Evaluation of the Impact of Malaria Control Interventions on All-Cause Mortality in Children Under Five Years of Age in Kenya 2003-2015

Kenya Malaria Impact Evaluation Group

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## Abbreviations

<table>
<thead>
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<th>Description</th>
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<tbody>
<tr>
<td>ACCM</td>
<td>all-cause child mortality</td>
</tr>
<tr>
<td>ACT</td>
<td>artemisinin-based combination therapy</td>
</tr>
<tr>
<td>An</td>
<td><em>Anopheles</em></td>
</tr>
<tr>
<td>ANC</td>
<td>antenatal care</td>
</tr>
<tr>
<td>BSc</td>
<td>bachelor of science</td>
</tr>
<tr>
<td>CQ</td>
<td>Chloroquine</td>
</tr>
<tr>
<td>CHEW</td>
<td>community health extension worker</td>
</tr>
<tr>
<td>CHV</td>
<td>community health volunteer</td>
</tr>
<tr>
<td>DFID</td>
<td>United Kingdom Department for International Development</td>
</tr>
<tr>
<td>DHIS2</td>
<td>District Health Information Software 2</td>
</tr>
<tr>
<td>DPT</td>
<td>diphtheria, pertussis, tetanus</td>
</tr>
<tr>
<td>DVBD</td>
<td>Division of Vector Borne and Neglected Diseases</td>
</tr>
<tr>
<td>FBO</td>
<td>faith-based organization</td>
</tr>
<tr>
<td>GDP</td>
<td>gross domestic product</td>
</tr>
<tr>
<td>GOK</td>
<td>Government of Kenya</td>
</tr>
<tr>
<td>HDSS</td>
<td>health and demographic surveillance system</td>
</tr>
<tr>
<td>Hib</td>
<td><em>Haemophilus influenzae</em> type B</td>
</tr>
<tr>
<td>IDSR</td>
<td>Integrated Disease Surveillance and Response</td>
</tr>
<tr>
<td>IGME</td>
<td>United Nations Inter-agency Group for Child Mortality Estimation</td>
</tr>
<tr>
<td>IPTp</td>
<td>intermittent preventive treatment in pregnancy</td>
</tr>
<tr>
<td>IRS</td>
<td>indoor residual spraying</td>
</tr>
<tr>
<td>ITN</td>
<td>insecticide-treated net</td>
</tr>
<tr>
<td>KDHS</td>
<td>Kenya Demographic and Health Survey</td>
</tr>
<tr>
<td>KEMRI</td>
<td>Kenya Medical Research Institute</td>
</tr>
<tr>
<td>KMIS</td>
<td>Kenya Malaria Indicator Survey</td>
</tr>
<tr>
<td>KNBS</td>
<td>Kenya National Bureau of Statistics</td>
</tr>
<tr>
<td>LiST</td>
<td>Lives Saved Tool</td>
</tr>
<tr>
<td>LLIN</td>
<td>long-lasting insecticidal net</td>
</tr>
<tr>
<td>MCH</td>
<td>maternal and child health</td>
</tr>
<tr>
<td>MCU</td>
<td>Malaria Control Unit</td>
</tr>
<tr>
<td>MERG</td>
<td>Monitoring &amp; Evaluation Reference Group</td>
</tr>
<tr>
<td>MOH</td>
<td>Ministry of Health</td>
</tr>
<tr>
<td>MOPHS</td>
<td>Ministry of Public Health and Sanitation</td>
</tr>
<tr>
<td>NGO</td>
<td>nongovernmental organization</td>
</tr>
<tr>
<td>NMCP</td>
<td>National Malaria Control Programme</td>
</tr>
<tr>
<td>NMS</td>
<td>National Malaria Strategy</td>
</tr>
<tr>
<td>PfPR</td>
<td><em>Plasmodium falciparum</em> prevalence</td>
</tr>
<tr>
<td>PMI</td>
<td>United States President's Malaria Initiative</td>
</tr>
<tr>
<td>PPP</td>
<td>purchasing power parity</td>
</tr>
<tr>
<td>RBM</td>
<td>Roll Back Malaria Partnership</td>
</tr>
<tr>
<td>RDT</td>
<td>rapid diagnostic test</td>
</tr>
<tr>
<td>RHIS</td>
<td>routine health information system</td>
</tr>
<tr>
<td>SP</td>
<td>sulfadoxine-pyrimethamine</td>
</tr>
<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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Acknowledgments

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Executive Summary

Background
Malaria remains a significant cause of morbidity and mortality in Kenya, particularly among young children. Approximately 70 percent of the population is at risk of the disease, but the malaria burden in Kenya is not homogenous. There are four main malaria epidemiological zones with risk diversity determined largely by altitude, rainfall patterns, and temperature. The four transmission zones are malaria-endemic (i.e., Lake Victoria and Indian Ocean coast), epidemic-prone (i.e., western highlands), seasonal-risk (i.e., primarily arid and semi-arid areas of the north and northeast), and low-risk including Nairobi. Malaria accounts for 16 percent of outpatient visits to health facilities nationally. From 2003 to 2015, the Government of Kenya and partners increased funding for malaria control significantly, which resulted in expansion of key interventions, including insecticide-treated nets (ITNs), indoor residual spraying (IRS), intermittent preventive treatment during pregnancy (IPTp), and prompt and effective malaria case management through prompt parasitological diagnosis and treatment. Measuring the effects of these investments is necessary to inform the National Malaria Control Programme (NMCP), partners and donors and to provide evidence for future policies, strategies, and activities to further reduce the burden of malaria.


Objectives
• Measure the degree to which malaria control interventions were implemented in Kenya.
• Assess malaria-related morbidity, mortality, and contextual factors before, during, and after the implementation of malaria control interventions in Kenya.
• Assess the plausible attribution of the expansion of malaria control interventions to changes in malaria-related morbidity, all-cause mortality, and malaria-related mortality among children under 5 years of age in Kenya.

Evaluation Design
The evaluation was based on pre- and post-assessments, which used a plausibility evaluation design, which measured changes in coverage of malaria interventions, malaria-related morbidity, and all-cause child mortality (ACCM) in children under age 5 years, while accounting for other contextual determinants of child survival during the evaluation period. The primary measure of impact was ACCM. Multivariable analysis was included to investigate associations between household ITN ownership and ACCM. Due to the variability in malaria transmission in Kenya, the analyses were disaggregated by malaria-epidemiological zones.

Data Sources
Data on intervention coverage, morbidity, and mortality were primarily from nationally representative, population-based household surveys. These surveys were the, 2003, 2008/9 and 2014 Kenya Demographic and Health Survey (KDHS) and 2007,
2010 and 2015 Kenya Malaria Indicator Surveys. Data from other sources, including the routine health information system (RHIS) and health and demographic surveillance system (HDSS) (via case studies), were used to complement and triangulate findings and to provide examples of subnational changes.

Expansion of Interventions
Between 2003 and 2015, the country substantially increased coverage of malaria prevention interventions, particularly ITNs and IRS (in more limited targeted areas from 2005 to 2012). Mass distribution of free long-lasting insecticidal nets (LLINs) were conducted to expand coverage in children under age 5 years and pregnant women in 2006 and since 2011, to ensure universal coverage (i.e., at least one net per two persons per household). The country adopted IPTp in 1998 and incorporated the treatment as part of the routine antenatal care (ANC) package of services. Subsequently, efforts to improve coverage targeting both community and facility-based health workers were implemented at various points of the evaluation period. Artemisinin-based combination therapy (ACT) was adopted as first-line treatment for uncomplicated malaria in 2004 and provided at no cost to patients in the public health sector in 2006. Access to accurate malaria diagnostic testing and effective case management according to treatment guidelines also significantly improved from 2011 to 2015.

Trends in Coverage of Interventions

Vector control
National household ownership of at least one ITN increased significantly, from 8 (95% confidence interval [CI]: 7–9) percent in 2003 to 63 (95% CI: 59–66) percent in 2015; in areas specifically targeted for distribution, such as the lake-endemic region, ownership increased from 12 (95% Cl: 9–16) percent in 2003 to 87 (95% CI: 82–90) percent in 2015. In households with at least one ITN, use among children under age 5 years increased from 66 (95% CI 66–77) percent in 2007 to 79 (95% CI 69–82) percent in 2015 and use among pregnant women increased from 70 (95% CI 63–75) to 82 (95% CI 76–87) percent during the same period.

IRS implementation for epidemic response started in 1999 in parts of the western highland epidemic-prone and seasonal-risk zones. Due to poor surveillance and weak prediction systems, particularly in the highland epidemic-prone zone, a government-led, coordinated IRS plan for epidemic prevention was introduced in 2005. IRS was conducted only in parts of counties within the highland epidemic-prone zone from 2005 to 2009. From 2010 to 2012, IRS was also conducted in parts of malaria-endemic counties bordering the highland epidemic-prone zone for vector control and malaria burden reduction.

Intermittent preventive treatment of malaria in pregnancy
Coverage with at least two doses of IPTp at the national level increased from 5 (95% CI: 4–6) percent to 15 (95% CI 13–17) percent from 2003 to 2008. Since 2009, IPTp has been targeted to the malaria-endemic zone only, in line with World Health Organization (WHO) recommendations. Uptake of IPTp2 increased in the coastal and lake malaria-endemic zones from 22 (95% CI: 12–35) percent and 29 (95% CI: 23–35) percent in 2010 to 60 (95% CI: 50–68.3) percent and 53 (95% CI: 43–62) percent
in 2015, respectively. Kenya adopted IPTp3 as policy in late 2015, putting it beyond the evaluation period.

Case management of malaria
Case management of children with fever also improved over this period. In 2010, 55 (95% CI: 48–63) percent of public-sector health facilities had malaria diagnostic capacity (via microscopy, rapid diagnostic tests [RDT] or both), and by 2015, 97 (95% CI: 93–99) percent had diagnostic capacity. The percentage of children under age 5 years with fever who sought treatment from appropriate providers was 60 (95% CI: 57–63) percent in 2003 and increased to 70 (95% CI: 66–74) percent in 2015. The proportion of children tested was 13 (95% CI: 10–17) percent in 2010 and increased to 39 (95% CI: 35–44) percent in 2015. The proportion of children who received the recommended first-line antimalarial treatment decreased from 42 (95% CI: 36–47) percent in 2003, when sulfadoxine-pyrimethamine (SP) was the first-line antimalarial, to a low of 11 (95% CI: 8–16) percent in 2007 one year after ACTs were introduced, and thereafter increased to 92 (95% CI: 88–95) percent in 2015. Overall, there was a reduction in the use of antimalarials to treat fever in children under age 5 years in non-endemic zones, perhaps indicating both a decline in malaria prevalence and an increase in the use of parasitological diagnosis before treatment.

Trends in Morbidity and Mortality

Morbidity
In Kenya, malaria parasitemia prevalence among children ages 6–59 months declined over the evaluation period nationally from 9 (95% CI: 7–12) percent in 2010 to 5 (95% CI: 4–7) percent in 2015. The decrease observed nationally was mainly due to decreases in the malaria-endemic zone, where prevalence declined from 33 (95% CI: 26–41) percent in 2010 to 17 (95% CI: 12–21) percent in 2015. Similarly, at the national level, the prevalence of severe anemia (i.e., hemoglobin less than 8 g/dL) among children ages 6–59 months declined from 4 (95% CI: 3–5) percent in 2010 to 2 (95% CI: 2–3) percent in 2015. Reductions in severe anemia prevalence were observed in all malaria risk zones between 2010 and 2015, with a greater decline in the malaria-endemic zone.

Mortality
In Kenya, at the national level, ACCM declined from 115 deaths per 1,000 live births in 1999–2003 to 52 deaths per 1,000 live births in 2010–2014, a 54 percent reduction. There were similar reductions in mortality rates among neonatal, post-neonatal, infant, and child populations. The reduction in ACCM was greatest among children living in the highest-risk zone compared to those in the lower-risk zones. Data from two HDSS sites confirm the substantial reduction in ACCM in malaria-endemic zones.

Contextual Factors
During the evaluation period, there were substantial changes in fundamental and proximal determinants of child survival in Kenya. The gross domestic product (GDP) per capita purchasing power parity (PPP) increased from US$2,146 in 2003 to US$2,818 in 2014. Most standard household attributes and assets ownership improved; the largest increases were in ownership of a telephone and access to improved sources of water and electricity. At the individual level, more women had
completed at least a primary education and women’s literacy improved from 2003 to 2014. Maternal health indicators, including health facility-based births, improved during the evaluation period. Improvements in child health included substantial increases in coverage of immunizations and vitamin A supplementation, and care-seeking for acute respiratory infections and diarrhea. The prevalence of stunted growth in children under 5 years declined by 4 percent from 2003 to 2014. HIV prevalence among women ages 15 to 49 years declined from 9 percent in 2007 to 7 percent in 2012, and coverage of antiretroviral drugs increased from 39 percent in 2007 to 61 percent in 2012.

Evidence That Malaria Interventions Contributed to a Decline in All-cause Child Mortality

The findings indicate that from 2003 to 2015, Kenya made remarkable progress towards increasing coverage of malaria prevention and control interventions for populations at risk of malaria. Household ownership and use of ITNs among pregnant women, young children, and general household members increased as did uptake of IPTp for prevention of malaria in pregnancy. Effective case management also improved nationally and particularly in the malaria-endemic zone. The expansion of malaria intervention coverage resulted in national reductions in malaria cases reported and prevalence of malaria parasitemia and severe anemia, with the greatest declines observed in the malaria-endemic zone.

During the same period, Kenya experienced substantial socioeconomic progress and improvements in non-malaria health intervention coverage. However, these improvements alone are unlikely to account fully for the 54 percent reduction in under 5-year mortality between 2003 and 2014. Based on malaria prevention and control intervention coverage patterns, ACCM patterns in the malaria epidemiological zones, and timing, it is plausible that malaria prevention and control interventions contributed to the decline in under 5-year mortality in Kenya.

The period of rapid reduction in under-5 mortality from 2003 to 2014 coincided with the rapid expansion of ITN distribution and with increased use of ITNs and ACTs. The Kaplan-Meir estimates clearly demonstrate improved survival during the 2010–2014 period, which coincides with increased malaria intervention coverage, compared to the earlier periods prior to and during expansion of malaria interventions. The Cox proportional hazards regression analysis also indicates a stronger protective effect of ITN ownership on child survival in the lake-endemic area, where the potential to benefit from malaria interventions was higher compared to other epidemiological zones. Therefore, the declining trends in under 5-year mortality in Kenya are consistent with the expected impact of the expansion of malaria control interventions.
1 Introduction

1.1 Context
Malaria is one of the leading causes of morbidity and mortality in Kenya. It accounts for 16 percent of all outpatient attendance and 15 percent of all admissions to health facilities nationwide (Ministry of Health, 2013). Malaria has been estimated to cause 20 percent of all deaths in children under age 5 in Kenya (Ministry of Health, 2014a). Increasing evidence shows that the epidemiology and risk of malaria in Kenya have changed over the past 15 years. However, the country is still in the control phase of the malaria elimination continuum with malaria prevalence in some endemic counties as high as 38 percent (NMCP, KNBS and ICF-International, 2016). Since 2000, there has been a rapid increase in the expansion of malaria control interventions due to increased investments by partners and donors. Policy changes and new interventions have been informed by global and regional recommendations and changes in the malaria situation in Kenya.

1.2 Purpose and Scope
Kenya’s Ministry of Health and the United States President’s Malaria Initiative (PMI), on behalf of the Roll Back Malaria (RBM) Partnership, commissioned an evaluation to measure the impact of expansion of key malaria interventions on all-cause mortality in children under 5 years of age during the evaluation period of 2003–2015. This report describes the trends in increased coverage of interventions as well as variations in coverage by malaria epidemiological zones. The evaluation also considers other contextual factors that may have contributed to the mortality decline over the period. The purpose of this report is to measure the impact of the massive investments and substantial expansion of malaria prevention and control interventions from 2003 to 2015. It also seeks to provide information to the Ministry of Health, National Malaria Control Programme (NMCP), and partners for evidence-based decision making for future malaria control policies, strategies, and activities.

1.3 Evaluation Design
The evaluation used a non-experimental design, a pre- and post-intervention expansion, to measure changes in malaria intervention coverage, malaria-related morbidity, and all-cause child mortality (ACCM) while documenting other contextual determinants of child survival and assembling a plausibility argument that malaria interventions contributed to the observed outcomes during the evaluation period (Rowe et al., 2009, Victora et al., 2011). Plausibility inferences assume that mortality reductions can be attributed to program efforts if improvements are found in population-level measurements of steps in the causal pathway of the impact model (Habicht et al., 1999). Specifically, for this impact evaluation, the underlying argument was the biological plausibility of causal association between malaria interventions, malaria-related morbidity, malaria-related mortality, and all-cause mortality in children under age 5 years.
If there is reduction in ACCM and anemia as malaria intervention coverage increases, the conclusion that malaria control activities reduced malaria-associated mortality becomes more plausible, assuming no major confounding factors are present (Carneiro et al., 2010). Indicators at the end of the evaluation period were compared with the counterfactual, which is the assumption that pre-intervention trends would have continued. Using plausibility inferences based on ecologic associations, these trends were then used to demonstrate whether mortality reductions were attributable to programmatic efforts to expand malaria control interventions. For this reason, the evaluation examined the levels and trends in ACCM, malaria parasitemia, severe anemia, coverage of malaria control interventions (i.e., long-lasting insecticidal nets [LLINs], indoor residual spraying [IRS], intermittent preventive treatment in pregnancy [IPTp], and prompt and effective case management), and other contextual determinants of child survival. The contextual factors were classified into fundamental and proximate determinants. Fundamental determinants included climatic factors, socioeconomic factors such as gross domestic product (GDP), education, and access to improved water and sanitation. Proximate determinants included access to health services, fertility-related risks, immunization coverage, HIV prevalence and interventions, and other predictors of maternal and child health such as nutrition and comorbidities, particularly diarrhea and pneumonia.

The evaluation used all-cause mortality in children under 5 years as the measure of impact because there was no reliable measure of malaria-specific mortality at the national scale. The Mortality Task Force of Roll Back Malaria’s Monitoring & Evaluation Reference Group (2014), suggests that evaluation of full-coverage malaria control programs relies on an ecological study design, often referred to as a plausibility study design (Figure 1.1), because of challenges with measuring malaria-specific mortality and defining a control or comparison group required for a traditional impact evaluation.

Figure 1.1: Framework for evaluating the impact of malaria control interventions on all-cause child mortality, Kenya 2003–2015
In addition to trend analyses, survival analyses were performed to compare the survival probability of children ages 6 to 59 months before (2000–2004), during (2005–2009), and after (2010–2014) the expansion of malaria control interventions in Kenya. The evaluation assessed routine health information systems (HIS) data and health and demographic surveillance system (HDSS) data from two sites to further support the plausibility argument. Furthermore, the Lives Saved Tool (LiST) (JHSPH, 2014), based on a mathematical model, was used to estimate the number of under-5 deaths potentially averted due to the expansion of LLINs between 2000 and 2014. The LiST model is used in this context as an advocacy tool and not necessarily as evidence of the impact of malaria interventions. Further details on the LiST model are in Annex 1.

### 1.4 Evaluation Indicators

The evaluation used the indicators and definitions as recommended by Roll Back Malaria Monitoring & Evaluation Reference Group (RBM-MERG) and used by NMCP. The indicators are shown in Table 1.1.

<table>
<thead>
<tr>
<th>Table 1.1: Population-based indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intervention area</strong></td>
</tr>
<tr>
<td><strong>Prevention</strong></td>
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<tr>
<td><strong>Vector control</strong></td>
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<td></td>
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<td></td>
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<tr>
<td></td>
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<tr>
<td>Prevention of malaria in pregnancy</td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Case management**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>7. Proportion of children under 5 years with fever in the previous two weeks who had blood taken from a finger or heel for testing (which is a proxy for malaria testing).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>8. Proportion of children under 5 years with fever in last two weeks for whom advice or treatment was sought from an appropriate provider.</td>
</tr>
<tr>
<td></td>
<td>9. Proportion of children under 5 years with fever who received any antimalarial treatment.*</td>
</tr>
<tr>
<td></td>
<td>10. Proportion of children under 5 years with fever who received the recommended antimalarial treatment within 24 hours.*</td>
</tr>
<tr>
<td></td>
<td>11. Proportion of children under 5 years with fever who received recommended first-line treatment (artemisinin combination treatment) among those who received any antimalarial treatment.</td>
</tr>
</tbody>
</table>

**Impact Measurement**

<table>
<thead>
<tr>
<th>Morbidity</th>
<th>12. Proportion of children ages 6 to 59 months with malaria infection measured by microscopy.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>13. Proportion of children ages 6 to 59 months with a hemoglobin of &lt;8g/dl.</td>
</tr>
<tr>
<td>Mortality</td>
<td>14. All-cause mortality in children under 5 years.</td>
</tr>
</tbody>
</table>

Note: ITN – insecticide-treated bed net; IPTp – intermittent preventive treatment in pregnancy

*These indicators are no longer recommended by Roll Back Malaria-Monitoring and Evaluation Reference Group but are included here because they are still used to track national malaria control program targets.


1.4.1 Insecticide-treated nets

RBM-MERG net indicators report on both ownership and use. ITN ownership is a household-level indicator, whereas ITN use is an individual-level indicator. Use at the population level was measured historically in populations with the greatest risk of malaria morbidity and mortality, such as children under 5 years and pregnant women.

1.4.2 Intermittent preventive treatment in pregnancy
IPTp coverage is measured by a RBM-MERG population-based indicator. Until October 2012, IPTp was defined as at least two doses of sulfadoxine-pyrimethamine (SP) after quickening and at least one month apart; these recommendations have since changed to give IPTp at each antenatal care (ANC) visit after the first trimester (WHO, 2012). This evaluation reported on two or more doses, which is in line with the Kenya policy that was in place during the evaluation period. IPTp3 was included in the revised strategy in October 2015 and a circular on IPTp3 implementation was sent to counties in October 2016, falling outside the period under evaluation.

1.4.3 Case management of malaria
RBM-MERG population-based indicators measure some elements of diagnosis and treatment of malaria. Facility-based data are often better suited to monitoring trends in malaria case management (such as proportion of suspected malaria cases tested, test positivity rate, and proportion of confirmed malaria cases receiving artemisinin-based combination therapy [ACT]) and are included in this report where relevant. Population-based surveys measure the proportion of children with fever receiving diagnostic tests for malaria, which is measured by a proxy indicator. Having blood taken from a finger or heel stick is a proxy indicator for having had a diagnostic test. Questions on care-seeking behavior for fever in children under 5 years and the type and timing of treatment with antimalarial drugs are also included.

1.4.4 Malaria-related morbidity
The prevalence of severe anemia (i.e., hemoglobin levels less than 8 g/dL) and prevalence of parasitemia in children ages 6 to 59 months were two outcomes examined. Severe anemia is a potential impact measure for total malaria-related disease burden, measurable at the population level with less seasonal variations than parasite prevalence (McElroy et al., 2000, Menendez et al., 1997, Snow et al., 1997). The prevalence of parasites is the most direct measure of malaria burden. Cross-sectional household surveys provide national and epidemiological-zone estimates of parasite prevalence to measure the impact of malaria control interventions. In addition, morbidity analyses were supplemented by routine surveillance data on malaria cases (i.e., malaria test positivity rates).
1.4.5 Mortality
In line with RBM-MERG guidance, the principal measure of impact in this evaluation is ACCM (Rowe et al., 2007, RBM, 2013, Rajaratnam et al., 2010). ACCM is preferable because population-level national data on malaria-specific mortality are not available. In addition, there are concerns about the sensitivity and specificity of the verbal autopsy method for detecting malaria deaths (Snow et al., 1997). Furthermore, malaria is thought to make an indirect contribution to ACCM that is equivalent to 50 percent to 100 percent of the mortality that can be directly attributed to malaria (Murphy and Breman, 2001). Mortality estimates used in this evaluation are derived from multiple Demographic and Health Surveys data sets rather than mortality estimates available from the United Nations Inter-agency Group for Child Mortality Estimation (IGME) (UN IGME, 2014). The level and detail of stratification needed to inform the plausibility design of this evaluation was not possible using IGME estimates. Furthermore, it is more appropriate to assess impact based on actual measured morbidity and mortality, rather than modeled estimates.

1.5 Data Sources
Intervention coverage, morbidity, and mortality data were obtained primarily from large population-based household surveys, including the Kenya Demographic and Health Survey (KDHS) in 1998, 2003, 2008/2009, and 2014 and the Kenya Malaria Indicator Survey (KMIS) in 2007, 2010, and 2015. Other sources of data that included HDSS data complemented findings and served as examples of subnational changes. Routine health data available via the HIS and integrated disease surveillance and response (IDSR) data were reviewed to complement survey findings as was data from quality of care (QOC) surveys for malaria case management. The annual economic survey reports were used to describe health system factors. Historical meteorological data were used to describe rainfall and temperature variation which occurred during the evaluation period. The evaluation identified other potential data sources, and selected the most relevant (Figure 1.2) after assessing the validity, strengths, and limitations of each source. A more detailed description of the data sets, survey methods, sample sizes, and other statistical parameters is in Annex 2.

1.6 Limitations of Evaluation Design
The impact evaluation was limited to the scope of the secondary data sets that were included in the analysis. Each of these sources has relative strengths and limitations,
particularly with respect to the level of data aggregation. By applying the defined inclusion criteria across the data sets, the evaluation attempted to minimize the effect of inherent limitations. The main shortcoming of plausibility inferences, as compared to probability inferences (derived typically from randomized controlled trial study designs), is that the observed difference and magnitude of changes in ACCM might not be entirely attributable to the expansion of malaria control interventions, and the role of other contextual factors cannot be adequately measured and controlled.
2 Country Background

2.1 Geo-location and Weather

Kenya is in East Africa and lies between 5 degrees north and 5 degrees south latitude and between 24 and 31 degrees east longitude. The country is bordered by Ethiopia to the north, South Sudan to the northwest, Uganda to the west, Tanzania to the south, and Somalia and the Indian Ocean to the east. The country covers a total area of 582,646 square kilometers, 2 percent of which comprises water bodies. It also has diverse physical features: Mount Kenya, the second highest peak in Africa, Lake Victoria, and the Great Rift Valley, which runs from Lake Turkana in the north through the Great Lakes region to the south. The country has a number of large rivers, including the Tana, Galana, Turkwel, and Nzoia. Eighty percent of the land area is arid or semi-arid.

The country has a hot and humid tropical climate along the 400 km Indian Ocean coastline and Lake Victoria, is temperate in the savanna grasslands around the capital, Nairobi, and is increasingly cooler toward Mount Kenya. The arid and semi-arid areas, the savanna plateau and the coastal hinterland, have considerably lower seasonal rainfall (Figure 2.1a) with an annual average of less than 250 to 500 mm. The Lake Victoria region and the western and central highlands receive the highest rainfall in the country and exhibit less seasonality. The “long rains” occur from March to June. The “short rains” occur from October to December. The hottest period is from February to March, and the coldest period is from July to mid-August. The varied topography and altitude contribute to large variations in ambient temperature (Figure 2.1b).

Figure 2.1: Kenya maps of rainfall and temperature, 2015

<table>
<thead>
<tr>
<th>a) Mean monthly rainfall (mm)</th>
<th>b) Mean temperature (°C)</th>
</tr>
</thead>
</table>

2.2 Administrative Divisions
Administratively, the country was divided into 47 counties in 2013, which replaced the previous administrative divisions of eight provinces and nearly 300 districts. The counties are shown in Figure 2.2.

Figure 2.2: Administrative map of the 47 counties in Kenya, 2015


2.3 Demography and Economy
Kenya’s population was 38.6 million in 2009 and estimated at 43.0 million in 2014, with an inter-censal growth rate of 2.9 percent per annum (KNBS, 2015). The total fertility rate in 2014 was 4.8 (KNBS and ICF-Macro, 2015), while overall life expectancy at birth was 61.5 years (UNDP, 2015).

Kenya is home to people of diverse cultures with more than 42 ethnic groups and as many languages. The Kenyan economy is predominantly agricultural, with a strong industrial base; agriculture is the livelihood for 80 percent of the population. The performance of the Kenyan economy during the period under review was varied, with an average growth rate of 5.1 percent (World Bank, 2016). The highest growth rate recorded was 8.4 percent in 2010 and the lowest rate was 0.2 percent in 2008, which coincided with the global recession. The GDP in 2014 was 60.9 billion current international dollars (Intl$) compared with 12.7 billion in 2003. The gross national income per capita increased from Intl$1,690 in 2003 to Intl$2,940 in 2014 (World
At the start of the millennium, approximately 50 percent of the population lived below the poverty line, dropping to 43 percent in 2012. Kenya’s human development index score increased by 22.6 percent from 0.447 in 2003 to 0.548 in 2014, positioning the country at 145 among 188 countries (World Bank, 2016).

2.4 Education and Literacy
Kenya had a national adult literacy rate of 72 percent, with higher literacy among males (78 percent) compared to females (67 percent), from 2008 to 2012 (World Bank, 2014). Youth ages 15 to 24 years had a literacy rate of 83 percent for males and 82 percent for females (World Bank, 2014).

2.5 Health System in Kenya

2.5.1 Health sector and devolution
In March 2013, Kenya transitioned to a devolved system of government that moved fiscal, planning, and oversight functions from central authorities to 47 new counties. One of the devolved functions was health, with specific functions assigned to national and county governments to facilitate progressive realization of the right to health by all. Policies and guidelines, norms and standards, capacity building, national referral hospitals, and technical assistance were assigned to the national government; county governments became responsible for health service delivery, including routine malaria prevention and control interventions and services.

2.5.2 Health service delivery structure
Kenya’s health delivery system is pyramidal, consisting of community, primary (i.e., dispensaries and health centers), secondary (i.e., county referral hospitals), and tertiary (i.e., national referral hospitals) levels of care (Table 2.1).

<table>
<thead>
<tr>
<th>Table 2.1: Structure of the Kenya health system, 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current structure</td>
</tr>
<tr>
<td>Tier 1</td>
</tr>
<tr>
<td>Tier 2</td>
</tr>
<tr>
<td>Tier 3</td>
</tr>
<tr>
<td>Tier 4</td>
</tr>
</tbody>
</table>

The six-level health service delivery system was in existence prior to devolution and was transitioned to a four-tier system in 2013 (Table 2.1), which consists of:

- Community health services: Includes all community-based health activities such as malaria community case management services delivered by community health volunteers (CHV).
- Primary care facilities: Includes all dispensaries, health centers, and maternity homes where the majority of malaria prevention and control interventions such as LLINs, IPTp and case management are delivered.
- County referral facilities: Includes hospitals that are operated and managed by county governments; most hospitals have large-volume outpatient
departments that provide malaria prevention and control interventions such as LLINs, IPTp and case management.

• National referral facilities: Includes specialized referral hospitals that are operated and managed by the national government.

At the community level, CHVs provide health promotion and limited preventive and curative services. They are supervised by community health extension workers (CHEW); all CHVs and CHEWs are linked to a primary-care facility. Primary care is delivered through dispensary, health centers and outpatient department clinics at hospitals where curative, reproductive, maternal and child health, and preventive services are offered. County hospitals provide both primary and secondary care while national referral hospitals provide primarily tertiary care services.

The main provider of health services is the Ministry of Health, which manages 4,201 (44 percent) of 9,506 health facilities (Table 2.2). The private non-profit sector also plays a significant role in service provision, with faith-based organizations (FBO) operating 11 percent and nongovernmental organizations (NGO) operating slightly more than 3 percent of all health facilities. The private for-profit sector operates 38 percent of health facilities, the majority of which are outpatient clinics. Overall, 95 percent of health facilities are primary-care facilities, and 5 percent are hospitals. Table 2.2 shows health facilities in Kenya in 2015 by type and ownership.

<table>
<thead>
<tr>
<th>Tier</th>
<th>Public</th>
<th>Private non-profit</th>
<th>Private</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MOH</td>
<td>Local Authorities</td>
<td>Other Gov’t</td>
<td>FBO</td>
</tr>
<tr>
<td>Level 2</td>
<td>3,195</td>
<td>83</td>
<td>250</td>
<td>768</td>
</tr>
<tr>
<td>Level 3</td>
<td>739</td>
<td>26</td>
<td>19</td>
<td>188</td>
</tr>
<tr>
<td>Level 4</td>
<td>252</td>
<td>0</td>
<td>2</td>
<td>67</td>
</tr>
<tr>
<td>Level 5</td>
<td>11</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Level 6</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>4,201</td>
<td>110</td>
<td>271</td>
<td>1,024</td>
</tr>
</tbody>
</table>

Note: FBO – faith-based organization; MOH – Ministry of Health; NGO – nongovernmental organization

2.5.3 Human resources for health

The health worker to population ratio has improved over the period under review, with the number of medical personnel increasing from 192 per 100,000 population in 2003 to 282 per 100,000 in 2014 (KNBS, 2004, KNBS, 2015). Table 2.3 shows the cadres of health worker to population ratios.
Table 2.3: Health worker to population ratios in Kenya, 2003–2014

<table>
<thead>
<tr>
<th>Type of personnel</th>
<th>2003</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Number per 100,000 population</td>
</tr>
<tr>
<td>Doctors</td>
<td>4,813</td>
<td>15</td>
</tr>
<tr>
<td>Dentists</td>
<td>772</td>
<td>3</td>
</tr>
<tr>
<td>Pharmacists</td>
<td>1,881</td>
<td>6</td>
</tr>
<tr>
<td>Pharmaceutical Technologists</td>
<td>1,405</td>
<td>4</td>
</tr>
<tr>
<td>BSc. Nurses</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Registered Nurses</td>
<td>9,869</td>
<td>33</td>
</tr>
<tr>
<td>Enrolled Nurses</td>
<td>30,212</td>
<td>100</td>
</tr>
<tr>
<td>Clinical Officers</td>
<td>4,804</td>
<td>16</td>
</tr>
<tr>
<td>Public Health Officers</td>
<td>1,216</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Bsc – Bachelor of Science degree

2.6 Malaria Control in Kenya

2.6.1 Epidemiology of malaria in Kenya
There are four main malaria epidemiological zones, with diversity in risk determined largely by altitude, rainfall patterns, and temperature. These four transmission zones are malaria endemic, epidemic-prone, seasonal transmission, and low transmission (Figure 2.3). Based on population-adjusted estimates of *Plasmodium falciparum* prevalence (*PfPR* among children ages 2 to 10 years (*PfPR*$_{2-10}$), 29 percent of Kenya’s 2015 population live in low-risk and malaria-free areas, 22 percent live in areas of seasonal malaria risk, 20 percent live in the highland epidemic-prone areas, and 29 percent live in malaria-endemic areas.
1. Endemic zone: The zone includes areas of stable malaria that have altitudes ranging from 0 to 1,300 meters around Lake Victoria in western Kenya and in the coast regions. The map above (Figure 2.3) shows the lake and coast regions as two different shades of dark brown; these two regions together comprise the malaria-endemic zone. Rainfall, temperature, and humidity are the determinants of the perennial transmission of malaria. Transmission is intense throughout the year, with annual entomological inoculation rates ranging between 30 and 100 (NMCP et al., 2016). In 2015, malaria parasite prevalence in children ages 6 to 59 months was 5.3 percent in the coast region and 16.6 percent in the lake Victoria region (NMCP et al., 2016).

2. Highland epidemic-prone zone: These areas border the endemic zone in the western part of the country. Malaria transmission in the western highlands is seasonal with considerable year-to-year variation. The entire population is vulnerable and case-fatality rates during an epidemic can be greater than in endemic regions. Malaria parasite prevalence in children ages 6 to 59 months was 2.6 percent in the epidemic-prone zone (NMCP et al., 2016).

3. Seasonal-risk zone: These are arid and semi-arid areas of northern and southeastern parts of Kenya that may experience short periods of intense malaria transmission during the rainfall season. Temperatures are usually high, and water pools created during the rainy season provide the malaria vector breeding sites. Malaria transmission is seasonal with considerable year-to-year variation. The whole population is vulnerable, and case-fatality rates during an epidemic can be up to 10 times greater than in the endemic region. Malaria parasite prevalence in children ages 6 to 59 months was 0.5 percent in the seasonal malaria risk zone (NMCP et al., 2016).
4. Low-risk zone: These areas include the central highlands including Nairobi. Mean daily temperatures are usually too low to allow completion of the sporogonic cycle of the malaria parasite in the vector. However, increasing temperatures and changes in the hydrological cycle associated with climate change are likely to increase the areas suitable for malaria vector breeding, with the possible introduction of malaria transmission in areas where it has never existed. Malaria parasite prevalence in children ages 6 to 59 months was 0.4 percent (NMCP et al., 2016).

2.6.1.1 Plasmodium species

*Plasmodium falciparum* is the main cause of malaria in Kenya, accounting for 96 percent of infections, 83 percent are pure infections and 13 percent are mixed infections with *P. malariae* or *P. ovale*. Four percent are due to *P. malariae*. Parasitemia surveys have not detected *P. vivax* since 2007.

2.6.1.2 Vector species

The major malaria vectors in Kenya are *Anopheles (An.) gambiae s.s.*, *An. arabiensis*, *An. merus*, and *An. funestus*. *An. merus* has a distribution largely within a 25-kilometer inland extent from the Kenya coast and is an important secondary vector within its range. The vectors are abundant during and immediately after the rainy season when larval habitats are abundant. *An. arabiensis* and *An. gambiae s.s.* appear to be sympatric in their distribution; however, there is evidence that *An. arabiensis* has begun to displace *An. gambiae s.s.* as the more dominant vector where both coincide (Bayoh et al., 2010). Molecular characterisation of the members of the *An. funestus* complex in Kenya has only been possible in the last decade (Kamau et al., 2002); where *An. funestus* has been previously reported might have been predominantly *An. funestus s.s* (Kamau et al., 2003, Kawada et al., 2012). The distribution of the predominant vectors, based on where entomologic monitoring occurred, is shown in Figures 2.4a–2.4d. Although some malaria vectors have recently been found to bite outdoors, over 90 percent of bites still occur indoors thus LLINs and IRS are still appropriate primary tools for malaria vector control (Bayoh et al., 2014).
2.6.1.3 Malaria disease burden

In 2014, malaria accounted for approximately 16 percent of outpatient attendance nationally (Ministry of Health, 2014a), and 15 to 20 percent of pediatric hospital admissions in malaria-endemic areas. Prior to 2007, malaria was the leading cause of morbidity and mortality. Malaria accounted for 30 to 50 percent of outpatient admissions, 20 percent of all hospital admissions, 3 to 5 percent of all deaths, and 20 percent of all childhood deaths (WHO, 2007b). Data from the Kilifi HDSS site, in the coastal-endemic zone, showed that malaria slide-positive acute-illness admissions accounted for 56 percent of all acute-illness admissions in children <14 years of age in 1998, declining to 7 percent in 2008, but rising to 24 percent in 2014 (Mogeni et al., 2016). Data from the Kilifi HDSS (PfPR2-10 4–8 percent) and Siaya HDSS (PfPR2-10 27–38 percent) both show a malaria-specific mortality in children under age 5 years ranging from 2.5 to 7 per 1,000 person years (Mogeni et al., 2016).

The national malaria prevalence among children 6 months to 14 years of age was 8 percent in 2015, which was a decrease from 11 percent in 2010 (NMCP et al., 2016). Prevalence was highest among children ages 10 to 14 years at 11 percent compared with
5 percent in children ages 6 to 59 months (NMCP et al., 2016). The lake-endemic zone had the highest prevalence nationwide at 27 percent, which was a decrease from 38 percent in 2010 (NMCP et al., 2016). The malaria maps in Figure 2.5 show the change in malaria parasite prevalence in children ages 2 to 10 years across Kenya from 2000 to 2015 based on Baysian geostatistical modelling estimates that predicted PfPR2-10 at a 1x1 km resolution (Ministry of Health, 2016). The data that underlie the maps were assembled from approximately 2,700 cross-sectional community surveys conducted from 1975 to 2015. The surveys were from over 2,000 geographically unique sites and included approximately 400,000 individuals (Ministry of Health, 2016). Eighty percent of the surveys were from rural areas and about half were from school health surveillance (Ministry of Health, 2016).

Figure 2.5: Population-adjusted, modelled estimates of *Plasmodium falciparum* parasite prevalence in children ages 2–10 years (PfPR2-10) in Kenya from 2000–2015

Source: Ministry of Health. The Epidemiology and Control Profile of Malaria in Kenya: Reviewing the Evidence
2.6.2 Malaria control strategy

Kenya has a long and storied history of malaria prevention and control. Malaria control strategies were implemented from the British colonial era at the beginning of the twentieth century through the WHO Global Malaria Eradication Program era in the 1960s through the 1980s that coincided with independence and into the present era, which started in the early twenty-first century. The strategies have included prophylaxis with quinine, pyrimethamine, and chloroquine, treatment with chloroquine or quinine and vector control with mosquito nets, IRS, and larviciding in selected areas.


The first National Malaria Strategy (NMS) 2001–2010 was developed in 2001 (Ministry of Health, 2001b). The control strategies were case management with SP, IPTp, implementation of the first national ITN program covering pregnant women and children under 5 years of age, and IRS for epidemic prevention and control in the highland epidemic-prone areas. The plan also provided a series of indicator targets congruent with the RBM targets established in Abuja, Nigeria in April 2000. These targets were as follows: 60 percent of vulnerable children and pregnant mothers sleep under an ITN; 60 percent of children with a fever in the last two weeks access effective treatment within 24–48 hours of symptom onset; and 60 percent of pregnant women access IPTp with SP during the second and third trimesters by 2006.

The second NMS 2009–2017 was launched in 2009 and revised in 2014, extending its implementation period and targets to include 2018 (MOPHS, 2009a; Ministry of Health, 2014a). The focus of the second strategy was scaling up to universal coverage with vector control and other preventive methods for all persons at risk and universal access to malaria diagnosis and treatment. Additional implementation milestones, including the launch of malaria control policies and guidelines, are shown in Table 2.4.
Table 2.4: Milestones in malaria policies and intervention implementation in Kenya, 1981–2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>Kenya Anti-Malaria Strategy launched by the Division of Vector Borne Diseases</td>
</tr>
<tr>
<td>1980s</td>
<td>Increasing chloroquine resistance and no effective sustained vector control method result in the rebound of malaria.</td>
</tr>
</tbody>
</table>
| 1992 | World Bank re-emphasizes significance of malaria control for economic and social development.  
World Bank recommends the Global Malaria Control Strategy adopted at the WHO Ministerial Conference.  
| 1994 | The Malaria Control Unit (MCU) created in the DVBD as the operational National Malaria Control Programme. |
First National Guidelines for Diagnosis, Treatment and Prevention of Malaria launched.  
Sulfadoxine-pyrimethamine (SP) replaces chloroquine as first-line treatment for malaria.  
Indoor residual spraying (IRS) adopted as a strategy for malaria epidemic prevention and response.  
Intermittent preventive treatment in pregnancy (IPTp) with SP adopted.  
Demographic and Health Survey conducted. |
| 1999 | First Health Sector Strategic Plan (HSSP) 1999–2004, which recognizes malaria as the highest priority public health issue.  
Guidelines for Malaria Epidemic Preparedness and Control in Kenya launched. |
| 2000 | The MCU in DVBD is elevated to a division and renamed the Division of Malaria Control (DOMC) within the Ministry of Health. |
Subsidized ITNs distributed to pregnant women and children under 5 at maternal and child health clinics (MCH) under a cost-sharing mechanism.  
Demographic and Health Survey conducted. |
| 2003 | Artemisinin-based combination therapy (ACT) adopted as first-line treatment for malaria.  
Amodiaquine adopted as interim first-line treatment before ACTs become available in the public sector.  
ITNs distributed free to pregnant women and children under 5 years at MCH clinics.  
Distribution of socially-marketed, subsidized nets to community members launched. |
| 2004 | Conventional ITNs, which need retreatment with insecticide at intervals, replaced by long-lasting insecticidal bed nets (LLINs).  
ACTs become available in the public sector at no cost to patients.  
Malaria rapid diagnostic test (RDTs) become available in the public sector in low-transmission zones.  
First free mass net distribution campaign targeting children under 5 years and pregnant women conducted.  
Integrated Disease Surveillance and Response launched. |
| 2007 | First Malaria Indicator Survey conducted. |
Table 2.4: Milestones in malaria policies and intervention implementation in Kenya, 1981–2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>Post-election violence results in population displacements with movement between malaria risk zones and disruption of health services. Pharmacy and Poisons Board bans importation and sale of non-recommended antimalarials, including oral artemisinin-based monotherapies.</td>
</tr>
<tr>
<td>2011</td>
<td>Demographic and Health Survey conducted. Guidelines for Malaria Epidemic Preparedness and Response revised. Free universal mass net distribution campaign conducted in Nyanza, Western, and Rift Valley provinces. District Health Information Software 2 (DHIS2) launched nationally.</td>
</tr>
<tr>
<td>2012</td>
<td>Malaria RDTs become available in all public health facilities nationally. Free universal mass net distribution campaign conducted in Coast and Rift Valley provinces.</td>
</tr>
<tr>
<td>2015</td>
<td>Malaria Indicator Survey conducted. Free universal mass net distribution campaign conducted in 17 counties in coastal and western Kenya.</td>
</tr>
</tbody>
</table>

2.6.3 Financing of malaria control interventions

Total health expenditures for malaria control came mainly from three sources including the Government of Kenya (GOK), external donors and partners, and households. GOK financing for malaria activities includes procurement of medicines for severe malaria, diagnostics, and insecticides as well as funding for program management activities at the national level. The country’s health budget as a
proportion of GDP remained fairly constant at about 5 percent between 2003 and 2014 (WHO, 2014). However, the per capita expenditure on health, including external donor resources, began a steady increase in 2004 and together with per capita government expenditure, increased significantly from 2010 (WHO, 2014). The increase in health expenditures coincided with increased funding for infrastructure and human resources in the health budget and external funding for universal coverage with LLINs.

Kenya’s major sources of external funding for malaria include the Global Fund to fight AIDS, Tuberculosis and Malaria (Global Fund), United States President’s Malaria Initiative (PMI), United Kingdom Department for International Development (DFID), World Bank, and other multilateral agencies and NGOs. These external resources have been the backbone of the fight against malaria in Kenya. While each source has had different financial planning and disbursement timelines, disbursements and procurements for commodities have been accounted for in the calendar year in which they were received. As shown in Figure 2.6, donor financing accounts for over 90 percent of malaria commodities and interventions. However, government expenditures on health service delivery are not easily quantified and thus not included in the figure. About half of malaria expenditures in 2012 and in 2014 was spent on vector control interventions (i.e., LLINs and IRS), about 15 percent was spent on antimalarial treatments, and 10 percent was spent on diagnostics (Figure 2.7). The data in Figure 2.7 is presented as an example; funding could be reliably allocated to specific intervention strategies during 2012 (i.e., a year without funding for a universal coverage mass LLIN distribution) and 2014 (i.e., a year with a universal coverage mass LLIN distribution).

![Figure 2.6: Sources of malaria financing in Kenya, 2003–2014](image)

Note: GOK – Government of Kenya; PMI – U.S. President’s Malaria Initiative; DFID – Department for International Development; UNICEF – United Nations Children’s Fund; MACEPA – Malaria Control and Elimination Partnership in Africa
Figure 2.7: Malaria expenditure by intervention in 2012 and 2014 in Kenya

Note: LLIN – long-lasting insecticidal net
3 Malaria Control Interventions

3.1 Insecticide-Treated Nets

3.1.1 Background

Evidence from clinical trials, including those undertaken in Kenya (Nevill et al., 1996, Phillips-Howard et al., 2003), has shown that ITNs provided significant protective efficacy against malaria infection, over 50 percent reduced risk of clinical disease, and a nearly 20 percent reduction in all-cause childhood mortality (Lengeler, 2004). To achieve the RBM milestones, protection of the population in malaria-endemic countries with ITNs was therefore considered the main preventive tool to reduce the burden of the disease (RBM and WHO, 2000, Roll Back Malaria, 2005). The major ITN issues debated at the time, however, were the appropriate target population, sources of funding, and the most effective and efficient way to scale up (Webster et al., 2005). Initial consensus in the malaria research and control community was around prioritizing children under age 5 years and pregnant women (Roll Back Malaria, 2005). The decision was based on the assumption that the majority of the sub-Saharan African population was exposed to stable malaria transmission, and these population sub-groups remained vulnerable because of lack of immunity due to age-limited exposure or compromised immunity due to pregnancy. The target set by the RBM partnership for 60 percent coverage of essential prevention and disease management interventions by 2006 was readily adopted in national malaria control strategies in almost all sub-Saharan Africa countries, including Kenya.

3.1.2 ITN policy in Kenya

The Kenya National Malaria Strategy (NMS) 2001–2010, launched in April 2001, aimed to ensure that 60 percent of at-risk children and pregnant women slept under an ITN by 2006 (Ministry of Health, 2001b). However, insufficient funding and the need to re-treat conventional nets every 6 months with insecticide affected achievement of targets. The NMS 2001–2010 did not outline any specific delivery approach but envisaged the targeting of children and pregnant women with subsidized ITNs. In 2000, the Ministry of Health and partners developed an ITN strategy paper (Ministry of Health, 2001a) in which various approaches to expand ITN coverage were outlined to reach a target of 60 percent of populations at risk by 2005. At this time, the main strategies for scaling up ITNs in Africa were through social marketing via the retail sector combined with limited distribution of nets at a subsidized cost through MCH clinics (Noor et al., 2007).

By 2007, however, evidence began to emerge from Kenya that free mass distribution was the most effective and equitable mechanism to achieve the scale-up of ITNs (Noor et al., 2007) and had a significant impact on reducing mortality among children under age 5 years (Fegan et al., 2007). This evidence was followed shortly by the WHO recommendation for universal coverage of ITNs by free mass distribution as the main method for scale-up supplemented with routine distribution and other mechanisms (WHO, 2007a).

The Kenya NMS 2009–2017, which replaced the NMS 2001–2010, reflected the WHO recommendation for universal coverage and targeted 80 percent population coverage.
of LLINs among those at risk (MOPHS, 2009). Free mass distribution was the main mechanism for scale-up combined with free routine distribution through MCH clinics and limited social marketing in targeted areas (MOPHS, 2009). Following an empirical mapping of malaria transmission in the country (Noor et al., 2009), 23 counties were targeted for subsequent free mass distribution campaigns in the lake- and coastal-endemic and highland epidemic-prone zones as well as specific sub-counties with focal malaria transmission (e.g., irrigation areas).

3.1.3 ITN implementation

3.1.3.1 Distribution strategy

Since 2001, several mechanisms for ITN distribution to populations at risk were implemented in Kenya (Noor et al., 2007, Snow et al., 2010, Noor et al., 2010). Initially, ITNs were accessed mainly from the private-for-profit retail sector and via limited focal distributions by research projects or NGOs (Snow et al., 2010, Shretta, 1999). Distribution of highly subsidized ITNs through MCH clinics and by social marketing via the retail sector and community-based organizations started in 2004. From May 2005 forward, LLINs largely replaced conventional ITNs (Noor et al., 2007). Kenya implemented the first free mass LLIN distribution campaign in 2006, with over 3 million LLINs distributed to children under age 5 years and pregnant women (Noor et al., 2007). In 2008, a national campaign to re-treat conventional nets with KO-TAB 1-2-3 and replace torn or damaged nets was undertaken in 55 districts (Snow et al., 2009). A total of 1.93 million nets were re-treated, and 207,290 torn nets were replaced.

The first universal coverage (i.e., one LLIN per two people per household) mass LLIN distribution occurred in three phases from 2011–2012 and the second in four phases from 2014–2015 in 23 counties and parts of three counties (i.e., areas with focal malaria transmission due to irrigation). Concurrently, free routine LLIN distribution via MCH clinics continued in 36 counties and social marketing of LLINs through community-based organizations continued in the 14 malaria-endemic counties. Table 3.1 summarizes ITN and LLIN distributions in Kenya since 2005 when major expansion efforts began and Figure 3.1 illustrates the mechanisms of net distribution since 2004.

Table 3.1: Nets distributed in Kenya, 2005–2015

<table>
<thead>
<tr>
<th>Year of distribution</th>
<th>Distribution mechanism</th>
<th>Type of net</th>
<th>Number distributed</th>
<th>Funders</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005–2015</td>
<td>Routine</td>
<td>LLIN &amp; ITNs</td>
<td>23,343,797</td>
<td>DFID, PMI, Global Fund</td>
</tr>
<tr>
<td>2006</td>
<td>Free mass campaign</td>
<td>LLIN</td>
<td>3,099,473</td>
<td>Global Fund</td>
</tr>
<tr>
<td>2011</td>
<td>Free mass campaign</td>
<td>LLIN</td>
<td>8,321,603</td>
<td>Global Fund, PMI, DFID, World Vision</td>
</tr>
<tr>
<td>2012</td>
<td>Free mass campaign</td>
<td>LLIN</td>
<td>2,790,749</td>
<td>Global Fund, DFID, World Vision</td>
</tr>
<tr>
<td>2013</td>
<td>Free mass campaign</td>
<td>LLIN</td>
<td>17,325</td>
<td>World Bank</td>
</tr>
<tr>
<td>Year</td>
<td>Campaign Type</td>
<td>LLIN</td>
<td>Source</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-----------------------</td>
<td>----------</td>
<td>-----------------------------</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>Free mass campaign</td>
<td>3,286,767</td>
<td>Global Fund, PMI</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>Free mass campaign</td>
<td>9,367,569</td>
<td>Global Fund, PMI</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>50,227,283</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: LLIN – long-lasting insecticidal net; ITN – insecticide-treated net; DFID – Department for International Development; PMI – U.S. President’s Malaria Initiative

Source: National Malaria Control Program data
3.1.3.2 Insecticide resistance

Insecticide resistance related to ITNs was first reported in Western Kenya and has continued to increase as pyrethroid-based LLINs and indoor residual spraying (IRS) using pyrethroids became the mainstays of vector control (Ochomo et al., 2014). High levels of pyrethroid resistance, as well as widespread resistance, have been observed in *An. arabiensis* and *An. gambiae s.s*. Holes from use have been shown to permit mosquito entry and feeding, thus providing little protection against these vectors. All *An. gambiae s.s* samples collected resting in LLINs with holes have been found to be homozygous for the knock down resistance kdr genotype L1014S (Ochomo et al., 2013). *An. funestus* populations in Western Kenya and Uganda have also been found to have extensive resistance to both pyrethroids and DDT, thus presenting challenges for the future control of these vectors (Mulamba et al., 2014). In contrast, *An. arabiensis* populations from an area of low malaria transmission around a rice irrigation scheme in Central Kenya showed complete susceptibility to all insecticide groups (Kamau and Vulule, 2006); while at the coast, *An. gambiae s.l.* collected from in Kilifi, Malindi, and Taveta showed different levels of resistance to deltamethrin, lambdacyhalothrin, and bendiocarb (NMCP, 2016). Despite increasing resistance to pyrethroids by the main malaria vectors, studies conducted in western Kenya from 2011 to 2014 did not find any evidence of association between insecticide resistance and malaria infection in children under 5 years of age (NMCP, 2016).

3.1.4 ITN coverage trends

3.1.4.1 Household ITN ownership

In 2003, just before the start of major ITN programmatic expansion efforts in Kenya, 8 percent of households in the country owned at least one ITN (Figure 3.2). In 2007, following the first free mass campaign in 2006, ownership of at least one ITN had increased to nearly half of all households. By 2015, household ITN ownership
nationally was 63 percent, although not all counties or epidemiologic zones are targeted for net distribution.

**Figure 3.2: Overall household ownership of at least one ITN in Kenya, 2003–2015**

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage of households with at least one ITN</th>
</tr>
</thead>
<tbody>
<tr>
<td>KDHS 2003</td>
<td>8</td>
</tr>
<tr>
<td>KMIS 2007</td>
<td>48</td>
</tr>
<tr>
<td>KDHS 2008</td>
<td>56</td>
</tr>
<tr>
<td>KMIS 2010</td>
<td>48</td>
</tr>
<tr>
<td>KDHS 2014</td>
<td>59</td>
</tr>
<tr>
<td>KMIS 2015</td>
<td>63</td>
</tr>
</tbody>
</table>

**Note:** ITN – insecticide-treated net  
**Source:** Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

In the lake- and coastal-endemic counties, household ITN ownership increased from 12 percent and 13 percent in 2003 to 87 percent and 73 percent in 2015, respectively (Figure 3.3). The malaria-endemic counties benefit from three concurrent net distribution channels: universal coverage mass distribution every 3 years, routine distribution to pregnant women and infants via MCH clinics, and social-marketing to rural households via NGOs and community-based organizations.

**Figure 3.3: Household ownership of at least one insecticide-treated net by endemicity zone in Kenya, 2003–2015**

**Note:** ITN – insecticide-treated net  
**Source:** Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

The gap between urban and rural ownership of at least one ITN also decreased, and by 2015, both residences had similar rates, with ownership slightly above 60 percent
(Figure 3.4). In contrast, by 2015, the households in the poorest quintile owned nearly 20 percent fewer ITNs than those in the highest wealth quintiles (Figure 3.5).

Figure 3.4: Household ownership of at least one insecticide-treated net by residence in Kenya, 2003–2015

![Figure 3.4](image)

Note: ITN – insecticide-treated net
Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

Figure 3.5: Household ownership of at least one insecticide-treated net by wealth quintile in Kenya, 2003–2015

![Figure 3.5](image)

Note: ITN – insecticide-treated net
Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

Figure 3.6 shows the percentage of households that have attained universal coverage of ITNs from 2003 to 2015. As with ITN ownership, universal coverage of ITNs at the household level increased significantly from 4 percent in 2003 to 40 percent in 2015. In
the lake- and coastal-endemic zones, universal coverage increased from 6 to 54 percent and 7 to 46 percent, respectively, from 2003 to 2015.

Figure 3.6: Percentage of households with one insecticide-treated net per two persons in Kenya, 2003–2015

Note: ITN – insecticide-treated net  
Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

3.1.4.2 ITN use by population, children under age 5, and pregnant women

Among all households

Use of ITNs, measured as the percentage of all household members sleeping under an ITN the night before the survey, was 5 percent among all ages in 2003, rising to 48 percent in 2015. Use of ITNs among children under 5 years increased from 6 percent in 2003 to 40 percent in 2010 and to 56 percent in 2015. Similarly, use among pregnant women increased from 3 percent in 2003 to 44 percent in 2015 (Figure 3.7).

Figure 3.7: Insecticide-treated net use among general population, children under 5 years of age, and pregnant women among all households in Kenya, 2003–2015

Note: ITN – insecticide-treated net  
Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)
Among households with at least one ITN

In households with at least one ITN, ITN use by all household members was much higher, increasing from 59 percent in 2003 to 71 percent in 2015. Among children under 5 years in households with at least one ITN, use of ITNs increased from 72 percent in 2003 to 79 percent in 2015. Due to overall low ITN coverage, there were insufficient numbers of women using ITNs recorded in the KDHS of 2003 to allow analysis. However, in the KMIS 2007, approximately 70 percent of pregnant women in households with at least one ITN slept under a net the night before the survey, which increased to 82 percent in 2015 (Figure 3.8). Use of ITNs in the lake-endemic zone increased from 53 percent to 76 percent in households with at least one ITN (Figure 3.9).

Figure 3.8: Insecticide-treated net use among general population, children under 5 years of age, and pregnant women in households with at least one ITN, 2003–2015

![Bar chart showing percentage who slept under an ITN the night before survey in households with at least one ITN from 2003 to 2015.]

Note: ITN – insecticide-treated net; KDHS 2003 had only 48 pregnant women in households with ITNs, which was too few to analyse.

Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

Figure 3.9: Insecticide-treated net use by household members in households with at least one ITN by malaria endemicity, 2003–2015

![Bar chart showing percentage of ITN use by household members of all ages in households with at least one ITN from 2003 to 2015 by malaria endemicity.]
3.1.4.3 Equity in ITN use

Use of ITNs among children under 5 years of age in all households

The gaps in ITN use by location of residence and wealth quintile were reduced between 2003 and 2015. There were no disparities in ITN use between children under 5 years in urban and rural areas by 2015. In 2003, 10 times more children under 5 years of age used ITNs in the highest compared to the lowest wealth quintile; by 2015, the ITN-use gap was reduced to 1.7 times between the highest and lowest wealth quintiles (Table 3.2). This suggests that the current disparity in ITN use by wealth quintile is largely due to disparities in access to ITNs (Table 3.2).

Table 3.2: Use of Insecticide-treated nets among children under 5 years by background characteristic in Kenya, 2003–2015

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>KDHS 2003</th>
<th>KMIS 2010</th>
<th>KMIS 2015</th>
<th>Percentage point change 2003–2015 (95% CI)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6.5 (5.5-7.8)</td>
<td>4.0 (3.8-4.3)</td>
<td>5.5 (50.3-60.4)</td>
<td>48.9 (46.5-51.2)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Female</td>
<td>5.5 (4.3-6.8)</td>
<td>3.9 (3.7-4.2)</td>
<td>5.6 (52.1-61.3)</td>
<td>51.3 (49.0-53.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>12.1 (9.5-15.3)</td>
<td>4.5 (3.9-5.1)</td>
<td>5.9 (51.4-67.7)</td>
<td>47.7 (44.7-50.7)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Rural</td>
<td>4.7 (3.8-5.9)</td>
<td>3.9 (3.7-4.1)</td>
<td>5.4 (48.9-59.8)</td>
<td>49.7 (47.7-51.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Wealth Quintiles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest</td>
<td>1.5 (0.8-2.9)</td>
<td>3.9 (3.6-4.1)</td>
<td>4.0 (32.0-48.4)</td>
<td>38.5 (35.8-41.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Second</td>
<td>3.0 (1.8-4.9)</td>
<td>3.9 (3.2-4.6)</td>
<td>5.6 (50.5-62.5)</td>
<td>53.6 (50.1-57.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Middle</td>
<td>6.2 (4.4-8.5)</td>
<td>3.8 (3.4-4.0)</td>
<td>6.0 (54.4-66.5)</td>
<td>54.3 (50.4-58.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fourth</td>
<td>7.4 (5.4-10.1)</td>
<td>3.8 (3.3-4.8)</td>
<td>5.3 (55.0-70.7)</td>
<td>55.8 (51.6-60.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Highest</td>
<td>14.6 (11.6-18.1)</td>
<td>4.6 (4.0-5.2)</td>
<td>6.6 (50.6-75.8)</td>
<td>52.1 (47.8-56.4)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total</td>
<td>6.0 (5.1-7.1)</td>
<td>4.0 (3.8-4.2)</td>
<td>5.6 (51.6-60.5)</td>
<td>50.1 (48.4-51.7)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Note: N=weighted number of children (denominator); An insecticide-treated net (ITN) is (1) a factory-treated net that does not require any further treatment (i.e., long-lasting insecticidal net or LLIN), or (2) a pre-treated net obtained within

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Note: ITN – insecticide-treated net

Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)
the past 12 months, or (3) a net that has been soaked with insecticide within the past 12 months.

*Baseline for the chi-square test is 2003 compared with results of KMIS 2015; data presented for baseline 2003, midline
2010 and endline 2015.

CI – confidence interval

Source: Kenya Demographic and Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)
Use of ITNs among pregnant women in all households

There were no differences in ITN use among pregnant women based on place of residence. In 2003, 4.5 times more pregnant women used ITNs in the highest compared to the lowest wealth quintile; by 2015, the ITN-use gap was reduced to 1.9 times between the highest and lowest wealth quintiles (Table 3.3).

Table 3.3: Use of Insecticide-treated nets among pregnant women by background characteristic in Kenya, 2003–2015

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>KDHS 2003</th>
<th>KMIS 2010</th>
<th>KMIS 2015</th>
<th>Percentage point change 2003–2015</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residence</td>
<td>% (95%CI)</td>
<td>N</td>
<td>% (95%CI)</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>6.6 (3.7-11.3)</td>
<td>174</td>
<td>38.1 (14.6-68.9)</td>
<td>47</td>
<td>60.0 (49.1-70.0)</td>
</tr>
<tr>
<td>Rural</td>
<td>5.1 (3.4-7.6)</td>
<td>463</td>
<td>39.3 (33.0-46.0)</td>
<td>335</td>
<td>56.3 (47.4-64.9)</td>
</tr>
<tr>
<td>Wealth Quintiles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest</td>
<td>1.7 (0.4-6.9)</td>
<td>143</td>
<td>43.3 (32.5-54.8)</td>
<td>140</td>
<td>35.0 (23.5-48.6)</td>
</tr>
<tr>
<td>Second</td>
<td>4.0 (1.6-9.5)</td>
<td>121</td>
<td>31.9 (15.2-55.5)</td>
<td>22</td>
<td>63.7 (50.8-74.8)</td>
</tr>
<tr>
<td>Middle</td>
<td>6.6 (2.8-14.6)</td>
<td>107</td>
<td>38.2 (28.5-49.0)</td>
<td>113</td>
<td>71.5 (56.0-83.2)</td>
</tr>
<tr>
<td>Fourth</td>
<td>7.4 (3.7-14.1)</td>
<td>109</td>
<td>46.8 (32.3-61.8)</td>
<td>50</td>
<td>52.4 (37.7-66.8)</td>
</tr>
<tr>
<td>Highest</td>
<td>7.6 (4.4-12.8)</td>
<td>157</td>
<td>29.3 (13.6-52.2)</td>
<td>57</td>
<td>67.0 (51.9-79.3)</td>
</tr>
<tr>
<td>Total</td>
<td>5.4 (3.9-7.5)</td>
<td>637</td>
<td>39.1 (32.1-46.7)</td>
<td>382</td>
<td>57.8 (51.0-64.2)</td>
</tr>
</tbody>
</table>

Note: N=weighted number of children (denominator); An insecticide-treated net (ITN) is (1) a factory-treated net that does not require any further treatment (i.e., long-lasting insecticidal net or LLIN), or (2) a pre-treated net obtained within the past 12 months, or (3) a net that has been soaked with insecticide within the past 12 months.

*Baseline for the chi-square test is 2003 compared with results of KMIS 2015; data presented for baseline 2003, midline 2010 and endline 2015.

CI – confidence interval Source: Kenya Demographic and Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

3.1.5 ITN summary

- Between 2003 and 2015, over 50 million free ITNs were distributed.
- Both overall ITN ownership, from 8 to 63 percent, and use, from 5 to 48 percent, increased significantly from 2003 to 2015.
- In the targeted lake- and coastal-endemic zones, with three concurrent ITN distribution channels, ownership increased from 12 to 87 percent and 13 to 73 percent, respectively, from 2003 to 2015.
- In households with at least one ITN, use among children under 5 years and pregnant women increased from 66 to 79 percent and 70 to 82 percent, respectively, from 2007 to 2015.
- Overall, universal coverage (i.e., at least one ITN per two person per household) or access increased from 4 to 40 percent from 2003 to 2015.
- In the targeted lake- and coastal-endemic zones, with three concurrent ITN distribution channels, universal coverage or access increased from 6 to 54 percent and 7 to 46, respectively, from 2003 to 2015.
- Although disparities by residence and socioeconomic status have been substantially reduced, the poorest quintile of the population continues to have lower ITN ownership and reported use compared to those in the wealthiest quintile of the population.
- Widespread resistance to pyrethroids and DDT has been documented in the main malaria vectors in western Kenya; however, evidence shows that LLINs remain effective as a malaria prevention intervention.
3.2 Indoor Residual Spraying

3.2.1 Background

In Kenya, IRS use started as early as 1944 in Kericho, located in the highland epidemic-prone zone, using DDT. Through the 1950s, IRS activities continued, focusing on farming and irrigation areas across the country. By the late 1970s, IRS activities had all but ceased, with malaria treated presumptively through the primary health care system as a febrile disease. The suspension of vector control activities and the gradual increase in chloroquine resistance led to a resurgence in malaria in the endemic areas in 1980s and 1990s. The 1997–1998 El Niño resulted in massive malaria epidemics across the country. In response to these epidemics, the government reintroduced IRS in 2000, focusing on highland epidemic-prone districts and using pyrethroids, and from 2005 to 2009, IRS was the main vector control strategy for epidemic prevention and response in the highland epidemic-prone zone. From 2010, the country adopted IRS as a vector control strategy for reduction of disease burden and implemented the strategy in three high-burden districts in the lake-endemic zone through 2012.

3.2.2 IRS policy

In 2005, the GOK introduced a coordinated approach for implementing IRS to prevent epidemics in the highland epidemic-prone zone. In the 2009 Integrated Vector Management Policy Guidelines, Kenya set a series of regulatory and implementation guidelines for IRS, including a recommendation to use IRS as a complementary vector control intervention in endemic areas with high stable transmission of malaria (MOPHS 2009b). The Pest Control Products Board was identified as the lead organization responsible for the registration of insecticides for public health use, including IRS, using “sufficient evidence of efficacy, cost-effectiveness, safety and conformity to WHO specifications” (add reference here). Since the start of contemporary IRS efforts in Kenya in 2000, pyrethroids have been the main insecticide used for IRS. With the emergence of high levels of pyrethroid resistance demonstrated in western Kenya, the NMCP and partners developed an IRS business plan to guide IRS implementation between 2015 and 2018 (Ministry of Health, 2015a) and an insecticide resistance management strategy in line with the WHO strategy for mitigation of insecticide resistance (Ministry of Health, 2015b).

3.2.3 IRS implementation

Since 2002, IRS has been largely focused in highland epidemic-prone counties with a goal of 85 percent coverage of targeted households (Ministry of Health, 2015a). The IRS program was implemented with funding mainly from the GOK, Global Fund, DFID, PMI, and WHO. The GOK and WHO supported the intervention from 2002 to 2005; the GOK, Global Fund and DFID supported it from 2005 to 2008; and the GOK and PMI provided support from 2008 to 2012. Lambda-cyhalothrin, deltamethrin, and alpha-cypermethrin (i.e., all pyrethroid insecticides) have been used in a single yearly spray cycle implemented just before the malaria high-transmission season, which generally starts in June.

In 2010, IRS began in districts in the malaria endemic counties of Migori and Homa Bay in an effort to rapidly reduce transmission. From 2005 to 2010, IRS coverage in target areas increased from less than 100,000 house units covering about 300,000 people to 1.6 million
housing units covering 4.8 million people or almost 90 percent of the target population in the districts as shown in Table 3.4. Due to global concerns around increasing resistance to insecticides, the NMCP began monitoring insecticide resistance in Kenya in 2009. The Kenya Medical Research Institute (KEMRI) started insecticide resistance monitoring in lake-endemic and highland epidemic-prone counties in 2009 (Kiambo Njagi, personal communication). Additional studies in the coastal-endemic and lake-endemic counties investigating the combined effectiveness of ITNs and IRS in a series of controlled trials started in 2010 (Charles Mbogo, personal communication). Figure 3.10 presents the malaria epidemiological zones covered by IRS from 2005 to 2012. The IRS program was stopped between 2013 and 2015 as the GOK reviewed and adopted strategic and regulatory frameworks for the implementation of non-pyrethroid insecticides (Ministry of Health, 2015a).

Figure 3.10: Malaria epidemiological zones covered by IRS implementation in Kenya from 2005–2012

Note: While data are provided by county, indoor residual spraying did not target entire counties for either epidemic prevention and response or burden reduction.

### 3.2.4 Trends in IRS implementation areas

During the implementation period, IRS was conducted in parts of highland epidemic-prone and lake-endemic counties. The coverage rose from less than 15 percent of all targeted structures in 2005 to over 90 percent in 2012. The total population protected varied by year based on the number of target house units sprayed as shown in Table 3.4.

<table>
<thead>
<tr>
<th>Year</th>
<th>Target housing units</th>
<th>Housing units sprayed</th>
<th>% Housing unit coverage</th>
<th>Population protected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 2005</td>
<td>680,000</td>
<td>93,000</td>
<td>13.7</td>
<td>279,000</td>
</tr>
</tbody>
</table>
3.2.5 IRS summary

- From 2000 to 2009, IRS using pyrethroids was implemented for malaria epidemic prevention and response in part of 12 highland epidemic-prone counties.
- From 2010 to 2012, IRS using pyrethroids was implemented in parts of three malaria-endemic counties, which bordered highland epidemic-prone counties, for burden reduction and in highland epidemic-prone counties only for epidemic response.
- From 2013 to 2015, no IRS was implemented as the GOK reviewed and adopted strategic and regulatory frameworks for use of non-pyrethroid insecticides to mitigate emerging pyrethroid resistance.

3.3 Intermittent Preventive Treatment in Pregnancy

3.3.1 Background

Due to the substantial risks posed to the life and well-being of the pregnant mother, foetus and neonate, malaria in pregnancy is considered an important health problem in malaria endemic countries (WHO, 2015). In addition to protection with ITNs during pregnancy, IPTp with SP beginning early in the second trimester is the other main malaria prevention approach in pregnancy. Following the results of a meta-analysis of efficacy studies (Garner and Gülmezoglu, 2006), WHO initially recommended at least 2 doses of IPTp during pregnancy (WHO, 2007c) for all pregnant women at risk of malaria. As SP resistance increased, studies showed that at least 3 doses of IPTp conferred greater protection, and consequently, WHO revised its recommendations to give IPTp at each ANC visit after the first trimester in areas of moderate-to-high malaria transmission (WHO, 2012).

3.3.2 IPTp policy

Both in the first and second NMS, IPTp was a key approach to prevent malaria in pregnant women in Kenya (MOPHS 2009a). Initially, IPTp was recommended nationally starting in 1998, but as the understanding of the heterogeneity of malaria in Kenya improved (Noor et al., 2009), the policy was changed to implementation only in areas of moderate to high transmission (MOPHS, 2009a), which included the 14 counties of the lake- and coastal-endemic zones. In 2011, the NMCP issued simplified IPTp guidance to all health facilities in the lake- and coastal-endemic zones providing focused ANC services to encourage a doses of IPTp with SP at each scheduled ANC visit after quickening, with a minimum of two doses at least 4 weeks apart, in order help meet national targets. In late 2014, Kenya revised the IPTp strategy to explicitly state that all pregnant women should receive at least three doses of IPTp with SP during ANC visits in the 14 malaria-endemic counties (Ministry of Health, 2014a).
However, the revised IPTp strategy was not operationalized until 2015, and only IPTp doses 1 and 2 were reported via the routine HIS through the end of 2015.

3.3.3 IPTp implementation
In 2002, the focused ANC and malaria in pregnancy program was rolled out nationwide to improve coverage of IPTp with SP. Starting in 2004, the Global Fund supported scaling up IPTp integrated with reproductive health services. Subsequently, funding from the Global Fund, PMI and other sources has been used to ensure the delivery of IPTp with SP routinely in targeted endemic areas.

3.3.4 SP resistance and implications for IPTp policy
Several studies showed rapidly expanding resistance levels and by 2003, SP had been designated a failed drug for the treatment of uncomplicated malaria in the Kenya (Bousema et al., 2003). However, the evidence of SP resistance on intermittent preventive treatment of malaria in pregnant women remains inconclusive (WHO, 2007c) Subsequently, the WHO still recommends SP for IPTp (WHO, 2012).

3.3.5 Trends in IPTp coverage
Data on IPTp coverage was obtained from national household survey data and defined using a denominator of women ages 15–49 with a live birth in the 2 years preceding the survey. In the lake and coastal malaria-endemic zones where the intervention is targeted, coverage of IPTp2 increased from 9 and 26 percent in 2007 to 53 and 60 percent in 2015, respectively (Figure 3.12).

Figure 3.11: Pregnant women who received at least two doses of intermittent preventive treatment during pregnancy nationwide in Kenya, 2003–2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Proportion of pregnant women receiving two or more doses of IPTp</th>
</tr>
</thead>
<tbody>
<tr>
<td>KDHS 2003</td>
<td>5</td>
</tr>
<tr>
<td>KMIS 2007</td>
<td>12</td>
</tr>
<tr>
<td>KDHS 2008</td>
<td>15</td>
</tr>
<tr>
<td>KMIS 2010</td>
<td>26</td>
</tr>
<tr>
<td>KDHS 2014</td>
<td>18</td>
</tr>
<tr>
<td>KMIS 2015</td>
<td>35</td>
</tr>
</tbody>
</table>

Note: IPTp – intermittent preventive treatment in pregnancy
Source: Kenya Demographic and Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

Figure 3.12: Pregnant women who received at least two doses of intermittent preventive treatment during their last pregnancy by endemicity in Kenya, 2003–2015
3.3.5.1 Equity in IPTp coverage
Although coverage increased across all socioeconomic classes from 2003 to 2015, coverage was marginally higher among the poorest households. Between 2003 and 2010, mothers with a secondary school or higher education were likely to receive at least two doses of IPTp2 compared to those with no education. However, by 2015, this difference had disappeared.

3.3.6 IPTp summary
- IPTp2 increased from 9 and 26 percent in 2007 to 53 and 60 percent in 2015 in the lake and coastal malaria endemic zones, respectively.

3.4 Malaria Case Management

3.4.1 Background
Prompt diagnosis and treatment with effective drugs is the cornerstone to reducing morbidity and mortality. The WHO has recommended artemisinin-based combination therapies (ACTs) for the treatment of uncomplicated malaria across malaria-endemic countries, especially those in sub-Saharan Africa where *P. falciparum* is the main parasite. Under the Test, Treat, and Track policy, the WHO also recommends the confirmation of parasitemia in people with malaria symptoms when they visit health facilities and treatment with ACTs for only those who are positive. In Kenya, ACTs are available, free in the public health sector and at subsidized prices in the private sector, following the introduction of the Affordable Medicines Facility-malaria (AMFm) in 2010.

3.4.2 Case management policy
Prior to 1998, the first-line drug for the treatment of uncomplicated malaria was chloroquine (CQ). Although CQ was a very effective drug for many years, more than 40 percent of malaria infections in children treated with CQ failed to clear by day 7 on the Kenyan coast by 1987 (Brandling-Bennett et al., 1988, Watkins et al., 1984, Spencer et al.,...
1984), and by 1991, widespread CQ-treated clinical failures had been reported across the country. In 1998, CQ was replaced with SP as the recommended first-line treatment, and national treatment guidelines were revised (Ministry of Health, 1998). However, by 2003, SP had failed across the country for the treatment of clinical malaria (Bousema et al., 2003). In 2004, the national policy changed from SP to an ACT, artemether-lumefantrine (AL), as the recommended first-line treatment of uncomplicated malaria (Ministry of Health, 2006). In 2006, the GOK made malaria RDTs available in public-sector facilities in low-transmission zones, and in 2009, the GOK extended the case management policy to include parasitological testing, via malaria RDTs or microscopy, for all patients with suspected malaria (MOPHS, 2009a). Prior to 2009, only patients over 5 years of age required parasitological testing before treatment; fevers in children under 5 years were presumptively treated as malaria in line with the integrated management of childhood illnesses (IMCI) guidelines (Ministry of Health, 2006). In late 2012, the GOK initiated a national rollout of malaria RDTs to increase parasitological testing prior to treatment, and by 2015, 97 percent of public-sector health facilities had malaria diagnostic capacity (Machini et al., 2016). Since 2010 in focused areas of the lake-endemic counties, community case management of malaria has been ongoing with Global Fund support, and integrated community case management (iCCM) has been ongoing with support from DFID, United National Children’s Fund (UNICEF) and WHO. The NMS 2009–2017 targets for malaria case management are that 100 percent of health facilities have AL and malaria diagnostics and 100 percent of patients with fever who present to health workers should receive parasitological diagnosis of malaria and recommended treatment (MOPHS, 2009a, Ministry of Health, 2014a).

3.4.3 Implementation of antimalarial and malaria diagnostic policy

Between 2006 and 2015, the main malaria case-management activities included the following: procurement and distribution of SP, AL, malaria RDTs, microscopes and microscopy supplies; development, revision, and distribution of new case-management guidelines (MOPHS, 2010, MOPHS, 2012, Ministry of Health, 2014b) and job aids for health workers; national in-service trainings for front-line health workers linked to guideline revisions for both case management and malaria diagnostics (Ministry of Health, 2014b); and strengthening of supervision and quality assurance.

3.4.4 Trends in diagnostic capacity and AL availability

The evaluation used the biannual nationally representative, health-facility surveys on quality of care for malaria in public and non-profit health facilities to assess trends in case management and malaria commodity availability. Between January 2010 and December 2015, ten health facility surveys were conducted. There were no reliable routine data on commodity availability before 2010. Compared to baseline in 2010, there was near universal capacity of health facilities to provide parasitological malaria diagnosis by the end of 2015 (Figure 3.13), representing a 42 percentage point increase in health facilities providing parasitological diagnosis. The increase in diagnostic capacity was due entirely to the increased availability of malaria RDTs, as a result of policy changes at the end of 2012.

Figure 3.13: National trends in malaria diagnostic capacity in public and non-profit health facilities in Kenya, 2010–2015
The commodity assessments on survey days showed that the availability of at least one AL pack was very high from 2010 to 2015 with the exception of 2014 (Figure 3.14). The proportion of health facilities stocking all four AL weight-band packs was significantly lower and more erratic throughout the monitoring period. The lack of malaria commodities observed at the health-facility level was a function of primarily the transition to a ‘pull’ system of commodity distribution following devolution of health service delivery to counties.
Stock-out of malaria medicine was defined as stock-out of at least 7 consecutive days over a 3-month period prior to the surveys. A substantial decline in AL stock-outs was observed with the proportion of health facilities reporting simultaneous stock-out of all four AL packs declining from 27 percent in 2010 to 12 percent during the last survey round (Figure 3.15).

Note: FU = follow up; AL = artemether-lumefantrine
3.4.5 Trends in malaria case management

3.4.5.1 Population-based indicators

Diagnostic testing in children

Universal parasitological diagnosis to confirm malaria in febrile patients before treatment was introduced in 2009. However, malaria RDTs were not available widely until 2014. Prior to 2009, presumptive treatment for malaria was the norm and was policy for children under 5 years consistent with IMCI guidance (Ministry of Health, 2006). Diagnostic testing was measured at the population level using a proxy indicator defined as the proportion of children under 5 years with fever who had blood taken from a finger or heel stick. Nationally, the proportion of children tested was 13 percent in 2010 and increased to 39 percent in 2015 (Figure 3.16).

Figure 3.16: Percentage of children under 5 years of age with fever in the 2 weeks before the survey who had blood taken from a finger or heel for testing in Kenya, 2010-2015

![Graph showing percentage of children with fever in the last two weeks who received a finger or heel prick test in Kenya from 2010 to 2015.]

Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

The lake- and coastal-endemic zones experienced the largest increases in diagnostic testing of children under 5 years. In the lake-endemic zone, diagnostic testing increased from 12 percent in 2010 to 58 percent in 2015, and in the coastal-endemic zone, testing increased from 14 percent in 2010 to 44 percent in 2015 (Figure 3.17).

Figure 3.17: Distribution of children under 5 years of age with fever in the 2 weeks before the survey who had blood taken from a finger or heel for testing by endemicity zone in Kenya, 2010-2015

![Graph showing distribution of children with fever in the last two weeks by endemicity zone in Kenya from 2010 to 2015.]

Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)
Table 3.5 shows the demographic characteristics of children under 5 years of age with fever in the 2 weeks preceding the interview who had blood taken from a finger or heel. Significant increases were observed in both urban and rural areas from 2010 to 2015, with coverage increasing from 28 percent to 44 percent in urban areas and from 12 percent to 37 percent in rural areas.

Table 3.5: Distribution of children under 5 years of age with fever in the 2 weeks before the survey who had blood taken from a finger or heel for testing, by demographic characteristic, in Kenya, 2010–2015

<table>
<thead>
<tr>
<th>Background characteristic</th>
<th>KMIS 2010</th>
<th>KDHS 2014</th>
<th>KMIS 2015</th>
<th>Percentage point change 2003-2005 (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% (95% CI)</td>
<td>n</td>
<td>% (95% CI)</td>
<td>n</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>14.1 (9.8-19.8)</td>
<td>445</td>
<td>35.2 (32.5-38.0)</td>
<td>2,402</td>
<td>36.7 (31.9-41.8)</td>
</tr>
<tr>
<td>Female</td>
<td>11.9 (8.4-16.6)</td>
<td>429</td>
<td>35.0 (32.3-37.7)</td>
<td>2,340</td>
<td>42.0 (36.3-47.9)</td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>27.9 (15.7-44.5)</td>
<td>85</td>
<td>38.8 (35.1-42.7)</td>
<td>1,484</td>
<td>44.0 (36.7-51.5)</td>
</tr>
<tr>
<td>Rural</td>
<td>11.7 (8.8-15.4)</td>
<td>789</td>
<td>33.3 (31.0-35.8)</td>
<td>3,258</td>
<td>37.2 (31.8-42.9)</td>
</tr>
<tr>
<td>Wealth Quintiles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest</td>
<td>9.1 (5.9-13.9)</td>
<td>396</td>
<td>30.6 (27.3-34.1)</td>
<td>1,524</td>
<td>29.2 (23.1-36.3)</td>
</tr>
<tr>
<td>Second</td>
<td>7.7 (3.3-16.9)</td>
<td>48</td>
<td>37.0 (33.3-40.9)</td>
<td>1,138</td>
<td>42.3 (33.9-51.3)</td>
</tr>
<tr>
<td>Middle</td>
<td>12.7 (8.8-18.2)</td>
<td>236</td>
<td>31.9 (27.8-36.2)</td>
<td>836</td>
<td>39.7 (31.3-48.7)</td>
</tr>
<tr>
<td>Fourth</td>
<td>12.4 (6.6-22.0)</td>
<td>109</td>
<td>34.1 (29.7-38.7)</td>
<td>706</td>
<td>37.5 (28.6-47.3)</td>
</tr>
<tr>
<td>Highest</td>
<td>37.3 (24.4-52.4)</td>
<td>85</td>
<td>44.5 (39.3-49.9)</td>
<td>538</td>
<td>51.8 (41.7-61.8)</td>
</tr>
<tr>
<td>Total</td>
<td>13.0 (10.0-16.7)</td>
<td>874</td>
<td>35.1 (33.1-37.1)</td>
<td>4742</td>
<td>39.2 (34.9-43.7)</td>
</tr>
</tbody>
</table>

Note: n=weighted number of children (denominator); baseline for the chi-square test is 2010 compared with results from 2015; data presented for 2010, 2014 and 2015.
Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

3.4.5.1.1 Treatment in children

In 2003, the percentage of children under the age of 5 years who had fever in the last 2 weeks and sought treatment for fever at an appropriate source (i.e., public and private health facilities, pharmacies and drug stores) was 60 percent. The percentage declined to 51 percent in 2007 and increased to 70 percent by 2015 (Figure 3.18). The percentage of children with fever who sought treatment and were given any antimalarials was 26 percent in 2003, reached a peak of 37 percent in 2010 then declined to 27 percent in 2015. Figure 3.19 shows that the percentage of children under 5 years with fever who were treated with any antimalarial decreased in all transmission zones except the lake-endemic zone from 2003 to 2015.

Figure 3.18: Treatment seeking for children under 5 years of age with fever in the 2 weeks prior to the survey in Kenya, 2003–2015
Among children under 5 years who received treatment for malaria, 42 percent of children received the recommended first-line treatment (i.e., SP) in 2003 compared to 92 percent of children who received the recommended first-line treatment (i.e., AL) in 2015 (Figure 3.20). A similar trend was observed by malaria-endemicity zones (Figure 3.21).

**Figure 3.20:** Children under 5 years of age treated with an antimalarial who received the recommended first-line treatment in Kenya, 2003–2015
Note: From 2003–2005, the recommended first-line antimalarial was sulfadoxine-pyrimethamine; from 2006–2015, the recommended first-line antimalarial was artemether-lumefantrine.

Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)
Treatment with the recommended first-line antimalarial did not vary by sex or residence of the child. By 2015, there was a substantial disparity in use of the recommended treatment by mother’s education, with 97 percent of the children whose mothers had a secondary or higher education receiving the recommended treatment versus 77 percent of children whose mothers had no education (Table 3.6).

Table 3.6: Use of recommended first-line treatment among children under 5 years of age who took an antimalarial, by demographic characteristic, in Kenya, 2003–2015

<table>
<thead>
<tr>
<th>Demographic characteristic</th>
<th>KDHS 2003</th>
<th>KMIS 2010</th>
<th>KMIS 2015</th>
<th>Percentage point change 2003–2015 (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>40.3 (33.6-47.3)</td>
<td>53.5 (43.6-63.2)</td>
<td>91.0 (84.3-95.0)</td>
<td>50.8 (43.7-58.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Female</td>
<td>42.7 (35.3-50.5)</td>
<td>50.4 (39.3-61.5)</td>
<td>92.3 (86.4-95.8)</td>
<td>49.6 (42.7-56.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>42.8 (36.6-49.3)</td>
<td>47.1 (24.6-70.8)</td>
<td>92.9 (82.6-97.3)</td>
<td>50.3 (43.8-56.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Rural</td>
<td>34.1 (24.5-45.3)</td>
<td>52.7 (44.5-60.8)</td>
<td>91.2 (85.7-94.7)</td>
<td>57.5 (48.5-66.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mother’s education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>44.3 (32.9-56.4)</td>
<td>56.6 (37.0-74.3)</td>
<td>76.8 (51.6-91.1)</td>
<td>32.6 (16.1-49.1)</td>
<td>0.001</td>
</tr>
<tr>
<td>Primary</td>
<td>39.3 (33.2-45.8)</td>
<td>54.4 (45.1-63.4)</td>
<td>90.0 (83.8-94.0)</td>
<td>50.8 (44.2-57.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Secondary</td>
<td>46.2 (35.7-57.1)</td>
<td>45.3 (31.4-60.1)</td>
<td>97.4 (91.0-99.3)</td>
<td>51.6 (42.3-60.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total</td>
<td>41.5 (36.0-47.3)</td>
<td>52.2 (44.4-59.9)</td>
<td>91.6 (87.1-94.7)</td>
<td>50.2 (45.2-55.2)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Note: n=weighted number of children (denominator); baseline for the chi-square test is 2003 compared with results from 2015; data presented for baseline 2003, midline 2010 and endline 2015. From 2003–2005, the recommended first-line antimalarial was sulfadoxine-pyrimethamine; from 2006–2015, the recommended first-line antimalarial was artemether-lumefantrine.

Source: Kenya Demographic Health Survey (KDHS); Kenya Malaria Indicator Survey (KMIS)

3.4.5.2 Health-facility-based indicators
The evaluation used the biannual nationally-representative, health-facility surveys, conducted between 2010 and 2015, on quality of care in public and non-profit health...
facilities to assess trends in malaria case management. In line with national case-management guidelines (MOPHS, 2010), a composite malaria case-management performance indicator was developed. To meet the performance indicator, the following criteria had to be met: 1) the febrile patient was tested for malaria; 2) if a positive test result was reported, the patient was treated with AL, and 3) if a negative test result was reported, the patient was not treated for malaria. Overall, the composite performance indicator significantly improved from 28.1 percent in 2010 to 61.2 percent in 2015. The recommended first-line treatment, AL, was used for the majority of patients with positive test results between 2010 and 2015. Among patients with a negative test result, a significant decline in treatment with an antimalarial was observed in 2015 compared to the 2010 (52 percent versus 7 percent) (Figure 3.22).

Figure 3.22: Trends in the performance of malaria diagnosis and treatment in accordance with national case-management guidelines among patients with fever seen at public and non-profit health facilities in Kenya, 2010–2015

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>2010</td>
<td>28</td>
<td>28</td>
<td>31</td>
<td>30</td>
<td>31</td>
<td>21</td>
<td>17</td>
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<tr>
<td>2011</td>
<td>43</td>
<td>44</td>
<td>44</td>
<td>57</td>
<td>48</td>
<td>55</td>
<td>47</td>
<td>57</td>
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<tr>
<td>2012</td>
<td>50</td>
<td>40</td>
<td>58</td>
<td>58</td>
<td>58</td>
<td>63</td>
<td>60</td>
<td>62</td>
<td>69</td>
<td>61</td>
</tr>
<tr>
<td>2013</td>
<td>53</td>
<td>57</td>
<td>43</td>
<td>50</td>
<td>44</td>
<td>57</td>
<td>67</td>
<td>62</td>
<td>69</td>
<td>66</td>
</tr>
<tr>
<td>2014</td>
<td>75</td>
<td>44</td>
<td>83</td>
<td>89</td>
<td>93</td>
<td>83</td>
<td>88</td>
<td>91</td>
<td>99</td>
<td>84</td>
</tr>
</tbody>
</table>

Note: FU – follow up, AM – antimalarial; +ve – positive; -ve – negative
*Composite performance indicator comprised three criteria: 1) febrile patient was tested for malaria; 2) if a positive test result was reported, the patient was treated with artemether-lumefantrine, and 3) if a negative test result was reported, the patient was not treated with an antimalarial.

3.4.6 Equity in malaria case management

Treatment with the recommended first-line antimalarial was variable with socioeconomic status across the national surveys with no discernible sustained trend (Figure 3.23).
3.4.7 Malaria case management summary

- The availability of malaria diagnostics increased from 55 to 97 percent in public sector health facilities from 2010 to 2015, with all of the gains from increased availability of malaria RDTs.

- The recommended first-line medication, AL, was available in 90 percent or more of public sector health facilities from 2010 to 2015, except for during 2014.

- Healthcare worker adherence to national treatment guidelines more than doubled from 28 to 61 percent nationally from 2010 to 2015 in public sector health facilities.

- Overall, children under 5 years of age treated with an antimalarial who received the recommended first-line medication increased from 42 to 92 percent from 2003 to 2015.

- In the lake- and coastal-endemic zones, children under 5 years of age treated with an antimalarial who received the recommended first-line medication increased from 40 to 94 percent and from 34 to 95 percent, respectively, from 2003 to 2015.
4 Trends in Malaria Morbidity

4.1 Background
The most commonly used measure of malaria transmission is the malaria parasite prevalence rate (Smith and Hay, 2009, Hay et al., 2008), measured during cross-sectional population surveys. In stable malaria-transmission areas, such as the lake- and coastal-endemic areas, severe anemia is a common consequence of malaria infection in children and contributes to a large proportion of deaths due to malaria (Korenromp et al., 2004, Odhiambo et al., 2008). Infection with the malaria \textit{P. falciparum} parasite causes the destruction of erythrocytes, or red blood cells, and reduces erythrocyte production in the bone marrow leading to anemia (Haldar and Mohandas, 2009). Changes in the prevalence of malaria parasites and severe anemia in young children in high-transmission settings are, therefore, strong signals of the changes in the burden of malaria. For purposes of monitoring the impact of malaria control interventions, severe anemia is defined as blood hemoglobin levels <8 g/dL (Korenromp et al., 2011).

Prior to the national expansion of malaria RDTs in 2012, most malaria cases seen at health facilities were diagnosed by clinical signs and symptoms, and fevers among children were empirically treated as malaria. Since 2010, national guidelines have recommended parasitological diagnosis for all persons suspected of having malaria (MOPHS, 2010)), but regular reporting of test results only started in earnest in 2015 (Githinji et al., 2017). Therefore, available routine health data from the health management information system, District Health Information Software 2 (DHIS2), do not provide sufficient data points for malaria indicators over time to inform the impact evaluation. Alternatively, malaria inpatient data from a set of hospitals (Okir et al., 2009, 2010, 2011, 2013) have been used to describe the trends in confirmed malaria cases.

4.2 Population-Based Trends in Malaria Morbidity in Children
There have been three national Kenya malaria indicator surveys that measured the prevalence of malaria parasitemia and anemia among children under 5 years of age at the community level in 2007, 2010 and 2015. Each of the three surveys measured malaria parasitemia and anemia in different age groups: 3 to 59 months (2007), 3 months to 14 years (2010), and 6 months to 14 years (2015). For comparison purposes, data for children ages 6 to 59 months were analysed across all surveys.

4.2.1 Trends in prevalence of malaria parasites in children
Malaria parasite prevalence in children under 5 years of age, as measured using microscopy, was 3.3 percent nationally in 2007, rose to 9.2 percent in 2010 and declined to 5.0 percent in 2015. In each survey, parasite prevalence was highest in the lake- and coastal-endemic areas. The rise in 2010 was mainly attributable to an increase in the parasite prevalence rate in the lake-endemic zone. However, by 2015, the parasite prevalence (16.6 percent) had been reduced by almost half in the lake-endemic zone compared to the 2010 prevalence (32.9 percent). In the coastal-endemic zone, the parasite prevalence rose from 3.1 percent in 2010 to 5.3 percent in 2015 (Figure 4.1).
Figure 4.1: Malaria parasite prevalence by microscopy in children under 5 years of age by malaria endemicity zone in Kenya, 2007–2015

<table>
<thead>
<tr>
<th>Malaria endemicity zone</th>
<th>KMIS 2007 (%)</th>
<th>KMIS 2010 (%)</th>
<th>KMIS 2015 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (National)</td>
<td>3.3 ± 2.9</td>
<td>0.0 ± 0.1</td>
<td>0.2 ± 0.1</td>
</tr>
<tr>
<td>Low risk</td>
<td>4.0 ± 3.1</td>
<td>9.2 ± 8.7</td>
<td>3.1 ± 2.6</td>
</tr>
<tr>
<td>Seasonal transmission</td>
<td>0.4 ± 0.0</td>
<td>0.2 ± 0.5</td>
<td>1.8 ± 1.3</td>
</tr>
<tr>
<td>Highland endemic</td>
<td>0.4 ± 0.3</td>
<td>0.1 ± 0.2</td>
<td>0.5 ± 0.2</td>
</tr>
<tr>
<td>Coastal Endemic</td>
<td>2.6 ± 1.8</td>
<td>0.2 ± 0.1</td>
<td>0.4 ± 0.1</td>
</tr>
<tr>
<td>Lake Endemic</td>
<td>4.0 ± 3.0</td>
<td>8.7 ± 7.9</td>
<td>3.1 ± 2.0</td>
</tr>
</tbody>
</table>

Note: Parasite prevalence data not available for Kenya demographic and health surveys due to lack of biomarker testing.
Source: Kenya Malaria Indicator Survey (KMIS)

Across the three surveys, malaria parasitemia prevalence was highest in the poorest quintiles and in rural areas (Table 4.1).

Table 4.1: Malaria parasite prevalence in children under 5 years of age by demographic characteristic in Kenya, 2007–2015

<table>
<thead>
<tr>
<th>Background characteristic</th>
<th>KMIS 2007 (%)</th>
<th>KMIS 2010 (%)</th>
<th>KMIS 2015 (%)</th>
<th>Percentage point change (95% CI)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3.4 (2.4-4.9)</td>
<td>9.7 (7.3-12.9)</td>
<td>4.9 (3.6-6.7)</td>
<td>1.5 (0.3-2.8)</td>
<td>0.015</td>
</tr>
<tr>
<td>Female</td>
<td>3.2 (2.1-4.9)</td>
<td>8.7 (6.1-12.2)</td>
<td>5.0 (3.6-6.8)</td>
<td>1.8 (0.5-3.0)</td>
<td>0.004</td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>1.4 (0.5-3.9)</td>
<td>1.0 (0.4-2.7)</td>
<td>1.9 (1.1-3.2)</td>
<td>0.5 (-0.6-1.7)</td>
<td>0.404</td>
</tr>
<tr>
<td>Rural</td>
<td>3.6 (2.4-5.2)</td>
<td>10.7 (8.0-14.2)</td>
<td>6.3 (4.6-8.5)</td>
<td>2.7 (1.5-3.9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Wealth Quintiles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest</td>
<td>3.9 (1.6-9.1)</td>
<td>1.060</td>
<td>13.8 (9.8-19.1)</td>
<td>1.807</td>
<td>5.7 (3.6-9.1)</td>
</tr>
<tr>
<td>Second</td>
<td>4.0 (2.6-6.1)</td>
<td>1.163</td>
<td>7.6 (3.9-14.1)</td>
<td>2.14</td>
<td>8.9 (6.4-12.4)</td>
</tr>
<tr>
<td>Middle</td>
<td>4.2 (2.4-7.2)</td>
<td>0.845</td>
<td>10.7 (7.4-15.2)</td>
<td>1.179</td>
<td>4.7 (3.1-7.2)</td>
</tr>
<tr>
<td>Fourth</td>
<td>2.8 (1.7-4.5)</td>
<td>0.982</td>
<td>3.7 (2.1-6.6)</td>
<td>0.461</td>
<td>2.9 (1.7-5.1)</td>
</tr>
<tr>
<td>Highest</td>
<td>0.7 (0.3-1.7)</td>
<td>0.630</td>
<td>0.6 (0.1-2.3)</td>
<td>0.491</td>
<td>0.9 (0.3-2.9)</td>
</tr>
</tbody>
</table>

Note: n=weighted number of children (denominator); *baseline for the chi-square test is 2007 compared with results from 2015; data presented for baseline 2007, midline 2010 and endline 2015. Parasite prevalence data not available for Kenya demographic and health surveys due to lack of biomarker testing.
Source: Kenya Malaria Indicator Survey (KMIS)
4.2.2 Trends in severe anemia prevalence (Hb<8g/dL) in children

Nationally, severe anemia showed similar trends as malaria parasitemia, rising from 4.4 percent in 2007 to 5.1 percent in 2010 before declining to 2.6 percent in 2015. Although severe anemia was highest in the coastal-endemic zone in 2007, declines were observed in each subsequent survey. However, severe anemia increased from 2007 to 2010 in the lake-endemic, highland epidemic-prone and seasonal-risk zones before declining in 2015; however, the declines were not statistically significant. Similar to malaria parasitemia, by 2015, the severe anemia prevalence (3.4 percent) had been reduced by over half in the lake-endemic zone compared to the 2010 prevalence (6.9 percent) (Figure 4.2).

Figure 4.2: Severe anemia prevalence in children ages 6 to 59 months overall and by malaria endemicity zone in Kenya, 2007–2015

-severe anemia prevalence in children (Hb<8g/dL) in children

Severe anemia declined across all wealth quintiles except the second quintile between 2003 and 2015. Between 2003 and 2015, severe anemia in children living in both urban and rural areas also declined significantly (Table 4.2).
### Table 4.2: Severe anemia prevalence in children ages 6 to 59 months by demographic characteristic in Kenya, 2007–2015

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>KMIS 2007</th>
<th>KMIS 2010</th>
<th>KMIS 2015</th>
<th>Percentage point change (95% CI)</th>
<th>p-value *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% (95% CI)</td>
<td>n</td>
<td>% (95% CI)</td>
<td>n</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>4.4 (3.4-5.6)</td>
<td>2,353</td>
<td>4.8 (3.5-6.4)</td>
<td>2,058</td>
<td>-1.9 (-3.0-0.8)</td>
</tr>
<tr>
<td>Female</td>
<td>3.6 (2.7-4.6)</td>
<td>2,305</td>
<td>3.2 (2.3-4.5)</td>
<td>2,094</td>
<td>-1.7 (-2.7-0.7)</td>
</tr>
<tr>
<td><strong>Residence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>6.6 (4.5-9.6)</td>
<td>644</td>
<td>1.6 (0.7-3.9)</td>
<td>479</td>
<td>-5.1 (-7.1-3.0)</td>
</tr>
<tr>
<td>Rural</td>
<td>3.6 (2.8-4.5)</td>
<td>4,014</td>
<td>4.4 (3.4-5.6)</td>
<td>3,673</td>
<td>-1.1 (-2.0-0.3)</td>
</tr>
<tr>
<td><strong>Wealth Quintiles</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Lowest</td>
<td>6.2 (4.2-9.1)</td>
<td>1,056</td>
<td>5.2 (3.8-7.1)</td>
<td>1,807</td>
<td>-3.3 (-5.0-1.5)</td>
</tr>
<tr>
<td>Second</td>
<td>3.2 (2.1-4.8)</td>
<td>1,158</td>
<td>3.4 (1.4-8.2)</td>
<td>214</td>
<td>0.4 (-1.2-2.1)</td>
</tr>
<tr>
<td>Middle</td>
<td>3.5 (2.3-5.4)</td>
<td>836</td>
<td>3.7 (2.4-5.8)</td>
<td>1,179</td>
<td>0.4 (-3.4-0.2)</td>
</tr>
<tr>
<td>Fourth</td>
<td>3.3 (2.2-4.9)</td>
<td>978</td>
<td>4.0 (2.5-6.5)</td>
<td>461</td>
<td>-2.1 (-3.6-0.7)</td>
</tr>
<tr>
<td>Highest</td>
<td>4.3 (2.9-6.3)</td>
<td>630</td>
<td>1.7 (0.8-3.7)</td>
<td>491</td>
<td>-3.2 (-5.0-1.3)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4.0 (3.2-4.8)</td>
<td>4,658</td>
<td>4.0 (3.1-5.0)</td>
<td>4,152</td>
<td>-1.8 (-2.5-1.0)</td>
</tr>
</tbody>
</table>

Note: n=weighted number of children (denominator); *baseline for the chi-square test is 2007 compared with results from 2015; data presented for baseline 2007, midline 2010 and endline 2015. Parasite prevalence data not available for Kenya demographic and health surveys due to lack of biomarker testing.

Source: Kenya Malaria Indicator Survey (KMIS)

### 4.3 Health facility malaria morbidity trends

In Kenya, routine malaria indicator data was reported to the HIS (i.e., DHIS2 and integrated disease surveillance and response [IDSR]) platform. Malaria indicator data from DHIS2 includes total malaria cases (i.e., clinical and confirmed cases) and malaria commodity consumption reported monthly in the logistic management information system integrated into DHIS2. The malaria indicators reported to IDSR include incidence and malaria test positivity rate (TPR) reported weekly. In 2013, IDSR reporting changed to electronic IDSR (i.e., eIDSR). The primary change was at the county level. Prior to 2013, health facilities transmitted reports via hard copies, emails and short message service (SMS or “text message”) to the district level for aggregation and data entry into Excel spreadsheets, which were sent to the provincial and then national levels. After 2013, the data that health facilities sent to the county was directly entered into the web-based eIDSR, which was then available to the national level. The changes in the systems and reporting structures have led to fluctuations in reporting rates over the evaluation period. The percentage of health facilities reporting any health indicator data via DHIS2 has been consistently at or above 90 percent since 2012 (Figure 4.3). The percentage of health facilities reporting any health indicator data via IDSR and LMIS has been less consistent at approximately 70 percent since 2013.
Due to reporting rates for eIDS R, which were below the benchmark of 85%, this evaluation did not analyze TPR data from the routine system. Figure 4.4 is an example of the routine malaria indicator data from DHIS2 showing the total malaria cases (i.e., confirmed plus clinical cases) since 2012. The apparent increase in confirmed malaria cases might be a reflection of the increased capacity to test and provide a proper malaria diagnosis as per national treatment guidelines (add reference). Overall, there is a declining trend in combined malaria cases, with clinical cases decreasing as confirmed cases increased.
4.3.1 Summary of malaria morbidity

- Malaria parasitemia prevalence increased from 3 to 5 percent nationally among children ages 6 to 59 months from 2007 to 2015.
- The prevalence of severe anemia (i.e., hemoglobin <8 g/dL) among children ages 6 to 59 months declined nationally from 4 to 2 percent from 2007 to 2015.
- In the lake- and coastal-endemic zones, the prevalence of severe anemia among children 6 to 59 months declined from 5 to 3 percent and 8 to 2 percent, respectively, from 2007 to 2015.
- Overall, combined malaria cases (i.e., confirmed plus clinical) reported monthly to the routine health information system decreased from 2012 to 2015 with over 90 percent of health facilities reporting.

5 Trends in All-Cause Child Mortality

5.1 All-Cause Child Mortality

Trends in ACCM rates for the period 2003–2014 were estimated using the Kenya Demographic and Health Surveys. The surveys represent direct estimates during the period 0 to 4 years before each survey. The ACCM declined from 115 deaths per 1,000 live births in 2003 to 52 deaths per 1,000 live births in 2014, a 54 percent reduction. The ACCM estimates show a sustained decline (Figure 5.1).
The magnitude of change in the ACCM rate varied by malaria-endemicity zone, with the largest reduction observed in the lake-endemic zone. In the lake-endemic zone, the ACCM rate decreased from 213 deaths per 1,000 live births in 2003 to 64 deaths per 1,000 live births in the period 2014. (Figure 5.2). The largest reduction in ACCM occurred in the lake-endemic zone. Because the lake-endemic zone had highest malaria transmission, the zone also had the greatest potential to benefit from malaria prevention and control interventions.
5.2 Age-Specific Mortality

Significant reductions in ACCM occurred in all age groups (i.e., neonatal, postneonatal, infant, and child) from 1999 to 2003 and 2010 to 2014 (Figure 5.3). The largest decline in mortality was among children ages 1–4 years of age (65 percent) (Figure 5.4).

Figure 5.3: Trends in age-specific all-cause mortality in Kenya, 2003–2014

Source: Kenya Demographic and Health Surveys (KDHS)

Figure 5.4: Relative percentage change in age-specific all-cause mortality rates in Kenya, 2003–2014

Source: Kenya Demographic and Health Surveys (KDHS)
5.3 Equity in Change in Mortality

In rural areas, ACCM declined from 119.3 deaths per 1,000 live births in 1999–2003 to 49.7 deaths per 1,000 live births in 2010–2014, a reduction of 58 percent. A decline of 39 percent in ACCM was observed in urban areas over the same period. The largest declines in ACCM during the evaluation period were observed among children in the poorest wealth quintile (64 percent) and among children whose mothers had no formal education (62 percent) (Table 5.1).

Table 5.1: All-cause child mortality, by demographic characteristic, in Kenya, 2003–2014

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>KDHS 2003 ACCM per 1,000 live births</th>
<th>KDHS 2008/9 ACCM per 1,000 live births</th>
<th>KDHS 2014 ACCM per 1,000 live births</th>
<th>Relative percent change (KDHS 2003 and KDHS 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>126.5</td>
<td>81.8</td>
<td>54.4</td>
<td>-57.0</td>
</tr>
<tr>
<td>Female</td>
<td>102.0</td>
<td>64.9</td>
<td>50.2</td>
<td>-50.8</td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>93.4</td>
<td>64.6</td>
<td>57.0</td>
<td>-39.0</td>
</tr>
<tr>
<td>Rural</td>
<td>119.3</td>
<td>75.5</td>
<td>49.7</td>
<td>-58.3</td>
</tr>
<tr>
<td>Wealth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest</td>
<td>145.7</td>
<td>88.7</td>
<td>52.8</td>
<td>-63.8</td>
</tr>
<tr>
<td>Second</td>
<td>113.2</td>
<td>78.3</td>
<td>55.6</td>
<td>-50.9</td>
</tr>
<tr>
<td>Middle</td>
<td>120.8</td>
<td>81.0</td>
<td>50.0</td>
<td>-58.6</td>
</tr>
<tr>
<td>Fourth</td>
<td>81.5</td>
<td>44.6</td>
<td>56.5</td>
<td>-30.7</td>
</tr>
<tr>
<td>Highest</td>
<td>98.3</td>
<td>68.4</td>
<td>46.6</td>
<td>-52.6</td>
</tr>
<tr>
<td>Mother’s education</td>
<td></td>
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</tr>
<tr>
<td>None</td>
<td>122.2</td>
<td>83.1</td>
<td>46.9</td>
<td>-61.6</td>
</tr>
<tr>
<td>Primary incomplete</td>
<td>143.4</td>
<td>90.4</td>
<td>58.0</td>
<td>-59.6</td>
</tr>
<tr>
<td>Primary complete</td>
<td>98.9</td>
<td>58.0</td>
<td>50.9</td>
<td>-48.5</td>
</tr>
<tr>
<td>Secondary or higher</td>
<td>69.1</td>
<td>60.2</td>
<td>49.9</td>
<td>-27.8</td>
</tr>
<tr>
<td>Total</td>
<td>114.5</td>
<td>73.6</td>
<td>52.3</td>
<td>-54.3</td>
</tr>
</tbody>
</table>

Source: Kenya Demographic and Health Surveys (KDHS)
5.3.1 Summary of all-cause child mortality

- The ACCM declined nationally by 54 percent from 115 deaths per 1,000 live births in 2003 to 52 deaths per 1,000 live births in 2014, with reductions observed in all malaria epidemiological zones.
- The lake-endemic zone had the largest mortality reduction at 70 percent from 213 deaths per 1,000 live births in 2003 to 64 deaths per 1,000 in 2014.
- Reductions in mortality occurred in all age groups (i.e., neonatal, postneonatal, infants, and children) from 2003 to 2014; the largest decline of 65 percent was observed among children ages 1–4 years of age.
- Mortality reductions were equitable from 2003 to 2014; mortality declined most in rural areas (58 percent), among children in the poorest wealth quintile (64 percent) and among children whose mothers had no formal education (62 percent).
6 Trends in Contextual Factors

6.1 Background
Impact evaluations based on plausibility inferences require collecting data on non-malaria programs and other factors, collectively referred to as contextual factors, which might offer alternate explanations for the observed changes in malaria transmission, morbidity, and ACCM. Appropriate consideration of contextual factors is essential for ensuring the internal and external validity of evaluations of large-scale health programs (Victora et al., 2005), particularly for evaluations that are conducted when rapid changes are under way in many other aspects of health services (Bryce et al., 2004). Contextual factors are also important to consider when the associations of interest are based on ecological data, which describes this evaluation. Contextual factors associated with childhood mortality and morbidity, including malaria, can be broadly categorized into the fundamental and proximate determinants of disease (Link and Phelan, 1996, Jones et al., 2003, Mosley and Chen, 2003, Stratton et al., 2008). Fundamental determinants are the social and economic conditions under which people live while proximate determinants are biological risks. The conceptual framework (Bryce et al., 2005, Rowe et al., 2007, Rowe et al., 2011,) for the evaluation design (Figure 6.1) incorporates numerous contextual factors within subcategories of the fundamental and proximate determinants of disease. A review of relevant information on the levels and trends of contextual determinants, both fundamental and proximate, of childhood mortality and morbidity follows. Contextual factors data were obtained from national household surveys such as the KDHS and KMIS as well as other sources such as the World Bank, WHO and UNICEF, as indicated.

Figure 6.1: Conceptual framework for the impact evaluation of the Kenya national malaria control program, 2003–2014

Note: LLIN – long-lasting insecticidal bed net; IRS – indoor residual spraying; IPTp – intermittent preventive treatment of malaria in pregnancy; GDP – gross domestic product; EPI – expanded program on immunization
6.2 Fundamental Determinants

6.2.1 Socioeconomic factors
A range of socioeconomic determinants at the community, household, and individual level are associated with child survival (Mosley and Chen, 2003, Wang, 2003, Boyle et al., 2006) as shown in the impact model in Figure 6.1.

6.2.1.1 Changes in gross domestic product
Economic poverty, at both the country and individual levels, strongly correlates with poorer health outcomes (Subramanian et al., 2002). The GDP per capita, a measure of population wealth in a country, is considered to be a typical macroeconomic determinant of health and has an inverse and significant relationship between income and child mortality (O’Hare et al., 2013). Studies exploring the effect of GDP per capita purchasing power parity (GDP-PPP) on childhood mortality have found that every unit increase in GDP-PPP is associated with a 27–29 percent proportionate decline in child mortality (Imam and Koch, 2004, Omariba et al., 2007, O’Hare et al., 2013). Previous national malaria impact evaluations have observed trends similar to and consistent with studies of GDP per capita and childhood mortality (add references here). Trends in GDP-PPP in US dollars and child mortality in Kenya are shown in Figure 6.2. Kenya’s GDP-PPP was US$2,146 in 2003 and US$2,818 in 2014, a 31 percent increase in constant international dollars to control for inflation (World Bank, 2016) (Figure 6.2).

Figure 6.2: Trends in gross domestic product per capita purchasing power parity and all-cause child mortality in Kenya, 2000–2014

Note: GDP – gross domestic product
Source: GDP data from World Bank, 2016; Mortality data from the Kenya Demographic Health Survey (KDHS)

6.2.1.2 Maternal education and marital status
Female literacy and education significantly influence under-5 mortality (Imam and Koch, 2004, Omariba et al., 2007, Nattey et al., 2013). The proportion of females ages 15–49 years with at least a primary school education in Kenya increased by 16.4 percentage points between 2003 and 2014, while the proportion of literate females ages 15–49 years also significantly increased by 9.5 percentage points over the same period. Marital status remained constant, at 54 percent throughout the evaluation period (Table 6.1).
6.2.1.3 Household factors

Household and microeconomic factors are important determinants of child health and malaria risk (Wang, 2003). Socioeconomic differentials at the household level are associated with access to malaria interventions (Yé et al., 2006, Mmbando et al., 2011, Günther and Fink, 2011), thereby increasing the vulnerability of the poorest to malaria (Worrall et al., 2005). Households with access to safe water and proper sanitation facilities have lower childhood mortality rates (Van Bodegom et al., 2012, Mesike and Mojekwu, 2012, Kayode et al., 2012).

There were changes in household-level fundamental determinants of mortality during the evaluation period. The proportion of households with access to improved drinking water sources increased from 40.5 percent in 2003 to 69.4 percent in 2014, and the proportion of households with access to improved sanitation facilities increased from 19.4 percent in 2003 to 22.7 percent in 2014. Households with improved flooring material (i.e., not earth, sand, or dung) increased by 14.9 percentage points to 52.7 percent, and households with electricity increased by 20.0 percentage points to 36.0 percent between 2003 and 2014. Households with telephones, mostly mobile phones, increased significantly from 12.9 percent in 2003 to 86.1 percent in 2014 (Table 6.2.).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator</td>
<td>KDHS 2003</td>
<td>KDHS 2014</td>
<td>Percentage point change (95% CI)</td>
<td>p-value</td>
</tr>
<tr>
<td>% women with at least a primary school education</td>
<td>49.4 (47.2–51.5) 8,195</td>
<td>65.8 (64.6–66.9) 31,079</td>
<td>16.4 (3.6–19.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>% women literate</td>
<td>78.5 (76.5–80.4) 8,195</td>
<td>88.0 (87.3–88.7) 31,079</td>
<td>9.5 (7.3–11.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>% women married</td>
<td>54.5 (53.0–55.9) 8,195</td>
<td>54.6 (53.6–55.5) 31,079</td>
<td>0.1 (-1.7–1.9)</td>
<td>0.891</td>
</tr>
</tbody>
</table>

Note: CI – confidence interval; p-values <0.05 are considered significantly different; percentage point change calculated as difference between percentage in 2014 (endline) and percentage in 2003 (baseline).

Source: Kenyas Demographic and Health Survey (KDHS)

| Table 6.2: Change in household attributes and asset ownership in Kenya, 2003–2014 |
|-----------------------------------------------|---------------------|---------------------|-----------------|-----|
| Indicator                                      | KDHS 2003            | KDHS 2014            | Percentage point change (95% CI) | p-value |
| Access to improved drinking water source      | 40.5 (37.4–43.7) 8,175 | 69.4 (67.8–70.9) 36,423 | 28.9 (25.1–32.8)   | <0.001 |
| Access to improved sanitation                 | 19.4 (17.4–21.6) 8,561 | 22.7 (21.1–24.3) 36,421 | 3.3 (0.3–6.2)    | 0.031  |
| Household has improved house flooring         | 37.8 (35.1–40.5) 8,548 | 52.7 (51.1–54.3) 36,423 | 14.9 (11.3–18.5)  | <0.001 |
| Household has electricity                     | 16.0 (14.0–18.3) 8,548 | 36.0 (34.3–37.7) 36,409 | 20.0 (16.8–23.1)  | <0.001 |
| Household has telephone                       | 12.9 (11.4–14.5) 8,543 | 86.1 (85.4–86.7) 36,408 | 73.2 (71.3–75.1)  | <0.001 |

Note: CI – confidence interval; p-values <0.05 are considered significantly different; percentage point change calculated as difference between percentage in 2014 (endline) and percentage in 2003 (baseline).

Source: Kenya Demographic and Health Surveys (KDHS)
6.2.2 Climatic variability

6.2.2.1 Climate and malaria in Kenya

Geography and climate variability are key determinants of malaria transmission in Kenya. Rainfall and temperature influence transmission in the four eco-epidemiological zones. In the arid and semi-arid low-transmission zone, higher than normal monthly rainfall and flooding are associated with outbreaks of vector-borne diseases, including malaria epidemics if vector control measures are not instituted in a timely manner (Maes et al., 2014). In the epidemic-prone western highlands, climate variability, particularly related to rainfall during El Niño cycles, has resulted in the occurrence of malaria epidemics (Githeko and Ndegwa, 2001, Hay et al., 2003, Zhou et al., 2004). For the first time in two decades, the coastal-endemic zone saw a rise in malaria prevalence beginning in 2011, paradoxically during a regional drought and well before the higher-than-average rainfall experienced in 2014 (Snow et al., 2015). In the lake-endemic zone of western Kenya, malaria transmission fluctuates less than other zones with seasonal variations in rainfall (Mutuku et al., 2009, Sewe et al., 2016).

6.2.2.2 Rainfall

Figure 6.3 shows the national annual rainfall compared with long-term average, computed from 1970–1999, for each year. The long-term average is shown on the graph as the “0” line. A period of drought followed the 1997–1998 El Niño cycle, which extended well into 2001. In 2006, there was unseasonable heavy rainfall during the short rains that resulted in severe flooding and malaria epidemics, particularly in the arid and semi-arid lands. From 2007 to 2009, every year was drier compared to the long-term average. From 2012 to 2014, Kenya has experienced normal to above-normal precipitation patterns. Additional information on rainfall anomalies by malaria-endemic zone is shown in Annex 3.

Figure 6.3: Long-term anomalies and actual yearly rainfall in Kenya, 2000–2014

Source: Kenya Meteorological Department, 2015.
6.2.2.3 Temperature
The maximum, minimum, and mean annual national temperatures between 2000 and 2014 are shown in Figure 6.4. The data show that the national-level annual temperature did not vary significantly from the long-term mean temperatures computed from 1970–1999. However, nine of the 15 years during the period from 2000 to 2014 had mean annual temperatures 0.1°C–0.6°C warmer than the long-term annual average. Detailed annual temperatures by endemicity zone are shown in Annex 4.
In conclusion, climate variability is an important factor in the different eco-epidemiological zones, particularly in the highland epidemic-prone and arid and semi-arid seasonal-transmission zones. Overall, neither rainfall nor temperature patterns suggest climate differences or anomalies existed during the period of rapid malaria intervention expansion that would have independently resulted in substantially different patterns of malaria morbidity and mortality during the latter years versus the earlier years of the evaluation period. Inter-annual weather patterns may have influenced annual variation of malaria transmission; however, there is no evidence that the weather patterns changed the longer-term trends of malaria transmission during the evaluation period.

6.3 Proximate Determinants

6.3.1 Maternal and reproductive health indicators

Visits to ANC are an important entry point to health services and care for women during and after pregnancy and thereafter for their infants (Lawn and Kerber, 2006). The ANC visits provide an opportunity for the identification and management of obstetric complications such as preeclampsia, delivery of tetanus toxoid immunization for the prevention of neonatal tetanus, IPTp, and identification and management of infections including HIV, syphilis, and other sexually-transmitted infections. Visits to ANC are also an opportunity to promote skilled birth attendance and healthy behaviours, such as breastfeeding, early postnatal care, and family planning. Focused ANC is a goal-oriented approach that categorizes pregnant women into those eligible to receive routine ANC (i.e., the basic universal component) in four focused visits during pregnancy and those who need specialised care for specific health conditions or risk factors (Lincetto et al., 2006). During the evaluation period, pregnant women were encouraged to attend at least four ANC visits. The proportion of women making at least four ANC visits increased by 5.3 percentage points, health-facility births increased by 21.4 percentage points and post-partum vitamin A supplementation increased by 39.8 percentage points from 2003 to 2014 (Table 6.3). During the evaluation period, there was also significant decrease in the proportion of
births with avoidable fertility risks. A summary of maternal and reproductive health indicators is shown in Table 6.3.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>KDHS 2003</th>
<th>KDHS 2014</th>
<th>Percentage point change (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four or more ANC visits</td>
<td>52.3 (50.2–54.4)</td>
<td>57.6 (56.4–58.8)</td>
<td>5.3 (2.8–7.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>At least two doses of tetanus toxoid</td>
<td>51.9 (49.9–53.9)</td>
<td>51.1 (49.4–52.7)</td>
<td>-0.8 (-3.5–1.8)</td>
<td>0.552</td>
</tr>
<tr>
<td>Birth with an avoidable fertility risk*</td>
<td>56.0 (54.2–57.8)</td>
<td>48.7 (47.5–49.9)</td>
<td>-7.3 (-9.6–-5.0)</td>
<td>0.001</td>
</tr>
<tr>
<td>Birth interval &gt;24 months</td>
<td>17.4 (16.3–18.6)</td>
<td>13.1 (12.5–13.8)</td>
<td>-4.2 (-5.6–-2.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Birth order &gt;3</td>
<td>69.4 (67.7–70.9)</td>
<td>64.3 (63.3–65.4)</td>
<td>-5.0 (-7.1–-2.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mother age &lt;18 or &gt;34 years</td>
<td>19.1 (17.8–20.4)</td>
<td>17.9 (17.1–18.7)</td>
<td>-1.2 (-2.7–0.4)</td>
<td>0.138</td>
</tr>
<tr>
<td>Delivery at health facility</td>
<td>40.1 (37.7–42.6)</td>
<td>61.5 (60.0–62.9)</td>
<td>21.4 (18.1–24.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Post-partum vitamin A</td>
<td>14.2 (12.8–15.7)</td>
<td>54.0 (52.1–55.8)</td>
<td>39.8 (37.2–42.1)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Note: ANC – antenatal care; CI – confidence interval; p-values <0.05 are considered significantly different; percentage point change calculated as difference between percentage in 2014 (endline) and percentage in 2003 (baseline).

*Births with avoidable fertility risk include children born to mothers <18 years or >34 years, birth order >3 or born <24 months after the preceding birth.

Source: Kenya Demographic and Health Surveys (KDHS)

6.3.2 Child health and Immunization

Childhood immunizations and maternal tetanus toxoid immunization are associated with substantial reductions in childhood mortality; hence, great emphasis has been placed on increasing their coverage (McGovern and Canning, 2015). Kenya adopted pentavalent vaccine (i.e., hepatitis B, H. influenzae type B (Hib), diphtheria, pertussis, and tetanus) in 2001. Pneumococcal vaccine was added to the expanded program on immunization schedule in 2012, and rotavirus vaccine was added in 2014 (Ministry of Health, 2013b).

The basic childhood immunization coverage indicators improved significantly by between 9 to 18 percentage points between 2003 and 2014, as did the proportion of fully-immunized children, which increased by 22 percentage points in the same period (Table 6.4). Maternal and child undernutrition resulting in intrauterine growth restriction, stunting, and severe wasting is an important underlying cause of child morbidity and mortality (Black et al., 2008). Micronutrient deficiencies, in particular vitamin A and zinc deficiencies, significantly contribute to disease burden in childhood. Early initiation and exclusive breastfeeding are important and cost-effective child survival interventions that reduce neonatal, infant, and child mortality (Bhutta et al., 2008, Bhutta and Labbok, 2011). The proportion of exclusively breastfed children under 6 months increased almost five-fold from 13 percent in 2003 to 62 percent in 2014. Among anthropometric indices, stunting and underweight declined by 44 and three percentage points, respectively, from 2003 to 2014. Vitamin A supplementation for children ages 6 to 59 months increased by 38 percentage points from 33 percent in 2003 to 71 percent in 2014 (Table 6.4).
Table 6.4: Summary of child health indicators in Kenya, 2003–2014

<table>
<thead>
<tr>
<th>Indicator</th>
<th>KDHS 2003 % (95% CI)</th>
<th>n</th>
<th>KDHS 2014 % (95% CI)</th>
<th>n</th>
<th>Percentage point change (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacille Calmette-Guerin vaccine</td>
<td>87.4 (84.3–90.0)</td>
<td>1,003</td>
<td>97.1 (96.3–97.7)</td>
<td>3,762</td>
<td>9.7 (6.5–12.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pentavalent vaccine, dose 3*</td>
<td>72.8 (68.9–76.3)</td>
<td>1,003</td>
<td>90.6 (89.2–91.9)</td>
<td>3,762</td>
<td>17.9 (13.6–22.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Polio vaccine, dose 3*</td>
<td>72.7 (69.0–76.4)</td>
<td>1,003</td>
<td>90.6 (89.2–91.9)</td>
<td>3,762</td>
<td>17.8 (13.5–22.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Measles vaccine, dose 1*</td>
<td>72.4 (68.5–75.9)</td>
<td>1,003</td>
<td>87.0 (85.6–88.3)</td>
<td>3,762</td>
<td>14.6 (10.5–18.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fully-immunized child*</td>
<td>59.9 (56.1–63.6)</td>
<td>1,003</td>
<td>81.7 (80.0–83.3)</td>
<td>3,762</td>
<td>21.8 (17.3–26.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>33.3 (31.0–35.7)</td>
<td>3,972</td>
<td>71.4 (70.2–72.5)</td>
<td>18,221</td>
<td>38.0 (35.3–40.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Stunting</td>
<td>29.4 (27.7–31.1)</td>
<td>5,949</td>
<td>25.8 (24.8–26.8)</td>
<td>18,656</td>
<td>-3.6 (-5.5–1.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Underweight</td>
<td>18.4 (12.4–15.1)</td>
<td>5,949</td>
<td>10.4 (10.0–11.4)</td>
<td>18,656</td>
<td>-3.1 (-4.6–1.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Wasting</td>
<td>5.1 (4.3–6.0)</td>
<td>5,949</td>
<td>4.1 (3.6–4.5)</td>
<td>18,656</td>
<td>-1.0 (-2.0–0.0)</td>
<td>0.047</td>
</tr>
<tr>
<td>Early initiation of breastfeeding</td>
<td>51.3 (48.3–54.2)</td>
<td>2,195</td>
<td>63.1 (60.9–65.4)</td>
<td>3,652</td>
<td>11.9 (8.1–15.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Exclusive breastfeeding of infants &lt;6 months</td>
<td>12.7 (9.5–16.8)</td>
<td>597</td>
<td>61.7 (57.5–65.8)</td>
<td>852</td>
<td>49.0 (43.4–54.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Complementary feeding of infants 6-9 months</td>
<td>87.2 (81.4–91.4)</td>
<td>393</td>
<td>82.1 (78.4–85.3)</td>
<td>639</td>
<td>-5.1 (-10.8–0.68)</td>
<td>0.084</td>
</tr>
</tbody>
</table>

Note: CI – confidence interval; p-values <0.05 are considered significantly different; *immunization coverage for children 12–23 months; percentage point change calculated as difference between percentage in 2014 (endline) and percentage in 2003 (baseline).

Source: Kenya Demographic and Health Surveys (KDHS)

6.4 Summary of Contextual Factors

Kenya experienced many positive cross-sectoral developments associated with improved child survival during the evaluation period as summarized in Table 6.5. Between 2003 and 2015, the most important indicators of socio-economic, maternal and child health improved significantly in Kenya. Many of the fundamental and contextual factors associated with child survival are as important as malaria prevention and control interventions, including GDP growth, access to drinking water, exclusive breastfeeding, vitamin A supplementation, full vaccination, and deliveries in a health facility (Table 6.5).
Table 6.5: Summary of evidence associated with all-cause child mortality in Kenya, 2003–2015

<table>
<thead>
<tr>
<th>Other contextual determinants</th>
<th>Evidence supporting reduction in mortality</th>
<th>Evidence supporting no change in mortality</th>
<th>Evidence supporting increase in mortality</th>
</tr>
</thead>
</table>
| Fundamental                  | • Improved GDP per capita PPP ($2,146 in 2003 to $2,818 in 2014, a 31 percent increase)  
• Improved maternal education and literacy (16 and 10 percentage points, respectively)  
• Improved household attributes and asset ownership (29, 20 and 73 percentage point increases in access to improved drinking water source, electricity and telephone, respectively) | • Cyclical rainfall and temperature variation  
• No change in proportion of married women  
• Limited improvement in household access to improved sanitation (3 percentage point increase) | • None |
| Proximate                    | • Increased births at health facilities (21 percentage points)  
• Improved full vaccination (22 percentage point increase)  
• Improved pentavalent and polio vaccination (18 percentage point increase each)  
• Improved measles vaccination (15 percentage point increase)  
• Improved vitamin A supplementation (38 percentage point increase)  
• Early initiation and exclusive breastfeeding for infants <6 months of age (12 and 49 percentage point increases, respectively) | • Limited improvement in four or more ANC visits (5 percentage point increase)  
• Limited improvement in births with avoidable fertility risks (7 percentage point decrease)  
• Limited improvements in stunting, underweight and wasting (4, 3 and 1 percentage point increases, respectively)  
• No change in two doses of tetanus toxoid  
• No change in complementary feeding of children ages 6–9 months | • Negative trend in birth interval >24 months (4 percentage point decrease) |

Note: ANC – antenatal care; GDP – gross domestic product; IPTp – intermittent preventive treatment in pregnancy; ITN – insecticide-treated net; PPP – purchasing power parity
Additional Analyses to Bolster the Evaluation Design

7.1 Case Studies

7.1.1 Kilifi Health and Demographic Surveillance System data

7.1.1.1 Brief description of the data

The Kilifi HDSS study area covers a population of approximately 260,000 people living in an area of 891 square km (Scott et al., 2012). A detailed description of the morbidity data has recently been published (Mogeni et al., 2016). Demographic data and clinical history for all children <15 years of age admitted to the pediatric ward at the Kilifi County Hospital between 2000 and 2015 were assembled directly from hospital registers. Screening for malaria parasites using microscopy has been continuous since the establishment of the inpatient pediatric surveillance system at the hospital.

7.1.1.2 Analytical approach

Descriptive data are presented for total inpatient pediatric malaria admissions and total under all-cause child mortality over time. Malaria slide-positive deaths were analysed per 1,000 person years as estimated from the longitudinal follow up of cases in the HDSS.

7.1.1.3 Results

Morbidity

The data from Kilifi County Hospital, in the coastal-endemic zone, show an almost threefold reduction in inpatient malaria cases in 2015 compared to the 2000 baseline. The data show a rise in inpatient malaria cases in 2014 and 2015, but the number of cases is substantially less than the number reported annually in the period of 2000 to 2004 (Figure 7.1).

Figure 7.1: Trends in inpatient malaria cases among children under 15 years of age at Kilifi County Hospital, in the coastal-endemic zone of Kenya, 2000–2015
Mortality

Data from the Kilifi County HDSS was based on inpatient records and showed a declining trend in ACCM from 2003 to 2014 (Mogeni et al., 2016). Malaria-specific mortality among inpatients remained relatively stable throughout the evaluation period (Figure 7.2).

Figure 7.2: Trends in all-cause and malaria-specific mortality among children under 5 years of age in Kilifi County Health and Demographic Surveillance System, 1990–2014

Note: PY – person years
Source: Kenya Medical Research Institute-Wellcome Trust Health and Demographic Surveillance System, Kilifi County, Kenya. Mortality data is from inpatient hospital records only.

7.1.1.4 Conclusion

- Overall, the annual number of inpatient malaria cases declined almost threefold between 2000 and 2015.
- Overall, there was a declining trend in the absolute number of all-cause deaths annually from 2003 to 2015.

7.1.2 Siaya HDSS data

7.1.2.1 Brief description of the data

Data were collected within the Kenya Medical Research Institute (KEMRI) and Centers for Disease Control and Prevention (CDC) HDSS in Siaya County, western Kenya. Briefly, the HDSS area covers a population of approximately 223,000 people residing in three sub-counties of Siaya County, spread over approximately 700 square km along the shores of Lake Victoria Adazu et al., 2005; Odhiambo et al., 2012). Mortality data were collected from the community and at two inpatient health
facilities, Siaya County Hospital and Lwak Mission Hospital. From 2003 to 2008, the cause of death was assigned by physician review of verbal autopsy data, and from 2009 onwards, a computer algorithm, interpretation of verbal autopsy (inter-VA), assigned cause of death from verbal autopsy data. Malaria morbidity was collected from annual community-based cross-sectional surveys during peak transmission periods. The presence of parasitemia was confirmed via microscopy for all participants. Data through 2012 were available for analysis.

7.1.2.2 Analytical approach

For morbidity, the prevalence of malaria parasitemia confirmed through microscopy was stratified by the following age groups: <5 years of age, ages 5–14 years, and ages ≥15 years. All-cause and malaria-specific deaths were summarized per year and by age groups and incidence rates were calculated per 1,000 person years.

7.1.2.3 Results

Morbidity

In the two Siaya (Figure 7.3) hospitals, there was an overall decrease in cases among children <5 years of age from 2003, with a rise in 2008 followed by a slow decline annually to the lowest number reported in 2012.

Figure 7.3: Trends in inpatient malaria cases among children <5 years of age in two hospitals in Siaya County Health and Demographic Surveillance System in Kenya, 2003–2012

Mortality

The Siaya County HDSS site in the lake-endemic zone showed a declining trend in all-cause and malaria-specific mortality in children under 5 years from 2004 to 2012 (Figure 7.4). From 2003–2012 in children under 5 years, the malaria-specific mortality rate decreased from 13.2 to 3.7 per 1,000 person-years; the declines were greatest in the first 3 years of life (Desai et al., 2014). There was an increase in ACCM in 2008 subsequent to social and healthcare system disruptions following the 2007 post-
election violence and population displacement, which remained elevated during the first 8 months of 2009 (Hamel et al., 2011).
7.1.2.4 Conclusion

- In two Siaya County hospitals, the overall absolute number of inpatients under 5 years of age with malaria parasitemia declined from 2003 to 2012.
- In the Siaya County HDSS site in the lake-endemic zone, both all-cause and malaria-specific mortality in children under 5 years of age declined from 2003 to 2012.

7.2 Multivariable Analysis

7.2.1 Kaplan-Meier survival analysis

7.2.1.1 Data

The full birth history data from the KDHS 2014 was transformed into 10-year retrospective longitudinal data reflecting individual child observations from birth until the date of the survey or, in the unfortunate event, the death of the child.

7.2.1.2 Analytical approach

Kaplan-Meier survival estimates were calculated and comparisons made for survival probability of children ages 0 to 59 months before and after the expansion of malaria control interventions. The outcome variable was defined as the age at which a child dies or the age at interview for those who survived. A dichotomous variable (coded 1 if the child died and 0 if not) was used to define the censoring status.

7.2.1.3 Results

Child survival improved during the evaluation period. At each age interval up to 5 years, the probability of surviving was higher during the period 2010–2014, after the
increased coverage of malaria interventions, compared with the period 2005–2009, during intervention expansion, and 2000–2004, before the malaria intervention expansion (Figure 7.5). Similar trends were observed in the lake-endemic, coastal-endemic, and seasonal-transmission zones. In the highland epidemic-prone zone, survival was lower in the period 2000–2004 but not significantly different in periods 2005–2009 and 2010–2014. In the low-risk zone, survival is higher in the period 2005–2009 compared to 2000–2004 and 2010–2014 (Annex 5).

Figure 7.5: Kaplan-Meier survival curves for children under 5 years of age by malaria intervention expansion period in Kenya, 2000–2014

Source: Kenya Demographic and Health Survey, 2014.

7.2.1.4 Conclusion

There were notable improvements in child survival, especially during the 2010–2014 period following the expansion of malaria prevention and control interventions nationally. Based on the observations across malaria-endemicity zones, particularly in the lake- and coastal-endemic zones which benefited the most from expansion, malaria control interventions might have contributed to these gains.

7.2.2 Regression analysis: Cox model

7.2.2.1 Data

The full birth history data from the KDHS 2014 was transformed into 10-year retrospective longitudinal data reflecting individual child observations from birth until the date of the survey or, in the unfortunate event, the death of the child.

7.2.2.2 Analytical approach

Cox’s proportional hazards models were used for the regression analysis, since they do not need specification of the form of the distribution of the baseline hazard rate (Cox, 1972; Cox & Oakes, 1984; Blossfeld et al., 1989). The models also allow for use of time-varying covariates: that is, characteristics whose status may change over time. When the hazard ratio is greater than one, there is a higher risk of mortality in the corresponding category as compared with the reference category. Conversely, the
risk of dying is lower when the hazard ratio is less than one. The hazard rate in the Cox model is computed as:

$$h(t / zj) = h0(t).exp(\beta j zj(t))$$

where the regression coefficients are to be estimated from the data. The term $h0(t)$ is the baseline hazard function (the hazard when $z=0$), $zj(t)$ is the individual covariates vector and $\beta j$ is a vector of the regression parameters that indicates the effects of these covariates, some of them varying with $t$ (hence, the term time-varying covariate). The relative hazards are given by $exp(zj(t)\beta)$.

For each malaria-endemicity zone, a model was developed that included all children ages 0 to 59 months for the 2-year period 2013–2014 of exposure to ITN ownership to account for recall bias related to duration of ITN ownership. During the survey, household heads were asked if they owned a net, and “How many months ago did your household get the mosquito net?” Respondents were supposed to indicate the precise number of months, if less the 36 months. To identify an individual child’s exposure to an ITN, data on the duration of ownership of ITNs and the time of retreatment of nets (if any) was used to construct a time-varying variable of ITN ownership for up to 2 years before the survey.

For each malaria-endemicity zone, the analysis time is measured in months from the beginning of the period (i.e., 2013 for the 2-year period) allowing the introduction of age as a covariate in the analysis. Each child is observed from the beginning of the observation period until right truncation by loss to follow up, death, or date of the survey. A dichotomous variable (coded 1 if the child died and 0 if the child is alive) is used to define the censoring status. The Cox proportional hazards model assessed the relationship between household ITN ownership and child mortality (deaths of children age 1 to 59 months) over the 24 months preceding the survey in each malaria-endemicity zone. The model was adjusted for several covariates including child’s age (month), child’s sex, mother’s age (year) at birth, mother’s education level, parity, household wealth quintiles, and place of residence because these co-variates are likely to be associated with both mortality and household ownership of ITN.

7.2.2.3 Results

Table 7.1 presents the results of the Cox proportional hazard model for Kenya and by malaria-endemicity zone. Nationally, household ownership of at least one ITN significantly reduces the risk of mortality among children aged 1 to 59 months by 56% (hazard ratio [HR]=0.44, 95% CI: 0.30–0.63) during the 24-month period before the survey. The lake-endemic zone contributes significantly to the national reduction in mortality risk associated with ITN ownership. In the lake-endemic zone, in households with at least one ITN, the mortality risk for children aged 1 to 59 months was reduced by 72% (HR=0.28, 95% CI: 0.14–0.55). Similar protective effects of ITN ownership were observed in the other malaria-endemicity zones; however, the results were not statically significant.
Among children ages 1 to 59 months, mortality risk decreased with age, with statistically significant mortality reductions observed for the 12–23 months and ≥24 month age groups. In all epidemiological zones, mortality risk among children aged >6 months was lower compared to children aged 1 to 5 months, but the hazard ratios and statistical significance varied by zone. In each epidemiological zone, mortality risk was also higher among children born to mothers aged ≥30 years. There were significant associations between mortality risk in children ages 1 to 59 months and child’s sex, mother’s age at birth, mother’s education, wealth quintile or place of residence.
Table 7.1. Effect of household ownership of at least one insecticidal bed net on mortality risk among children aged 1 to 59 months nationally and by malaria-endemicity zone in Kenya, 2012–2014

<table>
<thead>
<tr>
<th>Variable</th>
<th>National</th>
<th>Low risk</th>
<th>Seasonal risk</th>
<th>Epidemic-prone</th>
<th>Coast endemic</th>
<th>Lake endemic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predictor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household ownership of ITN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HH = no ITN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HH ≥ 1 ITN</td>
<td>0.44 (0.30 - 0.63)</td>
<td>0.37 (0.13 - 1.01)</td>
<td>0.54 (0.26 - 1.12)</td>
<td>0.80 (0.30 - 2.15)</td>
<td>0.44 (0.18 - 1.07)</td>
<td>0.28 (0.14 - 0.55)</td>
</tr>
<tr>
<td><strong>Covariate</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Child's age (months)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1-5 (reference)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6-11</td>
<td>0.70 (0.42 - 1.18)</td>
<td>0.73 (0.18 - 3.01)</td>
<td>0.84 (0.32 - 2.22)</td>
<td>0.29 (0.05 - 1.57)</td>
<td>0.86 (0.31 - 2.35)</td>
<td>0.77 (0.26 - 2.30)</td>
</tr>
<tr>
<td>12-23</td>
<td>0.54 (0.34 - 0.86)</td>
<td>0.44 (0.13 - 1.53)</td>
<td>0.61 (0.25 - 1.47)</td>
<td>0.47 (0.13 - 1.71)</td>
<td>0.28 (0.09 - 0.85)</td>
<td>0.89 (0.35 - 2.23)</td>
</tr>
<tr>
<td>≥24</td>
<td>0.28 (0.18 - 0.45)</td>
<td>0.19 (0.05 - 0.65)</td>
<td>0.20 (0.08 - 0.51)</td>
<td>0.55 (0.18 - 1.73)</td>
<td>0.18 (0.07 - 0.47)</td>
<td>0.34 (0.13 - 0.86)</td>
</tr>
<tr>
<td>Sex of Child</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Male (reference)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Female</td>
<td>0.87 (0.65 - 1.17)</td>
<td>0.72 (0.29 - 1.78)</td>
<td>0.94 (0.50 - 1.76)</td>
<td>0.70 (0.34 - 1.42)</td>
<td>0.70 (0.35 - 1.43)</td>
<td>1.06 (0.62 - 1.82)</td>
</tr>
<tr>
<td>Mother's age at birth (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20 (reference)</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>20-24</td>
<td>0.82 (0.50 - 1.37)</td>
<td>0.84 (0.17 - 4.26)</td>
<td>1.07 (0.32 - 3.51)</td>
<td>1.83 (0.50 - 6.72)</td>
<td>0.57 (0.20 - 1.57)</td>
<td>0.52 (0.19 - 1.43)</td>
</tr>
<tr>
<td>25-29</td>
<td>1.40 (0.86 - 2.26)</td>
<td>1.41 (0.29 - 6.86)</td>
<td>1.65 (0.53 - 5.11)</td>
<td>1.77 (0.44 - 7.15)</td>
<td>0.58 (0.21 - 1.63)</td>
<td>1.87 (0.85 - 4.10)</td>
</tr>
<tr>
<td>30-49</td>
<td>1.63 (1.02 - 2.58)</td>
<td>1.46 (0.29 - 7.50)</td>
<td>2.01 (0.66 - 6.19)</td>
<td>2.88 (0.78 - 10.58)</td>
<td>0.61 (0.23 - 1.58)</td>
<td>1.88 (0.88 - 4.01)</td>
</tr>
<tr>
<td>Mother's education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None (reference)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>1.17 (0.73 - 1.87)</td>
<td>-</td>
<td>1.14 (0.55 - 2.40)</td>
<td>2.07 (0.26 - 16.35)</td>
<td>0.77 (0.33 - 1.81)</td>
<td>0.45 (0.10 - 1.94)</td>
</tr>
<tr>
<td>Secondary or higher</td>
<td>0.93 (0.54 - 1.63)</td>
<td>-</td>
<td>0.64 (0.21 - 1.98)</td>
<td>1.92 (0.22 - 17.11)</td>
<td>1.00 (0.29 - 3.43)</td>
<td>0.26 (0.05 - 1.33)</td>
</tr>
<tr>
<td>Wealth Quintiles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lowest (reference)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>1.04 (0.67 - 1.63)</td>
<td>0.27 (0.02 - 3.48)</td>
<td>0.86 (0.32 - 2.29)</td>
<td>0.84 (0.32 - 2.20)</td>
<td>2.49 (0.82 - 7.52)</td>
<td>0.99 (0.47 - 2.07)</td>
</tr>
<tr>
<td>Third</td>
<td>1.24 (0.78 - 1.97)</td>
<td>0.90 (0.12 - 6.52)</td>
<td>0.84 (0.31 - 2.29)</td>
<td>0.73 (0.24 - 2.20)</td>
<td>4.15 (1.57 - 10.98)</td>
<td>1.11 (0.49 - 2.51)</td>
</tr>
<tr>
<td>Fourth</td>
<td>0.89 (0.53 - 1.50)</td>
<td>0.38 (0.04 - 3.37)</td>
<td>1.24 (0.50 - 3.10)</td>
<td>0.98 (0.32 - 2.98)</td>
<td>1.77 (0.45 - 6.90)</td>
<td>0.42 (0.13 - 1.38)</td>
</tr>
<tr>
<td>Highest</td>
<td>0.84 (0.49 - 1.45)</td>
<td>0.45 (0.06 - 3.16)</td>
<td>0.12 (0.02 - 0.81)</td>
<td>0.32 (0.06 - 1.70)</td>
<td>2.79 (0.84 - 9.21)</td>
<td>2.03 (0.70 - 5.89)</td>
</tr>
<tr>
<td>Place of residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban (reference)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>0.77 (0.56 - 1.05)</td>
<td>0.34 (0.11 - 1.06)</td>
<td>0.46 (0.24 - 0.90)</td>
<td>0.52 (0.25 - 1.10)</td>
<td>1.94 (0.93 - 4.01)</td>
<td>1.38 (0.74 - 2.58)</td>
</tr>
<tr>
<td>Person-months</td>
<td>26,418.70</td>
<td>32,933.22</td>
<td>72,775.24</td>
<td>64,148.31</td>
<td>77,612.53</td>
<td>62,470.30</td>
</tr>
<tr>
<td>N (deaths)</td>
<td>15,612 (175)</td>
<td>1,910 (19)</td>
<td>4,372 (39)</td>
<td>3,776 (32)</td>
<td>1,822 (31)</td>
<td>3,662 (53)</td>
</tr>
</tbody>
</table>

Note: ITN – insecticide-treated net; HH – household; bold indicates significance at 5% level; for low-risk zone, hazard ratio for mother’s education were not calculated because no deaths were recorded for the reference category (i.e., no education).
7.2.2.4 Conclusion

The Cox proportional hazard model indicates a strong association between a household’s ownership of at least one ITN and mortality risk reduction (56 percent) among children aged 1 to 59 months at the national level. The protective effect of ITN ownership on mortality risk for children ages 1 to 59 months was most pronounced in the lake-endemic zone (72 percent reduction), where the expansion of malaria prevention and control interventions was greatest during the evaluation period. The lake-endemic zone had the largest potential to benefit from increased ITN ownership and utilization because the population had the highest burden of malaria and highest ACCM rate throughout the evaluation period.
8 Plausibility Analysis and Conclusions

The section below summarizes the changes in malaria intervention coverage, malaria-related morbidity and ACCM in the period from 2003 to 2015 (Figure 8.1). An assessment of the plausible link between improvements in malaria intervention coverage and changes in malaria-related morbidity and ACCM while accounting for other contextual determinants of child survival in the causal pathway is described.

Figure 8.1: Summary of trends in coverage of malaria control interventions, malaria-specific morbidity, and all-cause child mortality in Kenya, 2003–2015

Note: ITN - insecticide-treated net; ACT- artemisinin-based combination therapy
Source: Data from the Kenya Demographic Health Survey (KDHS) and Kenya Malaria Indicator Survey (KMIS)

8.1 Increased Access to and Use of Malaria Prevention and Control Interventions

Key changes in malaria control interventions include, at the national level, significant increases in household ownership of at least one ITN from 6 percent in 2003 to 63 percent in 2015. In the lake- and coastal-endemic zones, ITN ownership increased from 12 percent and 13 percent in 2003 to 73 percent and 87 percent in 2015, respectively. Similar changes were observed for use of ITNs, with an increase of use from 5 percent in 2003 to 48 percent in 2015 nationally. In households with at least one ITN, use among children under 5 years and pregnant women increased from 66 to 79 percent and 70 to 82 percent, respectively, from 2007 to 2015. (Add the UC data here for ownership and use and include lake- and coastal-endemic zone data if available.) Although there have been no major disparities in ITN ownership and use between households in urban and rural areas, notable gaps in ITN ownership have
been observed between households in the lowest and highest wealth quintiles throughout the evaluation period.

IRS was initially implemented as an epidemic prevention and response tool in the highland epidemic-prone zone from 2002–2009. In 2010, IRS was expanded to include parts of three lake-endemic counties for malaria burden reduction. From 2005 to 2012, IRS coverage in the targeted areas expanded from less than 100,000 housing units with less than 300,000 people protected to over 600,000 housing units with 2.4 million people protected. At the height of the IRS program in 2010, over 1.5 million housing units and 4.7 million people were protected. From 2013 to 2015, IRS was not implemented due to emerging resistance to pyrethroids, resource constraints, and program priorities. Although IRS was expected to have a substantial impact on malaria morbidity and mortality locally, national-level impact was not expected given the geographically restricted use.

Since 2009, IPTp implementation has been restricted to only malaria-endemic counties (i.e., the lake- and coastal-endemic zones). In the malaria-endemic zones, IPTp2 coverage increased from 14 percent in 2007 to 56 percent in 2015. No disparities in IPTp coverage by socioeconomic status or education level were observed by 2015.

8.2 Improved Malaria Case Management
The availability of malaria diagnostics increased from 55 to 97 percent in public sector health facilities from 2010 to 2015, with all of the gains observed resulting from increased availability of malaria RDTs. Concurrently, the recommended first-line medication, AL, was available in 90 percent or more of public sector health facilities from 2010 to 2015, except for during 2014. Increased availability of malaria diagnostics and medications had a positive effect on case management; healthcare worker adherence to national treatment guidelines more than doubled from 28 to 61 percent nationally from 2010 to 2015 in public sector health facilities.

Nationally, the proportion of children under 5 years of age with fever who received malaria diagnostic testing was 12 percent in 2010 and increased to 39 percent in 2015. The lake- and coastal-endemic zones had the greatest improvement in malaria diagnostic testing from 11 and 18 percent in 2010 to 59 and 44 percent in 2015, respectively. Nationally, children under 5 years of age treated with an antimalarial who received the recommended first-line medication increased from 42 to 92 percent from 2003 to 2015. In the lake- and coastal-endemic zones, children under 5 years of age treated with an antimalarial who received the recommended first-line medication increased from 40 to 94 percent and from 34 to 95 percent, respectively, from 2003 to 2015.

8.3 Decline in Malaria-Related Morbidity
Malaria parasitemia prevalence increased from 3 to 5 percent among children ages 6 to 59 months from 2007 to 2015. However, over the same period, the prevalence of severe anemia among children ages 6 to 59 months declined nationally from 4 to 2 percent, and in the lake- and coastal-endemic zones, the prevalence of severe anemia
declined from 5 to 3 percent and 8 to 2 percent, respectively. During the period of greatest expansion of malaria prevention and control interventions from 2010 to 2015, malaria parasitemia prevalence decreased from 9 to 5 percent nationally and from 33 to 17 percent in the lake-endemic zone and severe anemia decreased from 4 to 2 percent nationally and from 7 to 3 percent in the lake-endemic zone. Households in lower wealth quintiles and located in rural areas had higher prevalences of both malaria parasitemia and severe anemia.

At the facility level in two health and demographic surveillance sites located in the malaria-endemic zones, there has been a decline in inpatient malaria cases during the evaluation period. At two hospitals in Siaya County, in the lake-endemic zone, the number of children under age 5 years admitted annually with malaria parasitemia decreased by 71 percent between 2003 and 2015. At Kilifi County Hospital in the coastal-endemic zone, there was an almost threefold reduction in inpatient pediatric malaria cases observed between 2003 and 2015.

### 8.4 Declining all-cause child mortality

A 54 percent reduction in all-cause mortality among children under the age of 5 years was observed from 115 deaths per 1,000 live births in 1999–2003 to 59 deaths per 1,000 live births in 2010–2014. The highest ACCM reductions were observed in the lake-endemic (70 percent) and seasonal-transmission zones (58 percent). Because the lake-endemic zone had the highest burden of malaria and all-cause mortality, the zone also had the greatest potential to benefit from malaria prevention and control interventions. Data from the Siaya County HDSS located in the lake-endemic zone show a declining trend in all-cause and malaria-specific mortality in children under 5 years of age during the period from 2004 to 2012.

Although reductions in mortality occurred in all age groups from 2003 to 2014; the largest decline was observed among children ages 1–4 years of age (65 percent). The ACCM reductions were equitable across the evaluation period. Mortality declined more in rural (58 percent) areas, among children in the poorest wealth quintile (64 percent) and among children whose mothers had no formal education (62 percent).

### 8.5 Contextual Factors and the Plausibility Argument

Review of fundamental and proximate contextual factors reveal a number of positive changes during the evaluation period, some of which would lead to improved child survival. During this period GDP per capita increased from $2,146 in 2003 to $2,818 in 2014. In addition, there was a notable increasing trend in GDP-PPP and an associated declining trend in mortality among children under 5 years. Significant improvements in household-level fundamental determinants of mortality were observed, including a 28.9 percentage point increase in the proportion of households with access to improved water sources and a 3.3 percentage point increase in households with access to improved sanitation. Increased access to clean water and sanitation potentially contributed to the reduction of mortality in children under 5 years of age related to diarrheal disease.

Maternal health indicators were less likely to be drivers of the reduction in mortality among children under 5 years in Kenya during the evaluation period, given that there
were only slight changes in ANC attendance from 52 percent in 2003 to 58 percent in 2014, and the static uptake of tetanus toxoid vaccine by pregnant women. On the other hand, child health indicators have shown improvements: there was increased immunization coverage for all the key antigens; the proportion of exclusively breastfed children under 6 months rose to 62 percent in 2014 from 13 percent in 2003; vitamin A supplementation for children ages 6 to 59 months increased by 38 percentage points, from 33 percent in 2003 to 71 percent in 2014; and there was a decline in stunting and underweight by 4 and 3 percentage points, respectively.

Climate variability does not appear to have substantially influenced malaria transmission over the evaluation period of 2003–2014.

### 8.6 Conclusion
The findings demonstrate substantial progress towards expanding coverage of malaria prevention and control interventions for populations at risk of malaria. Household ownership and use of ITNs among pregnant women, children under the age of 5 years, and general household members increased nationally and particularly in targeted malaria-endemic zones. Prevention of malaria in pregnancy significantly increased. Effective case management also improved nationally and in targeted malaria-endemic zones, particularly. Nationally, the overall number of malaria cases reported via the routine health information system declined as did inpatient malaria cases at sentinel sites in both the lake-and coast-endemic zones over the evaluation period. The national prevalence of severe anemia deceased with the largest declines observed in the malaria-endemic zones. Consequently, given the expansion of malaria prevention and control interventions and declining trends in malaria morbidity, malaria interventions very likely contributed substantially to the 54 percent reduction in ACCM measured between 2003 and 2015. Kaplan-Meier survival curves demonstrating that child survival was higher after the malaria intervention expansion and Cox proportional hazard regression analysis showing a strong protective effect of household ITN ownership on reduction of ACCM, particularly in the lake-endemic zone, provide additional evidence to support the plausibility argument that malaria-intervention expansion contributed to ACCM reductions in Kenya.
9 References


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