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## Estimated global resources needed to attain international malaria control goals

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### Introduction

Globally, there are more than a million malaria-related deaths each year. About four-fifths of these are in Africa.[1]

Effective interventions that reduce death and illness from malaria are still not widely accessible in most malaria-endemic countries. The World Health Assembly in 2005 urged Member States to establish policies and operational plans to ensure that at least 80% of those at risk of, or suffering from, malaria benefit by 2010 from major preventive and curative interventions, so as to ensure a reduction in the burden of malaria of at least 50% by 2010 and 75% by 2015.[2] These targets are echoed in the Roll Back Malaria Partnership Global Strategic Plan 2005-2015.[3] The United Nations Millennium Declaration set a target to halt and begin to reverse the global incidence of malaria by 2015.[4]

Achieving these targets will require additional financial resources. Comparison of estimated costs with present investments should help accelerate mobilization of funds and identify important country-level gaps.

This paper presents the methods used to construct a model for estimating the total financial costs of scaling up malaria control over 2006-2015 to achieve internationally agreed objectives and targets for the 81 most heavily affected malaria-endemic countries of the world's 107 malaria-endemic countries and territories. Pessimistic and optimistic scenarios with different assumptions about the effect of interventions on the needs for diagnosis and treatment provide upper and lower bounds of the estimation.

The exercise includes a set of widely recommended interventions. Besides commodities and distribution costs, we included costs for necessary health system strengthening activities (programme costs in Figures 1-4), especially for community health workers, training, communication, operational research and monitoring and evaluation. We did not include costs for running health facilities since the bulk of interventions will be delivered at the peripheral level, and effective prevention and treatment of malaria should reduce the number of severe malaria cases requiring hospitalization. While we included the costs of technical assistance for national programmes, we did not consider those

required at international level for managing such assistance, monitoring and evaluation, and research and development.
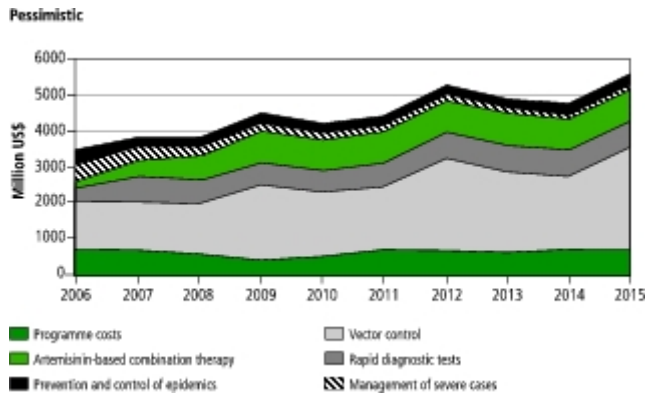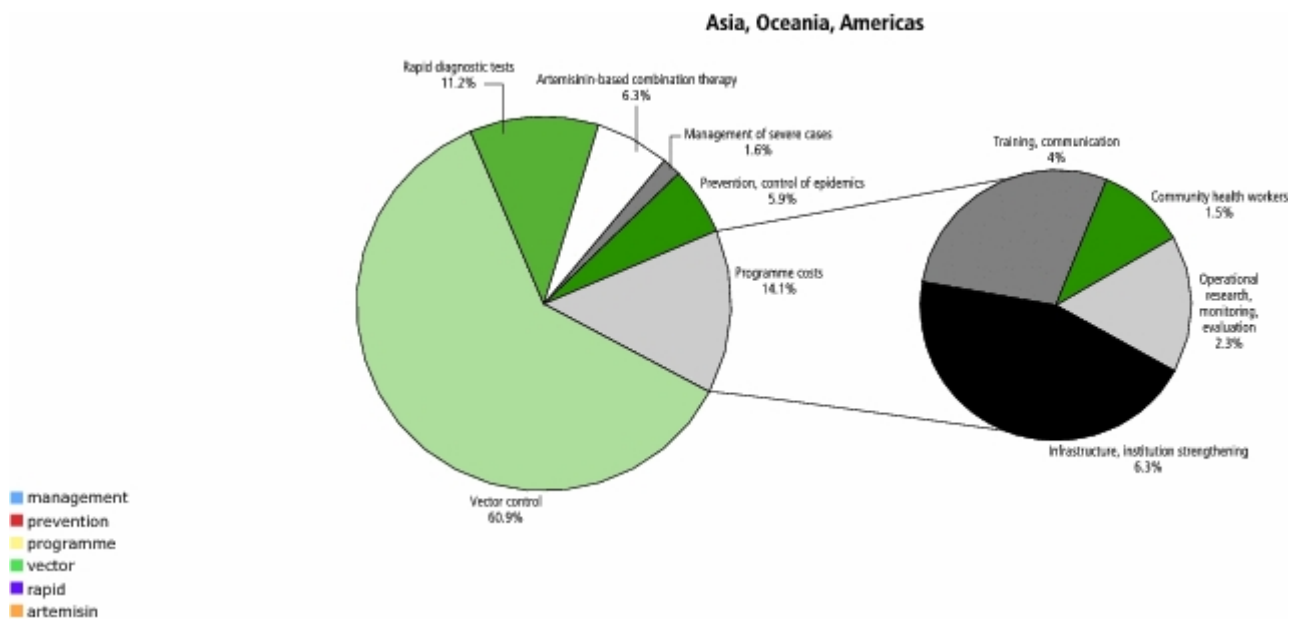
**Pessimistic**



Fig. 1. Estimated global malaria control intervention and programme costs from 2006–2015 according to the pessimistic scenario[a]



The analysis estimates the total cost of scaling up malaria control in each country, including the costs of existing levels of interventions. The needs calculated are then compared to current health expenditures and funding for malaria control by country.

## Methods

A detailed description, including assumptions and calculations, is available in the working paper *Methodology for estimating the costs of global malaria control (2006-15)*, at http://www.who.int/malaria/costing.

To arrive at the cost estimates, we selected countries for the analysis, estimated the population in need of each intervention, prepared scale-up scenarios, and calculated country-specific costs. All costs are calculated in 2006 US$.

### Countries

The 81 countries included (listed in Table 3, available at: http://www.who.int/bulletin) are those which have significant populations at risk of *Plasmodium falciparum* malaria. The remaining malaria-

endemic countries in the world are mainly affected by vivax malaria. The malaria risk there is highly variable, making the estimation of needs for prevention difficult. The inclusion of these countries could skew the estimates towards addressing problems which are not central to achieving the Millennium Development Goals. While the importance of vivax malaria should not be underestimated and its control may be challenging, these countries, with few exceptions, do not need external financial support for malaria control. Based on these criteria, all endemic countries in Africa south of the Sahara (but no country in North Africa) have been included. In the following, therefore, "Africa" refers to sub-Saharan Africa.

⬇ Table 3. Average estimated per-capita needs for malaria control in
🖥 2006 versus most recent per-capita total and government
     expenditure on health (US$)
     html, 19kb

## Epidemiological estimates

The proportion of people in each country exposed to a particular class of endemicity was assigned using sources ranging from climatic/environmental modelling[5] to clinical reporting of incidence (see http://www.mara.org.za/; http://www.paho.org/english/hcp/hct/mal/malaria.htm; http://www.searo.who.int/EN/Section10/Section21.htm; http://www.wpro.who.int/sites/mvp/epidemiology/malaria/). In countries where epidemiological data was unavailable, estimates were prepared using data from countries with similar epidemiological conditions but better health reporting. Population data and growth rates were obtained from United Nations Population Division 2004 projections, interpolated to yearly estimates using MortPack software.[6]

## Calculating country-specific costs

Commodity prices were derived primarily from "Sources and prices of selected products for the prevention, diagnosis and treatment of malaria."[7] We did not take into consideration the future price reductions likely to occur as a result of increased demand and production, nor possible increases due to the need to deploy novel medicines and insecticides because of resistance. Costs for malaria control interventions per country in a given year are estimated as unit cost (commodity plus delivery) multiplied by target population living in endemic areas for prevention, and by incidence of clinical episodes, for curative care. The scale and costs of other inputs were derived from typical programmes and budgets, including those described in successful proposals to the Global Fund to Fight AIDS, Tuberculosis and Malaria (see http://www.theglobalfund.org). Other expenses were based on country-specific estimates or were derived independently[8] (see http://www.dcp2.org/file/24/wp9.pdf).

## Interventions and services

### Vector control
We estimated the costs for provision of long-lasting insecticidal nets (LLINs) to all people living in endemic areas[9] at the rate of one net per two people, with replacement after three years. Other vector control

methods, especially indoor residual spraying, may be substituted in certain areas, using the LLIN cost estimate as a rough equivalent in cost per person protected. Actual cost differences may vary in either direction;[10] however, the long-term cost of LLINs is lower than that determined for conventional insecticide-treated mosquito nets in comparative studies.

### Intermittent preventive therapy (IPT)
We costed provision of IPT using sulfadoxine-pyrimethamine (SP), distributed by ante-natal care services, with three treatment courses (see http://www.afro.who.int/malaria/publications/malaria_in_pregnancy_092004.pdf) given to all pregnant women living in Africa in regions with moderate to intense transmission. Age-specific fertility rates reported by the UN Population Division in the 2003 World Fertility Report were used to determine the number of pregnancies expected annually.

### Rapid diagnostic tests (RDTs)
We assumed that RDTs would be used for all patients with malaria-like illness to detect *P. falciparum* in all areas with significant transmission of the parasite, except in children under five years in Africa up to 2010. WHO currently does not recommend using RDTs in this age-group in areas of intense transmission (see http://www.who.int/malaria/docs/ReportLABdiagnosis-web.pdf).[11]

### Artemisinin-based combination therapies (ACTs)
ACTs were assumed to be the first-line treatment. The average cost of treatment was calculated for each of three age groups and multiplied by the annual expected number of fevers suspected to be malaria. In hyper- and holo-endemic areas: 0-4 years: 4, 5-14 years: 2, above 14 years: 1 episode per person; in meso-endemic areas, the corresponding rates were 2, 1 and 1; and in hypo-endemic areas, 1, 0.5 and 0.5.

### Severe and complicated malaria
We assumed incidence rates of severe malaria ranging from 0.005 to 0.04 per person per year depending on endemicity and age-group. A median cost of US$ 29.50 for managing a single severe malaria case was derived from surveys in Africa (see http://www.who.int/malaria/cmc_upload/0/000/016/330/multicenter.pdf). This cost includes therapeutics and laboratory tests, but not transport and pre- and post-hospitalization costs.

### Epidemic prevention and response
Resources for malaria epidemic prevention and control were estimated for areas with unstable *P. falciparum* malaria. In sub-Saharan Africa, the MARA-linked datasets were consulted to determine countries and populations at epidemic risk. To identify countries beyond Africa, we used reports in peer-reviewed journals[12] as well as government and WHO regional office sources.

Costs were estimated for a "surveillance package" including training, computers and software, and for an "intervention package" including supplies, equipment and IRS operations to prevent or curb epidemics. Also costed were supplemental supplies of ACTs as well as the

increased need for management of severe malaria.

### Strengthening health infrastructure

We grouped countries according to the need for augmentation of infrastructure, based on the classifications described by the WHO Commission on Macroeconomics and Health.[13] For each group, we defined sets of trained personnel and equipment necessary for management, monitoring and evaluation, improvement of microscopy services, enhancement of transport capacity and strengthening supply management and logistics.

### Training for staff and community health workers

Many of the interventions represent new policies and procedures that will require training in treatment, diagnosis, delivery of preventive interventions, supervision, management and operational research. Estimates include costs of training of epidemiologists and entomologists, health service staff and community health workers.

### Communication

We provide estimates for producing and communicating information to communities on malaria prevention, early recognition of symptoms and the need to seek prompt treatment.

### Monitoring, evaluation and operational research

Estimates of the cost of monitoring and evaluation include routine assessment of surveillance data captured through health information systems, periodic surveys of health facilities in some countries, population surveys and studies on drug and insecticide resistance.

## Scale-up and impact of implementation on costs

Coverage of most interventions is expected to increase gradually to 95% or 100% in 2015 in accordance with internationally agreed targets. For severe malaria management, "coverage" was considered to be 100% throughout, because an episode of severe disease almost inevitably incurs costs on families and/or health services. For programme costs, complete coverage was assumed from the outset, reflecting the need for staff and infrastructure for scale up of control. Consideration was given to supply chain constraints affecting ACTs in the first two years.

Costs were evaluated in two scenarios: one with a pessimistic set of assumptions, in which the effect of interventions on malaria incidence and thereby the needs for diagnosis and treatment is less than would be expected from field trials, and one with an optimistic set of assumptions, where needs for diagnosis and treatment decrease to a greater extent. Estimates of impact in the two scenarios were based on evidence where available,[14] and on consensus among the authors. In the pessimistic scenario, vector control (exemplified by LLINs) at 80% coverage would reduce the need for RDTs, ACTs and severe malaria management by 50%, and in the optimistic scenario, by 75%. In the pessimistic scenario, 100% coverage with RDTs would reduce the need for ACTs by 25% in Africa and 50% elsewhere; in the optimistic scenario, the corresponding reductions would be 50% and 75%. In both scenarios, 100% coverage with ACTs would reduce severe malaria costs by 50%. For all these interventions, lower coverage levels would

result in proportionally lower impacts.

## Data on malaria financing

We extracted data on domestic annual funding for malaria control[15] and on annual per capita total and government expenditure on health[16] by country, where this information was available. These figures were then compared to the average estimated needs for funding for malaria control in each country.

## Results

The summation of the baseline estimates for the 81 countries for 2005 resulted in 660 million persons in falciparum malaria-endemic areas in Africa and 1.240 billion in Asia and the Americas. The annual number of malaria-like fever episodes was 1.064 billion for Africa and 399 million for Asia and the Americas; severe episodes were estimated at 10.7 million a year for Africa and 3.3 million for Asia and the Americas.

Table 1 shows the cost of scaling up malaria control programmes worldwide to reach internationally agreed targets for coverage of malaria control. A total of US$ 38 billion (optimistic scenario) to US$ 45 billion (pessimistic scenario) will be required from 2006 to 2015; on average, US$ 3.8 to US$ 4.5 billion per year. The average annual costs for Africa are US$ 1.7 billion and US$ 2.2 billion in the optimistic and pessimistic scenarios, respectively; outside Africa, the corresponding costs are US$ 2.1 billion and US$ 2.4 billion.

Figures 1 and 2 show the costs of specific interventions and programme costs over the 10-year period. In the two scenarios, the initial costs are identical. Vector control costs are dominant, increasing over time as a result of increasing coverage and population growth. While in the pessimistic scenario (Figure 1) case management costs are relatively constant after initial scale-up, in the optimistic scenario (Figure 2) they undergo a marked decline, especially after 2010. In both scenarios, the largest costs occur in 2012 and 2015. These peaks are mainly due to the periodic replacement cycles for LLINs. In reality, they would probably be smoothed by variable rates of scale up in individual countries.
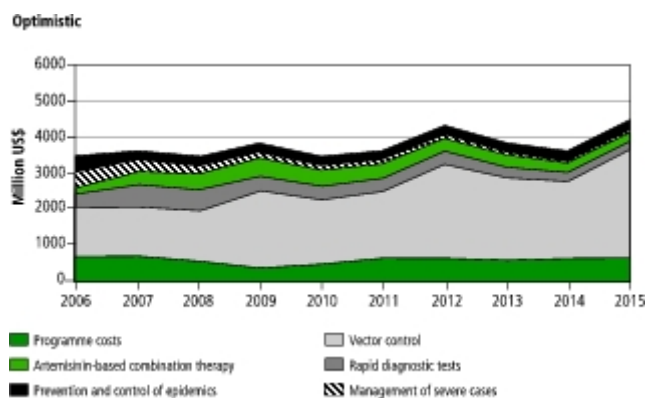


Fig. 2. Estimated global malaria control intervention and programme costs from 2006–2015 according to the optimistic scenario[a]

Figures 3 and 4 compare the distribution of expenditures by intervention

and type of programme cost in Africa and the rest of the world. Outside Africa, vector control costs are more dominant relative to case management costs because of the larger populations and lower malaria incidence rates. Infrastructure and institutional strengthening costs are higher in Africa, while training costs are higher outside Africa due to large populations needing interventions and higher human resource costs.
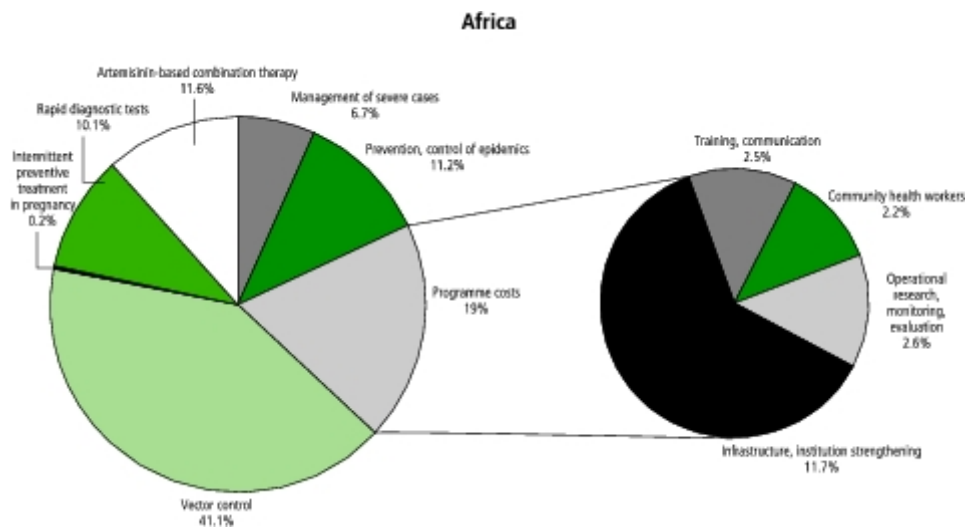


Fig. 3. Allocation to different interventions and types of programme costs in the optimistic scenario in Africa, averaged over the years 2006–2015

Country-by-country comparisons of resources needed for malaria control and those available from national sources demonstrate large gaps in nearly all countries (see Table 2, available at: http://www.who.int/bulletin). Only approximately 4.6% of estimated needed resources are available from domestic sources in the African countries, and 9.2% in the countries outside Africa. Estimates of available resources should be treated with caution, however, due to the difficulty of isolating malaria funding within the government health budget and of estimating malaria funding from nongovernment sources.

Table 3 (available at: http://www.who.int/bulletin) shows that, in some countries, particularly in Asia, the Americas and southern Africa, current levels of health expenditure could, with some adjustment, cover malaria control needs. In others, mainly in Africa, estimated needs constitute over two-thirds of total annual health expenditures; much greater external funding will be necessary to fill these gaps.

⬇ Table 1. Estimated costs for scaling up malaria control interventions,
🖥 2006–2015
    html, 6kb

⬇ Table 2. Comparison of available and needed domestic funding for
🖥 malaria control (US$ million), for countries for which data is available
    html, 14kb

## Discussion

Considering population growth, our estimate for populations in endemic areas in Africa is close to other recent estimates,[17] which are based on the same climate-based distribution model. The estimate of malaria-like fever episodes for Africa is lower than that of Snow et al., especially for

adults,[18] but it is higher than that of a field study in southern Ghana[19] and is based on a model which has proved useful for WHO's country-level work for supply planning in Africa. Outside Africa, estimation is fraught with greater uncertainty, because of the enormous epidemiological variability. Our estimate of population in areas endemic for *P. falciparum* outside Africa is about two-thirds of that of Snow et al.[20] This is not surprising, because we have used a more eclectic approach to identify populations that need protection by continuous vector control. Our calculation of malaria-like fevers is also more uncertain beyond Africa, where widely applicable data are scarce. We estimated that 75% of all severe cases occur in Africa, which corresponds well to current estimates of the distribution of falciparum malaria,[15] but our total estimate of severe cases is high (3-5%) compared to global estimates of falciparum malaria (see http://www.who.int/malaria/docs/incidence_estimations2.pdf), pointing to the need for population-based studies of this problem.

Although Africa's malaria burden is higher than that of the rest of the world, the total costs are higher for Asia and the Americas due to the enormous size of the populations estimated to need vector control coverage. In many countries effective control over some years may interrupt transmission in areas with low transmission potential so that vector control could be replaced by surveillance, greatly reducing costs. Likewise, in countries with intense malaria transmission, increasing urbanization, combined with integrated vector management, could lead to reductions in malaria burden and thus in both preventive and curative expenditures. Especially in areas of low to moderate transmission, the widespread use of ACTs could help reduce transmission. We have not attempted to model this due to lack of good data.

The high allocation to RDTs is meaningful, because as malaria incidence decreases, the costs of diagnosis relative to those of treatment should increase.

Some limitations of our analysis deserve mention. The numbers reported for the optimistic and pessimistic scenarios are not intended to represent an absolute "ceiling" or "floor" for the cost of malaria control. Synergistic interactions could reduce the amount of resources required to achieve goals. In areas of particular vulnerability or opportunity, it may be possible to adopt a more accelerated and costly programme, while in other locales, the targets assumed in this analysis may be too ambitious.

For country-level planning, it is essential to assess systemic strengths and weaknesses, and to regularly review performance to adjust the rhythm of financial inputs. Our projected allocations to health system strengthening constitute 16-21% of total costs. The real needs would vary greatly by country depending on health system characteristics. For example, where there is high coverage of government services, the substantial financing estimated for community workers could be allocated instead to support delivery through public health facilities.

The exclusion of vector source reduction methods from this analysis does not reflect their value, but rather their complexity. The training

component in this costing exercise is intended in part to build the capacity of managers and entomologists to develop locally appropriate long-term strategies.

Our results highlight the incongruity between goals and targets for malaria control set by the international community and the resources that are available to combat the disease. International funding has increased in recent years, with estimated annual contributions to malaria control from development agencies rising to US$ 600 million in 2004 from less than US$ 50 million in 2000 (see http://www.rbm.who.int/docs/hlsp_report.pdf). In 2005, estimated disbursements for malaria from bilateral donors, WHO and the Global Fund were approximately US$ 841 million. New major funding initiatives launched by the World Bank and the United States of America in 2005 suggest that resources for malaria control will continue to increase.

However, current international funding for malaria control represents approximately 20% of estimated total needs for gradual scale up. The continuity of funding is also of concern. It is unlikely that malaria control efforts will lead to the elimination of malaria in the countries included in this analysis. Therefore, high levels of coverage of curative and particularly preventive interventions will need to be maintained beyond 2015 in most places.

It is also important to monitor funding for malaria from all sources, including the private sector. To ensure long-term sustainability and national ownership of malaria control programmes, domestic funding should account for an ever-increasing proportion of total malaria spending.

Due to the generalizations needed to execute such a broad global costing, these estimates should not be used as a template for country-level planning. Nor are our estimates of commodity needs meant to be used as forecasting figures for industry. However, the estimates may be useful as benchmarks against which to assess planned inputs or global commodity need estimations. ∎

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