

# MONEY & MOSQUITOES

## THE ECONOMICS OF MALARIA IN AN AGE OF DECLINING AID

AFRICAN DEVELOPMENT BANK POLICY RESEARCH DOCUMENT 1



AFRICAN DEVELOPMENT BANK GROUP

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This report is the product of the Vice-Presidency for Economic Governance and Knowledge Management. It is part of a larger effort by the African Development Bank Group to promote knowledge and learning, share ideas, provide open access to its research, and make a contribution to development policy. The reports featured in this new Policy Research Document series are those considered to have a bearing on the mission of AfDB and its High-5 priority areas—to Power Africa, Feed Africa, Industrialize Africa, Integrate Africa, and Improve the Living Conditions of Africans. The authors may be contacted at [workingpaper@afdb.org](mailto:workingpaper@afdb.org)

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# SUMMARY

## WHAT ARE THE MAIN IDEAS?

Several studies have shown that with the scale-up of malaria control efforts, worldwide malaria deaths were cut in half between 2000 and 2014. If confirmed and sustained, this drop would translate into a large increase in life expectancy and potentially in economic outcomes, particularly in Africa. But with a decline in health aid and the shift from the MDGs to the SDGs, vertical aid (as for malaria) is no longer a priority, even though it might be highly efficient. Unfortunately, the number of malaria cases rose in several countries in 2016, suggesting that progress has stalled in the global fight against the disease.

## WHAT IS FUNDAMENTALLY AT ISSUE?

Is it possible to control or eliminate malaria without health aid? Should the delivery of health aid be based on efficiency? No easy answers, because large-scale malaria campaigns and health aid are difficult to assess for many reasons. Economics and epidemiology may have different views. Short-term successes might also be partly responsible for reversing aid trends. Indeed, long-term positive consequences and sustainability have not been sufficiently emphasized. For malaria, the balance might well be in favor of positive effects, whatever the short-term costs of programs and the “health-for-the-money” agenda. Assessing the cost-effectiveness of a worldwide effort is inherently challenging and involves outcomes other than health. Evaluating health system governance and financing, and understanding the interactions with individual interests and behaviors, are also difficult.

## WHY ARE THESE QUESTIONS IMPORTANT?

Given the impact of malaria on child health and mortality, stopping malaria aid would cost many lives. For development economists, malaria is unique because of its link with poverty and because many researchers have used malaria as a model to study the relationship between health and development and the demand for health care.

## WHAT FACETS REMAIN TO BE EXAMINED?

The risk of fast-developing drug- or insecticide-resistance cannot be averted, but the impact remains controversial. Subsidies, even if targeted, are probably not sufficient to eliminate malaria.

## WHAT DOES THIS MEAN FOR POLICY?

Several key factors can pave the way for committed governments to reach their objectives for health—especially effective surveillance and health systems, integrated vector control programs, and targeted treatment interventions. For this, they will have to step up their efforts in health funding and in domestic resource mobilization to go beyond aid.

African healthcare systems have for decades been heavily reliant on international donor funding from development banks, United Nations agencies, and organizations such as the Global Fund. In light of the global economy’s fragile recovery, African countries will need to reset their relationships with international aid agencies and bilateral partners and possibly look more to South–South cooperation and private–public partnerships. The next decades will clearly require greater domestic ownership of health systems and the involvement of new international aid players.



# INTRODUCTION

Something highly unusual happened on 5 September 2016: a small island country in the Indian Ocean, with a gross domestic product (GDP) per capita of only \$3,800, was declared malaria-free by the World Health Organization.<sup>1,i</sup> The news made a few headlines but went largely unnoticed and quickly faded away. Yet it was a momentous event, not only for Sri Lanka but for the global community of nations. And it was a powerful reminder that even the most dreadful socioeconomic challenges can be overcome with the right strategy, commitment, financing, and implementation capabilities.

Only 33 countries have been certified as malaria-free, and 95 countries and territories still had ongoing malaria transmission in 2015. According to the latest *World Malaria Report*, released in November 2017, there were 216 million cases of malaria in 2016, up from 211 million cases in 2015. The estimated number of malaria deaths stood at 445,000 in 2016, similar to the previous year's 446,000. Carrying a disproportionately high share of the global malaria burden, Africa in 2016 was home to 90 percent of malaria cases and 91 percent of malaria deaths. Some 15 countries—14 in Sub-Saharan Africa and India—accounted for 80 percent of the global malaria burden. Children under 5 are particularly susceptible to infection, illness, and death, with 70 percent of all malaria deaths. The number of under-5 malaria deaths declined from 440,000 in 2010 to 285,000 in 2016, but it still takes the life of a child every two minutes.<sup>2</sup>

How was Sri Lanka, at a level of development comparable to that of many African countries, able to beat the odds. Income per person in Sri Lanka is still below the level at which experts believe that countries typically succeed in eliminating malaria.<sup>3</sup> More than 80 percent of its people live in rural areas, in ecosystems that are ideal for *Anopheles culicifacies*, one of the main vectors for malaria in the region.<sup>1</sup> The regular movement of people between Sri Lanka and India (1.2 billion inhabitants) did not make things easy. Still, despite more than 20 years of civil conflict that only recently came to an end, Sri Lanka did it.

Sri Lanka's success is encouraging and even inspiring to other developing nations—especially those in Africa where malaria is a costly disease and a major impediment to economic growth. The WHO envisages the elimination of malaria in at least 35 additional countries by 2030—including in India and Indonesia, two large countries with a combined population of more than 1.5 billion. But more financial resources will be needed. Total funding for malaria control and elimination around the world reached an estimated US\$ 2.7 billion in 2016. Contributions from governments of endemic countries amounted to US\$ 800 million, 31 percent of the funding. Still according to the WHO, to reach the 2030 target of declaring 35 more countries malaria-free, annual funding will need to triple to nearly \$9 billion.

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i. Malaria is a life-threatening disease caused by parasites transmitted to people through the bites of infected female *Anopheles* mosquitoes. It is preventable and curable. Malaria elimination is defined as interrupting local mosquito-borne malaria transmission in a defined geographical area—zero incidence of locally contracted cases, although imported cases will continue to occur. Continued intervention measures are required. Malaria eradication is defined as the permanent reduction to zero of the worldwide incidence of malaria infection caused by human malaria parasites as a result of deliberate activities. Interventions are no longer required once eradication has been achieved.

Money obviously is not the only ingredient for success. Sri Lanka's long, hard, and ultimately successful fight against the disease shows that leadership and ownership are essential. So are aggressive strategies—mixing rapid diagnostic kits, indoor spraying, bednets, affordable medicine, close infection monitoring, nationwide electronic reporting systems, and effective capabilities on the ground. And so are well-functioning health systems. But even with the appropriate strategies, implementation requires substantial additional financing.

This report examines financing in the fight against malaria. It focuses on the role of foreign aid and analyzes whether possible to control or eliminate a disease such as malaria in Africa without health aid. After describing malaria control plans in Africa since 1998, it offers a stylized model of the economics of malaria and shows how health aid can help escape the “disease trap.”





# MALARIA CONTROL IN AFRICA IN THE 21<sup>ST</sup> CENTURY

It is more than a decade since the report from the Committee on the Economics of Antimalarial Drugs, led by Nobel Laureate Kenneth Arrow.<sup>4</sup> Several studies have since shown that worldwide malaria deaths declined dramatically between 2000 and 2014.<sup>5</sup> This massive reduction in malaria-related mortality may have effects that reach beyond health. Improving early childhood health paves the way for greater human capital accumulation, changed fertility patterns, and faster economic development. A decline in malaria can thus generate a wide range of outcomes, many of them positive.

However, interventions across the varied epidemiological settings of Africa remain poorly understood. Two influential articles have been recently published in *Nature* and the *New England Journal of Medicine*.<sup>6,7</sup> They link a large database of malaria field surveys with detailed reconstructions of changing intervention coverage to directly evaluate trends from 2000 to 2015—and to quantify the effect of malaria disease control. They found that the prevalence of *Plasmodium falciparum* infections in endemic Africa was halved. The incidence of clinical disease also fell by 40 percent and the death rate from malaria came down 57 percent. Malaria interventions have thus been efficient in reducing malaria's incidence across the continent, with insecticide treated nets (ITNs) the most efficient, accounting for an estimated 68 percent of the decline.

The two studies provide the best estimates so far, but economists and epidemiologists might diverge on the effect of malaria control campaigns on both

mortality and economic outcomes. Indeed, the contribution of malaria interventions to the decline in malaria is subject to debate. In particular, assessing causality is inherently difficult and probably needs a combination of methods.

According to the 2017 *World Malaria Report*, malaria infections increased globally by about 5 million from 2015 to 2016, for a total of 216 million, with apparent jumps in parts of Africa, Asia, and South America.<sup>2</sup> The number of people who died from the disease remained fairly steady, at around 445,000. Although data on malaria are often inexact in countries with weak health-care systems, many researchers are dismayed by the latest trends, which the agency attributes to flat funding for anti-malaria programs.<sup>8</sup>

Of several methods to control the disease, new protection methods and treatments are most important—Long Lasting Insecticide Nets (LLINs) and the so-called “next-generation LLINs,” particularly those with active ingredients other than, or in addition to, pyrethroids. Artemisinin combination therapies (ACTs) and sulfadoxine-pyrimethamine for pregnant women augment these methods as insecticide and parasite resistance both increase. With the introduction of ACTs, the popularity of chloroquine fell in the most malarious regions.

Second in importance are complementary malaria screening and prevention methods: rapid diagnostic tests and seasonal chemoprophylaxis. These technologies have had a large impact on morbidity and survival, at relatively moderate cost.

Third, and more controversial, are health system governance and financing. And last, and more difficult to assess, are personal behaviors related to education, information campaigns and incentives, and broader development and public health progress. Because of the increased resistance of the parasite and vectors to insecticides and treatments, these solutions are threatened today.

## **FIRST GLOBAL MALARIA ACTION PLAN: 1998–2015**

In 1998 the World Health Organization (WHO) launched a campaign to halve malaria deaths worldwide by 2010.<sup>9</sup> With this goal came the need for a global framework for coordinated action against malaria, and the Roll Back Malaria (RBM) Partnership was born. RBM served as a conduit to harmonize resources and actions among the many national, bilateral and multilateral actors in malaria control. By 2010 targeted funding from external actors had reached nearly \$2 billion annually.<sup>10</sup> Control efforts focused on prevention and treatment among the populations most at-risk through artemisinin-combination therapies. They also limited malaria transmission from mosquitoes to humans with insecticide treated nets and indoor residual spraying.

The Global Fund, established in 2002, sealed malaria control. It evolved out of a series of high-level discussions between donors and multilateral agencies that began toward the end of 1999. The primary external funders of malaria control campaigns are the Global Fund (since 2003), the U.S. President's Malaria Initiative (since 2006), and the World Bank's Booster Program for Malaria Control in Africa (also since 2006).

In 2012 the WHO Global Malaria Program and the Global Health Group at the University of California launched 10 case studies on malaria elimination. Through these reports, national malaria control programs and researchers reviewed evidence about what works—and what does not—in reaching and sustaining zero malaria transmission. But none of

the 10 countries—Bhutan, Cape Verde, Malaysia, Mauritius, Philippines, Réunion, Sri Lanka, Tunisia, Turkey, and Turkmenistan—are non-island African areas.

## **SECOND GLOBAL MALARIA ACTION PLAN: 2016–2025**

In 2015 the World Health Assembly endorsed the WHO Global Technical Strategy for Malaria 2016–2030, and the Roll Back Malaria Partnership approved Action and Investment to defeat Malaria 2016–2030 (AIM)—for a malaria-free world. The 2016–2030 strategy provides a comprehensive framework for countries to develop tailored programs for eliminating malaria. It emphasizes that progression toward malaria-free status is a continuous process that requires structuring programs in line with sub-national stratification by malaria risk. It underlines the need to ensure universal coverage of core malaria interventions, and proposes milestones and goals for 2020, 2025, and 2030. It also identifies areas where innovative solutions will be essential to achieve the goals, and outlines the global financial implications of implementing the strategy, which has three pillars:

- Ensure universal access to malaria prevention, diagnosis, and treatment.
- Accelerate efforts to eliminate and attain malaria-free status.
- Transform malaria surveillance into a core intervention.

The objectives are to reduce 2015's global malaria mortality rates by 40 percent in 2020 and by 75 percent in 2025, and to eliminate malaria in at least 20 countries by 2025.<sup>11</sup> According to WHO, about US\$ 100 billion is needed to reach the 2030 malaria targets, with an additional US\$ 10 billion to fund research and development for innovations in malaria, including new drugs and insecticides. This investment will deliver a significant return: nearly 3 billion malaria cases will be averted and more than 10 million lives saved.

# ECONOMICS OF MALARIA

## POTENTIAL EFFECTS OF MALARIA CONTROL FOR HEALTH AND ECONOMIC DEVELOPMENT

Malaria is a major threat particularly in Sub-Saharan Africa, imposing a heavy human and economic toll. Malaria has long been a topic of importance in the economics literature due to its drag on economic growth. Some of the first analyses on the cost of malaria probably went too far in attributing a significant part of Africa's economic difficulties to malaria. Careful considerations on the bidirectional causality between malaria and poverty or aggregate underdevelopment suggest that the costs of malaria were initially overestimated. An old estimate but one of the only estimates in 1991 revealed that the total cost of malaria for Sub-Saharan Africa was 0.6 percent of Sub-Saharan GDP in 1987.<sup>12</sup>

At a microeconomic level, reducing malaria reduces infant mortality and improves early childhood health.<sup>13,14</sup> These changes have the power to substantially influence household decisionmaking and to have a direct impact on other outcomes. Empirical evidence from eradication campaigns shows that reductions in malaria can increase live births,<sup>15</sup> improve educational attainment, literacy, and cognition,<sup>13,16-19</sup> and increase incomes, consumption, and labor productivity.<sup>16,18,20,21</sup> A decline in malaria can thus generate a wide range of outcomes, many of them positive.<sup>22</sup> The estimates reveal a globally positive impact of health aid: the campaign reduces infant mortality (5.2 percentage points) and fertility (0.4 births) and increases adult labor supply (5.3 percentage points), and educational attainment (0.5 years).

## TARGETING DEMAND OR SUPPLY?

On the demand side, financial constraints are the main reasons households give for not acquiring health products.<sup>23-29</sup> Indeed, demand for these products appears highly price-elastic. In addition, bednet coverage remains inequitable among different socioeconomic groups: higher income households are much more likely to possess a bednet,<sup>30-32</sup> though some studies show that demand for bednets increases with income but less than proportionally.<sup>33</sup> Liquidity constraints explain low adoption rates,<sup>34</sup> as do misdiagnosis and a lack of information.<sup>35</sup>

On the supply side, health centers, dispensaries, and hospitals deliver different types of medical activities: curative and preventive healthcare services in addition to daily health education. The literature on the efficiency of health care systems in developing countries generally focuses on hospital data or other aggregated data (health center, health district, regional, or national). Patient data or household data are generally less used for this purpose. Even so, the choices people make vary considerably across Africa, depending on the type of delivery strategies. For instance, low availability and failure in ITN distribution systems have been identified by Roll Back Malaria as the main limitations (other than cost) on large-scale ITN use. Cumulative attrition across the different steps of distribution programs, or small failures in the distribution process, result in people dropping out of the system.<sup>36</sup>

In a literature review of 127 reports and studies, community-based distribution campaigns achieve



rapid increases in bednet coverage, but this coverage fluctuates after a few years.<sup>37</sup> Continuous distribution mechanisms—routine services, retail outlets, assisted or unassisted commercial markets—avoid these fluctuations but are much slower in building high coverage. Continuous promotion of effective maintenance and routine healthcare education are also needed, and damaged nets must be replaced.<sup>38</sup> However, many of these strategies have not been assessed, and only some of the cost estimates have been derived using appropriate methods.<sup>39</sup>

A household survey conducted in 2009 in Haut Katanga, DRC, combines the data with estimates of malaria prevalence from the Malaria Atlas project.<sup>40</sup> Households behave rationally with respect to the disease. But health centers are not the most

effective in promoting possession of bednets, in areas where they are most needed for malaria control.

The governments of malaria-endemic countries often lack financial resources. So, health workers in the public sector are often underpaid and overworked. They lack equipment, drugs, training, and supervision. The local populations are aware of such situations, and cease to rely on the public facilities. The private sector also suffers from problems. Regulatory measures often do not exist or are not enforced. This encourages private consultations by unlicensed, costly health providers and the prescription and sale of drugs (some of which are counterfeits). This situation must be addressed if malaria is to be controlled.

## HEALTH AID TO ESCAPE THE DISEASE TRAP?

Economic epidemiological models show that individuals increase their protective behavior when malaria is more prevalent in a society.<sup>41–43</sup> The same could be observed for health aid generally at a very aggregate level: when the risk is higher, health aid increases. This is consistent with the literature on “prevalence-elastic behavior.” But this also means that when the risk of disease declines, as for malaria from 2000 to 2014, health aid will probably start to decline as well, so malaria will never be eliminated.

A malaria-related poverty trap—defined as malaria reinforcing poverty while poverty reduces the ability to deal with malaria—can, in theory, be observed when extreme poverty is initially very high. This points to a possible difficulty on the demand side and to situations where malaria eradication may be out of reach without massive health aid. A health trap may also be the result of a simpler process linked to the scale-up of preventive measures. The case of Namibia—with the World Bank Booster program combined with targeted government action—is a good example of getting out of the trap.

# A STYLIZED MODEL OF MALARIA AND HEALTH AID

The basic reproductive number under control ( $PfRc$ ), within the limits of stable *Plasmodium falciparum* transmission, provides the potential for the disease to spread within a naive population moderated by malaria control. The estimates of  $PfRc$  were generated using a malaria transmission model to describe the relationship between  $PfRc$  and the predicted probability distribution of parasite prevalence. Figure 1 shows the average  $PfRc$ , using data from the Malaria Atlas project of 42 African countries from 2000 to 2016. Though the estimates of  $PfRc$  encapsulate uncertainty in both the underlying prevalence estimates and in the parameterisation of the malaria transmission model, it is probably the best estimate at hand.<sup>6</sup>

To understand the effects of malaria aid on the basic reproductive number under control, we start from Berthélemy and Thuilliez, who consider  $R_0$  as a natural reproductive number and add individual protective decisions through a utility maximization program.<sup>43</sup> As usual, if  $R_{0Natural}$  is lower than 1, the disease converges toward elimination, which is far from the case today (figure 1, green line), even when taking control programs into account. From an economic perspective,  $PfRc$  can be considered as the result of the natural basic reproductive number multiplied by the proportion of nonprotected population:

$$PfRc = R_{0Natural}(1 - H) \quad (1)$$

where  $H$  is the aggregate protection in the population.

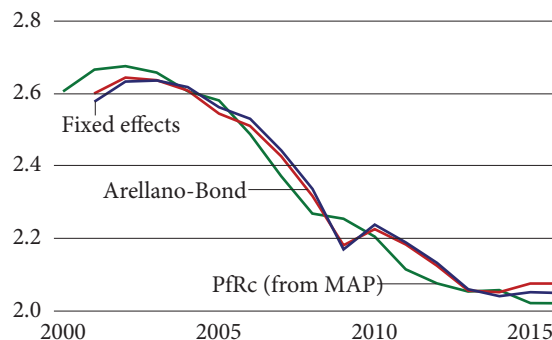
The fast reduction of  $PfRc$  observed since 2000 can be primarily considered as the positive result of Roll Back Malaria campaigns using protection tools such as LLINs—that is, an increase in  $H$ . Before the campaign, protection was relatively scarce. From an economic point of view, consider gradual increases in  $H$  as the result of adopting innovation. In economic analyses, such processes of adoption follow an ordinary logistic function, which is of course S-shaped. As a result, we model the dynamics of  $H$  as follows:

$$\frac{dH}{H} = (b - cH)dt, \quad b \leq c \quad (2)$$

In the long run,  $H$  converges to  $b / c$ . Note that in an equality,  $H$  tends to 1 and  $PfRc$  tends to 0. As a result, the rate of growth of  $PfRc$  is a nonlinear function of  $PfRc$ .

$$\frac{dPfRc}{PfRc \cdot dt} = -R_{0Natural} \left( \frac{b - c}{PfRc} \right) + \frac{c}{R_{0Natural}} PfRc + b - 2c \quad (3)$$

**Figure 1**  
**The MAP  $PfRc$  and the predicted  $PfRc$**



The derivative of this function is:

$\frac{R_{0\text{Natural}}(b-c)}{PfRc^2} + \frac{c}{R_{0\text{Natural}}}$ . It follows that for low values of  $H$  ( $PfRc$  close to  $R_{0\text{Natural}}$ ,  $H$  close to 0),  $dH > 0$  and  $dPfRc < 0$ . Symmetrically, for large values of  $H$  ( $R_{0\text{Natural}}$  close to 0,  $H$  close to 1),  $dH \leq 0$  and  $dPfRc \geq 0$ .<sup>ii</sup> This result is important because it shows that with the current strategy and even with a scale-up of LLINs, eliminating malaria is improbable because, for high protection coverage (large values of  $H$ ),  $PfRc$  will tend to increase. So a malaria trap persists. In the long run  $PfRc$  will converge to  $b/c$ . The persistence of such a health trap, associated with  $R_0(1 - b/c) > 1$ —with a long run  $PfRc$  higher than 1—suggests that without intervention (through aid), it will be impossible to get out of the trap, unless very large amounts of aid are invested, assuming that aid increases the adoption of LLINs and then increases  $b$ .

Our argument is not that only a big push could solve this situation, but that reducing the cost of adoption of the LLINs innovation by households through aid interventions may contribute to reduce the long-run  $PfRc$ .

To illustrate how health aid may alleviate this issue partially, we use the panel of 42 Sub-Saharan African countries to estimate the following growth model of  $PfRc$  and check whether malaria aid may enable escaping such a trap:

$$\begin{aligned} \ln(PfRc)_{Country,t} = & \alpha + \beta_1 \ln(PfRc)_{Country,t-1} \\ & + \beta_2 \ln(PfRc)_{Country,t-1}^2 \\ & + \beta_3 \text{Malaria Aid}_{Country,t} \\ & + \beta_4 \text{GDP per capita}_{Country,t} + \varepsilon_{Country,t} \end{aligned} \quad (4)$$

Malaria aid data are from WHO–World Malaria Reports and include disbursements from the Global Fund, the World Bank Booster Program, the U.S. President’s Malaria Initiative and the UK-Aid Department for International Development (DFID). GDP per capita is from WDI and  $PfRc$  is from the Malaria Atlas Project. GDP per capita proxies poverty incidence (not available on an annual basis),

which can reduce the adoption of protection innovations due to poverty trap mechanisms.<sup>41</sup> We measure  $dPfRc/PfRc$  as a logarithmic growth rate, estimated as a quadratic function of  $\ln(PfRc)$ . We next estimate the equation using a standard fixed-effects model (within country) or an Arellano-Bond model (which helps reduce the endogeneity bias inherent in dynamic fixed-effect estimations).

**Table 1**  
**Results from fixed-effects and Arellano-Bond estimates of equation 4**

Dependent variable is $\ln(PfRc)$	Fixed-effects model	Arellano-Bond model
Lag. $\ln(PfRc)$	0.817*** (0.046)	0.580*** (0.038)
Squared Lag. $\ln(PfRc)$	0.0359** (0.016)	0.0653*** (0.014)
Malaria aid	-0.00288* (0.002)	-0.0114*** (0.002)
GDP per capita	-9.84e-06*** (0.000)	-2.74e-05*** (0.000)
Intercept	0.122*** (0.025)	0.335*** (0.022)
Observations	645	602
Countries	42	42
Years	2000–2016	2000–2016

Results from these stylized models are provided in table 1 and figure 1 provides a static simulation of the model, as a simplified prediction of  $PfRc$  compared to the true values of  $PfRc$  provided by the Malaria Atlas Project. Table 1 shows that the predictions of the model are confirmed. The effect of the lagged values of  $\ln(PfRc)$  are positive. Predictions also perform well and show that the level of  $PfRc$  is far above 1 in all cases. Malaria aid has a significant negative effect on  $PfRc$  in Africa, an argument in favor of sustained development assistance, but current levels of malaria aid will not be enough. Dynamic predictions suggest that a level of aid of US\$ 25 to \$30 per capita would be needed to reach a  $PfRc$  of 1.

ii. Note that if  $R_{0\text{Natural}}$  is a function of  $H$  and not a constant as assumed above,  $dR_0/R_0$  is even less linear.

The current data summarized in figure 1 suggest a prevention adoption behavior that is S-shaped and has helped reduce  $PfPr_c$  from about 3 initially to about 2 in the long run, which would suggest a long run  $H$  of about 33 percent on average at current levels of aid and GDP per capita. This relatively low potential adoption may be partly explained by the poverty and malaria trap mechanisms studied in Berthélemy et al. (2013), in which individuals in a poverty trap would

not adopt LLINs even if they are subsidized. In recent years the poverty incidence (at \$1.90 a day) has on average been as high as 43 percent in Sub-Saharan Africa (according to the data provided by the World Bank Povcalnet website). The poverty-disease-trap mechanisms may help explain a large part of the problem. Poverty reduction strategies would thus be a natural complement of vertical aid to help eradicate malaria.



# DISCUSSION

## THE AID DILEMMA: DIFFICULTIES OF ASSESSING VERTICAL HEALTH AID AND LARGE-SCALE EFFORTS

Aid projects are often established in areas that on average have better health outcomes than non-aid locations, suggesting that aid does not necessarily reach populations in greatest need. This truism, known as the aid dilemma, makes aid inherently difficult to evaluate. Disease traps could also explain why empirical studies fail to find a significant positive effect of spending on health. A key question for policy and health makers is indeed whether or not health expenditure is instrumental in bringing about progress in health status.

Many studies have shown the difficulty of assessing health aid despite the fact that specific projects exhibit positive impact.<sup>44–46</sup> Malaria aid is no exception. Indeed, the availability of data, the fact that many malaria cases are asymptomatic, and the evaluation of large-scale programs that include general equilibrium effects make it difficult to attribute a causal effect from health aid to mortality or other factors. Approaches that mix period models, cohort models, and period-cohort models have shown that it is possible to assess such campaigns, even when they remain at the stage of control campaigns as opposed to fully successful elimination campaigns.<sup>22</sup> Estimates from calibrated models, which have been used extensively in the biomedical literature, are also complementary to this effort.<sup>47</sup> Last, recent initiatives such as new geographic aid data on the precise location, type, and time frame of bilateral and multilateral aid projects may help to disentangle this puzzle.

## IS SUBSIDIZATION SUFFICIENT TO CONTROL A PANDEMIC IN THE CONTEXT OF DECLINING HEALTH AID?

Of several ways to induce individuals and groups of individuals to change health-related behaviors, one is to provide subsidies. Free distribution dramatically increases use of ITN/LLINs (as well as other important products for the poor), compared with charging even very small user fees.<sup>48–50</sup> Poverty and income constraints and costs of prevention and treatment are important barriers in the case of malaria. The other way is to provide incentives that can be defined as changes in marginal utility—payments, coercion, supplies of complementary goods.

Theoretical models show that subsidization is probably not as sufficient as it has been recently argued in the empirical literature.<sup>51</sup> Notably, providing ITN/LLINs at subsidized prices may not be sufficient, so ITN/LLINs dissemination campaigns should include incentives of the very poor for using ITN/LLINs. Evidence suggests that programs implementing conditional cash transfers do promote increased coverage, but the effects have often been modest for vaccination for instance, and evidence for malaria nets is relatively limited. Moreover, these programs often require large public investments. Providing treatment at no cost for those most at needs is certainly needed, but this might reduce the use of prevention.<sup>42</sup> Prevention and treatments may act as substitutes rather than complements since the efficacy of treatment is much higher when both are distributed at no cost.



In sum, subsidization is crucial and should be supported by foreign aid, but might not be sufficient to sustain high level of adoptions and may generate perverse incentives, all the more in a context where diagnostic is not generalized.<sup>35,52</sup>

## **INFORMATION, SOCIAL MARKETING, AND NUDGES TO IMPROVE DECISIONS?**

Another potential explanation for low demand for prevention, despite substantial expected future gains, is the lack of information. Information can increase the demand for prevention.<sup>53</sup> A growing body of literature is trying to investigate the role of information in prevention campaigns to raise awareness about the needs for preventive care, improve take up, and sustain equitable use. In Africa mobile phone reminders could facilitate the diffusion of health knowledge and best practices and improve the delivery of public health services at low cost.

The main objective of providing information is to make individuals reconsider the tradeoff between a decision's costs and benefits in favor of preventive behaviors. Using marketing principles—advertising campaigns—to promote ownership and use of nets when they need to be purchased is not new. But today, bednets are largely distributed free of charge in most parts of Sub-Saharan Africa. Despite free distribution, the use of nets remains low in many places or even declines after free distribution.<sup>54,55</sup> In fact long-term assessment (more than two years) of bednet use after free distribution is relatively rare. Assessing the relative contribution of the quantity of information relative to the contents of health education messages and behavioral interventions will need careful research to nudge the demand for malaria prevention and care.

One might also be careful about potential adverse effects when designing an information campaign. Recent empirical results document, however, that households may reduce their protective behavior in response to public vector control.<sup>56</sup> Public action can substitute for individual gesture. Indeed, it is possible for individuals to “compensate” for public intervention by reducing the preventive action. For example, a policy eliminating larval sites at home, even with health education, may lead to an unchanged situation. Moreover, in the case where individuals do not take into account the negative aggregated effects of this individual compensation—negative externalities—the situation with public intervention can generate perverse effects and overcompensation. Overcompensation behaviors that generate a situation without more impaired public intervention than intervention can also occur if risk information is imperfect. Finally, certain psychological or cognitive factors may play a role in the case of public intervention (customs clearance, altered perception of risk, lassitude).

## **ENDOGENOUS COGNITIVE AND PSYCHOLOGICAL BARRIERS**

Several studies have shown that asymptomatic forms of malaria have an impact on cognition<sup>57–59</sup> and that severe malaria and even malaria treatments may have psychological and psychiatric effects.<sup>60</sup> Cognitive capacity is also reduced by high levels of poverty<sup>61</sup> that may also affect stress and affective states.<sup>62</sup> These mechanisms may in turn lead to short-sighted and suboptimal decisionmaking (present bias behaviors, difficulties in making tradeoffs). Such factors may reinforce the disease trap and affect the efficacy of behavioral interventions and nudges. Future research should target these potential explanations to find new policy responses and scale up prevention.

# CONCLUSION

The ambitious global goal set by the Roll Back Malaria Partnership in 1998—eliminate malaria as a major public health problem in Africa by 2015—was only partly achieved, and malaria remains a major public health problem in Africa today.

How to break the malaria trap? This question has already and obviously been asked. But in most research on malaria, the term “cycle” refers to the “biologic life cycle” of malaria. It may be useful to tackle the problem from a human behavior perspective. One main consequence of the existence of malaria traps for public health is that it is not possible to get out of the disease trap without exogenous public policy interventions or exogenous change in climate or epidemiologic conditions (“natural” disappearance of malaria in certain regions of Europe for instance). Public policies will allow one country or community to jump out of the disease trap, (characterized by a high and stable level of disease prevalence) to reach a lower and still stable equilibrium (characterized by lower disease prevalence) by modifying the initial conditions.

Since such policies are difficult to sustain with current declining malaria aid, what will be the effects of a transitory shock? The situation can be compared with the Italian eradication program in Sardinia (1901–1949), a malaria endemic island in Italy with temporal increase in malaria incidence. It is still not clear whether the disease disappeared thanks to the intensive use of DDT, but the failure to eradicate mosquitoes led to a situation referred to as “*anophelism without malaria*.” Of course, the differences are striking between and within countries, and control success or failure will not be due invariably to the same causes and conditions.

Sri Lanka is in the same situation today, but the geographic conditions in Sardinia and Sri Lanka are clearly not the same. The challenge is not only to control the disease, and possibly eliminate it, but also to maintain the efforts, which might be a completely different story in Africa than in Sardinia and Sri Lanka, considering different ecological, epidemiological, and economic puzzles. In the fight against malaria, the respective contribution of medical innovations, improved institutions and infrastructures, increased financing capacity, and faster economic development might well be country-specific.

Recent empirical findings highlight the importance of considering other outcomes in addition to health when investing in large-scale health interventions. Exposure to malaria control increases infant survival, reduces fertility, and improves children’s educational attainment and adult’s labor force participation. Some common presumptions about health aid may thus turn out to be wrong for malaria. But analyzing externalities, understanding the mechanisms, and tackling nonlinear aspects is challenging.

As a symbol of declining malaria aid, the new “America First” budget plans a 44 percent reduction in malaria support from the United States—but the President’s Malaria Initiative has been a major actor in this area. The drugs supplied in clinics by multilateral donors also improve overall health outcomes beyond those immediately targeted. But reducing malaria aid, we are going in the wrong direction. What can we do? Sustain life-saving programs and promote long-term evaluation with more precise health aid data.

Although Sri Lanka's success is specific because Sri Lanka is an island and outside Africa, the successful elimination of malaria in Sri Lanka points to the relevance of its lessons. Sri Lanka's road to elimination was tough, but several key factors paved the way to reach the objectives, such as government commitment, effective surveillance and health systems, and integrated vector control and treatment interventions. African governments should thus step up their efforts in health funding, and in domestic resource mobilization to go beyond aid.

Indeed, African healthcare systems have for decades been heavily reliant on international donor funding from development banks, United Nations agencies, and organizations such as the Global Fund. In light of the global economy's fragile recovery, African countries will need to reset their relationships with international aid agencies and bilateral partners and possibly look more to South-South cooperation and private-public partnerships. The next decades will clearly require greater domestic ownership of health systems and the involvement of new international aid players.



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**Thanks to scaling up malaria control and treatment, worldwide malaria deaths were cut in half between 2000 and 2014.**

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**In many African countries, malaria is again on the rise.**

**Reducing malaria aid is a move in the wrong direction.**

**To go beyond aid, African countries now have to step up their efforts in health funding and in domestic resource mobilization.**



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