ROLL BACK MALARIA

PROGRESS & IMPACT SERIES

Number 3 · September 2010

Saving Lives with Malaria Control: Counting Down to the Millennium Development Goals

Tulane University | JOHNS HOPKINS BLOOMBERG SCHOOL of PUBLIC HEALTH | World Health Organization | PATH

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Most of the malaria burden and its effect on child survival occur in sub-Saharan Africa; as a consequence, this report focuses on the African region; other reports from the Secretariat and RBM partners will address the burden of malaria outside of Africa. The data provided in this report were assembled from February 2010 through June 2010. Due to the constant updating of intervention coverage and the information supplied by countries and agencies, some numbers in this report may have since changed for this time interval; not all numbers are adjusted to a single date. However, such changes are generally minor and do not, at the time of publication, affect the overall picture of malaria intervention coverage and observed or estimated impact. Monetary amounts are listed in United States of America dollars.

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CONTENTS

ACRONYMS AND ABBREVIATIONS

ACT	*Artemisinin-based combination therapy*
AIS	*AIDS Indicator Survey*
ANC	*Antenatal care*
CHERG	*Child Health Epidemiology Reference Group*
CI	*Confidence interval*
DALY	*Disability-adjusted life year*
DHS	*Demographic and Health Surveys*
GMP	*Global Malaria Programme*
GNI	*Gross national income*
IRS	*Indoor residual spraying*
IPTp	*Intermittent preventive treatment for pregnant women*
ITN	*Insecticide-treated mosquito net*
IUGR	*Intrauterine growth retardation*
LBW	*Low birth weight*
LiST	*Lives Saved Tool – modelled estimates developed by the CHERG*
LLIN	*Long-lasting insecticide-treated net*
MDGs	*Millennium Development Goals*
MICS	*Multiple Indicator Cluster Survey*
MIS	*Malaria Indicator Survey*
RBM	*Roll Back Malaria*
RR	*Relative risk*
SP	*Sulfadoxine-pyrimethamine*
UNICEF	*United Nations Children's Fund*
USAID	*United States Agency for International Development*
US-PMI	*United States President's Malaria Initiative*
WHO	*World Health Organization*

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This report was co-authored by Thomas Eisele and David Larsen, both from the Department of International Health and Development at the Tulane University School of Public Health and Tropical Medicine; Neff Walker of Johns Hopkins University; Richard Steketee of the Malaria Control and Evaluation Partnership in Africa (MACEPA), a programme at PATH; and Richard Cibulskis of the World Health Organization's Global Malaria Programme.

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The authors remain responsible for any errors and omissions.

FOREWORD

Ten years ago, world leaders adopted eight comprehensive, time-bound goals to improve the state of the world by 2015—the Millennium Development Goals (MDGs). Now, in 2010, with five years left to go, the world is looking back to measure progress made over the past decade, and looking forward to determine what is required in the final push to reach these global targets. As we take stock, we must be able to measure the returns of our collective investments, not just in terms of inputs, but in terms of impact—the most precious of which are lives saved. How many children are alive today thanks to our efforts over the past ten years? How many more lives can we save and what will it take?

This report seeks to answer those questions, concentrating on the ultimate measure of our success—lives saved. It introduces a groundbreaking tool that can be used to translate our collective inputs into the number of lives saved, and estimates how many more we can save by the end of 2015. We demonstrate here the impact of our actions.

Our results are dramatic. They provide a clear signal that we are on track to achieving the malaria-related MDG by 2015, and that we will also contribute substantially to the two-thirds reduction in child mortality called for in MDG4.

As we approach the deadline of 31 December 2010 for achieving universal coverage with essential malaria interventions, set by African Heads of State in Abuja and by United Nations Secretary-General Ban Ki-moon, we find that many countries in sub-Saharan Africa are on track to protect their at-risk people through effective prevention with long-lasting insecticidal nets and indoor-residual spraying. The effort has saved nearly three-quarters of a million children across 34 malaria-endemic African countries over the past ten years. Even more telling is that 85% of these lives were saved in the past 5 years alone, the same time period during which funding intensified ninefold. As of this year, an estimated 485 children are saved every day from dying from malaria. Perhaps most important, if universal coverage with nets and spraying can be maintained through the MDG deadline of 2015, nearly 3 million additional African children's lives will be saved. If access to effective diagnosis and treatment can be scaled up as aggressively, an Africa free of malaria deaths may be within reach.

The results presented in this report also put the world on notice. Our efforts must be sustained. Should the fragile combination of funding, political attention, and effective tools that has put us on the path to universal coverage come undone, an estimated 476 000 more children will die and our investments will have been lost.

2010 marks an important year for two of the three largest external funders of the malaria fight. The Global Fund to Fight AIDS, Tuberculosis and Malaria and the World Bank's International Development Association (IDA) are seeking critical replenishments to help fuel the fight over the next 5 years. Continued support from the US President's Malaria Initiative and renewed efforts by the United Kingdom and other partners will also be critical.

Our efforts have changed the lives of millions of children, and will save millions more in the next five years. I can think of no other investment with greater returns.

Raymond G. Chambers, United Nations Secretary-General's Special Envoy for Malaria

EXECUTIVE SUMMARY

This report aims to introduce to the Roll Back Malaria (RBM) community the Lives Saved Tool, or LiST model, and its appropriate use and value in estimating lives saved through malaria prevention both retrospectively and prospectively. In addition, the report discusses the relevance of the LiST model in examining progress towards the United Nations Millennium Development Goals (MDGs).

Six of the eight MDGs for 2015 either fully or partially relate to health. Among these, malaria control is critical to MDG4 (reducing child mortality), MDG5 (reducing maternal mortality), and MDG6 (reducing HIV and other infectious diseases, including malaria), and important for several other health-related MDGs.

To achieve the MDGs, we must be able to accurately measure the progress of malaria prevention. This has proved difficult in the past. Vital registration (the recording of births and deaths in a country) could potentially provide the type of information needed to assess prevention efforts. Unfortunately, most child malaria deaths occur in countries where vital registration is unreliable and births and deaths are often simply not recorded.

However, as this report explains, the LiST model, which was developed by the child health community, can help to provide a clear picture of malaria prevention efforts. The model has become a key tool in assessing the impact of malaria prevention, including insecticide-treated mosquito nets (ITNs), indoor residual spraying (IRS), and intermittent preventive treatment for pregnant women (IPTp).

In the first half of the past decade, with no real investment in malaria prevention, little was achieved. However, a major injection of resources since 2006 has resulted in a substantial increase in the number of children's lives saved.

Indeed, using LiST modelling, it is estimated that in the past 10 years, scaling up malaria prevention has saved the lives of nearly three quarters of a million children in 34 malaria-endemic African countries, 85% of these in the past 5 years alone.

Furthermore, the results suggest that if current scale-up trends are maintained until 2015, another 1.14 million African children's lives will be saved between 2011 and 2015. However, if funding were to cease in 2010 and prevention efforts were to fall, an estimated 476 000 additional children would die in that same period.

This report outlines how the LiST model has been applied to track the progress of malaria prevention and to estimate the benefits that could flow from further scale-up of malaria prevention at the country level.

KEY POINTS

- The LiST model has become a key tool in estimating the effect on child survival of scaling up malaria prevention.

- From 2001–2010, scaling up malaria prevention is estimated to have saved nearly three quarters of a million (736 700) children's lives across 34 malaria-endemic African countries (representing 98% of the at-risk population in Africa). The vast majority of these lives were saved from 2006 onwards, when significant funding became available.

- In 2010, an estimated 485 children were saved every day from malaria-related death, representing an 18% reduction in child malaria mortality compared with 2000.

- Looking towards 2011–2015, several outcomes resulting from stable, increasing or decreasing prevention coverage can be forecast using LiST.
  i) If universal prevention can be achieved by the end of this year and maintained until 2015, an estimated 2.95 million African children's lives can be saved.
  ii) If current scale-up trends are maintained until 2015, 1.14 million African children's lives can be saved.
  iii) If country prevention rates are maintained at this year's levels until 2015 then 906 000 African children's lives can be saved.
  iv) If, instead, funding ceases and prevention levels are allowed to fall, an estimated 476 000 additional children would die (compared with stable coverage rates between 2010 and 2015).

- Achieving universal malaria prevention, combined with better access to diagnostic care and effective treatment, will contribute substantially to meeting MDG4 (reducing the under-five mortality rate by two thirds by 2015) and MDG6 (Target 6.c: halting and reversing trends in malaria incidence with successful scale-up of malaria control interventions).

- Every US $1025 spent on insecticide-treated nets will protect 380 children and save one child's life each year.

- The cost per disability-adjusted life years (DALYs) saved, at only US $41, makes ITNs one of the best public health investments available and is comparable to highly efficacious preventive strategies such as measles immunizations (US $39–43 per DALY saved).


MWINILUNGA MANAGEMENT
MALARIA RAPID DIAGMOSTIC TEST
PATIENT REGISTER
MONTH: March
YEAR: 2008
Name
Age
F
M
Address
History of fever
Type

INTRODUCTION AND BACKGROUND

The Roll Back Malaria (RBM) Partnership has focused from the outset on reducing malaria's contribution to mortality, especially in young children and pregnant women *(1)*. The partnership's planned tracking of the impact of prevention on all-cause infant and child mortality, and also on malaria-specific mortality where possible, has been incorporated in all recent malaria monitoring and evaluation documents *(2–4)*. Achieving the RBM target of universal coverage with malaria prevention is expected to directly contribute to meeting relevant health-related Millennium Development Goals (MDGs, see Box 1).

This report introduces to the RBM community the Lives Saved Tool, or LiST model, and its appropriate use and value in estimating lives saved through malaria prevention, both retrospectively and prospectively; in other words, how have we done in the past and how will we do in the future with different levels of financing and programme action? In addition, the report demonstrates the use of the LiST model in examining progress toward the MDGs.

Measuring and estimating infant and child mortality

Knowing which interventions work and which ones do not is crucial to the implementation of malaria control. For this reason, measuring all-cause and disease-specific under-five mortality has been part of most health-monitoring efforts in developing nations for both integrated and disease-specific intervention programmes.

The following age-groupings are the standard for measuring child mortality: neonatal (first 28 days of life); post-neonatal infant (1–11 months); child (1–4 years), and the sum of these from 0–59 months (or under-five mortality).

Ideally, birth and death records (vital registration) would inform these measurements, but settings with high child mortality typically have poor or incomplete record-keeping. So, in the absence of accurate direct data, estimates are made through national surveys, using population-based sampling. Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS) are two types of such surveys. In these surveys, women are asked about all births and any child deaths. These child deaths are frequently considered over a five-year interval (the summary estimate covers this full interval with an approximate mid-point about two and a half years prior to the survey) *(5)*. This approach does not provide a complete and timely picture especially when some of the benefits may occur over a short period during rapid scale-up of a disease control programme.

Improving methods for tracking child mortality

Several groups have sought to review and improve the methods for documenting global changes in child mortality. Groups include: the Health Metrics Network,[1] the Inter-Agency

1 Health Metrics Network: http://www.who.int/healthmetrics/en/

Group for Mortality Estimation;[2] academic institutions, such as the Institute for Health Metrics and Evaluation[3] at the University of Washington and the Department of International Health at the Johns Hopkins Bloomberg School of Public Health;[4] and the WHO and UNICEF-supported Child Health Epidemiology Group (CHERG).

The CHERG's work included an initial series of articles on child mortality, published in 2003 as the *Lancet* Child Survival Series *(6–13)*. As part of this work, a model was developed based on proven child health interventions that allowed researchers to estimate the number of lives that could be saved if these interventions were deployed at a high level in many countries.

Over the past seven years, refinements to the model and its ability to address population dynamics have led to an updated version, referred to as the Lives Saved Tool, or LiST model. The CHERG continues to assess child mortality *(14)* using this approach *(15–20)*. In this report, the LiST model was used to estimate the contribution of increased malaria prevention to improved child survival in malaria-endemic African countries.

Using the LiST model in malaria prevention

Malaria is a leading cause of child mortality in Africa, accounting for about 20% of all deaths. Fortunately, vector control through insecticide-treated mosquito nets (ITNs) and indoor residual spraying (IRS), as well as malaria prevention during pregnancy through ITNs and intermittent preventive treatment for pregnant women (IPTp), have been shown to significantly reduce the burden of malaria *(21–24)*.

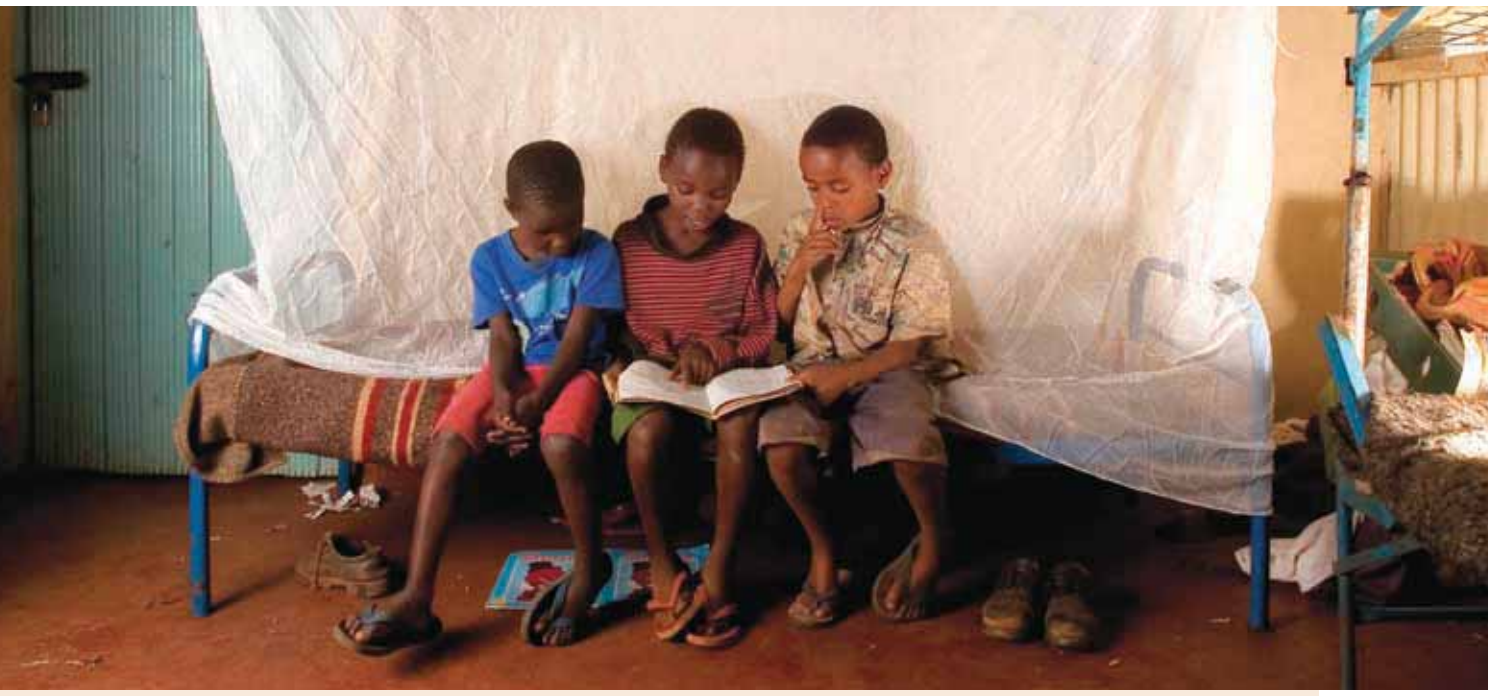
The LiST model generates estimates of lives saved by using two data sources: first, known efficacy of the interventions (ITNs, IRS, and IPTp) on improved child survival, obtained from controlled prevention trials; and second, documented changes in intervention coverage, obtained from nationally representative household surveys. Armed with this information, LiST can estimate changes in child survival that occurred in the past and what might happen in the future.

In this report, the LiST model is used to quantify child malaria mortality changes over the past decade (2001–2010) in 34 malaria-endemic countries in Africa. In addition, this report examines the number of lives that could be saved by malaria prevention scale-up for different coverage scenarios from 2011–2015 as we look towards achieving the MDGs. These results are published elsewhere in a peer-reviewed manuscript *(25)*.

2 Inter-Agency Group for Mortality Estimation (IGME): http://www.childinfo.org/files/First_TAG_meeting_minutes.pdf and http://www.who.int/whosis/mort/20080306mtgAgenda.pdf. Accessed on 2 August 2010.

3 Institute for Health Metrics and Evaluation: http://www.healthmetricsandevaluation.org/. Accessed on 2 August 2010.

4 Dept of International Health at the Johns Hopkins School of Public Health: http://www.jhsph.edu/dept/ih/IIP/list/index.html. Accessed on 2 August 2010.



Box 1: Malaria control and the MDGs

The United Nations Millennium Declaration signed in September 2000 commits world leaders to combating poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women. Eight MDGs are derived from this declaration and all have specific targets and indicators (see Table below). Seven of the eight goals either fully (4, 5, 6) or partially (1, 2, 3, 8) relate to health concerns. Among these, malaria control is critical for MDG4 and MDG6, and relevant to the others.

Millennium Development Goals	Malaria control targets or contributions
Goal 1. End poverty and hunger	Malaria control (and controlling other acute infectious diseases) contributes to reduced acute undernutrition and reduced poverty.
Goal 2. Universal education	Malaria control combats absenteeism due to illness and associated learning difficulties.
Goal 3. Gender equity	Malaria control efforts have been applied equitably across gender and there are specific strategies for malaria prevention in pregnancy.
Goal 4. Child health	Target 4: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate.
Goal 5. Maternal health	Malaria control includes specific prevention during pregnancy to improve both maternal and fetal health.
Goal 6. Combating HIV/AIDS and other diseases	Target 6c: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases. To reduce the incidence of malaria and the number of malaria deaths, efforts will be made to increase both the proportion of children under five years of age sleeping under insecticide-treated bed nets and the proportion of children under-five years of age with fever who are treated with appropriate antimalarial drugs.
Goal 7. Environmental sustainability	
Goal 8. Global partnerships	The Roll Back Malaria Partnership has promoted in-country, regional, and international partnerships across many sectors.

METHODS FOR ESTIMATING LIVES SAVED WITH MALARIA PREVENTION

The LiST model generates data based on estimates and assumptions about each country's population and growth rate, under-five mortality rate, cause-of-death patterns and estimates of coverage levels of proven child survival interventions *(26)*. The model used in this analysis and accompanying documentation can be downloaded from www.jhsph.edu/dept/ih/IIP/list/.

The LiST model estimates the number of children's lives saved within specific cause-of-death categories as a result of interventions being scaled up and takes into account the following: the number of children's deaths by cause projected to occur in each year (accounting for population growth over time), the protective effect for each intervention on cause-specific mortality, and increases in coverage for each intervention.

In this report, the LiST analysis estimating the improvement in child mortality rates through the impact of vector control (with either ITNs or IRS) included 34 malaria-endemic countries in Africa. This analysis accounted for 98% of the population at-risk of malaria on the continent, using 2000 as a baseline (Figure 2.1) *(27)*.

The LiST analysis estimating improvements in low birth weight with malaria interventions during pregnancy (with either IPTp or ITNs) included 27 countries with stable malaria transmission and available information on this strategy. This represented 82% of the population at risk of malaria on the continent, using 2000 as a baseline. Countries not included in the analyses and the rationales for their exclusion are described in Annex 2.

Estimates of cause-specific child deaths

In the LiST model, the total number of under-five child deaths for the baseline year of 2000 is based on official United Nations estimates *(28)*. The number of child malaria deaths for 2000 was estimated as the proportion of all child mortality attributable to malaria by the CHERG for each sub-Saharan African country *(29)*.

Figure 2.1

African malaria-endemic countries included in LiST model application

Thirty-four countries (accounting for 98% of the malaria-risk population in sub-Saharan Africa) were evaluated for ITN and/or IRS prevention; 27 countries (accounting for 82% of the malaria-risk population in sub-Saharan Africa) were evaluated for IPTp coverage; countries not included had either little malaria or insufficient data.

Estimates of intervention efficacy

The efficacy of vector control for preventing post-neonatal child malaria deaths is estimated to be 55%, based on a review of trials and studies *(30)*.

The efficacy of malaria-control measures during a woman's first two pregnancies—when she is most susceptible to malaria infection—for preventing low birth weight is estimated to be 35% in malaria-endemic areas *(30)*.

In the LiST model, the impact of malaria prevention during pregnancy is estimated using data on low birth weight resulting from intrauterine growth retardation (IUGR); prematurity is not considered. IUGR contributes to neonatal mortality by increasing the risk of dying due to diarrhoea, sepsis/pneumonia or asphyxia. During the post-neonatal period, IUGR slightly increases the risk of dying due to measles, malaria, diarrhoea or pneumonia *(16, 18)*.

Changes in coverage of malaria prevention

All estimates of malaria prevention coverage in this analysis were obtained from nationally representative household surveys, including the DHS, the MICS, the Malaria Indicator Survey (MIS) and the AIDS Indicator Survey (AIS).

Most malaria deaths and the burden of malaria in pregnancy occur in rural areas *(29, 31)*. It has also been shown that prevention coverage in rural areas has lagged behind urban areas in many African countries *(32)*. For these reasons, the level of malaria prevention coverage in rural areas was used to estimate, conservatively, the number of malaria deaths prevented at the national level as a result of scale-up.

In three countries where data were available (Kenya, Mozambique and Zambia), a composite indicator was used to estimate the number of child malaria deaths that were prevented by scaling up vector control. This composite indicator took into account the proportion of households protected by at least one ITN or long-lasting ITN (LLIN), and the proportion of households that received IRS in the previous 12 months *(33)*. In all other countries, the proportion of households with at least one ITN was used as the sole indicator (see Annex 2 for details).

Most vector control scale-up has occurred since the middle of the decade when substantial funding became available *(34)*. To capture this non-linear increase for the period 2004–2008, data from manufacturers were used to estimate the increase in ITN coverage between surveys for those years when there was no survey data. The slope between the earliest and most recent household surveys was used to inform the prevention increase for 2008–2010. In countries where there was only one household survey, the year 2000 was set to 2% (the continent average) and the survey estimates were used to establish the slope of increase (see Annex 2 for details).

To estimate the impact of malaria prevention during pregnancy on low birth weight and child survival, the higher of the following two indicators was used: the proportion of pregnant women using an ITN the previous night, or the proportion of women who had had a live birth in the previous two years and who had received two or more doses of IPTp during an antenatal care visit. The year 2000 was set to 0% for those countries using ITNs as the coverage indicator; the year prior to the country declaring IPTp as national policy was set to 0% for those countries using IPTp as the coverage indicator *(35)*. Linear interpolation was used from the baseline year to the first year of measured IPTp/ITN coverage; similarly, linear interpolation was used for the years between surveys. The slope between the earliest and most recent household surveys was used to inform the prevention increase for the years beyond the last household survey up to 2010. In countries where there was only one household survey, the initial year was set to 0% and the survey estimates were used to establish the slope of increase (see Annex 2 for details).

Uncertainty of the lives saved estimates

There is, of course, a degree of uncertainty surrounding the LiST model's estimates. In estimating the number of children saved as a result of vector control from 2001 to 2010, uncertainty bounds took into account the three primary data sources: estimated child malaria deaths within each country *(36)*; the estimated protective efficacy of vector control on malaria mortality *(30)*; and intervention coverage changes between 2000 and 2010 resulting from survey sampling error. The estimates of children saved as a result of malaria prevention during pregnancy took into account uncertainty in the two primary data sources: the estimated protective efficacy of malaria prevention in pregnancy; and coverage uncertainty due to survey sampling error *(30)* (see Annex 2 for details on methods).

Costs of ITNs

The cost of ITNs was derived from studies undertaken in six sub-Saharan Africa countries between 2006 and 2009 (see Figure 2.2). These studies *(36–38)* determined the cost of delivering an ITN in different programme settings such as mass campaigns, antenatal clinics and retail outlets.

Figure 2.2
Cost of delivering an insecticide treated mosquito net (ITN) to a household and cost per year of protection with ITNs in US$

Channel of delivery	Location	Year	Source	Total economic cost (three years)			Cost to deliver net in first year (US$)	Cost per year of protection (US$)
				Delivery	Net	Total		
Antenatal clinics (with charges for nets)	Burkina Faso	2006	De Allegri, 2009*	3.68	5.18	8.86	5.41	3.13
	Kenya (WHO)	2007		2.52	6.17	8.69	4.70	3.07
Antenatal clinics (nets provided free)	Democratic Republic of the Congo	2006	Becker-Dreps, 2009†	1.51	8.00	9.51	4.18	3.36
	Kenya	2008	WHO, unpublished	1.97	5.20	7.17	3.81	2.54
	Uganda	2007	Kolaczinski et al, 2010	2.27	5.26	7.53	3.97	2.66
	Zanzibar**	2005	WHO, unpublished	2.07	6.52	8.59	4.24	3.04
Mass campaign (nets provided free)	Uganda	2007	Kolaczinski et al, 2010	1.23	5.74	6.97	3.26	2.46
	Uganda	2007	Kolaczinski et al, 2010	0.76	5.26	6.02	2.62	2.13
	Uganda	2005–06	WHO, unpublished	1.05	5.80	6.85	3.10	2.42
	Uganda	2008–09	WHO, unpublished	1.24	5.63	6.87	3.23	2.43
	Zanzibar**	2005–06	WHO, unpublished	1.59	6.52	8.11	3.90	2.87
	Zanzibar**	2008–09	WHO, unpublished	1.62	6.13	7.75	3.79	2.74
Retail sales	Burkina Faso	2006	De Allegri, 2009*	3.69	5.13	8.82	5.50	3.12
	Kenya	2008	WHO, unpublished	2.06	5.20	7.26	3.90	2.57
	Median						3.90	2.70

* Life of a long-lasting ITN (LLIN) was adjusted to three years (not five years)

** (United Republic of Tanzania)

† Life of LLIN assumed to be three years

Note: In order to calculate cost per net delivered and cost per year of protection the cost of an LLIN was spread over three years using a discount rate of 3% (hence dividing by 2.83). The cost per net delivered includes full delivery costs and the first year of the life of the net. The cost per year of protection spreads all costs over three years. The median cost per year of protection is US $2.70.

The costs presented are *economic costs* in that they consider the value of all resources used in delivering ITNs (including resources that might have been donated for free, e.g. volunteer time). The costs of all items with a life-span of more than one year are spread over the expected life of the item. The economic costs differ from *financial costs* of a net in a household which consider money spent to procure and deliver the nets.

The cost of delivering an ITN to a household showed little variation between countries or by delivery channel in publicly supported programmes between 2005 and 2009 (Table 2.1). Costs for ITNs delivered by mass campaigns may be slightly lower than those delivered through antenatal clinics, but the number of studies is too small to assert this conclusively. The median cost of delivering an ITN, US $3.90, is similar to that reported elsewhere *(39)*.

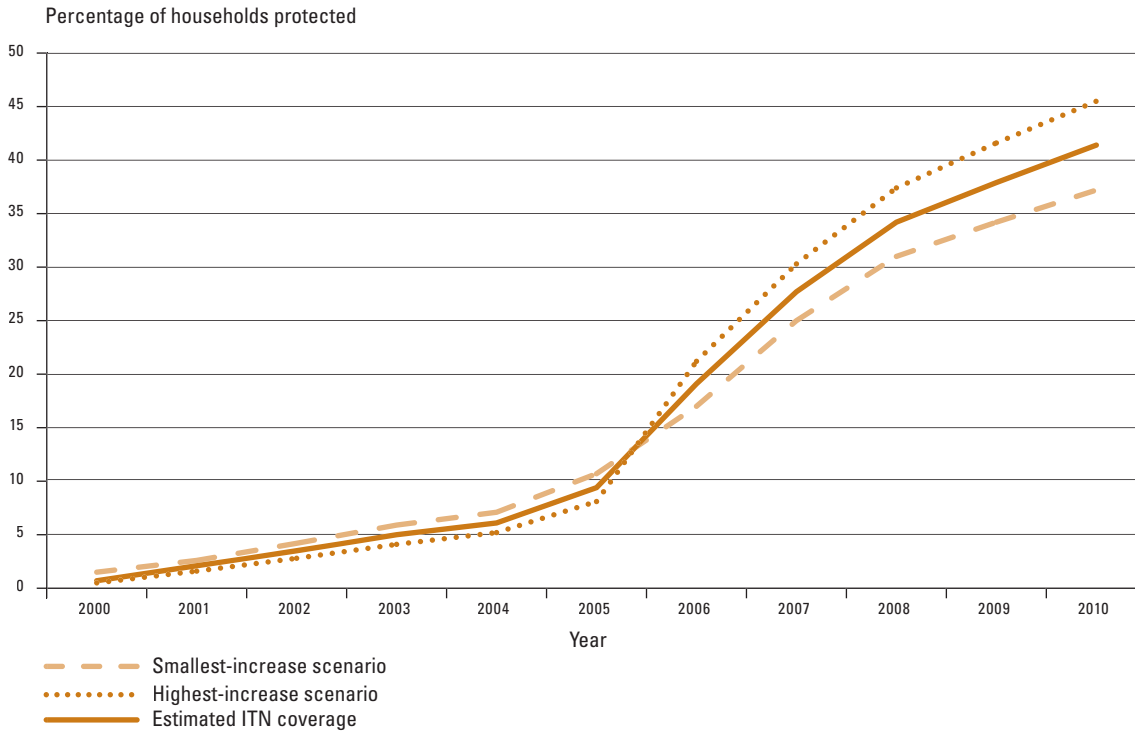
ESTIMATED LIVES SAVED IN AFRICA THROUGH MALARIA CONTROL 2001–2010

In the 34 malaria-endemic countries in Africa assessed in this analysis, the proportion of rural households protected by vector control (either ITNs or IRS) was estimated to have increased from 1% to 41%, with most of the increase occurring when substantial funding for prevention became available in the latter half of the decade (Fig. 3.1).

Figure 3.1

Proportion of rural households protected by ITNs and/or IRS in Africa

In rural households in 34 African countries, ITNs and/or IRS coverage increased slowly from 2000 to 2005 (from less than 1% to about 9%) and then began to increase more rapidly from 2006 to 2010 (reaching about 41%). Most of the improvement was in the past five years.

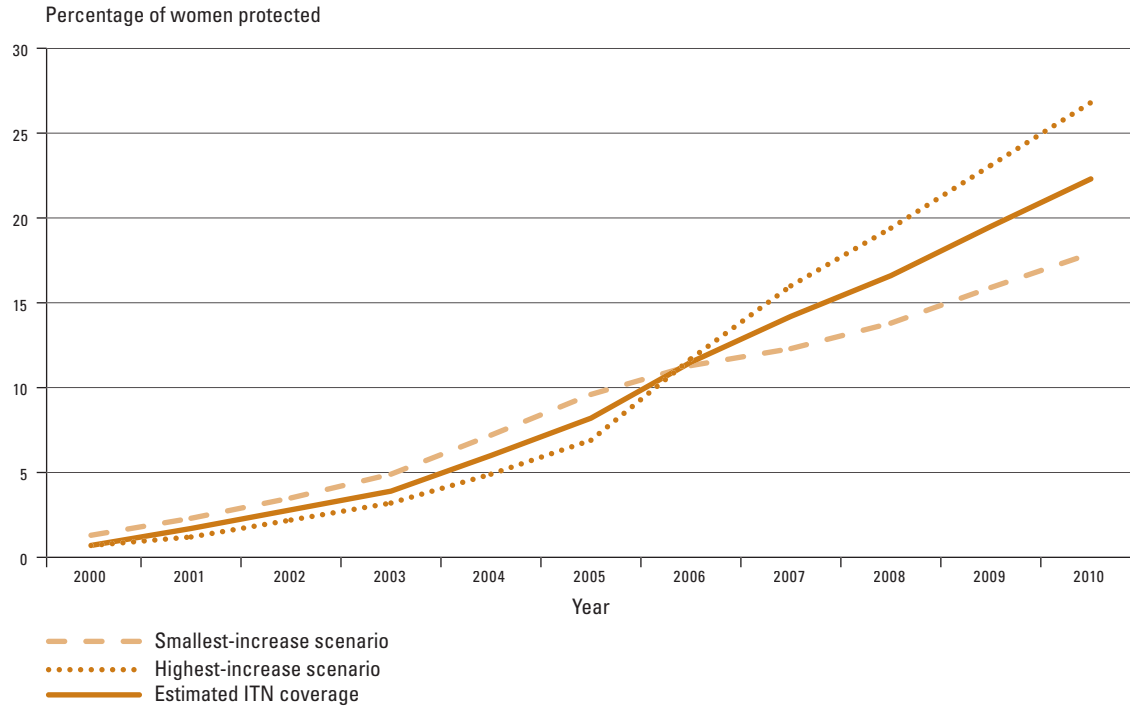


It is estimated that vector control alone through ITNs and IRS scale-up saved the lives of 714 600 children in the 34 countries from 2001 to 2010 (see Annex 1, Table A1.1).

Figure 3.2

Proportion of pregnant rural women protected by IPTp and/or ITNs in 27 African countries

In 27 African countries with stable malaria transmission, the proportion of pregnant women estimated to be protected by either IPTp or ITNs in rural areas increased from 1% to 22%.



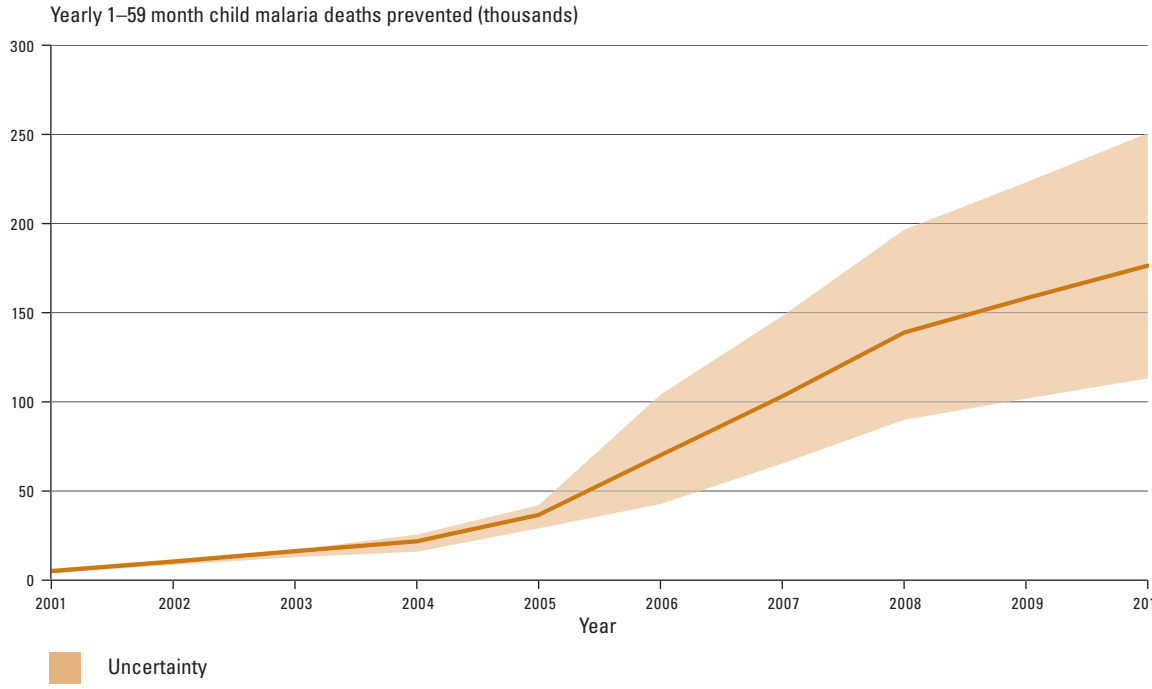
In the 27 countries included in this analysis, the proportion of pregnant women estimated to be protected by either IPTp or ITNs in rural areas increased from 1% to 22% (Fig. 3.2).

From 2001 to 2010, in the 27 countries analysed, IPTp and ITN during pregnancy saved an estimated 22 100 children's lives (see Annex 1, Table A1.2). Angola, Mozambique, Uganda, the United Republic of Tanzania and Zambia accounted for more than half (11 900) of this figure. This might seem a relatively low figure over the course of a decade, but malaria prevention in pregnancy generally has a more modest impact on child survival.

Figure 3.3

Children's lives saved by malaria prevention scale-up from 2001–2010

The LiST model estimates that malaria prevention scale-up (IPTp, ITN, IRS) over the past decade, when compared with rates in the year 2000, has saved the lives of 736 700 children (uncertainty bound 483 600–1 021 800) in 34 African countries. There was minimal progress in the first five years of the decade when few resources were available. The biggest impact will be seen this year, with a projected 18% decrease in malaria child deaths from 2000 levels.



Using the LiST model, it is estimated that scaling up malaria prevention over the past decade has saved 736 700 children's lives in the 34 malaria-endemic countries in Africa (Figure 3.3). It should again be emphasized that the vast majority of those lives were saved in the last five years of the decade after substantial funding for prevention efforts became available. The biggest impact will be seen this year (2010), with a projected 18% decrease in malaria child deaths from 2000 levels.

In Ethiopia, Mali, Mozambique, the United Republic of Tanzania, and Uganda alone, 256 000 child lives were saved due primarily to ITN scale-up. In Nigeria, Africa's most populous nation with about 152 million people, ITN coverage increased at a much lower level (0–10%) over this period based on available household survey data from 2008, resulting in an estimated 57 200 children being saved. However, it is estimated that 42 million ITNs have been procured for distribution in Nigeria since 2008. If this results in 50% household ITN coverage by the end of 2010 (instead of the estimate of 10% used here), an additional 121 000 child lives will be saved, resulting in a 25% overall reduction in malaria deaths across the 34 countries, compared with 2000.

Towards the MDGs: estimating for 2011–2015

As we look to the future, it is possible to estimate the number of lives that could be saved or lost based on increases or decreases in vector control coverage from 2011 to 2015. Five coverage scenarios were considered to estimate the number of children's lives that could be saved over the next five years (see Fig. 3.4).

A) *With rapid scale-up to universal prevention (100%) by the end of 2010 and maintained from 2011 to 2015*, an estimated 2.95 million children would be saved.

B) *With scale-up to universal prevention by the end of 2015*, an estimated 2.15 million children would be saved.

C) *With current country scale-up trends continued on the same slope until 2015*, an estimated 1.14 million children would be saved.

D) *With country coverage trends stabilized at 2010 levels*, an estimated 906 000 children would be saved.

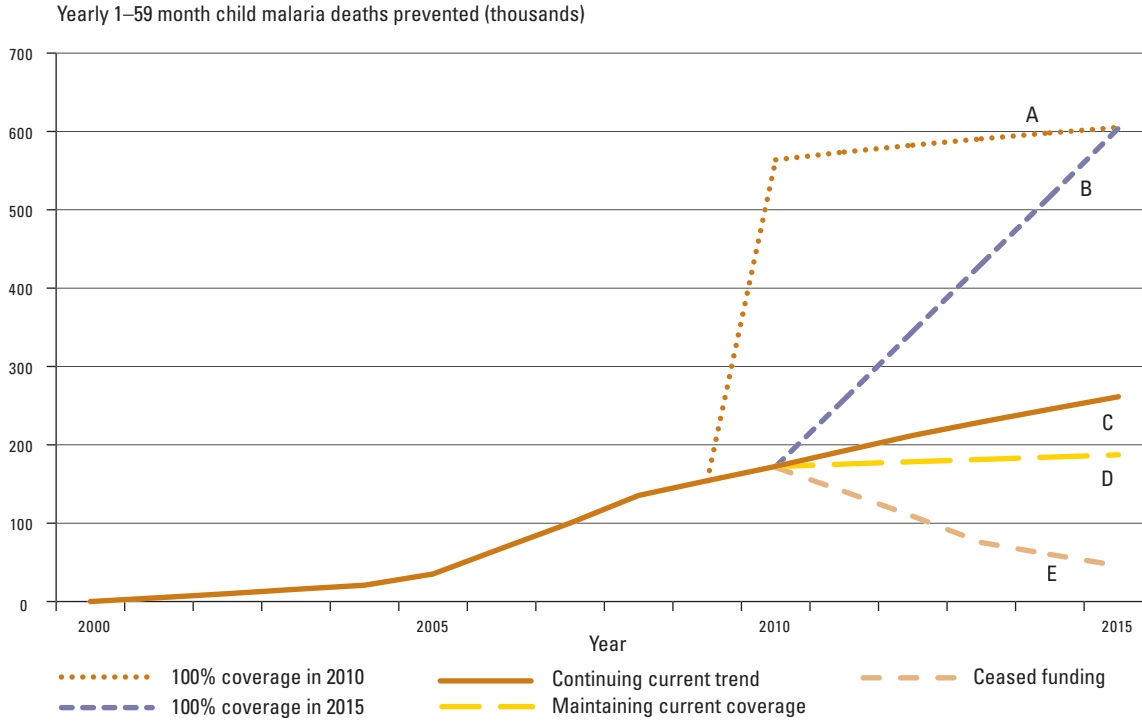
E) *If funding ceased and no new ITNs or IRS services were available*, an estimated 476 000 additional children would die compared with maintaining coverage levels from 2011 to 2015.

In the first scenario (rapid achievement of universal prevention with ITNs or IRS), there would be a 54% reduction in malaria child mortality compared with 2000. This would represent a 12% decline in all-cause under-five child mortality, a remarkable contribution to MDG4 with this single vector control intervention strategy.

Figure 3.4

Children saved by vector control based on 2011–2015 scale-up scenarios

*With rapid scale-up to universal prevention by 2010 and maintained until 2015 (**Line A**), an estimated 2.95 million children would be saved; with scale-up to universal prevention by the end of 2015 (**Line B**), about 2.15 million children would be saved; with current country scale-up trends continued on the same slope until 2015 (**Line C**), about 1.14 million children would be saved; with current country coverage trends stabilized at 2010 levels (**Line D**), about 906 000 children would be saved; but if funding ceased and no new vector-control services were available (**Line E**), about 476 000 children would die (compared with the scenario of Line D).*



Cost per life saved

Estimates from the LiST model suggest that an average of 114 000 lives were saved each year between 2006 and 2009. With an estimated 43 million ITNs available per year during this period, approximately 380 ITNs are required to save one life in one year (43 million ITNs divided by 114 000 lives saved). Given that the cost per year of protection is approximately US $2.70, the cost to save one life is roughly US $1025.

Each of the estimated lives saved was in young children aged 0–4 years. The 2005 life expectancy at birth in sub-Saharan Africa was approximately 50 years, which suggests that each child saved may live an average of 45 years longer. It is customary to summarize the long term benefits of health programmes in terms of their impact on disability-adjusted life years (DALYs). A DALY is a year of healthy life lost to disease. Saving a child's life from malaria with an ITN is equivalent to gaining 25 DALYs (see Box 2). Hence the cost per DALY gained by ITNs is approximately US $41 (US $1025 divided by 25 DALYs). The cost-per-DALY-gained for ITNs is comparable to similar highly efficacious preventive strategies such as measles immunization: measles prevention by vaccination costs approximately US $39–43 per DALY gained.

Box 2: Calculating cost per life saved

Calculating the cost per life saved and for disability-adjusted life years (DALYs) averted is shown below.

- **Number of lives saved per year between 2006 and 2009 = ~114 000**
- **Average stock of nets per year from 2006 to 2009 = ~43 million**
- **Median cost per net delivered = ~US $2.70**
- **Number of nets per life saved = 43 million/114 000 = ~380***
- **Cost per life saved = 380 × 2.70 = ~US $1025**
- **Number of DALYs gained per life saved = 25**
- **Cost per DALY gained = 1025/25 = US $41 (based on the cost of ITNs to all ages)**

*This estimate is comparable to that of Komatsu et al (2010) of 300 nets per life saved *(40)*.

To estimate the additional years of life gained by malaria control we subtract the average age of malaria death from the life expectancy at birth without malaria. When considering years of life gained in the future, it is customary to give lower weight to lives gained in the future since benefits that do not appear for 10 years are not considered as valuable as those that are immediate. This is done through a process known as discounting (*41*). In this way, 45 years of extra life in the future are valued as 25 additional disability-adjusted life years now.

The cost per DALY gained by ITNs presented here is similar to that reported on the WHO Choice web site (US $29–41) *(42)*. Note that while the costs have been derived for all age groups the benefits in terms of lives saved and DALYs gained has only been estimated for children, hence the cost per DALY gained in children could be much lower.

To estimate correctly the increased lifespan, we need to compare the potential years of life gained for each age group with the life expectancies for children that have the intervention. It is customary to give lower weight to lives gained in the future since benefits that do not appear for 10 years are not deemed as valuable as those that are immediate. This is done through a process known as discounting *(41)*. In this way, 45 years of extra life in the future are valued as 25 additional DALYs.

DISCUSSION AND CONCLUSION

For the global health community and the RBM Partnership in particular, achieving MDG4 (reduce by two thirds, between 1990 and 2015, the under-five mortality rate) and MDG6 (to have halted and begun to reverse by 2015 the incidence of malaria and other major diseases) will be remarkable accomplishments.

Measuring progress towards the MDGs will continue to be a challenge in settings with limited resources where malaria and high rates of child mortality are common. Proven models, such as the LiST model, can help estimate current and future progress *(18–20)*.

The LiST model estimates that scaling up malaria prevention has saved the lives of an estimated three-quarters of a million (736 700) children in 34 malaria-endemic countries in Africa, the vast majority in the past five years when substantial funding has become available. Put another way, in the past decade an average of 202 children have been saved each day from dying of malaria thanks to prevention scale-up. In 2001, an average of 14 children were saved daily; in 2010, the number is up to 485.

The estimates, based on ITNs, IRS, and IPTp coverage, indicate that the following countries reduced child malaria deaths by at least 20%: Gambia (24%), Guinea-Bissau (30%), Mali (25%), Senegal (21%), Togo (20%) and Zambia (21%).

The analysis in this report indicates that most of the children's lives have been saved since 2006, when scale-up of ITNs accelerated across Africa. Vector control, mostly through ITNs, accounted for 97% of the estimated children's lives saved over the past decade.

If universal vector control with ITNs and targeted IRS is achieved by the end of this year, nearly three million children could be saved between 2010 and 2015, resulting in a halving (54%) of child malaria deaths since 2000 after accounting for population growth. This would represent a 12% decline in the rate of all-cause child mortality based on the single vector control intervention. However, if funding were to cease and vector control strategies were no longer available, in the 2011–2015 interval an estimated 476 000 additional children would die, using stable coverage at current levels as the point of comparison.

Rapidly achieving and maintaining universal coverage with vector control should be the highest priority for malaria prevention. Millions of children's lives depend on it.

The LiST estimate of 736 700 children's lives saved over the past decade may seem modest, but calculations have been deliberately conservative in several ways:

- The LiST analysis did not include lives saved due to prompt treatment of fevers with artemisinin-based combination therapy. By 2009, all but one malaria-endemic country in Africa had adopted this therapy as the first-line drug for uncomplicated *P. falciparum* malaria *(35)*. Increased access to effective antimalarials, in conjunction with the increased use of rapid diagnostic tests, probably prevented many more malaria deaths over the past decade.
- The LiST analysis does not account for the positive benefits from vector control scale-up on the overall community, whereby people

living in households without an ITN or IRS, but living near houses that have these interventions, will benefit from the prevention *(42)*.

- The LiST analysis does not account for the benefits in reducing indirect malaria mortality, whereby malaria is prevented as a co-infection that can lead to nutritional and immune compromise and exacerbate illnesses (diarrhoea, respiratory, measles and others) that contribute to a child death *(44)*. This indirect malaria mortality may be equal to or greater than the effect of direct-malaria mortality.
- The effect of malaria prevention in pregnancy is measured only through IUGR and not through prematurity, which has the larger impact on neonatal mortality *(30)*.
- ITN coverage of pregnant women was estimated by ITN use the previous night. This probably underestimates the protection women receive by living in a community which benefits from vector control.
- The LiST analysis defaulted to the most conservative estimates of prevention changes, making interpolations between surveys. Furthermore, current estimates do not account for the significant push during 2010 to procure and distribute more than 200 million nets, an effort that will certainly save many more children's lives.
- Finally, data linking household IRS coverage to household ITN possession were available in only three countries, resulting in an overall underestimation of the true proportion of households protected by either of those interventions.

Of particular note, LiST estimates do not include the expected decreases in under-five child mortality owing to "indirect" malaria mortality; as malaria transmission is reduced deaths from other causes are expected to decrease because malaria contributes to increased risk death from causes such as pneumonia, diarrhoea and measles as it impairs a child's nutritional status and immune system. Because such reductions are likely to be of the same order of magnitude as reductions in direct malaria mortality (44), actual lives saved from malaria control may be observed to be substantially higher than expected from LiST estimates and this has been observed in several locations (Ethiopia, Rwanda, and Zambia). Moreover, if universal access to diagnosis and effective treatment were made available, many additional malaria deaths could be prevented and these are not currently included in the LiST estimate.

Modelling results suggest that funding for malaria prevention in Africa over the past decade has contributed significantly to saving children's lives. Declines in child malaria deaths as a result of achieving universal prevention, especially in combination with improved access to diagnosis and effective case management, will contribute substantially to meeting MDG4 (reducing the under-five mortality rate by two thirds by 2015). Moreover, most African countries will be able to meet the MDG6 (Target 3) of halting and reversing trends in malaria incidence with successful scale-up of malaria prevention.

However, it has been estimated that there remains up to a 90% deficit in per-capita funding for full malaria prevention scale-up in several African countries. National governments and malaria control programmes, international donors, and the many partners involved in malaria control are implored do more to enable countries to achieve and maintain universal coverage as rapidly as possible *(43-45)*.

The RBM community is examining progress towards universal prevention by the end of 2010, with a view to achieving the MDGs by 2015. The LiST model is being used as one of several tools to track progress towards both of these goals. While the RBM community is encouraged by the recent progress, most of which has come in the past five years, sustained and expanded efforts will be required in the years leading to 2015 and beyond. While progress in malaria prevention will not by itself achieve MDG4, the numbers suggest that achieving MDG4 will absolutely require progress in malaria control.

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ANNEX 1. COUNTRY DATA TABLES

Table A1.1

Estimated malaria deaths in children 1 to 59 months old prevented by vector control scale-up from 2001–2010

Country	Malaria deaths 2000	Malaria deaths prevented					
		2001	2002	2003	2004	2005	2006
Angola	13 891	1	217	592	867	1 016	2 428
Benin	10 549	6	56	110	166	421	1 208
Burkina Faso	18 763	55	112	168	593	1 098	1 780
Burundi	4 387	1	39	79	121	195	305
Cameroon	20 574	4	8	12	11	165	338
Central African Republic	5 168	32	65	99	134	213	300
Chad	18 256	74	152	235	324	622	992
Congo	3 852	17	34	52	72	147	231
Côte d'Ivoire	18 057	0	0	0	0	15	476
Democratic Republic of the Congo	78 877	0	318	674	1 047	1 759	2 603
Ethiopia	22 168	76	153	234	316	409	4 497
Gambia	1 876	18	36	56	76	225	528
Ghana	22 067	126	255	387	491	1 165	3 274
Guinea	16 628	18	35	54	73	92	228
Guinea-Bissau	2 091	82	169	260	354	536	688
Kenya	14 552	109	224	318	284	899	3 425
Liberia	4 748	24	48	73	99	148	262
Madagascar	14 368	201	407	640	848	1 418	3 418
Malawi	10 327	323	660	1 013	1 384	1 831	2 295
Mali	22 663	423	866	1 336	1 834	3 016	6 935
Mauritania	1 453	0	0	0	24	40	54
Mozambique	34 449	207	422	650	866	3 399	4 652
Niger	12 312	124	258	405	568	1 023	3 650
Nigeria	293 122	726	1 462	2 295	2 427	2 551	2 667
Rwanda	1 810	9	18	28	40	123	401
Senegal	11 552	62	125	192	265	1 277	2 529
Sierra Leone	7 919	41	85	132	184	291	640
Somalia	2 228	11	22	34	46	75	131
Sudan	32 516	148	297	446	592	1587	3 102
Togo	4 787	137	278	426	578	1 005	1 201
Uganda	40 864	482	994	1 534	2 114	2 820	3 715
United Republic of Tanzania	39 485	777	1 595	2 453	3 384	4 564	5 946
Zambia	13 862	599	613	632	645	1 029	2 963
Zimbabwe	102	0	1	1	2	3	4
Total	820 323	4 913	10 024	15 620	20 829	35 177	67 866

Country	Malaria deaths prevented				Total deaths prevented	Uncertainty	
	2007	2008	2009	2010		Lower bound	Upper bound
Angola	3 997	5 694	6 430	7 206	28 448	18 441	42 912
Benin	1 608	3 121	3 455	3 788	13 939	9 281	19 675
Burkina Faso	2 454	3 552	4 238	4 944	18 994	13 164	26 170
Burundi	530	659	728	797	3 454	2 447	4 589
Cameroon	518	705	786	851	3 398	1 938	5 296
Central African Republic	442	677	733	792	3 487	2 479	4 649
Chad	1 390	1 864	2 031	2 216	9 900	4 186	17 396
Congo	354	451	486	524	2 368	803	4 238
Côte d'Ivoire	826	1 197	1 294	1 408	5 216	2 882	8 337
Democratic Republic of the Congo	3 550	4 663	5 378	6 070	26 062	14 964	39 606
Ethiopia	7 675	8 529	9 805	11 115	42 809	30 780	54 563
Gambia	777	1 085	1 117	1 152	5 070	3 702	6 582
Ghana	4 154	5 026	6 050	7 081	28 009	19 164	38 635
Guinea	453	582	608	642	2785	1 313	4 822
Guinea-Bissau	1 145	1 169	1 192	1 213	6 808	5 055	8 677
Kenya	6 493	7 504	8 686	9 851	37 793	27 570	49 330
Liberia	374	514	1 666	2 083	5 291	2 662	8 270
Madagascar	4 529	6 161	6 648	6 728	30 998	20 722	41 039
Malawi	2 906	3 906	4 401	4 903	23 622	17 499	30 310
Mali	10 877	12 916	13 266	13 596	65 065	45 884	85 641
Mauritania	73	87	106	126	510	281	732
Mozambique	5 941	7 943	8 943	10 007	43 030	23 291	63 033
Niger	4 392	5 115	5 996	6 922	28 453	20 059	37 885
Nigeria	3 730	11 664	13 850	15 844	57 216	29 911	95 681
Rwanda	674	792	914	1 037	4 036	3 006	5 289
Senegal	3 532	5 133	5 887	6 640	25 642	18 194	34 325
Sierra Leone	1 737	2 006	2 321	2 651	10 088	7 015	13 767
Somalia	189	232	261	291	1 292	894	1 720
Sudan	4 684	7 597	8 154	8 733	35 340	22954	43 574
Togo	1 452	1 468	1 692	1 926	10 163	7 478	13 124
Uganda	5 561	7 013	7 859	8 761	40 853	26 673	54 978
United Republic of Tanzania	8 774	10 600	12 248	14 021	64 362	44 885	83 068
Zambia	4 386	5 587	6 392	7 192	30 038	21 407	40 188
Zimbabwe	6	8	9	9	43	17	84
Total	100 183	135 220	153 630	171 799	715 261	471 001	988 185

Table A1.2
Estimated under-five child lives saved by malaria prevention in pregnancy scale-up 2001–2010

Country	Neonatal deaths in 2000	Malaria deaths prevented										Total deaths prevented	Uncertainty	
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010		Lower bound	Upper bound
Angola	31 944	42	96	155	226	286	361	452	529	619	715	3 481	2 002	4 592
Benin	9 170	1	2	3	4	5	6	7	8	10	11	57	29	75
Burkina Faso	18 884	0	0	0	0	1	2	4	5	7	9	28	7	92
Cameroon	17 481	0	0	0	8	18	30	42	54	66	79	297	157	465
Central African Republic	7 460	0	0	0	3	6	9	13	16	20	24	91	48	141
Congo	3 498	0	0	0	0	1	3	4	6	8	9	31	6	68
Côte d'Ivoire	25 131	0	0	0	0	21	46	73	101	129	158	528	281	813
Democratic Republic of the Congo	123 285	0	0	0	19	55	83	93	123	151	179	703	407	1 036
Gambia	2 504	0	4	7	11	15	19	24	29	34	39	182	117	243
Ghana	21 887	0	0	3	28	57	88	123	154	182	216	851	512	1 179
Guinea	14 408	0	0	0	0	3	7	12	16	18	23	79	24	168
Guinea-Bissau	2 525	0	0	0	0	3	7	11	15	20	24	80	42	113
Kenya	32 910	5	11	20	29	37	50	61	74	87	100	474	262	660
Liberia	5 971	2	3	6	8	10	31	56	89	114	144	463	245	648
Malawi	13 392	17	36	57	57	95	121	139	162	185	208	1 077	610	2 190
Mali	30 833	10	22	36	50	65	80	97	114	131	150	755	385	1 044
Mozambique	47 116	0	0	0	0	0	130	276	424	572	727	2129	1 232	2 962
Niger	19 853	6	14	23	33	44	57	69	83	98	113	540	300	726
Nigeria	190 668	0	5	11	44	87	105	171	237	303	351	1 314	768	2 006
Senegal	14 466	0	0	0	16	33	154	181	211	268	329	1 192	765	1 550
Sierra Leone	11 971	0	0	0	0	6	58	119	202	280	366	1 031	645	1 415
Somalia	15 591	0	0	0	0	2	3	5	7	10	12	39	11	88
Togo	7 549	0	0	0	0	11	23	35	47	60	73	249	140	369
Uganda	33 951	17	38	63	90	119	150	179	212	245	281	1 394	767	1 883
United Republic of Tanzania	39 467	30	67	108	148	188	228	269	311	354	398	2 101	1 171	2 922
Zambia	14 614	44	94	148	205	265	330	385	398	452	510	2 831	1 712	3 643
Zimbabwe	9 247	0	0	0	2	5	8	22	23	27	22	109	42	134
Total	765 776	174	392	640	981	1 438	2 189	2 922	3 650	4 450	5 270	22 106	12 588	33 576

Note: Malaria prevention in pregnancy–women received IPTp during last two pregnancies or if pregnant at time data were recorded, used ITNs previous night. Countries without stable malaria transmission or a policy of IPTp were excluded.

ANNEX 2. TECHNICAL NOTES

Technical notes and additional description of methods for estimating malaria deaths prevented from 2001 to 2010 using the Lives Saved Tool

1. African countries included in this analysis

Thirty-four countries in malaria-endemic Africa were included in the analysis of the impact of vector control on child mortality. Equatorial Guinea, Eritrea and Gabon were excluded due to lack of available data. Botswana, Cape Verde, Comoros, Djibouti, Lesotho, Namibia, Sao Tome and Principe, South Africa and Swaziland were excluded due to the low number of malaria deaths in these countries. The 34 countries included in the analysis represent 97.6% of the population at risk of malaria in sub-Saharan Africa or 99.3% of malaria deaths in 2000 *(1, 2)*. Twenty-seven malaria-endemic countries were included in the analysis of the impact of malaria prevention in pregnancy on malaria child deaths. Botswana, Burundi, Cape Verde, Comoros, Djibouti, Eritrea, Ethiopia, Lesotho, Mauritania, Namibia, Rwanda, Sao Tome and Principe, South Africa and Swaziland were excluded because malaria prevention in pregnancy has little to no effect in countries with low transmission. There is no official policy for malaria prevention in pregnancy with intermittent preventive treatment (IPTp) in these countries *(3, 4)*. Chad, Equatorial Guinea, Gabon, Madagascar and Sudan were excluded due to lack of available data. The 27 countries included in the analysis account for 81.5% of the population in sub-Saharan Africa at risk of malaria and 85.5% of the malaria child deaths in sub-Saharan Africa *(1, 2)*.

2. LiST model overview

The LiST model used in this analysis and accompanying documentation can be downloaded from www.jhsph.edu/dept/ih/IIP/list/. The LiST model is a computer-projection model used to estimate the number of deaths that can be prevented as a result of scaling up effective child health interventions. A complete description of the uses of the model and background details on its creation, including expert technical inputs, is described in detail elsewhere *(5)*. The LiST model is programmed as a module in the demographic projection model SPECTRUM, as described elsewhere *(6)*. The LiST model uses a simple cohort model that follows children through five age bands from birth to five years to estimate the number of neonatal and child deaths that could be prevented in different intervention scale-up scenarios.

The model can be used to make future projections of deaths prevented from intervention scale-up, compared with a baseline of the current year, or can be used retrospectively to estimate the number of deaths that were prevented in the past from intervention scale-up, compared with a historical baseline year. The model estimates child deaths prevented (within specific cause-of-death categories) due to intervention scale-up within a specified country as a function of three primary parameters: first, the number of child deaths by cause projected to occur in each year (including population growth parameters over time); second, the protective effect (PE) on cause-specific mortality (PE = 1-relative risk × 100) for each intervention being scaled up; and third, increases in population coverage of each intervention. The model computes the number of deaths prevented by cause each year, accounting for population growth, as the difference between the estimated deaths that occur with intervention scale-up and the estimated deaths that would have occurred had no scale-up occurred beyond the level at a baseline year. The following basic

equation is used within the model to estimate the number of malaria deaths for children aged 1–59 months that were prevented due to increases in vector control coverage (ITNs and IRS), where cause (i) is malaria and intervention (j) is vector control:

$\%RedMort^{ij}_{s}$ = $[I^{ij} \times (P^{i}_{t} - P^{i}_{0})]/(1 - \underline{I^{ij}} \times \underline{P^{i}_{0}})$, where:
$\%RedMort^{ij}_{s}$ = % reduction in mortality from cause i by scale-up of intervention j
$\underline{I^{ij}}$ = effectiveness of intervention j in reducing mortality from cause i
$\underline{P^{i}_{0}}$ = baseline coverage of the intervention j
$\underline{P^{i}_{s}}$ = scale-up coverage for the intervention j

LiST then calculates the number of malaria deaths prevented among children aged 1–59 months from vector control scale-up (s) with the following equation, where cause (i) is malaria and intervention (j) is vector control:

$$DeathsAverted^{ij}_{s} = DeathsAvertedTotal_{s} \times (\%RedMort^{ij}_{t}/\%RedMort^{Total}_{s})$$

While low birth weight is due to either IUGR or preterm delivery, the effect of malaria prevention interventions during pregnancy (either through ITNs or IPTp) on low birth weight in the LiST model acts solely through IUGR. The estimate of under-five child deaths prevented due to malaria prevention in pregnancy acts through IUGR, which has two effects in the LiST model for estimating under-five child deaths prevented, as noted elsewhere *(7, 8)*. First, children with IUGR have a greater relative risk (RR) of dying during the neonatal period, with increased RR of dying due to diarrhoea (where RR is 2.0), sepsis/pneumonia (where RR is 2.0), and asphyxia (where RR is 2.3). Second, IUGR increases the chance that the child will be stunted, which in turn increases the RR for measles, malaria, diarrhoea and pneumonia deaths in the post-neonatal period. In this analysis, the effect of malaria prevention in pregnancy acted only on deaths from the first two pregnancies of women in each country. The following basic equation is used within the model to estimate the number of malaria deaths of children aged 1–59 months that can be prevented in pregnancy, where cause (i) is deaths from IUGR and intervention (j) is the composite indicator for ITNs and IPTp in the first two pregnancies:

$\%RedIUGR^{i}$ = $I^{i} \times (P^{i}_{t} - P^{i}_{0})/(1 - I^{i} \times \underline{P^{i}_{0}})$, where:
$\%RedIUGR^{i}$ = percentage of reduction in IUGR due to intervention scale-up of j
I^{i} = proportion by which intervention j reduces IUGR
P^{i}_{0} = baseline coverage of the intervention j
P^{i}_{s} = scaled-up coverage for the intervention j

3. Key assumptions of the LiST model analysis used here

- The impact of the intervention remains constant across levels of intervention coverage.
- All deaths prevented due to vector control scale-up are caused solely by malaria.
- The protective effect of vector control interventions on malaria mortality in children aged 1–59 months is constant across this age range.
- Intervention coverage for a given year represents the yearly mean coverage over the period.
- The model does not account for any possible synergistic effect between ITNs and IRS, or IPTp and ITNs, for preventing child deaths

- Coverage by a malaria prevention intervention is assumed independent from coverage by another malaria prevention intervention.

4. Within-country estimates of cause-specific child deaths

Within the LiST model, the number of disease/condition-specific deaths among children under-five years of age in each country is based on country-specific estimates of cause-specific mortality for all low- and middle-income countries, whereby a disease/condition-specific mortality profile is applied to the estimated total number of deaths among under-five children for each country each year. These estimates were developed for the 2000–2003 period for WHO and UNICEF by the CHERG *(9)* and then reviewed by national programmes before being adopted as the official UN estimates of cause-specific mortality for under-five children. The number of malaria deaths in children aged 1–59 months in our baseline year of 2000 was estimated as the proportion of the under-five all-cause mortality envelope attributable to malaria by the CHERG for each sub-Saharan African country *(10)*.

5. Estimates of intervention effectiveness

As described in detail elsewhere, the protective effect of vector control for preventing malaria deaths in children aged 1–59 months has been estimated to be 55% (ranging from 49–60%) based on a systematic review of related trials and studies. The protective effect of malaria prevention during pregnancy for preventing low birth weight has been estimated to be 35% (95% confidence interval [CI] 23–45%) during the first two pregnancies in malaria-endemic areas based on a systematic review of related trials *(11)*.

6. Methods for obtaining survey-point estimates for malaria prevention coverage from 2000 to 2010

The majority of malaria deaths occur in rural areas. It has also been shown that intervention coverage in rural areas lags behind urban areas in many countries in Africa, especially prior to 2005 *(12, 13)*. For these reasons and to be most conservative, the level of malaria prevention intervention coverage in rural survey strata was used to estimate for each country the malaria deaths prevented from intervention scale-up at the national level.

6a) Estimating yearly vector control intervention coverage (ITNs/IRS) 2000 to 2010

As outlined elsewhere *(11)*, estimates of the proportion of households protected by vector control in the LiST model are defined as a household owning either at least one ITN or LLIN (henceforth referred to as ITN), or having received IRS in the previous year. Vector control coverage estimates from 2000–2010 were used in the LiST analysis to estimate the malaria deaths prevented from 2001–2010, compared with a baseline in 2000. These estimates were obtained from reports of national household surveys that included the DHS, the MICS, the MIS, and AIS. If the survey was conducted across two calendar years (i.e. from 2005 to 2006), the estimate was applied to the earlier year.

Empirically estimated standard errors adjusted for correlated data at the cluster level were ascertained from all available survey datasets to obtain 95% CIs about survey estimates. For those surveys without available datasets and where standard errors were not reported (33 of 74), standard errors were imputed using a linear regression model that included sample size, point estimate, and type of survey. This resulted in the following model (R^2 = 0.8137, F-test = 36.72, df= 40, P-value < 0.0001):

Model 1

Standard error = 0.8946405 + -0.0000283 × (sample size) + 0.0121927 × (estimate) + 1.326496 × (MIS) + -0.3979849 × (MICS)

Most DHSs and MICS from 2000–2001 did not ascertain information on the number of ITNs per household, only on the proportion of under-five children sleeping under an ITN the previous night. To estimate household possession of an ITN from such surveys without household possession information, we used the empirical relationship (ratio) between ITN household possession and child ITN use reported in surveys within the same country at a later time. Empirically estimated standard errors for these estimates were then imputed using Model 1. This method of household ITN estimation was used for the following countries from 2000 to 2001: Angola, Benin, Burundi, Cameroon, Central African Republic, Côte d'Ivoire, Democratic Republic of the Congo, Gambia, Guinea-Bissau, Kenya, Malawi, Niger, Rwanda, Senegal, Sierra Leone, Togo, Uganda, the United Republic of Tanzania, and Zambia (Table A2.1).

The bulk of the scale-up of ITNs/IRS occurred after 2004 across Africa *(14)*. To avoid using a linear interpolation between survey data points, for the period of 2004 to 2008 ITN procurement data from manufacturers for each country were used to inform ITN coverage estimate changes between survey estimates as follows. Predicted estimates of the proportion of households with more than one ITN within each country from 2004 to 2008 were ascertained from a basic linear regression model. The model quantified the observed relationship between net delivery data from manufacturers, aggregated yearly, and ITN household coverage estimates from household surveys. Data on the delivery of ITNs and LLINs to countries from manufacturers from 2004 to 2008 were obtained from the Net Mapping Project (John Millner, United States Agency for International Development). Under this project, yearly data on the number of ITNs and LLINs bought and shipped to countries were obtained from Sumitomo/A-Z, Vestergaard-Frandsen, Clarke, BASF, Intection/BestNet, and Tana Netting. Estimates of national ITN household possession from nationally representative household surveys from 2004 to 2008 were obtained as outlined above. ITNs reported delivered by manufacturers as older than three years (i.e. those nets delivered to countries more than three years ago) were subtracted from the cumulative number of nets each year. To account for the lag between ITN manufacturer delivery to the country and availability to the household, yearly cumulative ITN delivery estimates were lagged by one year. The three-year lagged cumulative ITN delivery estimates were then standardized across countries by the number of households within the country, with the final variable henceforth referred to as yearly corrected ITN delivery estimates. There were 47 data points across countries from 2004 to 2008, with both a survey-derived estimate of ITN household possession and yearly corrected ITN delivery estimates. In addition to the yearly corrected ITN delivery estimates, the following covariates were included in the regression model and tested for model fit: year, proportion of households within each country at-risk for malaria (as defined by MARA, http://www.mara.org.za), the gross national income for 2006 and a dichotomized variable (0,1) indicating if the country was a President's Malaria Initiative (PMI) country in a particular year. The fit of models with the squaring, cubing, log, exponent, and quadratic of yearly corrected ITN delivery estimates was assessed using an F-test. The following model had the best fit ($R^2 = 0.7099$, F-test = 20.07, df= 46, P-value < 0.0001):

Model 2

Proportion of households with ≥1 ITN = -8612.68154 + 18.74738 × (corrected net delivery) + -0.00095456 × (proportion of households at-risk of malaria) + 4.30381 × (year) + -0.00466 × (GNI) + 9.40987 × (PMI)

The predicted estimates from model 2 were not actually used in the LiST analysis reported here in place of survey estimates (Table A2.2). Rather, the per cent changes year to year (slope of the

line) from the predicted results of model 2 were used to inform changes in household ITN possession between household survey estimates from 2004 to 2008. In the case that this per cent change showed a decline in coverage, ITN coverage was held constant until it began to rise again. An actual decline in ITN coverage is not expected due to the large increase in funding for malaria interventions throughout this time period. This occurred in four instances: Côte d'Ivoire, Nigeria, Togo, and Zambia.

Coverage from 2000 to 2003 was estimated using linear interpolation from the earliest survey point estimate to the 2004 estimate obtained using the above method. For those countries without a survey estimate in 2000, the 2000 estimate was set to the survey estimate in 2001, with its respective 95% CIs. If the country did not have a 2000 or 2001 survey, the estimate in 2000 was set to 1.9, the mean estimate across all 2000–2001 survey estimates, with the exception of Gambia in 2000 (Gambia had high net coverage in 2001, 20.2%, due to the ITN trials that occurred, and was therefore excluded). The standard error from the earliest survey was then applied to the 2000–2003 midpoint estimate to obtain uncertainty intervals. A survey in 2003 in Mauritania estimated household ITN possession to be 0.6, and so this value, with its respective 95% CI, was used for the 2000–2002 period. This process yields the most conservative slope and although perhaps overestimating the proportion of rural households owning an ITN in 2000, it will yield the most conservative impact on lives saved throughout the decade.

Coverage for 2009 to 2010 was projected by applying the linear slope between the most recent survey and the earliest survey. This approach yielded the most conservative slope for this period while maintaining the expected increase in coverage due to increasing funding. For countries whose coverage estimate was projected to reach more than 80%, vaccination coverage was used as the maximum limit to population coverage by an intervention. Vaccination coverage was determined from latest household surveys (DHS or MICS) as either caregiver report or the actual record of vaccination. The following countries were projected to achieve more than 80% coverage using the above outlined methods: Gambia, Guinea-Bissau, Madagascar, Mali, Senegal, and Zambia. Senegal and Zambia both had vaccination coverage exceeding the estimated household ITN coverage, so the estimates were not limited. The following limits were used for the other countries: Gambia at 99.3% (BCG vaccine), Guinea-Bissau at 86.4% (BCG vaccine), Madagascar at 75% (polio vaccine) and Mali, at 83.8% (polio vaccine).

Madagascar had no nationally representative survey that measured ITN coverage. A subnational survey of all malarious regions conducted in 2008 was used as an alternative. Chad had no nationally representative survey that measured ITN household possession. The 2004 DHS conducted within the country did, however, show the proportion of households owning a mosquito net to be 61% among rural households. The ratio of the proportion of households owning a mosquito net to the proportion of households owning more than one ITN was ascertained for Burkina Faso and then applied to Chad. The standard error was then imputed using model 1 to achieve 95% CIs. Burkina Faso was used because of the similarity in climate, mosquito net culture and proximity of survey date. Sudan's household survey did not specify between urban and rural populations, so the overall proportion of households owning more than one ITN was used.

Resultant ITN/IRS coverage changes for each country from 2000 to 2010, with uncertainty, are presented in Annex 3.

6b) Estimating yearly intervention coverage for malaria prevention in pregnancy (IPTp/ITN) from 2000 to 2010

As outlined elsewhere *(11)*, protection by malaria prevention in pregnancy, defined as the higher of the estimates of either proportion of pregnant

women using an ITN the previous night or the proportion of women who had a live birth in the previous two years who received two or more doses of sulfadoxine-pyrimethamine (SP) during an antenatal care visit (IPTp), were used in the LiST analysis. These estimates were obtained from the final reports of DHS, MICS, MIS, and the Office of National Statistics (ONS) surveys (Table A2.3). In three surveys, the number of doses of SP or where it was received was not specified (Congo 2005, Liberia 2005, and Malawi 2000) ; in these cases the overall IPTp coverage estimate provided by the survey was used. In three surveys, the number of doses of SP or where it was received was not specified (Congo 2005, Liberia 2005, and Malawi 2000) ; in these cases the overall IPTp coverage estimate provided by the survey was used.

Standard errors were ascertained from survey datasets to obtain 95% CIs about survey-point estimates. Where standard errors about the estimate were unavailable (6 of 40), the standard errors were imputed using a linear regression model that included sample size and point estimate. This resulted in the following model (R^2 = 0.5866, F-test = 27.25, df= 37, P-value < 0.0001):

Model 3

Standard error = 0.9892653 + -0.0002029 × (sample size) + 0.0299353 × (estimate)

The year prior to the country declaring IPTp with SP as national policy was set to 0%, for those countries using IPTp as the coverage indicator (4, 15, 16). It was unclear what year Liberia had adopted the policy and so the year 2000 was set to 0 in its case. Where the higher indicator for malaria prevention in pregnancy was ITN use by pregnant women, the coverage of ITNs among pregnant women was set to 0% in 2000.

Linear interpolation was used between the first year of measured coverage and the next available survey-point estimate. Linear interpolation was also used between multiple surveys where available. The slope between the most recent household survey and the earliest household survey was used to inform the increase for years beyond the most recent household survey through to 2010. In the case that there was only one household survey in the country, the year set to 0 was used in place of the earliest household survey.

Maximum coverage estimates were limited at the proportion of women receiving any ANC for countries projected to reach more than 80% coverage of IPTp/ITNs. Senegal was the only country reaching more than 80% coverage but the estimate did not surpass ANC coverage and so no limit was applied. Coverage was assumed never to decrease unless surveys estimated otherwise.

Resultant IPTp/ITN coverage changes for each country from 2000 to 2010, with uncertainty, are presented in Annex 3.

7. Uncertainty

Uncertainty bounds about total estimated malaria deaths prevented from vector control from 2001 to 2010 were based on a non-probabilistic sensitivity analysis of the uncertainty of the three primary model parameters: estimated malaria deaths within each country; the estimated PE of vector control on malaria mortality; and intervention coverage changes from 2000–2010. Using this approach, lower and upper uncertainty bounds were estimated using a best-case/worst-case scenario. The uncertainty about the number of malaria deaths among children aged 1–59 months was derived from the 95% CIs about the proportion of all deaths due to malaria in this age group in 2000 estimated by the CHERG *(2)*. The reported range of 41 to 60% about the 55% PE of vector control for preventing malaria mortality was used as the uncertainty about this parameter in this analysis *(11)*. The uncertainty about ITN scale-up is dependent on the per cent change or the slope of the vector control coverage curve, from 2000

to 2010. Under the largest-increase scenario, the per cent change in coverage was set to that from the lower bound of the 95% CI in 2000 to the upper bound in 2010, resulting in the greatest slope during this period. Under the smallest-increase scenario, the per cent change in coverage was set to that from the upper bound of the 95% CI in 2000 to the lower bound in 2010, resulting in the least slope during this period. The slope of each bound between 2000 and 2010 was informed by the slope of the midpoint over this period (see Fig. 3.1 in the main report for resultant uncertainty of vector control scale-up from 2000 to 2010).

Uncertainty bounds about the total estimated child lives saved due to malaria prevention during pregnancy from 2001–2010 were based on a non-probabilistic sensitivity analysis of the uncertainty of two primary model parameters: the estimated PE of malaria prevention in pregnancy on preventing low birth weight; and intervention coverage. The 95% CI of 23% to 45% about the 35% PE of malaria prevention in pregnancy for preventing low birth weight was used as the uncertainty about this parameter in this analysis *(11)*. The uncertainty about IPTp/ITN scale-up under the largest-increase/smallest-increase scenario followed the methodology for vector control outlined above. Linear interpolation was used between bounds (see Fig. 3.2 in the main report for resultant uncertainty of malaria prevention in pregnancy scale-up from 2000 to 2010).

8. Estimating total continental coverage

Yearly coverage estimates for each country were weighted according to each country's 2005 population estimate (mid-point of the 2000 to 2010 period) to estimate the continental coverage rates of vector control in rural areas and malaria in pregnancy prevention in rural areas.[17]

Table A2.1
Vector control coverage estimates from household surveys

Country	Year	Rural HH estimate (%)	Sample Size	Rural HH standard error	95% confidence interval	Survey
Angola	2001	1.4[a]	1 968	0.4[b]	0.7–2.1	MICS
Angola	2006	25.9	1 500	3.5	19.0–32.7	MIS
Benin	2001	4.7[a]	3 185	0.8[b]	3.0–6.3	DHS
Benin	2006	21.4	10 279	0.8	20.0–22.9	DHS
Burkina Faso	2003	3.2	6 898	0.4	2.4–4.1	DHS
Burkina Faso	2006	15.2	5 010	0.6	14.1–16.4	MICS
Burundi	2001	1.2[a]	3 325	0.3[b]	0.6–1.9	MICS
Burundi	2005	8.5	7 020	0.4	7.8–9.1	MICS
Cameroon	2000	0.9[a]	2 071	0.4[b]	0.2–1.6	MICS
Cameroon	2004	1.0	5 616	0.2	0.6–1.5	DHS
Cameroon	2006	3.5	4 808	0.3	2.9–4.1	MICS
Central African Republic	2000	1.4[a]	8 963	0.2[b]	1.0–1.7	MICS
Central African Republic	2006	11.2	7 628	0.3[b]	10.5–11.9	MICS
Chad	2004	20.7[c]	4 295	1.0[b]	18.7–22.7	DHS
Congo	2005	2.1	2 028	0.3	1.5–2.6	DHS
Côte d'Ivoire	2000	2.1[a]	4 919	0.3[b]	1.5–2.6	MICS
Côte d'Ivoire	2005	2.2	2 473	0.5	1.3–3.1	DHS
Côte d'Ivoire	2006	6.3	4 348	0.5	5.3–7.4	MICS
Democratic Republic of the Congo	2001	0.2[a]	6 559	0.2[b]	0.0–0.6	MICS
Democratic Republic of the Congo	2007	7.1	5 188	1.0	5.2–9.0	DHS
Ethiopia	2000	0.0	14 072	0.5[b]	0–0.9	DHS
Ethiopia	2005	3.1	10 055	0.6	1.9–4.2	DHS
Ethiopia	2007	56.2	6 154	2.7[b]	50.8–61.6	MIS
Gambia	2000	21.9[a]	2 300	0.7[b]	20.6–23.2	MICS
Gambia	2006	61.6	3 230	0.9	59.9–63.3	MICS
Ghana	2003	4.8	3 733	0.6	3.5–6.1	DHS
Ghana	2006	25.8	3 822	0.8	24.3–27.4	MICS
Ghana	2008	37.5	6 603	1.2	35.2–39.9	DHS
Guinea	2005	2.7	4 562	0.3	2.1–3.3	DHS
Guinea-Bissau	2000	2.9[a]	3 571	0.3[b]	2.2–3.6	MICS
Guinea-Bissau	2006	54.1	3 071	0.9	52.3–56.0	MICS
Kenya	2000	3.3[a]	1 439	0.4[b]	2.5–4.2	MICS
Kenya	2003	5.8	5 662	0.6	4.6–7.0	DHS
Kenya[e]	2007	47.7	5 929	1.4[b]	45.0–50.4	MIS
Liberia	2005	6.7	6 337	2.0[b]	2.7–10.7	MIS
Liberia	2009	51.8	2 278	3.2	45.4–58.2	MIS
Madagascar	2008	70.5[f]	2 860	2.1[b]	66.3–74.7	ONS
Malawi	2000	3.1[a]	2 528	0.8[b]	1.4–4.7	DHS

Country	Year	Rural HH estimate (%)	Sample Size	Rural HH standard error	95% confidence interval	Survey
Malawi	2004	24.8	11 939	0.8	23.2–26.5	DHS
Malawi	2006	37.5	27 711	0.4	36.8–38.3	MICS
Mali	2006	48.4	8 859	1.5	45.3–51.4	DHS
Mauritania	2003	0.6	2 218	0.8[b]	0.0–2.2	DHS
Mauritania	2007	8.5	6 393	0.4	7.8–9.3	MICS
Mozambique[e]	2007	28.8	2 740	2.5[b]	24.0–33.6	MIS
Niger	2000	3.6[a]	3 227	0.4[b]	2.9–4.3	MICS
Niger	2006	44.2	5 298	1.5	41.1–47.2	DHS
Nigeria	2003	3.1	4 291	0.6	1.9–4.2	DHS
Nigeria	2008	7.6	23 346	0.4	6.8–8.5	DHS
Rwanda	2000	1.8[a]	2 410	0.4[b]	1.1–2.5	MICS
Rwanda	2005	11.8	8 165	0.7	10.5–13.1	DHS
Rwanda	2007	53.8	6 229	2.7[b]	48.5–59.1	MIS
Senegal	2000	4.8[a]	6 500	0.3[b]	4.2–5.4	MICS
Senegal	2005	22.2	4 296	1.1	20.1–24.3	DHS
Senegal	2006	38.4	1 807	2.3	33.9–43.0	MIS
Senegal	2008	69.9	6 304	1.6	66.7–73.0	MIS
Sierra Leone	2000	0.9[a]	1 961	0.4[b]	0.1–1.6	MICS
Sierra Leone	2005	6.5	2 375	0.5	5.4–7.5	MICS
Sierra Leone	2008	36.7	4 328	1.5	33.7–39.7	DHS
Somalia	2006	11.0	3 768	0.5	10.0–12.1	MICS
Sudan	2006	18.4[d]	24 036	0.4[b]	17.6–19.2	ONS
Togo	2000	1.5[a]	2 411	0.4[b]	0.8–2.2	MICS
Togo	2006	42.5	4 312	0.9	40.8–44.2	MICS
Uganda	2000	0.3[a]	6 793	0.7[b]	0–1.7	DHS
Uganda	2006	14.0	7 480	0.9	12.2–15.9	DHS
United Republic of Tanzania	1999	0.1	2 669	0.8[b]	0.0–1.7	DHS
United Republic of Tanzania	2004	13.8	7 576	1.0	11.8–15.8	DHS
United Republic of Tanzania	2007	32.6	6 662	1.2	30.2–35.0	AIS
Zambia	2000	3.3[a]	2 896	0.4[b]	2.5–4.0	MICS
Zambia	2001	10.9	5 112	0.9	9.2–12.6	DHS
Zambia[e]	2006	37.9	1 786	3.0	32.1–43.7	MIS
Zambia	2007	53.7	4 469	1.8	50.1–57.3	DHS
Zambia[e]	2008	66.3	2 882	2.7	60.9–71.7	MIS
Zimbabwe	2005	7.2	6 229	0.8	5.6–8.7	DHS

Note: Vector control-houses protected by either ITNs and/or IRS.

a) These estimates are derived from the ratio of children sleeping under an ITN the night before.
b) These standard errors are imputed using model 1.
c) Chad ITN estimate was derived using the ratio of mosquito nets to ITNs of Burkina Faso, 2003.
d) Sudan's estimate is for total country, not specific to rural areas.
e) Estimated with households protected by either ITNs or IRS; all others just use ITN household possession.
f) Madagascar estimate is among households in malarious regions.

Table A2.2

Model-derived estimates of proportion of households with more than one ITN, estimated from cumulative ITN procured in model 1

Country	2004	2005	2006	2007	2008
Angola	11	16	26	41	55
Benin	8	13	26	33	57
Burkina Faso	9	14	21	27	36
Burundi	12	17	25	40	48
Cameroon	4	8	12	17	21
Central African Republic	10	14	19	26	39
Chad	8	13	18	23	29
Congo	8	12	17	25	31
Côte d'Ivoire	5	9	14	21	28
Democratic Republic of the Congo	3	8	14	20	28
Ethiopia	5	10	27	44	49
Gambia	11	15	23	30	49
Ghana	5	10	24	39	46
Guinea	9	13	20	30	36
Guinea-Bissau	12	18	22	39	42
Kenya	6	11	30	54	60
Liberia	11	16	34	50	70
Madagascar	10	15	34	43	58
Malawi	9	23	27	33	43
Mali	9	13	29	43	75
Mauritania	9	15	19	25	28
Mozambique	7	20	27	33	43
Namibia	0	1	10	20	44
Niger	9	14	39	44	49
Nigeria	0	0	0	0	1
Rwanda	11	26	34	55	63
Senegal	10	26	33	44	63
Sierra Leone	11	16	22	56	62
Somalia	11	16	25	33	39
Sudan	4	9	15	22	35
Togo	16	27	32	38	31
Uganda	16	20	26	37	45
United Republic of Tanzania	13	18	22	26	31
Zambia	8	13	33	43	68
Zimbabwe	9	14	18	24	30

Table A2.3
Malaria in pregnancy intervention coverage estimates from household surveys 2000–2010

Country	Year	Rural HH estimate	Sample Size	Rural HH standard error	95% confidence interval	Survey
Angola	2006	26.4[c]	269	1.6	23.3 – 29.5	MIS
Benin	2006	2.3[c]	1962	0.2	1.9 – 2.7	DHS
Burkina Faso	2006	0.3	156	0.2	0.0 – 0.7	MICS
Cameroon	2006	8.9	685	1.3	6.4 – 11.5	MICS
Central African Republic	2006	4.7	2510	0.6[b]	3.5 – 5.9	MICS
Congo	2005	3.2[a]	933	0.9[b]	1.5 – 4.9	DHS
Côte d'Ivoire	2006	7.2	2258	0.7	5.9 – 8.5	MICS
Democratic Republic of the Congo	2007	4.4	2130	0.8	2.9 – 5.9	DHS
Gambia	2006	33.8	2052	1.1	31.8 – 35.9	MICS
Ghana	2003	0.9	1076	0.3	0.3 – 1.5	DHS
Ghana	2006	26.1	944	1.6	22.9 – 29.3	MICS
Ghana	2008	43.5	811	2.5	38.6 – 48.3	DHS
Guinea	2005	1.2	2122	0.3	0.7 – 1.7	DHS
Guinea-Bissau	2006	7.1	531	0.7	5.8 – 8.4	MICS
Kenya	2003	4.4	1802	0.6	3.3 – 5.5	DHS
Kenya	2007	12.8	1644	1.0[b]	10.4 – 14.4	MIS
Liberia	2005	4.3[a]	510	1.0[b]	10.4 – 14.4	MIS
Liberia	2009	44.8	1009	2.9	39.0 – 50.5	MIS
Malawi	2000	28.3	4180	0.9	26.6 – 30.0	DHS
Malawi	2004	42.5[a]	4246	1.0	40.5 – 44.4	DHS
Malawi	2006	45.7	9279	0.7	44.3 – 47.1	MICS
Mali	2006	5.6[c]	1896	0.5	4.5 – 6.6	DHS
Mozambique	2007	16.1	1016	1.3[b]	13.6 – 18.6	MIS
Niger	2006	4.9	1311	0.3	4.4 – 5.4	DHS
Nigeria	2003	0.2	1544	0.1	0.0 – 0.4	DHS
Nigeria	2008	3.7	8311	0.3	3.1 – 4.3	DHS
Senegal	2005	10.0	3126	0.8	8.4 – 11.7	DHS
Senegal	2006	46.5	1352	2.3	41.9 – 51.1	MIS
Senegal	2008	54.2	4450	1.4	51.3 – 57.0	MIS
Sierra Leone	2005	1.1	103	1.0[b]	0.0 – 3.0	MICS
Sierra Leone	2008	29.3[c]	238	1.3	26.8 – 31.8	DHS
Somalia	2006	0.7	1426	0.2	0.3 – 1.1	MICS
Togo	2006	18.5	1213	1.3	15.9 – 21.1	MICS
Uganda	2006	16.2	2956	0.9	14.4 – 18.0	DHS
United Republic of Tanzania	2004	18.6	1908	1.0	16.6 – 20.7	DHS
United Republic of Tanzania	2007	27.9	2550	1.5	25.0 – 30.8	AIS
Zambia	2006	52.5	1030	1.9	48.6 – 56.3	MIS
Zambia	2007	59.1	1830	1.8	55.5 – 62.7	DHS
Zambia	2008	58.1	1658	1.7	54.7 – 61.5	MIS
Zimbabwe	2005	7.4	1642	1.0	5.5 – 9.4	DHS

Note : Malaria in pregnancy interventions—IPTn or ITNs, which ever is higher.

a) These estimates were not specified as 2+ doses of SP received at antenatal care.
b) These standard errors are imputed using model 3.
c) These estimates are for pregnant women sleeping under an ITN the night before the survey; all others are IPTp received among women having given birth in the previous two years.

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ANNEX 3. WEB INFORMATION

The RBM web site (http://rollbackmalaria.org) includes additional information on the country-specific estimates for malaria prevention scale-up that were developed in this analysis.

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