfeeding increased from 23% to 48% ( $p<0.001$ ). A change of 5% ( $p<0.001$ ) percentage points was observed between 2005 and 2010 for exclusive breastfeeding. Moreover, the prevalence of pneumonia decreased significantly from 13% to 5%, while the prevalence of diarrhea remained similar, at 22% and 21%, respectively, in 2005 and 2010 (Table 40).

Only nutritional indicators failed to show progress in relation to infant and child health. An assessment of the nutritional indicator showed an increase in growth retardation from 16% to 26%, and an increase in wasting from 7% to 10%.

**Table 40: Evolution of contextual factors related to child health in Senegal, 2005–2010**

Factors	DHS 2005		DHS 2010		Percentage point change* %(95%CI)	p-value**
	% (95%CI)	N	% (95%CI)	N		
<b>IMCI Coverage</b>						
Oral rehydration therapy for diarrhea **	26.7 (24.8--28.5)	2168	27(25.1-28.8)	2243	0.3(-2.3;2.9)	0.41
**Oral rehydration salts for diarrhea (ORS)	15.1(13.4-16.6)	2168	22(20.3-23.7)	2243	6.9(4.6-9.2)	0.001
<b>Vaccine coverage</b>						
BCG	91.7 (90.5-92.9)	2024	94.7 (93.7-95.6)	2199	3.0 (1.4-4.5)	0.001
DPT3	78.3 (75.5-80.1)	2024	82.6(81.0-84.2)	2199	4.3 (1.9-6.7)	0.001
polio3	72.9 (70.9-74.8)	2024	72.7(70.8-74.5)	2199	-0.2 (-2.8;2.5)	0.442
Measles	73.9 (71.9-75.8)	2024	82.1(80.5-83.7)	2199	8.2 (5.7-10.7)	0.001
Complete vaccine coverage	58.0(55.9-60.0)	2024	63.8 (61.7-65.9)	2199	5.8 (-8.7;-2.8)	0.001
<b>Micronutrient Supplementation</b>						
Vitamin A	74.4(73.5-75.2)	10077	79.3(78.5-73.5)	11633	4.9(3.7-6.0)	0.001
<b>Nutritional Status</b>						
Stunting	16.3(14.9-17.6)	2883	26.5(25.1-27.9)	3761	10.2(8.2-12.1)	0.001
Underweight	17.3(15.9-18.7)	2883	17.7(16.5-18.9)	3761	0.4(-1.4;2.2)	0.33
Wasting	7.6(6.7-8.4)	2883	10.1(9.0-11.2)	3761	2.5(-3.8;-1.1)	0.001
<b>Breastfeeding</b>						
Early initiation of breastfeeding	22.7(21.6-23.7)	6221	48.0(46.5-49.4)	4509	25.3(23.5-27.1)	0.001
Exclusive breastfeeding for <6 months	34.1(32.9-35.2)	6221	39.0(37.5-40.4)	4509	4.9(3.0-6.7)	0.001
<b>Other Childhood Illnesses</b>						
Prevalence of diarrhea	22.3(21.4-23.1)	9709	20.6(19.4-21.3)	10893	-1.7(-2.8;-0.5)	0.001
Prevalence of ARI	13.2(13.5-13.8)	9709	5.4(4.9-5.8)	10893	-7.8(-8.5;-7.0)	0.001

\* The degree of variation is calculated in absolute terms from 2005 to 2010. \*\*Pearson  $\chi^2$  one-sided test. ARI= Acute respiratory infection

**Source:** DHS 2005, 2010

## Summary on Contextual Factors

The changing climatic factors over the period 2001–2010 that affect rainfall, temperature, and the vegetation, potentially could create sustained environmental conditions favorable for malaria transmission. Improvement in economic and sociodemographic indicators in the communities may have contributed to progress in maternal and child health, as illustrated by progress in ANC visits and immunization among children. While nutritional indicators failed to show improvement between the baseline and the post intervention periods, acute respiratory infections (ARI) in children

under 5 years in Senegal decreased significantly. Improvement in some of the contextual factors may have contributed to the reduction of malaria morbidity and all-cause mortality in children under 5 years; however, the scale-up of key interventions for malaria control appears as the most likely factor to explain the observed reductions.

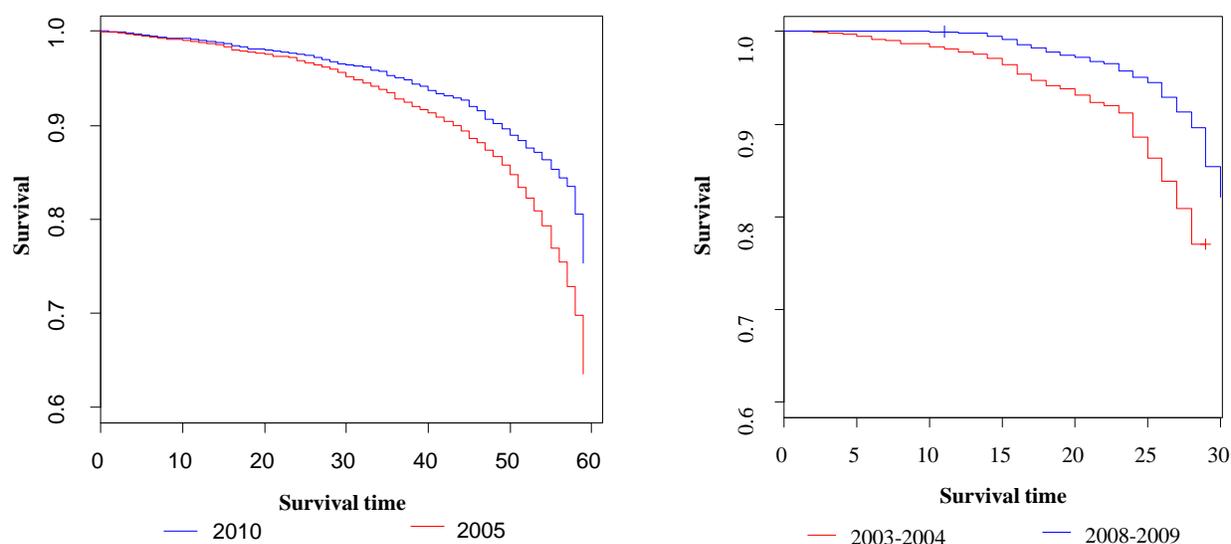
## Further Analyses

### Kaplan Meier Survival Analysis of All-Cause Mortality

Survival analyses were performed on the 2010 DHS database, using date of birth of children surveyed and the date of death for children under age 5 who died before the evaluation period. The outcome variable was survival status, alive or deceased at the time of evaluation. Mortality documented in the 2010 DHS covered the period 2005–2010. This approach was appropriate for the determination of trends in mortality over the 5-year period.

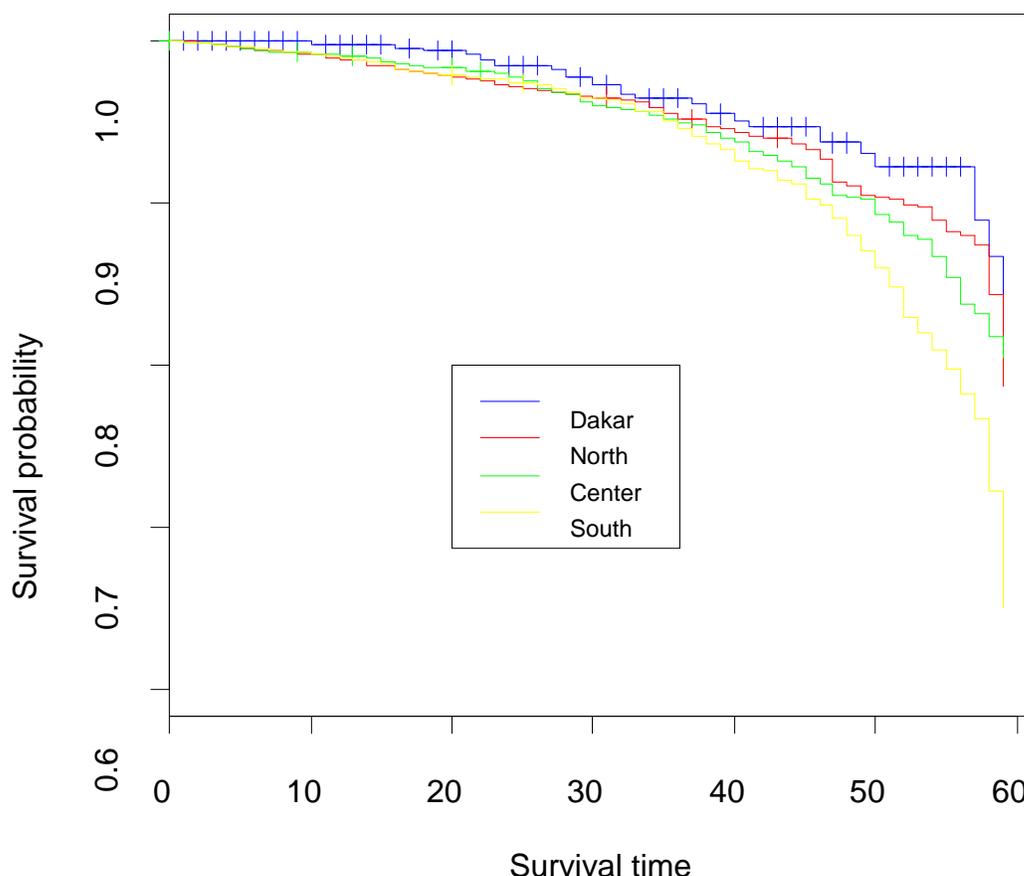
Comparison of Kaplan Meier survival curves before and after interventions were scaled-up showed better child survival during the period 2005–2010, compared to the period 2000–2005 (Figure 40).

**Figure 24: Kaplan-Meier survival curves comparing the periods before and after scale-up of interventions**



When we compared child survival between the different epidemiological zones, except for the region of Dakar, children living in areas of low prevalence of malaria had better survival than children living in areas of higher prevalence.

**Figure 41: Kaplan Meier survival curves by epidemiological zone**



### **Multivariate Analysis of All-Cause Mortality in Children Under 5 Years**

To further document the impact of ITN ownership on mortality, multivariate analyses were performed using survival status of children under 5 years as the outcome variable. A Poisson regression model was fitted to allow adjustment for key contextual factors using aggregated residuals as described by Bennet et al, 2002.<sup>(31)</sup>

The all-cause mortality in children under 5 years was significantly lower during the period after the scale-up of malaria control interventions (2010) compared to the baseline period (2005) (OR: 0.63; 95% CI: 0.46–0.86). The death rate among children under 5 years of age was higher in regions where ownership of least one net per household was less than 30% (the median household ITN ownership measured during 2005 and 2010) which suggests a lower risk of death among children living in areas with

higher ITN ownership (OR = 0.66; 95%CI: 0.46–0.93) (Table 41). (The methodology used in the analysis is presented in the annexes).

**Table 41: Risk of death (all-cause death) in children under 5 years estimated after fitting a Poisson regression model**

	Deaths per 1,000	OR ( 95% CI)	ORa* ( 95% CI)	p-value
<b>Period</b>				
Before intervention, 2005	115.5	<i>Ref</i>	<i>Ref</i>	
Post intervention, 2010	72.5	0.63 (0.46-0.86)	0.92 (0.48 – 1.73)	0.69
<b>ITN Ownership</b>				
Less than 30%**	119.8	<i>Ref</i>	<i>Ref</i>	
30% and above	79.2	0.66 (0.46-0.93)	1.3 (0.69 – 2.4)	0.37

\* OR=odds ratio; ORa=adjusted odds ratio. All odds ratio were adjusted for the following contextual factors: the level of education of the household head, vaccine coverage, frequency of diarrhea, frequency of fever and acute respiratory infections, the prevalence of malnutrition (growth retardation, weight) delay and frequency of early breastfeeding. All analyses were conducted by region. The adjusted ORs were obtained in two steps using the Poisson regression model aggregated residuals, as described by Bennet, et al.

\*\* The cut-off point of 30% is chosen based on the median level of ITNs ownership in the regions in 2005 and 2010.

## Mortality Modeling Using the LiST Model

The LiST (Lives Saved Tool) model developed by Johns Hopkins University ([www.jhsph.edu/dept/ih/IIP/list/](http://www.jhsph.edu/dept/ih/IIP/list/)) was used to estimate the number of child deaths averted after the scale-up of effective interventions. This model has been used by malaria control evaluation experts to estimate the number of lives saved after the scale-up of ITNs in 34 countries in sub Saharan Africa and the scale-up of IPTp in 27 countries. LiST is a computer program that estimates the impact of mortality and stillbirth following the expanding of proven effective interventions for maternal and child health. The choice of a set of interventions for child health is important in the political world of resource-limited countries to ensure maximum impact on mortality.

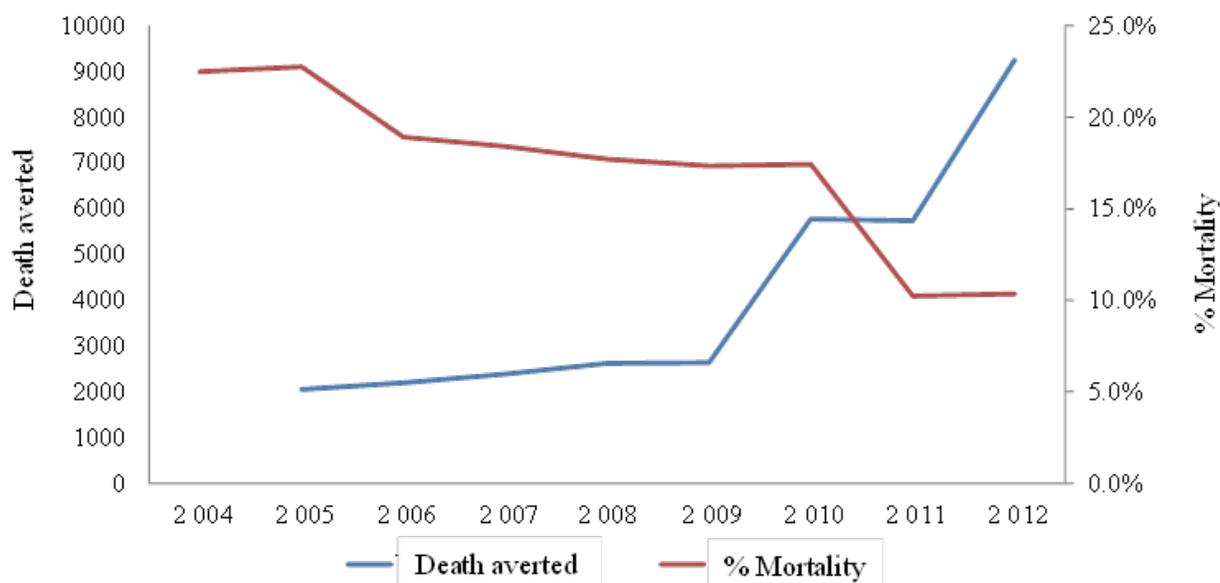
Coverage data of other interventions than malaria were obtained primarily from the DHS database.

ITNs are a cornerstone strategy for malaria prevention in Senegal. Figure 42 shows the number deaths averted as a result of the scale-up of ITNs and IPTp from 2004–2010. This figure does not take into account other malaria control strategies, such as malaria

case management through access to diagnosis and treatment as they are not included in the LiST model.

It is estimated that after 5 years of scale-up ITNs and IPTp, approximately 5,774 deaths of children aged 1–59 months were averted, compared to what would have happened if these interventions had not been implemented after the coverage level achieved in 2005. A substantial increase in the number of lives saved was observed in 2009, corresponding to the period of accelerated malaria control intervention scale-up (Figure 42).

**Figure 25: Evolution of the number of lives saved and the percentage of deaths due to malaria in children under 5 years from 2004–2010 in Senegal**



## Case Studies

### Evolution of Mortality in the Demographic Surveillance Area of Niakhar, Dielmo, and Ndiop

The following information was obtained with the assistance and collaboration of Dr. Cheikh Sokhna and his team at L'Institut de recherche pour le développement (IRD).

Niakhar is in the central part of Senegal, 120 km southeast of Dakar. This rural town is mostly populated by the Serer. The climate is Sahelian. Since 1960, the IRD has set up a demographic and health surveillance system in Niakhar, where malaria is endemic, with a peak transmission from August–November.

A recent evaluation by IRD showed that mortality in children under 5 years decreased gradually from 1963–2010; however, mortality rates remained fairly constant from 1990–2000, which coincided with the emergence of chloroquine-resistant malaria parasites and the outbreak of a meningitis epidemic in 1990. Mortality attributable to malaria in Niakhar decreased from 13.5 per 1,000 from 1992–1999 to 2.2 per 1,000 in 2010.

Trape JF, Wild C, Ndiaye O, Douillot L, Marra A, Diallo A, Cisse B, Greenwood B, Milligan P, Sokhna C & Molez JF (2012). New malaria control policies and child mortality in Senegal: reaching Millennium Development Goals. *J Infect Dis.* 2012 February 15; 205(4): 672–679. doi:10.1093/infdis/jir805.

### Reduction of Mortality in Health Districts Where Home Management of Malaria was Introduced

Effective case management of malaria requires early diagnosis and treatment within 24 hours of the onset of signs and symptoms. Home management of malaria (HMM) improves access to care for populations with limited access to formal health services. In Senegal, a pilot program of HMM implemented in 2008 demonstrated the feasibility of the integrated use of RDTs and ACTs in isolated villages by voluntary home care providers, locally known as DSDOM. The scale-up of this strategy began in 2009 with the involvement of 408 villages, followed by an expansion to 861 villages in 2010. Analyses compared morbidity and mortality data from districts where HMM was scaled-up in 2009 to data from similar districts where HMM was scaled in 2010.

From July 2009–May 2010, DSDOM managed 12,582 suspected cases, and 93% (11, 672) of these cases were tested using RDTs. Among cases tested for malaria infection by RDT, 37% (4,270) were positive, of which 97% (4,126) were treated and cured. Home care providers referred 6,871 patients to health posts for appropriate care. Among these patients, 6,486 had a negative RDT, 119 were infants under 2 months, 105 were pregnant women, and 161 were severe cases. No deaths occurred in these patients.

While the total number of outpatient consultations increased by 16% in the intervention districts compared to 11% in the control districts, the number of confirmed malaria cases dropped by 27%, both in the intervention and control districts; the effect was largely attributable to the distribution of ITNs nationwide, targeting all children under 5 years just before the beginning of the high transmission season in 2009. A similar decrease in hospitalizations resulting from malaria also was observed in both the intervention and control districts for reductions of 43% and 41%. Only the incidence of hospital deaths resulting from malaria decreased significantly in the intervention districts compared to control districts. In the control districts, malaria deaths declined by 23.4%, but the difference was not significant. In the intervention districts, the incidence of hospital deaths resulting from malaria decreased by 62.5% (95% CI: 43.8–81.2).

This analysis reinforces the hypothesis that HMM contributes to a reduction in malaria mortality by targeting isolated and most at risk populations, and providing free access to diagnosis and treatment of malaria.

Thiam S, Thwing J, Diallo I, Fall FB, MB Diouf, Perry R, Ndiop M, ML Diouf, Cisse MM, MM Diaw, Thior M. Scale-up of home-based management of malaria rapid diagnostic tests based on artemisinin and -based combination therapy in a resource-poor country: results in Senegal. *Malar J.* 2012 September 25; 11:334. doi: 10.1186/1475-2875-11-33.

## Discussion

The scale-up of effective interventions started in 2006 and continued through 2010. During this period, substantial efforts were made to significantly increase coverage of malaria control measures for coverage levels observed in 2005. Several years after the scale-up of malaria control interventions, it was relevant to assess the contribution of these interventions to malaria control in Senegal.

Data from various national surveys (DHS 2005, MIS 2006, MIS 2008, and DHS 2010) and routine data collected by NMCP were the main databases used to support this evaluation. These data were complemented by data from various sources, such as the national meteorological service, universities, and research institutions.

## Limitations

This assessment was primarily based on national survey data (DHS, MIS). Most information collected during these cross-sectional surveys (except mortality data), covered the period during which the survey was conducted. Of note, the majority of the data were collected during the dry season, when ITN use is lower than during rainy season. In addition, because the various surveys were conducted during different months for some regions, this may lead to classification bias. In some areas, a large part of the sampled population was surveyed in March and April, when the prevalence of malaria infection is low. This is likely to result in lower estimates of country-level prevalence of malaria that would limit the validity of the study. To address this concern, we conducted a sensitivity analysis using various scenarios. The first scenario was to include only regions where more than 75% of the required sample had been surveyed by February 2011, the latest, in the analysis. The second scenario was to simulate malaria infection prevalence for regions where the survey was completed after February 2011 using national parasite prevalence averages. The third scenario included only regions that were surveyed during the same periods in the analysis. Results from all three scenarios were consistent and corroborated with the conclusion from the survey that parasite prevalence has decreased; however, the magnitude of the reduction was smaller and varied depending on the scenarios.

In the absence of longitudinal data, it is difficult to properly document the impact on mortality of the interventions. To minimize this bias, data collected from different sources was triangulated. A Poisson regression model with estimation of the strength of the association between predictors and the outcome variable using aggregated residuals was used to perform multivariate analysis with regional rather than individual data. Estimation of deaths averted using the LiST model did not take into account other malaria interventions, such as care management through access to diagnosis and treatment, which may underestimate the total number of deaths averted.

## Coverage of Effective Malaria Interventions

Malaria control interventions in Senegal are mainly focused on vector control, prevention of malaria in pregnant women, and early treatment of cases. Over the 5-year period, vector control relied on two key strategies, the promotion of ITN use and IRS. Overall, ITN use at the household level has increased by 28.3 percentage points from 2005 to 2010. A higher increase was observed in rural areas (33.9 percentage points) than in urban areas (21.5 percentage points). The largest increases were recorded in the central and southern epidemiological zone and among the poorest populations, which are also the most at risk of malaria. The analysis of ITN use in children under 5 years showed a greater increase among children aged 12–23 months (30 percentage points), the most vulnerable group.

IPTp coverage among pregnant women in Senegal increased significantly from 2005–2010 (27 percentage points); however, a slight decrease of IPTp coverage was recorded from 2008–2010. Unlike ITNs, the increase in the use of IPTp by pregnant women was greater in urban areas (30.6 percentage points) than in rural areas (24.3 percentage points). This can be explained by the difference in the accessibility of health care services. The DHS V survey reported that 62.1% of women had attended four or more ANC visits in urban areas, compared to 41.5% in rural areas. The first ANC visit was undertaken earlier in urban areas (3.3 months) than in rural areas (3.8 months). While analysis by epidemiological zone showed a significant increase in IPTp coverage in the south, where malaria transmission is higher than in the rest of the zones, but IPTp coverage remains lowest in the south. The wealthiest populations experienced a higher increase in IPTp coverage than the poorest, suggesting that free distribution does not necessarily remove inequity.<sup>(31-32)</sup> The differential access to free drugs for IPTp may be explained by the requirement for patients to pay for ANC services in general before accessing health facilities. Many other authors suggested that provision of free commodities, such as drugs, is not sufficient to promote the access to health care systems by the poor. Additional costs to patients, such as the cost for transportation, are often more expensive than medical care.<sup>(33)</sup>

Laboratory confirmation is a key component of malaria case management. In recent years, RDT coverage has been expanded in all regions of Senegal, resulting in a modest increase in access to diagnosis. A higher increase was observed in urban areas (6.2 points) than in rural areas (3.8 points). The largest increases were experienced in Dakar and in the wealthiest population, reflecting inequity of access to health care services. This issue is beyond the malaria control program, and it requires a global solution that should focus on interventions to improve living standards for the poorest populations.

## Impact on Parasitaemia

Baseline data on parasitemia before the MIS survey in 2008 were not available; nevertheless, we observed a significant decrease in parasitemia from 2008–2010. The

decrease in parasite prevalence was greater in the most at risk populations who also were shown to have the highest increase in ITN coverage (rural areas, south, and the two poorest quintiles).

Data from national surveys on malaria parasite prevalence suggest a reduction of parasitemia at the country level because parasite prevalence decreased from 5.7% in 2008 to 2.9% in 2010. Sub-national analysis confirmed the declining trend of parasite prevalence across Senegal, nearing zero in some areas, such as Saint Louis in the north.

These trends were further confirmed by routine data collected for the RBMME database. Even after the introduction and scale-up of RDTs in 2007 and 2008, a decline in the incidence of malaria was observed in 2009 compared to 2008. The use of ACT for malaria treatment declined during the same period; however, the low parasite prevalence at the country level hides important epidemiological disparities; areas of high transmission remain in the southern regions.

### **Impact on Anemia**

The prevalence of severe anemia in children under 5 years dropped significantly in the periods before and after scale-up of malaria control measures; from 20.2% in 2005 to 14.1% in 2010 ( $p < 0.001$ ).

In tropical areas, the cause of anemia is often multifactorial, but malaria remains a major cause of tropical anemia.<sup>(34)</sup> Intestinal worms also may contribute to the onset of anemia, through the disturbance of absorption of iron and other nutrients, and an increase in nutrient loss. Nutritional disorders also are major causes of the occurrence of anemia in the tropics.

Because of the close association between malaria and anemia, the decrease in parasitemia observed after the scale-up of malaria control interventions could contribute to a reduction in the prevalence of anemia among children under 5 years. Similar observations have been reported in Vélingara, where a 40% reduction in the prevalence of anemia after the introduction of a combination of several malaria control interventions in children younger than 10 years was observed<sup>(35)</sup>; however, the level of reduction of anemia (6 percentage points between 2005 and 2010) is not proportional to the reduction of parasitemia, suggesting that other factors continue to influence the distribution of anemia in children. An increase in the prevalence of malnutrition during the study period may have contributed to reducing the impact that the interventions would have had on anemia.

### **Impact on Mortality**

Mortality among children under 5 years has been the subject of several studies. Objective 4 of the MDGs is to reduce mortality by 75%. All-cause mortality in children under 5 years declined significantly from 2005 to 2010, with estimates of 121 and 72 per 1,000 live births, respectively, a relative decrease of 40%. Age-specific analysis showed a

significant decrease in all age categories, with a marked decrease in the 24–59 month group.

A relative decrease of 40% also was observed in rural areas, where mortality dropped from 139‰ in 2005 to 84‰ live births in 2010. A similar level of reduction occurred in urban areas (39%).

Determinants of under-5-years child mortality are complex and multifactorial. Several approaches have been used to better understand this major public health problem. For this evaluation, we used the conceptual framework of Chen and Mosley, which was developed to explain death among children under 5 years in developing countries.<sup>(36)</sup> This framework identified the proximate and background factors. Proximate factors are mainly related to the mother and the child, while the background factors primarily include factors related to the household and the community. These can be grouped under the term “contextual factors.” The results of this impact assessment showed a significant decrease in the mortality of children under 5 years of age in Senegal. Deaths of children under 5 years of age were more pronounced in the regions where fewer than 30% of households owned an ITN. After adjusting for contextual factors that influence child survival, however, we did not find a statistically significant association between malaria interventions and all-cause mortality in children under 5 years.

Several studies<sup>(37-38)</sup> have examined the association between socioeconomic status and health. Financial resources allow for better access to basic health services, education, and drinking water and improve the well-being of populations. In the WHO report on health inequities, Wilkinson and Marmot<sup>(39)</sup> showed the important role played by inequity in health. Even when services are free, they benefit the wealthiest more<sup>(31-32)</sup> because of their greater capacity to access them. Senegal has experienced an increase in GDP per capita, which rose from USD \$492 to \$1,055 over the past decade. Living conditions of households also experienced significant improvement. The results of DHS IV and V showed better access to drinking water and electricity. Hygiene and sanitation also have improved considerably in recent years, such as house flooring. An increased level of education among women, key for their empowerment, was also observed. All of these factors can contribute to reducing mortality in children under 5 years. Mortality declined from the poorest to the richest wealth quintile, with the greatest decrease in the second poorest quintile (48.4%) and lowest in the fourth quintile (28.3%).

The health of women is closely related to that of children, especially in the first years of life. Significant efforts have been made in Senegal to improve maternal health. These major efforts aim at improving access to care for pregnant and delivering women. To meet this aim several health centers and health posts were built. Implementing free delivery policies has enabled women to give birth under better conditions at health facilities with attendance of qualified personnel. The proportion of women who delivered in the presence of qualified personnel has increased from 52% in 2005 to 64%

in 2010, thus contributing to reduced risk of infection and ensuring better management of complicated cases.

Infectious diseases (diarrhea, ARI, HIV, and measles) are a major cause of death among children under 5 years. Vaccination is an effective intervention against infant mortality. Through the EPI program, especially the scale-up of national immunization days and the introduction of new vaccines, and with support from development partners, Senegal has made considerable efforts to improve immunization coverage. The proportion of fully immunized children has further increased, from 42% in 2000 to 58% in 2005, and 63% in 2010. Introduction of new vaccines, such as the anti-Haemophilus vaccine, allowed for better protection for children. A significant reduction in pneumonia and acute respiratory infections was observed from 2005 to 2010 (from 13.2% to 5.4%). Exclusive breastfeeding up to 6 months post-delivery improves child survival through protection of newborns against infectious diseases and malnutrition. The proportion of children exclusively breastfed increased from 34% in 2005 to 39% in 2010; however, the proportion of children with diarrheal disease did not change significantly during the same period. The prevalence of HIV infection remained stable at 0.7% in the period; however, case management of HIV-infected children has improved considerably, reducing the risk of death. The prevalence of malnutrition, regardless of the form, remained stable from 2005 to 2010 (peaking in 2008), suggesting a lack of improvement of nutritional factors during this period.

The changing environmental factors could contribute to sustaining and even increasing malaria transmission; however, evidence points to a decline in the prevalence of malaria from 2005 to 2010.

## **Plausibility Argument and Conclusion**

### **Plausibility Argument**

The conceptual model used is appropriate for explaining the effect of health interventions. At first, we examined available resources, immediate results, and their effects in an effort to explain the impact of the interventions. Finally, we analyzed the evolution of the main causes of death among children under age 5 years to better assess the contribution of malaria interventions in the reduction of child mortality.

### **Reduction in Mortality**

Globally, all-cause mortality in children under 5 years has declined significantly from 2005 to 2010. In Senegal, it has been established that causes of death in children under 5 years of age are generally multifactorial. Along with the scale-up of malaria control measures, tremendous success was achieved in other development sectors that promote child survival. It is conceivable that the observed reduction of deaths in children under 5 years of age between the two periods was the result of an overall improvement in child survival in Senegal.

All-cause mortality in children under 5 years was significantly lower in the period after the scale-up of malaria control measures, compared to the reference period. Based on the LiST model, the scale-up of ITNs and IPTp from 2004–2010 was associated with 5,774 averted deaths in children aged 1–59 months in Senegal. A significant increase in the number of lives saved was observed in 2009, the period that corresponded to the scale-up of control interventions, particularly national distribution of ITNs to children under 5 years.

Efforts deployed by the NMCP through the implementation of various interventions have contributed significantly to the decline in malaria mortality in children under 5 years in health facilities.

### **Scale-up of Malaria Interventions**

#### ***Prevention***

With the help of development partners, many interventions have been implemented. These interventions consisted mainly of provision of ITNs to households, IRS, and IPTp. Coverage of these interventions increased considerably in recent years, particularly in areas where malaria was the most important because for the vulnerability of the population (poor and rural). A substantial improvement in ITN ownership was achieved in Senegal from 2005 to 2010. Use of ITNs among pregnant women increased from 8.6% in 2005 to 36.0% in 2010. A similar improvement was observed in children under 5 years of age, with an increase from 7.2% in 2005 to 34% in 2010. IPTp to protect the mother and child also increased significantly (from 11.9% to 38.6%) during the 5-year period.

## ***Malaria Case Management***

Access improved significantly to quality and cheaper health care by the population with the introduction of ACT for treatment and RDTs for improved diagnosis diagnosis. In addition, many care providers were trained in malaria case management. From 2007 onward, the introduction of RDTs at health facility and community levels contributed to better differential diagnosis and discrimination of other infectious diseases. This allowed for better identification of cases, even in the most remote places in Senegal because of the ease of use of RDTs. The advent of HMM to deliver malaria care at home, even in difficult to access rural areas, where the largest number of deaths usually occurs, has greatly contributed to expanding malaria case management across Senegal. Survey data, while not showing an increase in ACT coverage, show an increase in access to diagnostics. These data were important for showing evidence that significantly high malaria diagnostic coverage was achieved (despite the use of the case management flowchart, which recommends that patients with signs and symptoms that suggest infection other than malaria must not be tested for malaria). In addition, the reduction of treatment with ACTs may reflect a decrease in the use of ACT because of a decrease in the burden of malaria, as shown by routine data.

## ***Reduction of Morbidity***

Severe anemia in children under 5 years has decreased from the periods before and after the scale-up of malaria control measures, from 20.2% in 2005 to 14.1% in 2010. National survey data showed an overall reduction of the prevalence of malaria infection, which decreased from 5.7% in 2008 to 2.9% in 2010. In 2005, results from routine data ranked malaria as the leading cause for consultation in health facilities.

We also observed a decline in malaria-associated anemia from 2005 to 2010. Severe anemia has declined significantly in children aged 12–23 months who usually have high parasite prevalence. Similar results were observed in Tanzania (Tanzania report). Because of the close association between malaria and anemia, the reduction in parasite prevalence observed after the scale-up of malaria control measures could induce a reduction in the prevalence of anemia among children under 5 years. It is worth noting that decreased parasite prevalence and reduced anemia were observed in the same regions and the same wealth quintiles.

## ***Conclusion***

Overall, coverage and access to various prevention and malaria case management interventions implemented in Senegal have increased significantly from 2005 to 2010 throughout the country. This progress was made possible by the good organization set up by NMCP through a clear vision, and voluntary and effective implementation of strategies. Good organization combined with a substantial increase in financial resources for malaria control by the partners, was key for effective scale-up of malaria interventions of proven efficacies.

Globally, parasitemia decreased by almost 50% and more in the most at-risk populations. Severe anemia in children under 5 years declined significantly between the periods before and after the scale-up of malaria control interventions. Because of the close association between malaria and anemia, the decrease in malaria parasite prevalence observed after the deployment of control measures could induce a reduction in the prevalence of anemia among children under 5 years.

All-cause mortality in children under 5 years was significantly lower in the period after the scaling of malaria control interventions compared to the reference period.

This study showed an association between the decrease in parasitemia, anemia, and mortality among children under 5 years of age. A similar association was observed between parasitaemia, anemia, and child mortality in Tanzania impact evaluation.

Taking into account contextual factors and with the support of modeling, we can assume that the decline in mortality resulting from malaria has had great effect on all-cause mortality in children under 5 years in Senegal, while not ruling out the impact of other efforts to improve child survival.

## References

1. WHO. WHO Evidence Review Group : Intermittent prevention treatment of malaria in pregnancy (IPTp) with sulfadoxine-pyrimethamine (SP). July 2012.
2. Granja A, Machungo F, Gomes A, Bergström S, Brabin B. Malaria-related maternal mortality in urban Mozambique. *Ann Trop Med Parasitol*. 1998 Apr: p. 257-63.
3. Guyatt H, Snow R. Malaria in pregnancy as an indirect cause of infant mortality in sub-Saharan Africa. *Trans R Soc Trop Med Hyg*. 2001 Nov-Dec: p. 569-76.
4. Marchant T, Schellenberg J, Nathan R, Abdulla S, Mukasa O, Mshinda H, et al. Anaemia in pregnancy and infant mortality in Tanzania. *Trop Med Int Health*. 2004 Feb: p. 262-6.
5. Ndiaye O, Le Hesran JY, Etard JF, Diallo A, Simondon F, Ward M, et al. Variations climatiques et mortalité attribuée au paludisme dans la zone de Niakhar, Sénégal, de 1984 à 1996. *Cahiers d'études et de recherches francophones/Santé*. 2001: p. 25-33.
6. Mouchet J, Faye O, Juivez J, Manguin S. Drought and malaria retreat in the Sahel, west Africa. *Lancet*. 1996 Dec: p.1735-6.
7. Bouma MJ, Sondorp HL, van der Kaay HJ. Climate change and periodic epidemic malaria. *Lancet*. 1994 June: p.1440.
8. Brown V, Abdir Issak M, Rossi M, Barboza P, Paugam A. Epidemic of malaria in north-eastern Kenya. *Lancet*. 1998 Oct: p.1356-7.
9. Awono-Ambéné HP, Robert V. Survival and emergence of immature *Anopheles arabiensis* mosquitoes in market-gardener wells in Dakar, Senegal. *Parasite*. 1999: p.179-84.
10. Diouf I, Deme A, Ndione JA, Gaye AT, Rodriguez-Fonseca B, Cissé M. Climate and health: observation and modeling of malaria in the Ferlo (Senegal). *C R Biol*. 2013. May-June: p.253-60.

11. Hoshen M, Morse A. A weather-driven model of malaria transmission. *Malar J.* 2004 Sep; p. 3:32.
12. Jones AE, Morse AP. Application and Validation of a Seasonal Ensemble Prediction System Using a Dynamic Malaria Model. *Journal of Climate.* 2010 Aug; p. 4202-4215.
13. Ermert V, Fink A, Jones A, Morse A. Development of a new version of the Liverpool Malaria Model. I. Refining the parameter settings and mathematical formulation of basic processes based on a literature review. *Malar J.* 2011a.
14. Ermert V, Fink A, Jones A, Morse A. Development of a new version of the Liverpool Malaria Model. II. Calibration and validation for West Africa. *Malar J.* 2011b.
15. Alonso P, Lindsay S, Armstrong Schellenberg J, Gomez P, Hill A, David P, et al. A malaria control trial using insecticide-treated bed nets and targeted chemoprophylaxis in a rural area of The Gambia, west Africa. 2. Mortality and morbidity from malaria in the study area. *Transactions of the Royal Society of Tropical Medicine and Hygiene.* 1993 June; 87(2).
16. Lengeler C. Insecticide-treated bed nets and curtains for preventing malaria. *Cochrane Database Syst Rev.* 2004.
17. Gimnig J, Kolczak M, Hightower A, Vulule J, Schoute E, Kamau L, et al. Effect of permethrin-treated bed nets on the spatial distribution of malaria vectors in western Kenya. *Am J Trop Med Hyg.* 2003 Apr; p. 115-120.
18. Hawley W, Phillips-Howard P, ter Kuile F, Terlouw D, Vulule J, Ombok M, et al. Community-wide effects of permethrin-treated bed nets on child mortality and malaria morbidity in western Kenya. *Am J Trop Med Hyg.* 2003 Apr; p. 121-7.
19. Pluess B, Tanser F, Lengeler C, Sharp B. Indoor residual spraying for preventing malaria. *Cochrane Database Syst Rev.* 2010 Apr.
20. Song C, Na K, Warren B, Malloy Q, Cocker DR 3. Impact of propene on secondary organic aerosol formation from m-xylene. *Environ Sci Technol.* 2007 Oct; p. 6990-5.

21. Garner P, Gülmezoglu A. Drugs for preventing malaria in pregnant women. *Cochrane Database Syst Rev.* 2006 Oct.
22. Steketee R, Nahlen B, Parise M, Menendez C. The Burden of Malaria in Pregnancy in Malaria-Endemic Areas. *American Journal of Tropical Medicine and Hygiene.* 2001: p. 28-35.
23. WHO. A Strategic Framework for Malaria Prevention and Control during Pregnancy in the African Region. Brazzaville: Regional Office for Africa; 2004.
24. ter Kuile F, Terlouw D, Phillips-Howard P, Hawley W, Friedman J, Kariuki S, et al. Reduction of malaria during pregnancy by permethrin-treated bed nets in an area of intense perennial malaria transmission in western Kenya. *Am J Trop Med Hyg.* 2003 Apr;68(4 Suppl):50-60. 2003 Apr: p. 50-60.
25. Eisele T, Larsen D, Anglewicz P, Keating J, Yukich J, Bennett A, et al. Malaria prevention in pregnancy, birthweight, and neonatal mortality: a meta-analysis of 32 national cross-sectional datasets in Africa. *Lancet Infect Dis.* 2012.
26. Thwing J, Eisele T, Steketee R. Protective efficacy of malaria case management and intermittent preventive treatment for preventing malaria mortality in children: a systematic review for the Lives Saved Tool. *BMC Public Health.* 2011 Apr.
27. Thiam S, Thior M, Faye B, Ndiop M, Diouf M, Diouf M, et al. Major reduction in anti-malarial drug consumption in Senegal after nation-wide introduction of malaria rapid diagnostic tests. *PLoS One.* 2011 Apr.
28. Thiam S, Thwing J, Diallo I, Fall F, Diouf M, Perry R, et al. Scale-up of home-based management of malaria based on rapid diagnostic tests and artemisinin-based combination therapy in a resource-poor country: results in Senegal. *Malar J.* 2012 Sep.
29. Drame PM, Machault V, Diallo A, Cornелиe S, Poinsignon A, Lalou R et al. IgG responses to the gSG6-P1 salivary peptide for evaluating human exposure to Anopheles bites in urban areas of Dakar region, Senegal. *Malar J.* 2012 Mar: p. 1-11.

30. Faye A, Diouf M, Niang K, Leye M, Ndiaye S, Ayad M, et al. Social inequality and antenatal care: impact of economic welfare on pregnancy monitoring in Senegal. *Rev Epidemiol Sante Publique*. 2013 April: p. 180-5.
31. Bennett S., Parpia T, Hayes R, Cousens S. Methods for the analysis of incidence rates in cluster randomized trials. *Int J Epidemiol*. 2002 Aug: p. 839-46.
31. Faye A, Manga N, Seck I, Niang K, Leye M, Diagne-Camara M, et al. Access to intermittent preventive treatment (IPT) in a situation of abolition of user's fee: role of economic welfare. *Bull Soc Pathol Exot*. 2012 Aug: p. 215-9.
32. Nabyonga J, Desmet M, Karamagi H, Kadama PY, Omaswa FG, Walker O. Abolition of cost-sharing is pro-poor: evidence from Uganda. *Health Policy Plan*. 2005 Mar: 100-8.
33. Kruk ME, Porignon D, Rockers PC, Van Lerberghe W. The contribution of primary care to health and health systems in low-and middle-income countries: a critical review of major primary care initiatives. *Soc Sci Med*. 2010 Mar: p.904-11.
34. WHO. World Malaria Report 2011. ; 2011.
35. Tine R, Faye B, Ndour C, Ndiaye J, Ndiaye M, Bassene C, et al. Impact of combining intermittent preventive treatment with home management of malaria in children less than 10 years in a rural area of Senegal: a cluster randomized trial. 2011 Dec 13;10:358. 2011 Dec: p. 10:358.
36. Mosley W, Chen L. An analytical framework for the study of child survival in developing countries. 1884. 2003: p. 140-145.
37. Subramanian S, Belli P, Kawachi I. The macroeconomic determinants of health. *Annu Rev Public Health*. 2002: p. 287-302.
38. Villermé L. Tableau de l'état physique et moral des ouvriers employés dans les manufactures de coton, de laine et de soie Paris: Jules Rouard; 1840.
39. Marmot M, Wilkinson RG. Psychosocial and material pathways in the relation between income and health: a response to Lynch et al. *BMJ* 2001. May: p.1233-6.

