Value for Money in Malaria Programming: Issues and Opportunities

Paul Wilson and Ya'ir Aizenman

Abstract

Although there have been studies of the cost-effectiveness of particular malaria interventions, there has been less analysis of broader aspects of value for money in malaria programming. In this paper, Paul Wilson and Ya'ir Aizenman examine opportunities for value for money in malaria control, extensively analyzing the effectiveness of interventions and current trends in spending. The authors conclude that on the whole resources for malaria control are well spent, but also note some areas where meaningful efficiencies might be possible, including (i) improving procurement procedures for bed nets, (ii) developing efficient ways to replace bed nets as they wear out, (iii) reducing overlap of spraying and bed net programs, (iv) expanding the use of rapid diagnostics, and (v) scaling up intermittent presumptive treatment for pregnant women and infants. In some ways, improving value requires increasing the quality of services--for example, while changing insecticides might increase the cost of spraying campaigns in the short run, it could save much larger amounts in the long run by forestalling resistance. In addition to these recommendations, this paper offers a framework for analyzing value for money in malaria and considers a comprehensive set of factors, from spatial heterogeneity in malaria transmission to mosquito resistance to insecticides. If better results can be achieved at lower cost--and often they can be--donors and recipients alike should better utilize such opportunities. This paper offers not only recommendations to achieve better results in malaria, but also a platform for evaluation of global health interventions that will be useful in future analyses.

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Foreword

If you had a fixed budget to reduce malaria deaths, how would you choose to spend your funding? Would you purchase bed nets or opt for the spraying of insecticides or both? Where would you spray, where would you provide nets, and where would you do nothing at all? Would you buy high quality long-lasting but expensive bed nets, or cheaper ones that might wear out and need replacing sooner? And what about treatments, diagnostics or monitoring and evaluation? Regardless of the specifics of your choices, you would probably want to maximize your impact. And you certainly wouldn't want to misuse the resources you have.

Despite enormous progress in combating malaria across the globe, malaria still causes over half a million deaths annually. Effective solutions exist, such as bed nets, insecticides, combinations drugs, and diagnostics. New technologies—from vaccines to genetically altered mosquitoes—are in the works. But funding for malaria treatment and prevention is typically underrepresented in global health spending. In 2009 malaria received 17% of the total funding that HIV/AIDS funding received in the same year, while causing up to 43% of the total deaths due to AIDS. Although donor funding for malaria is still substantial, $2 billion in 2011, this amount is still not enough to provide many needed services to everyone who requires them in disease-endemic countries. Furthermore, over the last two years spending for malaria has stagnated. Health spending in general is not projected to increase in the current economic climate.

However, stagnant budgets need not mean stagnant programs. Improvements in efficiency could improve malaria outcomes with a given budget. Increasing the value for money (VfM) in malaria can be achieved by investing in effective interventions that maximize impact per dollar spent. VfM encompasses many dimensions of program design including achieving the maximum possible impact from a set of resource inputs, choosing that optimal set of inputs, allocating resources so as to maximize the welfare of the community, and aligning incentives to achieve disease control and elimination. While these dimensions operate at the global, national and sub-national levels, and depend on the decisions and actions of many inter-connected entities along the way to produce a desired health outcome, in the case of many global health funders, the mechanisms available to leverage improved efficiency are the dollars themselves, management and incentives attached to the money, technical assistance, economies of scale and measurement and accountability.

Boosting VfM is a way to improve outcomes given fixed budgets. In this paper, Paul Wilson and Ya'ir Aizenman examine opportunities for VfM in malaria control, extensively analyzing the effectiveness of interventions and current trends in spending. They discuss areas of potential improvement, as well as areas that are high performing, map out new areas where

research should be conducted and suggest new tools to be developed. Along with their analysis, they bring to the paper their expertise—Paul Wilson is a professor and economist at the Mailman School of Public Health at Columbia University and Ya'ir Aizenman was a member of the drug access team at the Clinton Health Access Initiative (CHAI) and is currently with Dalberg Global Development Advisors. This paper is based on a report that Wilson and Aizenman prepared for CHAI.

While in general the authors conclude that on the whole resources for malaria control are well spent, they find that there are some areas where meaningful efficiencies might be possible, including (i) improving procurement procedures for bed nets, (ii) developing efficient ways to replace bed nets as they wear out, (iii) reducing overlap of spraying and bed net programs, (iv) expanding the use of rapid diagnostics, and (v) scaling up intermittent presumptive treatment for pregnant women and infants. Along the way, they lay out a framework for analyzing VfM in malaria and consider a comprehensive set of factors, from spatial heterogeneity in malaria transmission to mosquito resistance to insecticides. For instance the authors note that while changing insecticides might increase the cost of spraying campaigns in the short run, it could save much larger amounts in the long run by forestalling resistance.

As CGD moves forward with its Value for Money in Global Health Initiative, we hope to bring important work such as this to the forefront of discussion of aid effectiveness. If better results can be achieved at lower cost—and often they can be—donors and recipients alike should embrace such opportunities. And in situations where it is not clear how to attain the best value for money, more research will be needed. Paul Wilson and Ya'ir Aizenman offer not only recommendations to achieve better results in malaria, but also offer a platform for evaluation that will be useful in future analyses.

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Executive Summary

After years of rising death tolls, many African countries are making progress in controlling malaria. Basic interventions—effective drugs, rapid diagnostics, bednets, and spraying—are being scaled up; in a growing number of countries there is clear evidence that cases and deaths have fallen. This progress has been made possible by a dramatic increase in international resources for malaria control, from about $200 million in 2004 to more than $1.5 billion in 2009. More than 90% of this funding comes from two sources, the Global Fund and the US President's Malaria Initiative (PMI).

But these gains are fragile, as donor funding is not secure and even at current levels is insufficient to achieve and maintain universal coverage of basic interventions in all malaria-endemic countries. In this context, value for money becomes an essential consideration, as malaria programs look to achieve the greatest benefit from limited funds.

Although there have been studies of the cost-effectiveness of particular malaria interventions, there has been less analysis of broader aspects of value for money in malaria programming. This report presents the results of a preliminary overview of opportunities for greater efficiency in malaria control, carried out by the Clinton Health Access Initiative (CHAI) with funding from the Bill and Melinda Gates Foundation. This study does not ask whether malaria control is a good investment – this case is already very strong – but suggests a framework for analyzing value for money in malaria programs, identifies areas where significant improvements in efficiency might be possible, and proposes an agenda for further research and analysis.

Value for money in malaria programming results from three kinds of decisions: where to intervene, what to do, and how to do it.

Spatial targeting happens at the international level, as donors allocate aid among countries, and at the country level, as malaria programs decide where to focus resources, especially for vector control. As malaria transmission is very heterogeneous, these decisions have important implications for efficiency. The allocation of donor funds among malaria-endemic countries is not a focus of this report.

At the same time, donors and program officials must choose which interventions to provide in which circumstances. As with spatial targeting, these choices are most pronounced in vector control, since insecticide-treated bednets (ITNs), indoor residual spraying (IRS), and in some cases other interventions, may be most appropriate in different settings. Some activities, such as diagnosis and behavior change communication, influence value for money by making other prevention or treatment interventions more effective or less costly. Together, choices about how much to spend on which interventions in which settings contribute to what economists call *allocative efficiency*.

The way that malaria interventions are implemented affects value for money through several channels. *Delivery efficiency* can be optimized by choosing the most efficient way to bring

commodities or services to those who need them. *Commodity costs* can be minimized by efficient procurement and—at the international level—by altering market structure or helping suppliers to reduce manufacturing costs. The concept of *aid* or *donor efficiency* reflects the considerable differences between models of aid delivery, particularly the relatively hands-on model of the US government's President's Malaria Initiative (PMI) and the proposal-driven and country-implemented model of Global Fund to Fight AIDS, TB and Malaria. Finally, *administrative efficiency* subsumes a range of important dimensions of program implementation, including the quality and of program management as well as the extent of fund or commodity diversion.

Patterns of expenditure

The analysis of prospects for increasing value for money must begin with an understanding of how resources are currently being spent. Our analysis focuses primarily on donor funding, which contributes the bulk of resources for malaria programs in most sub-Saharan African countries. According to figures compiled by WHO for the World Malaria Report, the largest share of donor resources, about 44% of combined Global Fund and PMI expenditure in 2009, is spent on vector control. Within this category, bednet programs account for more than 80% of spending; most of the rest goes to spraying. Bednets themselves are the dominant cost of bednet programs, consuming 84% of PMI ITN spending in 2009, for example.

These data imply that large gains in value for money will require reducing bednet requirements (through better spatial targeting, longer net life, or more efficient replacement), developing and deploying cheaper alternative interventions, or cutting bednet prices.

Treatment accounted for 24% of donor spending in 2009, while spending on diagnostics remained small (3%). In this category too, the majority of expenditure (56% in the case of PMI) goes to commodities such as drugs and rapid diagnostic tests (RDTs). These figures do not include the Affordable Medicines Facility for Malaria (AMFm), which constitutes a separate large stream of donor spending on malaria treatment.

The remaining 29% of Global Fund and PMI spending in 2009 went to other specific interventions, advocacy, monitoring and evaluation, training, and administration.

Preliminary data gathered by CHAI in four African countries with successful programs largely confirms this breakdown of malaria expenditure, as well as the large share borne by international donors relative to national governments.

Current expenditures constitute the baseline against which efficiency gains will be measured. However, projections of resource needs can also be used to draw attention to likely trends and to highlight discrepancies between current spending and what would be required to meet agreed targets. Resource needs estimates in Roll Back Malaria's Global Malaria Action Plan suggest that vector control will remain the most important area of expenditure, that

spending on treatment will decline as malaria burden falls and diagnosis improves, and that spending on RDTs should rise.

This simple analysis highlights the importance of vector control to value for money, the crucial role of commodity costs, especially bednets, and the likely growth of spending on diagnosis relative to treatment.

Vector control

The most important issues in vector control for value for money are spatial targeting, the choice between bednets and spraying, strategies for replacing bednets, bednet durability, and bednet prices.

There is great variation in intrinsic transmission potential within some sub-African countries, suggesting that there could be efficiency gains from more effective targeting of vector control resources. But malaria control plans already take into account areas with no malaria risk, and an analysis of vector control options for low-risk areas suggests that there is no straightforward way to redeploy currently available interventions to reduce costs while maintaining an acceptable level of protection. This is because surveillance and case management are too weak to allow vector control to be suspended even in low-risk areas (and strengthening surveillance sufficiently might not be cheaper than continued vector control), and because no alternative to high bednet or IRS coverage has been shown to be both cheaper and sufficiently effective. Thus in the short run, there do not appear to be large gains from better spatial targeting. In the longer run, local elimination coupled to strengthened surveillance to detect imported cases may be cheaper than continued vector control in some low-risk settings.

Bednets and IRS are now the mainstay of vector control programs: other interventions, including larviciding, environmental management, and housing modification may have a role in some urban areas but are not currently a focus of most programs. If IRS is more expensive per person protected than ITNs, as most of the available data suggest, the most efficient strategy would be to reserve IRS for areas where bednet use is low or where it can be used, with strengthened surveillance, in response to epidemics. If recent PMI budget data suggesting substantial economies of scale in IRS programs are borne out by further analysis, however, the cost difference may be less than generally thought. As IRS has the additional advantage that insecticides can be changed in response to resistance, it may be worth considering spraying as the primary vector control intervention in a broader range of circumstances.

Resistance to the pyrethroid insecticides used in ITNs is a growing concern, and a very important value-for-money issue over the long run. Using multiple insecticides in vector control programs and investing more in developing new ones should be a higher priority.

Most spraying is currently done in areas slated to be covered by bednet programs: this overlap may not be good value for money. Research currently underway should provide some estimate of the additional protection provided by combining the two interventions, which could then be weighed against the additional cost.

Free, mass distribution has emerged as the most effective, and cost-effective, strategy for initial scale-up of bednet coverage. There is of yet no consensus on the best way to *maintain* high coverage, however. This choice will have big implications for value for money, as failing to replace lost or worn-out nets will reduce program effectiveness while replacing still-good nets could become a significant waste of resources. Repeated mass distribution is probably not the best way, by itself, to sustain high coverage, and will have to be at least supplemented by continuous distribution channels.

The most straightforward way to cut the cost of bednet programs would be to extend the useful life of ITNs. The main obstacle to capitalizing on longer-lasting nets—and to motivating manufacturers to produce them—is the absence of a practical way to predict measure net life in the field from measurable net properties.

As net purchases account for more two-thirds of vector control expenditure, net prices are critical to value for money. Prices have fallen in recent years, perhaps in part because the number of WHO-approved manufacturers has grown. But it is not clear that this decline will continue. A preliminary analysis of net procurement data suggests that there could be gains of 10% or so from more efficient procurement. Notably, PMI has consistently obtained lower prices than countries procuring on their own with Global Fund money. There is not enough publicly available information to know whether manufacturing costs can be reduced substantially.

Diagnosis and treatment

The most important issues for value for money in this area are increased RDT use, including in the private sector, and commodity prices.

The WHO has recommended confirmation of all suspected malaria cases, and many countries are attempting to scale up use of RDTs. RDTs could avert much unnecessary spending on artemisinin-combination treatments (ACTs), especially as the fraction of childhood fevers that are actually malaria falls. However, given the relative cost of RDTs and ACTs and imperfect adherence to test results, universal RDT use probably will not cut total case management costs substantially. Still, a number of studies have shown that RDTs are cost-effective when the benefits of more appropriate treatment of non-malarial fevers are considered. They are thus good value for money but not necessarily cost-saving. As affordable ACTs become more widely available in drug shops through the AMFm, finding ways to encourage appropriate use of RDTs in this context, including perhaps an RDT subsidy, should become a high priority.

There is little prospect for dramatically reducing the cost of existing ACTs, as the market is already competitive and much work has already gone into optimizing production processes. A new ACT, DHA-PPQ, is expected to cost less than the most widely used current treatment, and should be rolled out as quickly as possible.

In considering drug prices, it is important to keep in mind that while procurement prices matter for donor expenditure, consumer prices determine uptake and thus the impact of treatment. AMFm seems to be driving down retail prices of ACTs.

It will probably be difficult as well to achieve big reductions in the prices of RDTs relying on current technology, as this market is also quite competitive. Since expenditure on RDTs should eventually exceed spending on drugs, the development of new, cheaper diagnostic technologies should be a higher priority: current spending on diagnostic R&D is dwarfed by spending on other malaria technologies.

Administrative and aid efficiency

Malaria programs, like other health programs, are hampered in many countries by inadequate planning and poor implementation, resulting in persistent stock-outs of essential commodities, barriers to access, and low quality of services. These problems stem from lack of administrative capacity as well as shortages of trained staff and other health system weaknesses. The impact on value for money is difficult to quantify, but it is undoubtedly substantial in some settings. For example, effective case management is impossible if drugs and diagnostic kits are not consistently available in peripheral health facilities. Moreover, there is no doubt that diversion of funds or commodities is a significant problem in some countries, as recent investigations by the Global Fund's Office of the Inspector General have revealed. But it would be a mistake to generalize from these cases, and there is simply no good data on the overall scope of the problem.

Just as problems in program implementation at the country level reduce value for money, current donor aid mechanisms impose their own costs and inefficiencies. The PMI and Global Fund models differ in important respects, with the US government's greater reliance on contractors to oversee or even deliver services providing greater protection against fraud and in some cases more efficient implementation, at the cost of limiting local government ownership and flexibility. These issues are not unique to malaria programs, and it is likely that the best model depends both on the setting and on the priority given to obtaining results quickly versus sustainability.

Conclusions and recommendations

The analysis summarized here concludes that there is little chance of *transformative* efficiency gains in malaria programming in the short to medium term. This conclusion derives primarily from the need to sustain high coverage of vector control interventions. even in

relatively low-risk areas and even as malaria burden falls; from the finding that there is no gross misallocation of resources among malaria interventions; and from the relatively modest prospects for reducing the prices of key malaria commodities.

There are nonetheless some opportunities for meaningful improvements in value for money, including:

- More efficient procurement of bednets
- Extending the useful life of bednets
- Reducing the overlap of ITN and IRS programs, at least until more is known about the possible benefits.
- Switching insecticides used for IRS to delay resistance
- Accelerating the availability and appropriate use of RDTs

There are probably not major savings to be found in reducing the prices of current ACTs or in further refining models for delivering nets during initial scale-up.

Further research and analysis in several areas will be crucial to sustaining or increasing value for money. Important areas of research are:

- Practical ways to assess and predict bednet durability in the field
- Models for continuous bednet replacement based on household need
- Relative cost and effectiveness of IRS and ITN in different settings, alone and in combination
- Ways to encourage appropriate use of RDTs in conjunction with AMFm-subsidized ACTs in the informal private sector
- Better and more detailed information on the spatial distribution of intrinsic malaria transmission risk

In the long run, this analysis implies that transformative reductions in the cost of controlling malaria will require new control tools.

1. Introduction

After decades of neglect and rising death tolls, countries and international donors have finally brought improved tools, commitment, and resources to a renewed attempt to bring malaria under control and, in some settings, to plan for elimination. The results have been promising: in sub-Saharan Africa, where 90% of malaria deaths occur, mortality rates are estimated to have declined by a third since 2000, and cases or deaths have fallen by at least 50% in 8 countries plus Zanzibar.[1] International funding for malaria control, primarily from the Global Fund to Fight AIDS, Tuberculosis and Malaria; the US President's Malaria Initiative (PMI); and the World Bank, has increased from $200 million in 2004 to $2 billion in 2011.[2] These resources have made possible dramatic gains in ownership and use of insecticide-treated bednets (ITNs), increased indoor residual spraying (IRS), and replacement of antimalarial drugs rendered useless by parasite resistance with more expensive but effective artemisinin-based combination therapies (ACTs).

These advances are both incomplete and fragile. Many African countries, including many of the most populous such as Nigeria and the DRC, have barely begun to scale up basic interventions, while some that have reduced malaria burden have already begun to see ominous suggestions of resurgence.[3] Progress is also threatened by growing mosquito resistance to common insecticides and the specter of parasite resistance to artemisinin drugs. There is no doubt that unless effort—and, crucially, funding—are sustained, recent progress will be quickly lost and malaria will resurge, as has happened many times before.[4] Sustaining commitment and funding will be challenging, as donor nations grapple with budget constraints and other priorities compete for attention. Ominously, the Global Fund recently announced in late 2011 that it was canceling its next scheduled proposal round, and donor funding may now begin to decline.[5]

To make the case for long-term financing, the malaria community must not only demonstrate the health and economic benefits of achieving and sustaining control, but convince donors and endemic country governments that malaria control resources are being spent in the most effective way.[6] If there are opportunities to achieve the same or better

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[1] WHO, 2011 World Malaria Report (referred to below as WMR 2011), pp. xi-xii.

[2] WMR 2011, p. 15.

[3] See for example Zambia NMCP (2011): "Zambia 2010 Malaria Indicator Survey Provides Evidence for Action," available at http://www.nmcc.org.zm/files/ZambiaMISFactSheet2010_000.pdf; WHO, Rwanda malaria country profile 2010, available at http://www.who.int/malaria/publications/country-profiles/profile_rwa_en.pdf.

[4] Smith, D. L.; Cohen, J. M.; Moonen, B.; Tatem, A. J.; Sabot, O. J.; Ali, A.; Mugheiry, S. M. (2011). "Solving the Sisyphean Problem of Malaria in Zanzibar". Science 332 (6036): 1384–1385. doi:10.1126/science.1201398. PMID 21680828.

[5] WMR 2011, p.15.

[6] The Clinton Health Access Initiative, the University of California at San Francisco's Evidence to Policy Initiative, and the African Leader's Malaria Initiative recently published an analysis of the health and economic

results at lower cost, malaria programs should move quickly to seize them; if careful examination reveals no gross inefficiencies, funders can be reassured that their money is well spent.

Other international health programs face growing funding constraints as well, of course. HIV programs in particular are scrambling to find efficiencies quickly as resources fail to keep pace with needs. By beginning to address value for money now, the malaria community can be better prepared for tougher times.

This report presents the findings of a preliminary analysis of value for money in malaria control, carried about by the Clinton Health Access Initiative (CHAI) with funding from the Bill and Melinda Gates Foundation. Our goal is not to make definitive recommendations, but to chart as broadly as possible the landscape of possible efficiencies in malaria programming, to point to some areas that seem particularly promising, both in the short and longer run, and to estimate, where possible, the scope for gains. We also propose a research agenda on value for money, identifying areas where further analysis or field studies are needed.

We stress that our goal is not to demonstrate that malaria control is a cost-effective use of resources money – this case is already very strong[7] – but to explore the potential for further gains. Are there ways to use current resources to reduce malaria burden more rapidly? In countries that have made progress against malaria in recent years, are there policy changes or new initiatives that could allow this progress to be sustained at lower cost?

The scope of this study, although broad, is limited in four ways. First, we have focused on sub-Saharan Africa. Although malaria remains a serious problem in parts of Asia, burden has been falling in much of Asia and Latin America for decades, and the quite different nature and generally much lower intensity of transmission as well as generally greater economic development create a very different context for malaria control. Second, we have emphasized those countries that have achieved a degree of control in recent years. This focus is consistent with the overall theme of sustaining progress, but it also presents an opportunity to explore the implications of initial success and thus to anticipate issues that

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benefits of sustaining malaria control, "Maintaining the gains in malaria control" (September 2011), available at http://globalhealthsciences.ucsf.edu/GHG/e2pi-maintaining-the-gains.aspx. This work was carried out in parallel with the work on value for money presented here.

[7] Numerous studies have established the particular interventions that are the focus of current programs are highly cost-effective by accepted standards. See Morel, C. M.; Lauer, J. A.; Evans, D. B. (2005). "Cost effectiveness analysis of strategies to combat malaria in developing countries". BMJ 331 (7528): 1299. doi:10.1136/bmj.38639.702384.AE. PMC 1298848. PMID 16282381. and Yukich, J. O.; Lengeler, C.; Tediosi, F.; Brown, N.; Mulligan, J. A.; Chavasse, D.; Stevens, W.; Justino, J. et al. (2008). "Costs and consequences of large-scale vector control for malaria". Malaria Journal 7: 258. doi:10.1186/1475-2875-7-258. PMC 2625363. PMID 19091114. Moreover, recent analyses of expenditure and impact in countries that have succeeded in bringing these interventions to national scale suggests that programs as a whole are excellent value for money. See CHAI, E2Pi, ALMA (2011): "Maintaining the gains in malaria control".

will become important in other settings. However, much of our analysis will apply equally to countries at earlier stages of scale-up.

Third, we have focused on existing malaria control interventions. Although the introduction of new tools, notably a vaccine, will give rise to pressing new questions on the allocation of funding, it is too difficult to address these questions without knowing how effective these tools will be, how they will be used, and how much they will cost.

Finally, we have not examined the allocation of donor funding for malaria control among endemic countries. Although these choices certainly have implications for value for money, we concluded we would not be able to add much to published and on-going work in this area by Snow and colleagues, among others.[8]

In the next section we define what we mean by value for money and outline a framework for analyzing this dimension of malaria control. In Section 3 we review the available information on the breakdown of current malaria expenditure and projections of resource needs; this pattern of expenditure is the starting point for our analysis. In subsequent chapters we analyze opportunities for improving value for money in each of the major areas of expenditure.

2. Definitions and framework

2.1 Defining value for money

Value for money (VfM) can be defined in general terms as the relationship between the benefits resulting from programs or interventions and the resources expended on them. In the case of health programs, benefits can be lives saved, cases averted, or a composite health measure such as Disability-Adjusted Life Years (DALYs) averted, as well as direct and indirect economic benefits. Value for money can therefore be increased by cutting costs, but also by spending more on highly effective interventions. Value for money is closely related to cost-effectiveness, but the latter term is typically applied to particular interventions, while value for money is also used in assessments of entire programs and takes into account the choice of interventions, strategies for delivering them, and overall management and administration. Information on the cost-effectiveness of particular malaria interventions in particular settings is of course a critical input to an assessment of value for money.[9]

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[8] Snow, R. W.; Guerra, C. A.; Mutheu, J. J.; Hay, S. I. (2008). Krishna, Sanjeev. ed. "International Funding for Malaria Control in Relation to Populations at Risk of Stable Plasmodium falciparum Transmission". PLoS Medicine 5 (7): e142. doi:10.1371/journal.pmed.0050142. PMC 2488181. PMID 18651785.

[9] For a review of studies of the cost-effectiveness of malaria interventions, see White, W.T., Conteh, L, Cibulskis, R & A.C. Ghani (2011): "Costs and cost-effectiveness of malaria control interventions – a systematic review. Malaria Journal 10:337.

A related concept is "efficiency". We will not refer to the overall efficiency of malaria programs, but will sometime use "efficiencies" to mean specific opportunities to improve value for money.

This general definition of value for money as the relationship between expenditure on malaria control health and health benefit—in the case of malaria, deaths or cases averted—raises a number of issues.

- **Costs to whom:** Malaria control involves expenditures by national governments, international donors, and households, who often pay for treatment and may purchase bednets or other prevention tools. In principle we consider all costs, but our primary focus is on donor expenditure, which constitutes the bulk of total malaria spending (see Section 3). We will not consider the costs of malaria itself (as opposed to malaria control), such as time lost to work or school and reduced investment, although these costs—and the corresponding benefits of malaria control—may be substantial and important to making a case for sustaining control. Similarly, we focus on benefits to malaria control—reductions in cases or deaths—but in discussing the use of rapid diagnostic tests we note that a broader perspective that includes other disease control benefits might lead to a different conclusion.
- **Time horizon:** In some cases the most cost-efficient policy choice in the short term may not be the most efficient over the longer run, for example in decisions about insecticide use in the face of possible resistance. We try to highlight these trade-offs where they seem particularly important.
- **Efficiency and equity:** As is well know, there are circumstances in which efficiency—and value for money more broadly—can come into conflict with equity. The allocation of limited resources to populations at greatest risk, which will in many cases give the greatest value for money, inevitably disadvantages other populations. Moreover, where there is great geographic diversity of malaria risk, malaria programs face a difficult choice between the goal of universal coverage of key interventions and the objective of using resources where they will have the most benefit. Only governments can make these choices, but this report can try to shed light on the relevant trade-offs.
- **Constant resources or constant impact:** When resources are fixed, as they often are in the short run, maximizing value for money means achieving the greatest impact with the available funds. Alternatively, however, one could aim to achieve or maintain a certain level of malaria control at the least cost. Although in most cases analyses from the two points of view will yield similar conclusions, the appropriateness of particular interventions or intervention combinations from a value-for-money perspective will depend in the first case on the resource constraint and in the second case on the level of control that a country is hoping to achieve or sustain. In particular, the appropriate allocation of resources may be quite different when one is trying to achieve elimination in a particular setting than when the goal is to sustain control. In general we focus on sustaining control but mention the special circumstances of elimination in a few instances.

2.2 Program choices and value for money: a simple framework

Malaria programs reflect a series of choices made by donors and national program managers. These choices can be organized into a simple hierarchy, which can in turn serve as a useful framework for analyzing value for money (see Figure 1).

First, policymakers must decide *where* to intervene. These choices, which we will call *spatial targeting*, happen at two levels. At the international level, donor funds for malaria control must be allocated among malaria-endemic countries. For bilateral initiatives such as PMI, this choice is made by donors, but in the case of the Global Fund—the largest source of funds for malaria programs—allocation results from the submission and approval of country proposals, subject to the Fund's eligibility and prioritization rules.

Clearly this choice has implications for value for money at the global level, as a dollar of donor money could have very different impact in different countries, depending on the burden of the disease, the tools available, and the commitment and capacity of the recipient governments. Donors must also consider the ability of endemic countries to finance malaria control with their own resources. A recent analysis found that the allocation of donor funding was broadly linked to malaria risk, but it is clear that some countries have received more or less funding than a simple formula would suggest.[10] We will not consider this issue further, except to stress that current malaria burden cannot be the only criterion for determining funding need, as this would greatly disadvantage countries that have succeeded in reducing this burden but need continued financing to sustain these gains. The cases and deaths averted by maintaining control should be given as much weight as reductions in burden.

At the country level, the nature and degree of malaria risk is often quite heterogeneous, and malaria programs must decide whether to focus their efforts on certain regions or populations and how to tailor the mix of interventions to local conditions. There may be important gains from more careful targeting of certain interventions, especially in vector control, to the regions or populations where they can do the greatest good. It is worth noting that some of the countries that have received substantial attention and resources from donors, including Kenya, Tanzania, and Ethiopia, are among those in sub-Saharan Africa with the greatest heterogeneity of malaria risk. This magnifies the importance of spatial targeting for overall value for money. This report examines the potential for efficiencies in targeting of vector control in Section 4.

Second, malaria programs must decide *what* to do to reduce malaria burden, that is, which interventions to provide and what share of budgets to spend on each. Resources must be allocated among the major arms of malaria control (vector control, other prevention

[10] See Snow, R.W. et al (2010) and Snow, R.W. et al (2008), op cit, and WMR 2010, Chapter 3. See also Institute for Health Metrics and Evaluation (2010): "Financing for global health 2010: Development assistance and country spending in economic uncertainty." pp. 36-38.

interventions, diagnosis and treatment, and surveillance) as well as among particular interventions in each category, for example between bednets and spraying for vector control. Programs should spend money on particular interventions only if they are effective in a particular setting and if the same results could not be obtained in another way for lower cost. The potential for efficiency gains from better choice of interventions thus depends on the availability of interventions that can substitute to some degree for one another. In the case of malaria, the greatest potential for reallocation among interventions is probably in vector control, where IRS and ITN, and perhaps other interventions, may be considered substitutes in many settings. In principle, vector control and treatment can also substitute for each other, in that effective vector control reduces the need for treatment and prompt and reliable diagnosis and treatment might allow vector control to be relaxed in some settings.

Some important activities influence value for money by making other prevention or treatment interventions more effective or less costly. For example, measures such as behavior change communication (BCC) that make households who own bednets more likely to use them increase the effectiveness of ITN programs but impose costs of their own. Diagnosis influences both the cost and the quality of treatment, and can be considered either a separate category of intervention or an element of a case management delivery model. The potential for widespread use of rapid diagnostic tests (RDTs) to reduce expenditure on case management is considered in Section 5.

Spatial targeting and intervention choice are tightly linked, as the most appropriate mix of interventions is different in different settings. From a value-for-money perspective, choices about the allocation of resources among interventions and across regions and populations contribute to *allocative efficiency*.

Finally, program managers must choose *how* to deliver the chosen interventions to the targeted communities, households, and individuals. For example, bednets can be distributed in conjunction with measles immunization campaigns, provided through routine antenatal or infant immunization services, sold commercially with or without social marketing and subsidy, or delivered and hung house-to-house by community health workers. These delivery models may differ in effectiveness or cost, and as a result there may be efficiency gains from switching to the approach that work best in a particular setting. These choices contribute to *delivery efficiency*, sometimes also called *technical efficiency*.

Preventing and treating malaria also requires purchase of commodities such as bednets, drugs, and diagnostics; in fact, commodities account for more than half of donor malaria expenditure (see Section 3). Thus measures that reduced *commodity prices* paid by malaria programs would be among most important kinds of efficiency gains.

Allocating resources appropriately, purchasing commodities, and delivering interventions requires planning and management at many levels. Thus *administrative efficiency* is a crucial determinant of value for money, although it is difficult to define and harder to measure. It is not enough to consider the share of total expenditure going to overhead, however defined:

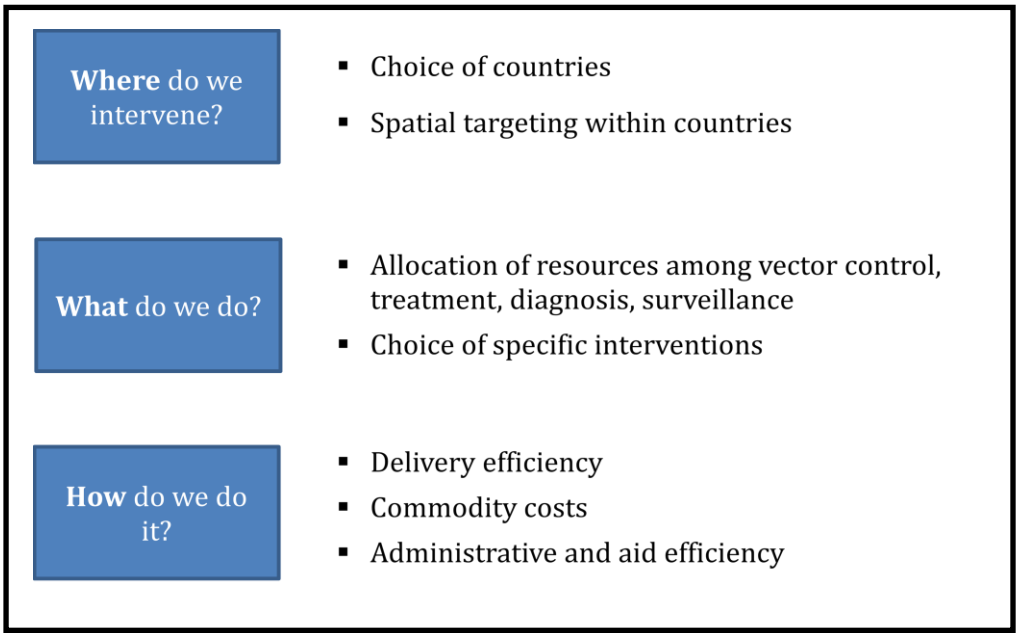
although reducing administrative expenses might free resources to be spent on prevention and treatment, spending *more* on management and training might in some cases improve planning and implementation and thus increase overall efficiency. For this reason it is notoriously difficult to determine the "right" amount to spend on program management.

Outright fraud and corruption, for example diversion of funds or commodities, may be important in some places, and as such would certainly affect value for money. This is not an important focus of this study, but the issue must be acknowledged.

Finally, as most malaria programs in sub-Saharan Africa rely heavily on donor funding, the way these resources are provided has important implications for value for money. Although aid mechanisms such as the Global Fund and PMI deserve much credit for recent progress against malaria, there may be ways that they could be improved to allow more of the resources that donors commit to malaria control to reach the field and to reduce the administrative burdens that they impose on national malaria programs. These issues of *donor* or *aid efficiency* transcend malaria and even health programs, however, and are not a focus of this report.

This framework is quite similar to those that are being used to analyze value-for-money in other health areas, including HIV/AIDS. Although this report is organized primarily around the major funding areas (vector control and case management), we will make reference to these efficiency categories.

Figure 1. A framework for value for money in malaria programming



3. Patterns of expenditure on malaria control

Analysis of current and projected malaria control expenditure is a natural starting point for consideration of potential efficiencies, as the areas of greatest expenditure will in general present the greatest opportunities for savings.

3.1 Current spending

The best available data on current malaria expenditure at the global level are compiled in the World Malaria Report (WMR). According to this source, international donors disbursed almost $1.5 billion to malaria-endemic countries in 2009, an extraordinary increase from about $200 million in 2004. The great majority of these funds, about 92% in 2009, came from two sources, the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) the US government's President's Malaria Initiative (PMI).

Data on the contribution of malaria-endemic countries themselves to the funding of malaria programs are poor, but the available information, compiled by WHO, suggests that national government expenditures are quite small relative to donor funding in most Africa countries.[11] This general conclusion was confirmed by detailed analyses conducted recently by CHAI in four countries (see below).[12] For this reason we focus primarily on donor expenditure.

Two important caveats should be kept in mind, however. First, even if government contributions to malaria-specific initiatives managed by national malaria programs are small, governments are largely responsible for the health system costs associated with malaria diagnosis and treatment, including health worker salaries and infrastructure costs. These expenditures may be very large where malaria burden is high. Second, patients and their families often bear substantial costs themselves, buying drugs in the private sector (and sometimes in public facilities) and paying for some hospitalization costs as well[13,14,15]. Households also buy bednets and other prevention tools, although these expenditures are probably falling now that nets are being provided for free in many countries.

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[11] See Chapter 3 of the 2011 World Malaria Report.

[12] Clinton Health Access Initiative, unpublished data.

[13] Sauerborn, R.; Shepard, D. S.; Ettling, M. B.; Brinkmann, U.; Nougtara, A.; Diesfeld, H. J. (1991). "Estimating the direct and indirect economic costs of malaria in a rural district of Burkina Faso". Tropical medicine and parasitology 42 (3): 219–223. PMID 1801150.

[14] Njau, J. D.; Goodman, C.; Kachur, S. P.; Palmer, N.; Khatib, R. A.; Abdulla, S.; Mills, A.; Bloland, P. (2006). "Fever treatment and household wealth: The challenge posed for rolling out combination therapy for malaria". Tropical Medicine and International Health 11 (3): 299–313. doi:10.1111/j.1365-3156.2006.01569.x. PMID 16553910.

[15] Ettling, M. B.; Shepard, D. S. (1991). "Economic cost of malaria in Rwanda". Tropical medicine and parasitology 42 (3): 214–218. PMID 1801149.

Figure 2A shows the breakdown of malaria spending by the Global Fund and PMI in 2009 across major intervention categories, derived from the 2010 World Malaria Report. We consider each category in turn:

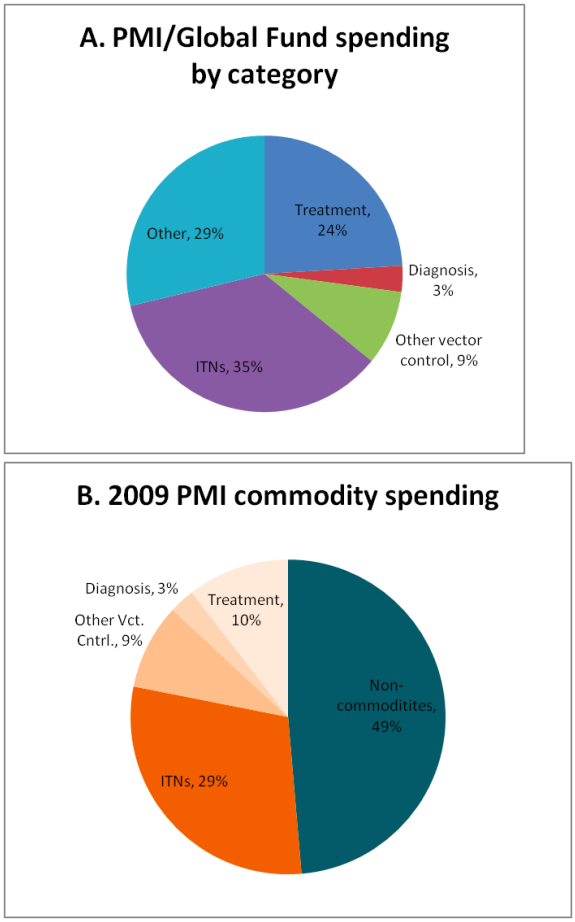

Figure 2: Composition of donor malaria spending. A. Combined Global Fund and PMI spending in 2009 by major intervention category. B. PMI spending in 2009 by class of commodity. Source: data compiled by WHO for the World Malaria Report 2010. ITNs: Insecticide-treated bednets.Vector control

Vector control accounts for the largest share of donor expenditure, about 44% of combined Global Fund and PMI spending in 2009. Within this category, bednet programs dominate expenditure, absorbing more than 80% of donor vector control spending and more than a third of total spending. Most of remaining vector control spending is on IRS. While both the Global Fund and PMI spend heavily on bednets, most funding for spraying comes from PMI.

A striking characteristic of bednet programs is the importance of commodity costs. In 2009, for example, 84% of PMI ITN spending went to the nets themselves. This share has probably risen in recent years, as net delivery costs have tended to fall more rapidly than bednet prices (see Section 4). In contrast, commodities (insecticides and spray equipment)

contribute a smaller share (37%) of PMI spending on IRS. This is important, as countering the development of resistance will likely require using much more expensive insecticides.

Treatment and diagnosis

Treatment is the second largest category of donor expenditure (24%), while spending on diagnostics remains relatively small (an estimated 3%) in spite of new WHO guidelines calling for parasitological confirmation of all suspected malaria cases. Most of donor spending on treatment and diagnosis again goes to commodities, 56% according to PMI's breakdown. Considering only donor expenditure leaves out most non-commodity costs of case management, however, as these costs are typically borne by governments or by donors through other mechanisms such as health system support and basket funding.

Another important stream of spending on malaria treatment not included in the WMR figures is the Affordable Medicines Facility for Malaria (AMFm), which has begun subsidizing purchase of ACTs through the private as well as the public sector in seven pilot countries. According to the Global Fund, which is managing AMFm, donors have committed $216 million for Phase 1, which runs through 2012;[16] of this, $105 million had been spent through September 2011.[17] Since, according to the WMR figures, the Global Fund and PMI spent about $330 million on treatment in 2009, the AMFm represents a substantial additional flow of resources.

Movement toward a policy of universal parasitological diagnosis can be expected to increase expenditure on RDTs and, together with falling malaria burden, reduce spending on ACTs. (This relationship is analyzed in Section 5.) The 2009 data, however, affirm that current spending on diagnostics remains well below what would be required for universal diagnosis (see below).

Other donor spending

The spending classified here as "other" includes small amounts on specific interventions, including intermittent presumptive treatment for pregnant women and infants (IPTp and IPTi), and larger expenditures on programmatic functions such as advocacy, M&E, procurement, and training, as well as on "administration". Somewhat more detailed breakdowns are available (and are presented in the WMR) for the Global Fund and PMI separately, but differences in classification make it difficult to combine these data. The Global Fund reports spending 14% on "planning administration, and overhead", while PMI says "staffing and administration" account for 5% of its total expenditure. Thus there may be savings to be had from more efficient administration, but no firm conclusions are possible without a more detailed analysis of how this money is being spent.

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[16] The Global Fund To Fight AIDS, Tuberculosis and Malaria (2011). AMFm Frequently Asked Questions. Updated: July 2011.

[17] WMR, 2011, Chapter 3, page 16.

Analysis of spending at the country level

As part of a larger initiative to make the case and plan for sustainable financing of malaria programs in countries that have achieved a degree of control over malaria transmission in recent years, CHAI has gathered detailed data on malaria expenditures in four countries: Tanzania, Ethiopia, Rwanda, and Senegal. This work largely confirms the broad patterns suggested by the global data presented in the WMR. In particular, international donors account for most of malaria-specific expenditure in these countries, and vector control, in particular the purchase and delivery of bednets, is the largest category of spending. Spending on diagnostics remains far smaller than spending on anti-malarial drugs.

Spending on research

The data shown in Figure 2 do not include research and product development. But according to a recent PATH report, malaria R&D funding has grown rapidly in recent years, reaching over $600 million in 2009.[18] Although our report focuses on existing technologies, choices about R&D priorities have profound implications for future value for money: cost-effective new technologies could bring dramatic gains, while other research, for example on new drugs and insecticides, could forestall major efficiency losses from drug or vaccine resistance.

From 2004-2009, 38% of malaria R&D funding went towards the drug portfolio, 28% towards vaccine development, 23% towards basic research, 4% towards vector control, and 1% towards diagnostic R&D (6% was unspecified). Given the potential for cost savings from reducing the price, increasing the quality, and improving the ease-of-use of RDTs, and the potentially catastrophic cost (and public health) consequences of widespread mosquito resistance to the most common (and cheapest) insecticides used in IRS and ITNs, research funding for diagnostics and vector control should be a higher priority.

3.2 Projected resource needs

Current expenditures are the baseline against which any short-term efficiency gains would be measured. But patterns of malaria control can be expected to evolve as scale-likely expenditure exist, and there have been attempts to project resource *needs* for malaria programs. Notably, the Global Malaria Action Plan (GMAP), released by the Roll Back Malaria Partnership (RBM) in 2008, includes projections of resource needs all the way to 2040.[19] Although this is to some extent an advocacy document aimed at mobilizing additional resources, it is also a useful analysis of the financial implications of current policy guidance and coverage targets.

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[18] PATH. *Staying the Course? Malaria Research and Development in a Time of Economic Uncertainty.* Seattle: PATH; 2011.

[19] Roll Back Malaria Partnership (2008). Global Malaria Action Plan: For a malaria-free world.

The most obvious difference between the GMAP estimates of needs and the data on current expenditure is the global total: while current international expenditure is about $1.5 billion, the GMAP estimates that more than $6 billion would be needed for 2009. But this figure includes needs for $760M in malaria R&D, and much of the remaining discrepancy is in the estimates for Asia. For Africa alone the GMAP calls for $1.8 billion for Africa; this increases to $2.6 billion in 2010, implying a smaller but still quite significant gap between resource needs and available resources. This is already a very important point: as the prospects for raising (and sustaining) malaria funding on this scale are not good, donors and countries almost certainly face tough choices. Even if interventions can be delivered more efficiently than the GMAP projections assumed, it is very likely that coverage targets for all interventions cannot be met in all settings in the current funding climate.

Two other findings from the GMAP projections provide useful insight into future spending patterns, and thus the context for longer-term efficiency gains. First, vector control dominates total projected spending to an even greater degree than in current expenditure, accounting for 60% of resource needs in 2010 and reaching 79% by 2020. This is largely because treatment needs are expected to fall as control programs drive down incidence, while vector control will need to be maintained as long as transmission risk remains. It is worth noting, however, that the GMAP projections assume that both ITNs and IRS are required in many settings; eliminating or reducing this overlap would cut projected vector control expenditure significantly.

Second, case management spending is dominated by diagnosis, not treatment as is the case today. This projection reflects the assumption that the universal diagnosis recommendation is adopted and successfully implemented, as well as declining malaria burden. Even if neither prediction is fully realized, these projections have important implications for analysis of potential efficiency gains.

3.3 Implications for VfM

These expenditure data are far from perfect, but the general patterns are clear enough to allow us to highlight several important implications for VfM.

1. Importance of vector control, particularly bednets. Vector control is already the most important component of malaria spending, and its share can be expected to rise as vector control interventions are scaled up and treatment costs fall. Within the vector control category, bednets currently dominate spending. Although the GMAP projects almost equivalent spending on IRS, the current consensus seems to be that nets should be the mainstay of vector control programs in most settings (see Section 4). These realities imply that *major improvements in malaria value for money require big efficiency gains in ITN programs.* These gains would have to come from finding ways to reduce the need for nets, increase their impact, or reduce their unit cost. Efficiencies in other areas, including case management, can

be important in absolute terms, but cannot have a transformative effect on overall resource needs.

2. Importance of commodity costs. Spending on commodities made up 51% of total PMI expenditure in 2009. Bednets alone consume 29% of total expenditure; drugs, diagnostics and other vector control commodities (for example, insecticides for IRS) account for the rest of commodity spending. The share of commodities—and bednets—in the GMAP resource needs projections, as well as in the country-specific spending data, is at least as large. This fundamental feature of malaria control programs means that efforts to reduce prices of the key commodities must be a central focus of the value-for-money agenda.

In particular, the very high fraction of vector control funding that goes to buying bednets implies that savings in net delivery or other operational costs can have proportionately only a modest impact, although the importance of ITN programs to total expenditure implies that gains in net delivery efficiency will be more important than equivalent gains for other interventions.

3. Shrinking importance of drug costs relative to diagnosis. Within the smaller but important category of case management, expenditure is currently dominated by treatment, particularly procurement of ACTs. But the combination of falling malaria burden and the shift away from presumptive treatment can be expected to reduce treatment costs substantially. The impact of these trends can already be seen in Senegal, where a policy of universal diagnosis was implemented in 2007 and prescription of ACTs in the public sector fell by more than 50% by 2009.[20] As a result, reductions in treatment costs will be much less important to overall VfM than efficiencies in vector control. An important caveat to this conclusion is that in many countries much of malaria treatment happens through the informal private sector, where subsidized ACTs are becoming available through AMFm. There are substantial challenges to widespread and correct use of diagnostics in this sector, and until these problems are solved they will limit the impact of improved diagnosis on ACT consumption.

4. Increasing RDT costs. The policy of universal diagnosis also implies greater expenditure on diagnostics, primarily rapid diagnostic tests (RDTs). It is likely, therefore, that diagnostics, and RDT costs, will soon become a more important area for potential efficiency gains than treatment.

Many of the issues raised by these high-level conclusions are discussed in greater detail in following sections of the report.

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[20] Thiam, S.; Thior, M.; Faye, B.; Ndiop, M. D.; Diouf, M. L.; Diouf, M. B.; Diallo, I.; Fall, F. B. et al. (2011). Pied, Sylviane. ed. "Major Reduction in Anti-Malarial Drug Consumption in Senegal after Nation-Wide Introduction of Malaria Rapid Diagnostic Tests". PLoS ONE 6 (4): e18419. doi:10.1371/ journal.pone.0018419. PMC 3071817. PMID 21494674.

4. Vector control

Chapter highlights

1. Given the heterogeneity of malaria transmission, better targeting of vector control would appear a promising area for efficiency gains. There is little evidence, however, that substantial vector control resources are currently spent on areas with no malaria risk, and there is no obvious strategy for low-risk areas that saves money while still providing an acceptable level of protection. Surveillance and case management are not strong enough to suffice on their own and there is no vector control strategy that is both sufficiently effective and cheaper than broad bednet coverage.

2. The main intervention choice in vector control is between ITNs and IRS. Most programs currently favor ITN as the "base intervention", in part on the assumption that IRS is more expensive per person protected. However, a preliminary analysis of IRS budgets suggests that spraying costs may fall substantially with program scale.

3. Most spraying is currently done in areas slated to be covered by bednet programs: this overlap may not be the most efficient allocation of vector control resources.

4. The convergence on free, mass community distribution and the relatively low cost of distribution relative to the cost of nets themselves mean that further gains from optimizing net delivery during initial scale-up are probably small.

5. There is as of yet no consensus on the best way to *maintain* high coverage, however, and getting net replacement right will have big implications for value for money.

6. Bednet purchases account for perhaps two-thirds of vector control expenditure. Prices for long-lasting insecticide-treated nets have fallen modestly in recent years, while production volume has grown enormously. Changes in purchasing behavior are unlikely to lower prices by more than a further 10% or so: large buyers tend to have access to the lowest prices already. However, PMI is able to access systematically lower prices than individual countries, suggesting that there is some scope for savings through smarter pooled purchasing.

7. The bednet market is dominated by a single manufacturer and there are significant regulatory barriers to entry. However, the number of qualified suppliers is growing and this may lead eventually to greater competition and lower prices. There is not enough information on manufacturing costs to judge whether substantial supply-side savings are possible.

8. Extending the useful life of nets could dramatically improve value for money. But gains in this area depend on better understanding how long nets actually last in the field. A practical way to *predict* net durability from measurable properties is needed to guide procurement and motivate manufacturers to prioritize greater durability.

10. The spread of resistance to current insecticides, especially pyrethroids, is a serious threat to malaria control and to value-for-money. Both the use of multiple insecticides in vector control programs and the development of new ones need to be higher priorities.

Vector control is the single largest category of malaria control expenditure, accounting for 44% of spending by the two largest donors, PMI and GFATM, and similarly large shares of spending by governments and donors together in the four countries recently studied by CHAI. Vector control dominates the projected resource requirements in the Global Malaria Action Plan to an even greater extent. This is therefore the most important area for value for money.

Following the schema outlined in Section 2, we will consider potential opportunities in spatial targeting at the country level, in choice of interventions, in delivery efficiency, and in commodity costs.

4.1 Spatial targeting of vector control

Although the great majority of the population of sub-Saharan Africa is at risk of malaria, and in many countries most people are considered to be at high risk, there is nonetheless great heterogeneity in the intensity of transmission potential across the continent and within many if not most countries. In theory, at least, this heterogeneity represents an opportunity to get better value for money by improving the targeting of vector control interventions and by better tailoring the mix of interventions to local conditions.

It is important to emphasize that what matters most for decisions about vector control is the intrinsic or pre-intervention intensity of transmission rather than the current level of transmission, as past experience suggests that where intrinsic potential is high, malaria will rebound unless high coverage of vector control interventions is maintained.

This section will first consider whether there are substantial savings to be found in reducing expenditures in areas where there is very little risk and then consider options for efficiency gains from alternative approaches to areas of relatively low risk.

Savings in areas with no malaria risk

One obvious way to capitalize on spatial heterogeneity of transmission would be to not invest in vector control in areas where there is very little or no malaria transmission potential. How many people in sub-Saharan Africa are at no risk, and how much is currently being spent on unnecessary measures to protect them from malaria?

The World Malaria Report estimates the population of each country at high risk, at low risk, or living in malaria-free areas.[21] These breakdowns are based on country case reporting, and malaria-free areas are defined as those where there is "no continuing, local, mosquito-borne malaria transmission and all reported malaria cases are imported".[22] According to data in the 2010 report, 93 million people in sub-Saharan African, or 11% of the population, are at no risk. Moreover, 95% of people in this category live in four countries: Ethiopia, Kenya, South Africa, and Zimbabwe. At least 10% of people in 6 much less populous countries (Botswana, Burundi, Cape Verde, Namibia, Swaziland, and Mauritania) are also listed as living in malaria-free areas. Although it is theoretically possible that some of these areas have been rendered malaria-free by effective control measures, which could not be suspended without risking the revival of transmission, the very high standard for this classification ("no cases for several years") and the relatively recent scale-up of control in most settings suggest that most of these are areas with no intrinsic transmission potential.[23]

By this standard, the total scope for savings from not providing vector control where it is not needed cannot exceed about 10% of potential vector control expenditure under a scenario of universal coverage of total population regardless of risk. In reality, the scope is considerably lower, however, as malaria programs already attempt to restrict control measures to areas at risk, at least in the countries where the bulk of people at no risk live. In particular, review of Global Fund proposals, PMI operational plans, and national malaria strategies from Kenya, Ethiopia, and Zimbabwe reveals that these countries recognize substantial areas as malaria-free and do not target these areas for bednet distribution or spraying. In South Africa, malaria risk—and vector control measures (primarily IRS)—are restricted areas near the borders with Mozambique, Zimbabwe, and Swaziland.

Thus malaria control plans in these countries do attempt to target vector control measures to areas with at least some malaria risk. But targeting of vector control can only be as good as data on malaria risk, and there are many reasons to believe that these data are in general poor. Existing epidemiological maps rely on very different kinds of data: reported incidence (WMR), parasite prevalence in population surveys (the Malaria Atlas Project), and modeling of climate and other factors thought to determine suitability for malaria transmission (the Mapping Risk in Africa (MARA) project). The challenge is compounded by the fact that malaria epidemiology is changing. To the extent that decreases in transmission are the result of control measures, current burden cannot be used, by itself, to identify areas where vector control can be suspended. A measure of intrinsic transmission potential is thus needed, although data on actual transmission before broad expansion of vector control can serve as a proxy.

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[21] WMR 2010, Annex 7a

[22] WMR 2010

[23] Parts of South Africa, where spraying and other control efforts have been maintained for decades, may be an exception.

Vector control in low-risk areas

While malaria-free areas of Africa may be relatively small, and fairly well reflected in control strategies, areas of low risk pose a more complicated challenge.

To begin with, there is no single definition of "low risk", and the relevant level of risk will depend on the policy question. The WMR defines areas of low transmission as those with fewer than one case annually per 1000 individuals[24]. MARA defines "hypoendemic" areas as those with parasite prevalence in children below 10%[25], while the MAP project defines low risk as prevalence below 5%. Moreover, most low-risk areas are characterized by highly unstable malaria, with risk of serious epidemics, but others have short but regular seasonal transmission.[26]

According to the WMR data, 16% of the population of sub-Saharan Africa is at low risk, and at least 10% of the population of 16 countries falls into this category. Ethiopia has by far the largest population classified as at low risk, but Kenya, Madagascar, Tanzania, Cameroon, and North Sudan also have more than 5 million people each in this category. Together these six countries account for almost 80% of the population at low risk by the WMR definition in sub-Saharan Africa. Most of these areas are semi-arid or at higher altitude. A less stringent definition would of course give a higher estimate of people at low risk.

Where transmission is low but not zero, vector control cannot be suspended without putting the population at some risk. Although ideally there would be efficiency gains from tailoring control strategies to local conditions, including by using less powerful but cheaper approaches in areas of lower risk, several limitations of currently available vector control tools make these gains difficult to realize.

1. Weakness of case management

If malaria cases were consistently diagnosed early and treated effectively, it might be possible to forgo broad coverage of vector control measures in low-risk regions and reserve resources for higher-transmission areas. In some countries such a policy would reduce costs and increase average value-for-money substantially, since the cost-effectiveness of bednets and other prevention interventions depends on malaria risk.[27] Moreover, rates of bednet use are

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[24] WHO (2010). Methods for preparing the country profiles. Available on the World Malaria Report 2010 website at http://www.who.int/malaria/world_malaria_report_2010/en/.

[25] MARA/ARMA (1998). Towards an Atlas of Malaria Risk in Africa First Technical Report of the MARA /ARMA Collaboration. Available at http://www.mara.org.za/tr/ENG_MARA_Tech_Rep.pdf,

[26] Hay, S. I.; Smith, D. L.; Snow, R. W. (2008). "Measuring malaria endemicity from intense to interrupted transmission". The Lancet Infectious Diseases 8 (6): 369–378. doi:10.1016/S1473-3099(08)70069-0. PMC 2653619. PMID 18387849.

[27] One possible caveat to this assertion is that in some circumstances the proportional reduction in malaria burden resulting from a given level of vector control coverage's may be higher in areas of lower transmission potential, because of saturation effects at very high transmission levels.

often lower in low-risk areas, further reducing the benefit of bednet programs. When resources for vector control are limited, it almost certainly makes sense to prioritize higher-risk areas, and the gains could be considerable.[28] Gains from targeting high-risk regions depend on the range of risk and on the fiscal constraint: as universal coverage is approached, the differences among strategies diminish.

But a policy of withholding vector control from low-risk areas would undoubtedly cost lives in these areas, given poor access to and low quality of health services in many areas, and would be ethically suspect and politically challenging to implement. Moreover, it would run counter to the broadly endorsed RBM Partnership goal of "achieving universal coverage for all populations at risk of malaria".[29] This illustrates the sometimes powerful tension between value-for-money and equity, and between efficiency and universal coverage goals.

2. Weakness of surveillance

Since in many low-risk areas the major concern is epidemic malaria, a more palatable alternative to abandoning vector control altogether in these areas is to strengthen surveillance (and perhaps the ability to forecast epidemics) and to react quickly when transmission is detected. If the necessary infrastructure were maintained, IRS would probably be the best way to respond. In fact, Kenya's National Malaria Strategy calls for switching from IRS in all epidemic-prone highland districts to focused epidemic response spraying,[30] although the plan also aims to provide universal bednet coverage.

Experts interviewed for this study agreed that the quality of surveillance was not good enough in most areas for reactive vector control to be a safe strategy, although some suggested that it should in principle be possible to take this approach if surveillance could be strengthened. The scope for value-for-money gains would depend on the additional expense of surveillance, on the frequency and geographic extent of episodes requiring reactive spraying, and on the fraction of the population in this risk category.

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[28] A very simple calculation for Tanzania suggests that if funding were sufficient only to achieve 50% coverage of bednets at the national level, a strategy of covering high-prevalence regions first might prevent 45% more cases than a strategy of even distribution. This estimate depends on two major assumptions: that differences in prevalence documented in the 2007 MIS were primarily due to differences in intrinsic transmission potential, not existing coverage of vector control interventions (perhaps not too outlandish if Zanzibar is ignored); and that incidence is roughly proportional to prevalence, as is suggested for prevalences below 50% in Patil, A. P.; Okiro, E. A.; Gething, P. W.; Guerra, C. A.; Sharma, S. K.; Snow, R. W.; Hay, S. I. (2009). "Defining the relationship between Plasmodium falciparum parasite rate and clinical disease: Statistical models for disease burden estimation". Malaria Journal 8: 186. doi:10.1186/1475-2875-8-186. PMC 2746234. PMID 19656373.

[29] WMR 2010

[30] Kenya Ministry of Health and Sanitation, Division of Malaria Control (2007). National Malaria Control Strategy 2009-2017. P 25.

3. Lack of cheaper vector control interventions

In principle, less effective but cheaper control interventions could be used in low-risk areas. Unfortunately, there is no good evidence that any of the possible alternatives to IRS and ITN (larviciding, environmental management, housing modification) are either sufficiently effective to be used in isolation or cheaper than bednets, except perhaps in some urban areas.[31] *This constraint is a crucial obstacle to capitalizing on spatial heterogeneity without leaving large populations unprotected.* A recent paper on the distribution of risk in Kenya made this point as follows: "While these communities enjoy a low risk of infection, risks are not absent and thus cost-efficient suites of interventions must be tailored to meet their needs. This poses a challenge where universal coverage of ITN and presumptive fever treatment with Artemisinin-based combination therapy remain the single bedrock of most national malaria control strategies across Africa."[32]

4. Difficulty of reducing coverage or intensity of IRS or ITN

Given that cheaper vector control interventions are not generally available, an alternative is to reduce coverage of the "base" intervention, either ITN or IRS, in low-risk areas. It is known that where transmission is less intense, lower coverage of bednets is required to achieve a given level of control, although a certain threshold of coverage must still be reached to achieve a "mass effect" through which community members not using nets are also protected.[33] In general, though, it may be politically and operationally difficult to tailor bednet coverage targets to local epidemiology, in part because it is not clear how partial coverage targets would be communicated. Three possible approaches are:

- Aim for universal coverage in some areas, universal coverage of children under five and pregnant women in others. The savings could be substantial, since children under 5 and pregnant women typically make up less than 25% of the population in African countries. But an important objection to such a strategy is that risk is less concentrated in young children in areas of unstable transmission than in areas of high, stable transmission.[34] Moreover, this would represent a partial return to previous, abandoned RBM targets and thus would seem a step backwards.
- Aim for universal distribution on initial scale-up, but rely on distribution through ANC and child health programs for keep-up in low-risk areas. This seems to be the strategy Kenya is moving towards.[35]

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[31] DFID (2010). Malaria: Burden and Interventions: Evidence Overview. Working Paper (Version 1.0).

[32] Noor, A. M.; Gething, P. W.; Alegana, V. A.; Patil, A. P.; Hay, S. I.; Muchiri, E.; Juma, E.; Snow, R. W. (2009). "The risks of malaria infection in Kenya in 2009". BMC Infectious Diseases 9: 180. doi:10.1186/1471-2334-9-180. PMC 2783030. PMID 19930552.

[33] Lengeler, C. (2004). Insecticide-treated bed nets and curtains for preventing malaria (Review). The Cochrane Collaboration, John Wiley.

[34] Reyburn, H.; Mbatia, R.; Drakeley, C. et al (2005) JAMA 293:1461-70.

[35] PMI Kenya MOP 2011.

- Distribute sufficient nets to achieve universal coverage everywhere, but target programs for promoting bednet use (behavior change communication and net hanging) to higher-risk areas. This strategy might save some money, but the gains would in general be modest, since expenditure on communication campaigns is generally small compared to the cost of the nets themselves. Moreover, if bednet use is low without these campaigns, the money spent on the nets is largely wasted.

These approaches may give malaria programs some leeway to vary bednet coverage and expenditure according to risk, but the fact remains that it is not in general easy, or perhaps desirable, to target vector control by modulating bednet coverage.

Together, these constraints imply that in the short run there is no straightforward way to capitalize on variation in transmission risk to reduce expenditure on vector control.

Over the longer term, it is worth exploring whether it might be possible to eliminate malaria transmission locally in some low-risk areas and whether this would allow vector control measures to be suspended. The analysis of elimination feasibility in Zanzibar concluded that in that setting it would be very challenging to maintain elimination without continued vector control, and that maintenance of elimination would probably be more expensive than sustaining the current very low level of transmission.[36] But the economics of elimination might be different in an intrinsically low-risk area, primarily because the response to imported cases would not need to be as intense (and expensive). It is nonetheless far from certain that local elimination would be more cost-effective than continued vector control—a recent analysis concluded that elimination is unlikely to be cost-saving in most settings, although other benefits could make it a good investment.[37] As with elimination at the national level, the feasibility of local elimination depends on many factors in additional to local epidemiological conditions, including the likely rate of imported cases from other regions and countries, which in turn will depend on prevalence in adjoining areas and on population movements.

In summary, tailoring the choice of vector control interventions or their coverage to local epidemiology would in theory be an attractive way to increase value for money. But the challenges of modulating the intensity of the current favored base intervention, bednets, coupled to the lack of an attractive, lower-cost alternative intervention capable of providing adequate protection in low-risk areas, make it difficult to take advantage of spatial differences in practice. Moreover, although a few African countries have substantial areas at no or low risk, across the continent almost three quarters of the population is at high risk, at

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[36] Zanzibar Malaria Control Programme (2009). "Malaria Elimination in Zanzibar: A Feasibility Assessment" (2009)..

[37] Sabot, O.; Cohen, J. M.; Hsiang, M. S.; Kahn, J. G.; Basu, S.; Tang, L.; Zheng, B.; Gao, Q. et al. (2010). "Costs and financial feasibility of malaria elimination". The Lancet 376 (9752): 1604. doi:10.1016/S0140-6736(10)61355-4.

least according to the most recent WHO definitions and estimates, which limits the scope for savings from spatial targeting even if a suitable strategy were available.

There is considerable evidence that malaria risk also varies at a very local level – among households or neighboring villages.[38] In theory, it might be possible to focus vector control resources on hotspots of transmission. But collecting – and updating – the necessary information would be a daunting task.

4.2 Choice of interventions

The bulk of current vector control spending by donors is on bednets: this intervention accounted for 80% of spending in this category in 2009; IRS is a distant second. Other interventions, including environmental management, larviciding, and housing modification, are not major foci of the recent scale-up of malaria programs. Some studies suggest, however, that households spend significant amounts on other mosquito control products, especially coils.[39]

The issue of allocation of vector control expenditure among interventions can thus be reduced to three main questions:

- In which settings should ITNs be the primary or "base" vector control intervention and in which circumstances should programs primarily rely on IRS?
- Are there circumstances in which it makes sense to provide both ITNs and IRS to the same communities or households?
- What should be the role of other, currently less popular interventions?

The choice between ITNs and IRS

The available evidence indicates that bednets and spraying are both effective in reducing malaria incidence.[40] Although IRS has been the subject of fewer randomized controlled trials than ITNs, the historical evidence of its effectiveness is overwhelming. There is very little data, however, on the *comparative* effectiveness and cost of the two strategies in specific settings.

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[38] Bousema T, Griffin JT, Sauerwein RW, Smith DL, Churcher TS, et al. (2012) Hitting Hotspots: Spatial Targeting of Malaria for Control and Elimination. PLoS Med 9(1): e1001165. doi:10.1371/journal.pmed.1001165; Carter, R., Mendis, K.N. & Roberts, R. (2000): 'Spatial targeting of interventions against malaria'. WHO Bulletin 78: 1401-1411; Bejon, P. et al (2010): Stable and Unstable Malaria Hotspots in Longitudinal Cohort Studies in Kenya. PloS Med 7(7).

[39] Njau, J.; Staatz, C.: & McFarland, D. (2011). Financial and non-financial household costs of malaria: a review of literature. Presentation at RBM 17th MERG meeting, New York, 16 June 2011.

[40] Lengeler, C. (2004). Insecticide-treated bed nets and curtains for preventing malaria (Review). The Cochrane Collaboration, John Wiley; Pluess B, Tanser FC, Lengeler C, Sharp BL. Indoor residual spraying for preventing malaria. Cochrane Database of Systematic Reviews 2010, Issue 4. Art. No.: CD006657.

Although the two interventions are often considered, for want of more detailed data, comparably effective, ITNs, and specifically long-lasting insecticidal nets or LLINs, are currently the primary vector control intervention in most sub-Saharan countries, with most national programs aiming to achieve universal coverage. (An important exception is South Africa, which has long relied on IRS. IRS also remains the foundation of many programs outside Africa.) Coverage of IRS has also grown substantially in recent years but remains much lower than that of ITNs: according to the WHO, about 50% of African households owned at least one ITN in 2011, while about 11% of population at risk was protected by IRS in 2010.[41] Two-thirds of international donor funding for spraying comes from PMI, while most of the rest is from the Global Fund.

Two main considerations probably account for the current preference for ITN as the base intervention. First, IRS is generally assumed to be more expensive than ITNs on a per household or per person basis: the fully-loaded cost of distributing a net is generally agreed to be between $1.30-1.85 per person per net-year, while the cost per person-year of protection of IRS campaigns has been found to range from $2.16[42] to $3.27[43] to as high as $7.09[44]. Second, many experts consulted for this project expressed the view that bednet use was more sustainable than spraying, especially after malaria burden falls.

These assumptions may warrant reconsideration. On the cost side, an analysis of the cost PMI-funded IRS programs in 12 countries between 2008 and 2010 revealed that lower larger programs have significantly lower costs, suggesting substantial economies of scale (see Figure 3).[45] The cost of many of the larger programs was below $3.00 per person-year of protection.

Although the cost per person protected in the PMI programs remains above typical estimates for bednets in most cases, the evolution of costs with program size suggests that at very large scale (programs reaching 5 million people or more), the costs of the two interventions could become competitive.

These data are only suggestive, as very few programs have achieved large scale. Moreover, it is important to keep in the mind that this study was carried about by RTI International,

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[41] WMR 2011, chapter 4.

[42] Worrall, E.; Connor, S. J.; Thomson, M. C. (2008). "Improving the cost-effectiveness of IRS with climate informed health surveillance systems". Malaria Journal 7: 263. doi:10.1186/1475-2875-7-263. PMC 2639594. PMID 19108723.

[43] Yukich J., F Tediosi, and C Lengeler. "Operations, costs and cost-effectiveness of five insecticide-treated net programs (Eritrea, Malawi, Tanzania, Togo, Senegal) and two indoor residual spraying programs (Kwa-Zulu-Natal, Mozambique)". Swiss Tropical Institute, Basel, Switzerland (2007). 130 pp.

[44] Sine, Jeffrey, and A Doherty. "Indoor Residual Spraying (IRS) for Malaria Control Indefinite Quantity Contract (IQC) Task Order 1 (TO1): Analysis of 2008 Expenditures in Five IRS TO1 Countries." RTI International, Research Triangle Park, NC (2010).

[45] RTI International (2011): "An economic analysis of the costs of indoor residual spraying in 12 PMI countries, 2008–2010". Report prepared for USAID.

which implements PMI-funded spraying programs and thus has an obvious interest in the expansion of this intervention. There would clearly be value in more independent cost analysis of large IRS programs in Africa.

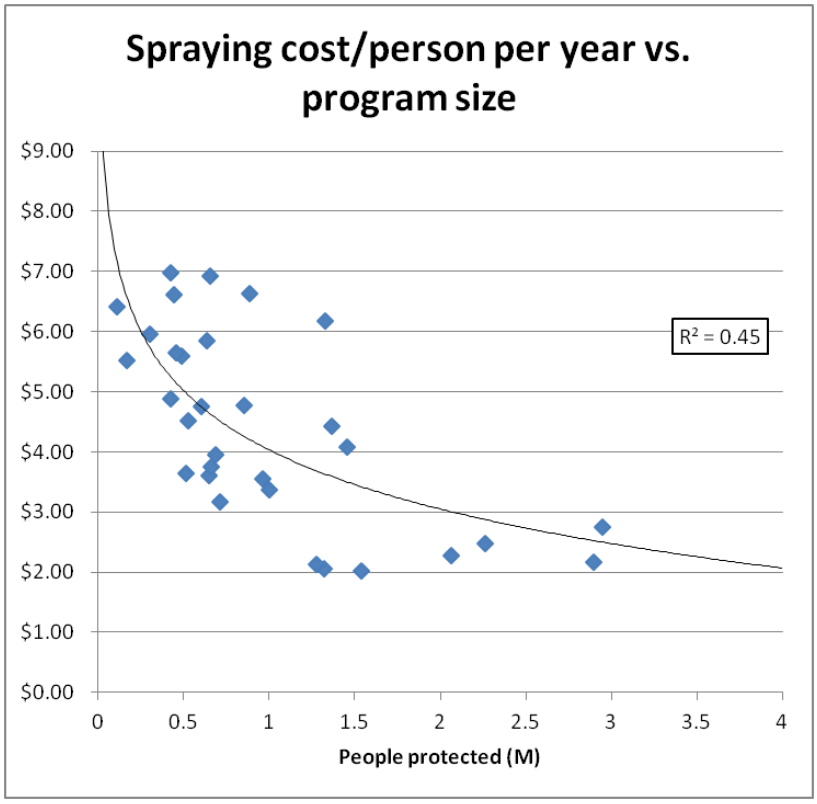

Figure 3: Relationship between unit cost of indoor residual spraying and program scale. Source: authors' analysis of data presented in an RTI International report.[46] One data point (for Burkina Faso) was left out as an outlier.

These apparent economies of scale, if they are real, probably have two sources: cost optimization with experience and large up-front fixed costs such as for spray equipment that can be amortized over several years. It is worth noting that there are probably economies of scale in bednet distribution as well. For instance, Stevens (2005) observed that in Malawi the cost per net of the national ITN program fell by 60% over five years as the annual number of nets distributed increased by an order of magnitude. But in the case of bednets the scope for further reduction is limited by the large share of commodity costs.

The assumption that bednets are a more sustainable strategy, for its part, rests to a great extent on the hope that a "culture of bednet use" can be instilled and will ensure continued use even when malaria rates fall – this hope is largely untested. There is little doubt that both net and spraying programs face serious challenges in sustaining public acceptance over the

[46] Plot generated by the authors using data in the 2011 RTI report for USAID (previous citation).

long term. While the effectiveness of bednet programs depends on the nets being used, spraying programs depend on acceptance of the inconvenience and intrusiveness of home spraying.

An additional consideration in the choice between ITN and IRS is insecticide resistance. Although resistance is a threat to both interventions, IRS has the advantages of greater choice of insecticides, greater ease of switching, and the feasibility of insecticide rotation. While switching away from DDT and pyrethroids increases the cost of IRS, no alternative to pyrethroids is currently available for bednets (see Section 4.6 below).

A disadvantage of spraying programs is that they may be more difficult for national governments to sustain, even with donor funding. Most PMI-funded IRS programs are managed by US contractors, and the operational complexity, quality challenges, and risks of environmental contamination make hand-over to national governments more challenging. Finally, IRS may not be practical in some areas because of inadequate roads and other factors.

We present these arguments not to propose that spraying should replace bednets as the mainstay of African vector control programs, but to suggest that in choosing between the two interventions, policymakers should take into account the effect on relative costs of program scale, as well as other potential advantages of IRS.

Even where ITNs remain the foundation of vector control programs, there may be an important role for IRS in specific circumstances. Although the reason for deploying IRS in particular areas has not always been clearly spelled out, three rationales seem to predominate:

- Use in areas of unstable malaria, where bednets may not be widely used and where IRS can both prevent and control epidemics. As explained in the section on spatial targeting, with adequate surveillance IRS could be used reactively in these areas, with potential value-for-money gains.
- Use to rapidly reduce malaria transmission. In these cases, the expectation is typically that IRS would be phased out after a few years and replaced with bednets.
- Use in combination with ITNs to achieve very low levels of transmission, for example in the lead-up to elimination.

The evidence is in general insufficient to assess the virtue of these strategies, although they seem reasonable and are well articulated in recent guidance issued by WHO.[47]

The implications of the choice between IRS and ITNs for value-for-money depends on the cost and effectiveness of the two interventions in particular settings. If ITNs are as effective in all settings and IRS is indeed at least 50% more expensive than bednets, as the cost ranges

[47] WHO Global Malaria Programme (2010). Malaria Global Fund Proposal Development. WHO Policy Brief, May 2010.

presented above would suggest, switching to ITNs could save an amount equal to about a third of current expenditure on spraying. But these assumptions are unlikely to hold.

Combining nets and IRS

There is already substantial overlap in IRS and ITN coverage, and most spraying is being done in areas slated for bednet distribution. In fact, Zambia is apparently the only country with an explicit policy exempting areas receiving IRS from free bednet programs.[48] Although the two interventions are increasingly combined in high-transmission areas in order to drive down burden more rapidly or more completely than either could do on its own, there is in fact relatively little rigorous evidence on the incremental benefits of combination. The available evidence on balance suggests that in most settings there is additional protection,[49] but the outcome may depend on the insecticides used, the vector species, and the quality of spraying implementation, among other factors.[50] Some modeling studies have even suggested that in some circumstances combined IRS and ITN could be less effective than either alone, apparently because the repellent effect of some insecticides used in one intervention can prevent mosquitoes being killed by the other.

From a value-for-money perspective, of course, evidence of some incremental effectiveness would not be sufficient to justify combining IRS and ITNs: the additional decline in disease burden must be worth the additional cost. The appropriate standard depends on the budget constraint or the target level of transmission, in particular whether a country or region is preparing for elimination, and on whether the resources that would be required could be used to greater effect to increase coverage of either vector control intervention alone (or to strengthen diagnosis or treatment). The stakes are quite high: if in fact there is little additional benefit from combination, there are potentially large savings from foregoing IRS in areas with high net coverage or from restricting free net distribution in areas where spraying is judged to be the superior intervention.

Several studies on combining IRS and ITNs are planned or underway, including one in the Gambia and one in the Lake Zone of Tanzania.[51]

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[48] Okumu, F & Moore, S. (2011). Combining indoor residual spraying and insecticide-treated nets for malaria control in Africa: a review of possible outcomes and an outline of suggestions for the future. Malaria Journal 10:208.

[49] Kleinschmidt I, Schwabe C, Shiva M, Segura JL, Sima V, Mabunda SJA, Coleman M (2009). Combining indoor residual spraying and insecticide-treated net interventions. Am J Trop Med Hyg 81:519.

[50] Okumu & Moore (2011), op cit.

[51] Pinder, M. et al (2011): "To assess whether indoor residual spraying can provide additional protection against clinical malaria over current best practice of long-lasting insecticidal mosquito nets in The Gambia: study protocol for a two-armed cluster-randomised trial." Trials 12:147; Peter McElroy, CDC –Tanzania, personal communication.

Finally, we note that while decisions on interventions are in theory made at the country level and coordinated by national malaria programs, donors such as PMI, which is the leading funder of IRS programs in Africa, clearly have substantial influence. Programs funded by different donors may not always be well coordinated, and this may explain some of the overlap between IRS and ITN programs.

Other vector control interventions

Larviciding can reduce malaria transmission, as a recent study in Dar Es Saalam showed.[52] But this method is probably only practical in urban areas, where breeding sites are fewer and can be systematically identified, as high coverage is apparently required to achieve significant impact.[53] Environmental management, measures aimed at reducing vector habitat, has clearly been responsible for lasting reductions in malaria burden in some settings.[54] But there is less experience with this set of approaches in Africa, and most of the studies are quite old. Adding screens and other housing modifications or changes in house construction were also important in the decline of malaria in the US and other high-income countries, and can contribute in urban areas in Africa.[55] Given that environmental management and housing modification in particular have the potential to be very sustainable approaches, there is a strong rationale for further research on their effectiveness and cost in African settings. But the consensus of experts interviewed for this study was that the evidence for these interventions is not strong enough to justify relying on them as the primary vector control strategy, except perhaps in some very low-transmission urban environments.[56]

A variety of new vector control interventions are being developed and tested, but our survey only considered existing tools.

4.3 Bednet Delivery

Data from several sources indicate that bednet distribution (i.e. non-commodity) costs represent approximately 20% of the total cost of net programs, or $56M of estimated

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[52] Geissbühler Y, Kannady K, Chaki PP, Emidi B, Govella NJ, et al (2009). Microbial larvicide application by a large-scale, community-based program reduces malaria infection prevalence in urban Dar es Salaam, Tanzania. PLoS One 4(3): e5107.

[53] Raghavendra K, Barik TK, Sharma P, Bhatt RM, Srivastava HC et al (2011). Malaria vector control: from past to future. Parasitol Res. 108(4):757-79.

[54] Keiser J, Singer BH, Utzinger J. (2005). Reducing the burden of malaria in different eco-epidemiological settings with environmental management: a systematic review." Lancet Infect Dis. 5(11):695-708.

[55] Ogoma SB, Kannady K, Sikulu M, Chaki PP, Govella NJ, Mukabana WR, Killeen GF (2009). "Window screening, ceilings and closed eaves as sustainable ways to control malaria in Dar es Salaam, Tanzania." Malar J. 8:221.

[56] See also two recent reviews: Raghavendra K, Barik TK, Sharma P, Bhatt RM, Srivastava HC et al (2011). Malaria vector control: from past to future. Parasitol Res. 108(4):757-79; DFID (2010). Malaria: Burden and Interventions: Evidence Overview. Working Paper (Version 1.0).

spending in 2009. Both budgetary data from PMI[57] and published literature[58,59,60,61] suggest that distribution costs for a wide variety of programs amount to around $1.00-$1.50 per net.

The key question for value-for-money is whether certain bednet distribution models (continuous programs or discrete campaigns; community-, retail-, or routine-services-based approaches; subsidized or free; etc) are more cost-effective than others. The RBM vector control working group's formal guidance recommends mass campaigns as the best method for rapidly scaling up coverage, although it notes that other mechanisms will be required to provide a continuous supply.[62] This is in large part because these campaigns have large economies of scale: Killian found that of the four channels with enough studies to provide meaningful numbers, community-based campaigns had the lowest cost per net delivered. Continuous distribution through routine health services cost slightly more, and continuous retail and continuous community-based strategies were 50-100% more expensive.[63]

Until recently, it had often been argued that requiring users to contribute to the cost of bed nets would reduce waste and ensure that nets reached those who most valued them. However, a randomized trial in Kenya found that net uptake dropped by 60% when users were asked to pay $0.60 for nets instead of receiving them for free.[64] The WHO concluded that the results of the study "end the debate" over user costs and issued a formal recommendation that all nets be "distributed either free or highly subsidized."[65]

The convergence on free, mass community distribution as the main strategy for rapidly reaching high net coverage and the relatively low cost of distribution relative to the cost of

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[57] World Malaria Report, 2010

[58] Cibulskis, R, et. al. Cost Analysis of ITN programs in Kenya, Uganda, and Zanzibar. Presentation delivered at the 17th meeting of the RBM Partnership Monitoring and Evaluation Reference Group. 15-17 June 2011, New York, NY.

[59] De Allegri, M.; Marschall, P.; Flessa, S.; Tiendrebeogo, J.; Kouyate, B.; Jahn, A.; Muller, O. (2009). "Comparative cost analysis of insecticide-treated net delivery strategies: Sales supported by social marketing and free distribution through antenatal care". Health Policy and Planning 25 (1): 28–38. doi:10.1093/heapol/czp031. PMID 19752178.

[60] Bonner, K.; Mwita, A.; McElroy, P. D.; Omari, S.; Mzava, A.; Lengeler, C.; Kaspar, N.; Nathan, R. et al. (2011). "Design, implementation and evaluation of a national campaign to distribute nine million free LLINs to children under five years of age in Tanzania". Malaria Journal 10: 73. doi:10.1186/1475-2875-10-73. PMC 3078903. PMID 21453519.

[61] See also Figure 3.4 and accompanying references in the World Malaria Report 2011.

[62] RBM Vector Control Working Group (VCWG). Consensus Statement on Continuous Distribution Systems for Insecticide Treated Nets. June 16, 2011.

[63] Kilian A, et. al. "Journal review of delivery strategies for insecticide treated mosquito nets-are we ready for the next phase of malaria control efforts?" *TropIKA.net*. Jan/March 2010; (1)

[64] Cohen, J.; Dupas, P. (2010). "Free Distribution or Cost-Sharing? Evidence from a Randomized Malaria Prevention Experiment*". Quarterly Journal of Economics 125: 1. doi:10.1162/qjec.2010.125.1.1.

[65] WHO (2007), "WHO releases new guidance on insecticide-treated mosquito nets," World Health Organization News Release, August 16, 2007, http://www.who.int/mediacentre/news/releases/2007/pr43/en/index.html

the nets themselves mean that further gains from optimizing net delivery during initial scale-up are small.

Bednet replacement

Even so-called long-lasting bednets have a finite life in the field, however (see next section), and sustaining high coverage will require an efficient way to replace nets as they are lost or wear out. There is as of yet no consensus on the best way to do this, and getting net replacement right will have large implications for value for money. A strategy of mass campaigns repeated at regular intervals has several disadvantages.[66] Because net coverage begins to fall even in the first year after a campaign as a result of loss, damage, and population growth (some estimates suggest a loss of 10-15% per year[67]), average coverage will be low unless campaigns are supplemented by other distribution mechanisms. Moreover, repeat campaigns would be wasteful, as some older but still effective nets would be replaced. Neither inefficiency—gaps in coverage from tardy replacement or waste from premature replacement—is captured by a standard "cost per net distributed" metric.

Ideally, nets would be replaced continuously as they wear out, but no practical strategy for identifying replacement need at the household level has been developed, and the necessary monitoring is likely to be expensive. A recent consultancy in Tanzania has weighed a number of options and recommended a combination of an existing subsidized voucher scheme and a new continuous distribution channel through either schools or the broader community.[68]

In conclusion, further optimization of bednet delivery models during initial scale-up is not a particularly promising area for efficiency gains. Attention should be focused instead on the best way to replace nets, including from a value-for-money perspective.

4.4 Bednet Durability

A critical factor affecting the long-term cost of bednet programs is the durability of the nets: how do their insecticidal properties or physical integrity degrade over time? LLINs that last five years on average could cost programs as much as 40% less over time than nets that three years, although the actual savings will depend on the strategy for replacing nets and, of course, on the additional cost of the longer-lasting nets. In practice, however, there is little hard data either on how long nets last in the field or on how their physical condition affects their protective performance.

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[66] Lengeler, C.; Grabowsky, M.; McGuire, D.; Desavigny, D. (2007). "Quick wins versus sustainability: Options for the upscaling of insecticide-treated nets". The American journal of tropical medicine and hygiene 77 (6 Suppl): 222–226. PMID 18165496.

[67] Koenker, H., Yukich, J. & A. Mkindi (2011): Recommendations for maintaining universal coverage in Tanzania. Presentation on the results of a consultancy for the National Malaria Program.

[68] Koenker, et. al. (2011).

The distribution of net lifespans is as important as the average value, since net distribution mechanisms must replace nets that fail before their average expected lifespan and, ideally, avoid replacing nets that last longer than expected.

Although net manufacturers have claimed that their nets can last up to five years, there are so far relatively few rigorous field studies.[69] Skovmand judges from the published literature that a "conservative estimate… [would be] that polyester nets can last physically about 2.5 years and polyethylene nets around 4 years."[70] However, in practice estimates of net life vary widely.[71]

It is worth noting that net life seems to vary considerably with location.[72] As a result, Jo Lines of WHO argues that "[h]ighly intensive studies giving a small amount of elaborate data from a few places would be helpful, but the primary need is for a large volume of simple data from many places, in order to reveal patterns of geographic variation."[73] Lines estimates that for areas featuring campaigns of over $2M the cost of monitoring could be under 1%. Moreover, he suggests that the savings that would result from using provably more durable nets could be over 10% (or even 15-30%). WHO has now published guidelines for monitoring net durability in the field.[74]

In order to translate information on net lifespan into guidance for purchasers, we also need a practical way to *predict* net life from measurable properties. Currently, the WHO's Pesticide Evaluation Scheme (WHOPES – see next section), which assesses ITNs, does not rank the durability of approved nets. However, the WHO Global Malaria program, in consultation with industry, donors, and technical working groups, is now developing "simple… transparent and auditable" criteria for measuring net durability.[75]

Several manufacturers are working on extending the life of their nets. Recent innovations include using polyethelyne and reinforcing the bottoms of polyester nets. In the absence of

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[69] Examples are Smith, S.C et al (2007): "Evaluation of bednets after 38 months of household use in northwest Ghana" . Am. J. Trop. Med. Hyg. 77(Suppl 6): 243-248; Kilian, A. et al (2008): "Long-term field performance of a polyester-based long-lasting insecticidal mosquito net in rural Uganda." Malaria Journal 7:49; Kilian, A. et al (2011): "Evidence for a useful life of more than three years for a polyester-based insecticidal mosquito net in Western Uganda". Malaria Journal 10:229.

[70] Skovmand, O. "Insecticidal Bednets for the Fight Against Malaria – Present Time and Near Future". *The Open Biology Journal,* 3 (2010), 92-96

[71] See Line, J. (2011): "Vector Control Progress and Issues". Presentation to the meeting of the RBM Vector Control Working Group, Geneva, February 7-9, 2011.

[72] Lines, J. "Vector Control Progress and Issues." Presentation to the RBM Vector control working group, February 2011.

[73] Jonathan Lines, personal communication (May 2011)

[74] WHO (Pesticide Evaluation Scheme and Global Malaria Program Vector Control Unit (2011): "

[75] Lines, J. "A system to improve Value for Money in LLIN procurement, through market competition based on cost per year of effective coverage: Concept Note." WHO/GMP, 9 May 2011 Available at http://www.who.int/malaria/publications/atoz/gmpllin_effective_coverage_concept_note/en/index.html.

good measures, there is no reliable way to know how effective these changes will be, or how far net life can be extended.

In the long run, focusing on net life should bring considerable benefits. Once robust measurement protocols are developed, and the results properly considered in tenders, manufacturers will have strong incentives to develop better, longer-lasting nets. In turn, this could effectively expand the lifespan of nets from three to five years or beyond, reducing both commodity costs and the frequency of redistribution campaigns.

4.5 Bednet Prices

The costs of bednets themselves accounted for 84% of PMI's expenditure on ITN programs in 2009 and 29% of total malaria program expenditure.[76] Thus, reducing the prices that countries pay for LLINs could be one of the most important ways to cut costs and increase value for money.

In theory, bednet prices could be brought down by changes in procurement practices, reductions in manufacturing costs, or by changes in market structure to increase competition or supply security. All of these approaches have contributed to a spectacular reduction in the cost of antiretroviral drugs in low- and middle-income countries over the past decade.[77] It is not yet clear what the scope is for similar interventions in bednet markets, but the importance of this market to malaria VfM is increasingly recognized and other groups are doing more in-depth investigations.[78] We will present here a brief overview of the market and some preliminary analyses of the prospects for reducing prices. We focus primarily on the procurement side, as very little recent data are available on manufacturing costs.

Market overview and price history

As malaria-endemic countries have scaled up distribution of bednets in recent years, global purchases of long-lasting insecticide-treated nets have increased dramatically, from only 5M worldwide in 2007 to an estimated 140M in 2010 (we focus on LLINs as opposed to nets requiring retreatment). Demand is expected to stay high, though 2010 may represent a peak: UNICEF estimated in October 2010 that financed demand for nets would be roughly 100M a year from 2011 through 2013[79].

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[76] WMR 2010

[77] Soni, A; Magaziner I (2005) "Getting More for the Money: How Lower-Price ARVs Were Possible, Progress to Date & the Challenges Ahead". *Global Aids Link* 94: 6-8.

[78] We note in particular the on-going analysis by the Results for Development Institute (R4D). We thank Kanika Bahl and Pooja Shaw of R4D for comments on this section of our report, which led us to revise our analysis in several respects. For an overview of the R4D work, see http://www.resultsfordevelopment.org/focus-areas/long-lasting-insecticide-treated-bed-nets.

[79] http://www.unicef.org/supply/files/Update_on_Global_Efforts_to_Scale_Up_LLINs.pdf

Prices of bednets purchased with Global Fund money can be tracked in the Fund's Price & Quality Reporting (PQR) database. According to these data, bednet prices have begun to decline: from 2007 through 2011, prices for the four most popular net sizes declined by an average of 19% (see Figure 4). One possible explanation for this decline is that the number of WHOPES-approved manufacturers (see below) has increased from three in October 2007 to ten in 2011, although the market remains dominated by Vestergaard Frandsen, which received 60% of the orders listed in the PQR during 2009/10.

Price reductions through improved procurement

Analysis of price data from the PQR database and from PMI data suggests there is some scope for cost savings through changes in procurement practices, but that these potential savings are modest.

The PQR data show that there is some variation in the prices that countries have paid for specific net types, but it appears that on average large purchasers are already getting lower prices. For the most popular 180x190x150 net type, if all countries were able to access the lowest price paid in 2010, the savings would only be 10% (across all net types, the savings would be slightly higher, at 14%).

The PMI data yield a similar conclusion, but it is worth noting that the PMI prices are consistently lower than those in the Global Fund data base. For instance, PMI's average price for the 180x190x150 net in 2010 was $3.89, a 14% discount from the PQR average; for the period from 2008-2011 PMI prices averaged 10% below those reported in the PQR. It would be worth exploring the reasons for the consistently lower prices obtained by PMI.[80]

[80] There are important differences in the way that PMI- and Global Fund-funded nets are procured. PMI tends to procure nets through a subcontractor such as the John Snow Institute and then donate them to recipient governments, while the Global Fund leaves the tendering and purchasing process up to the recipient countries themselves. Countries have the option of using joint mechanisms such as Voluntary Pooled Procurement, using subcontractors, or running tenders themselves.

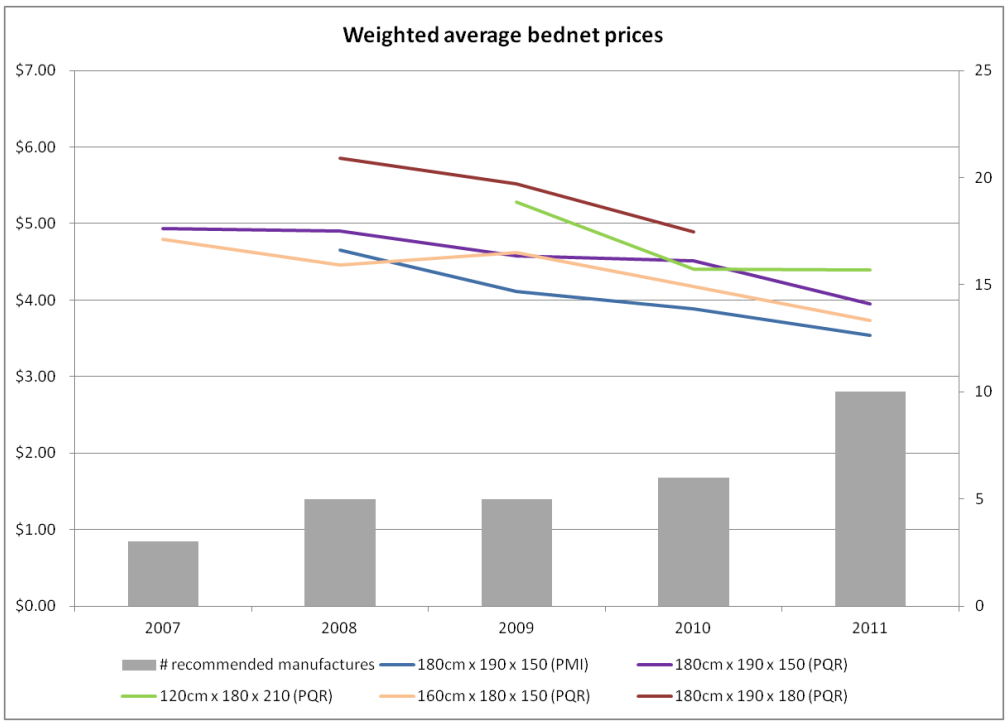

Figure 4: Trends in bednet suppliers and prices. Average prices for five sizes of long-lasting insecticidal nets purchased with Global Fund resources and number of manufacturers who have received interim or final certification by the WHO Pesticide Evaluation Scheme (WHOPES). Sources: Global Fund Prize & Quality Reporting Database; WHOPES.[81]

In 2010, several countries made several purchases of nets of the same size in the same year, paying different prices. This represents a small but potentially easy-to-reach opportunity for cost savings: if countries were able to consistently access the lowest price they paid for nets within the same calendar year, they would save 6% in total.

It is sometimes suggested that countries often place orders on short notice and that this may drive up prices. However, analysis of PQR data shows that there is little historical correlation between price paid and the time between order date and delivery date.

Bednet quality and diversity

While it is reasonable to focus on bringing down the cost of bednets, net quality also matters. It may well be worth paying more for a stronger net that may last longer, or for a type of net that may be more popular with local users. But the lack of good information on either consumer preferences (and their effect on use) or net durability in the field makes it difficult to set an appropriate balance between price and other desirable features. This tension was illustrated by the tender for Tanzania's 2007 national under-5 campaign, when

[81] The analysis presented here differs from a similar figure in Chapter 3 of the World Malaria report in that we included all purchases recorded in the PQR database, while the WMR figure used only transactions for which the price without shipping and handling was recorded.

the National Malaria Control Programme's strong preference for 100-denier polyethelene nets limited competition to a single (local) manufacturer and resulted in "delays negotiating [the] issue with the different donors [GFATM, the World Bank, and PMI] lasting several months".[82,83]

There may be longer-term benefits to reducing the diversity of net types available to purchasers. LLINs come in several materials (polyester, polyethylene, and polypropylene), colors (white, blue, green, khaki, etc), weights (deniers ranging from 75 to 150), shapes (conical or rectangular), and sizes (extra-small to extra-large). As a result, purchasers can choose from over 225 potential products. Settling on a smaller number of products—commoditizing the market—would likely lead to price gains through increased transparency and competition and greater economies of scale, though potentially at the expense of innovation and consumer preferences.

A similar tension exists over the development of new and innovative bednet designs. For instance, Vestergaard Frandsen's Permanet 3.0 features a mix of fabrics for greater comfort and a reinforced bottom for greater durability, but commands a price premium. It is difficult to know whether the benefits of better nets and of encouraging further innovation are worth the greater direct costs and increased fragmentation of the market.

Prospects for Voluntary Pooled Procurement

The Global Fund's Voluntary Pooled Procurement (VPP) mechanism was intended to allow smaller purchasers to benefit from the economies of scale that come from large orders and to allow countries of all sizes to benefit from best-in-class procurement practices. In 2009 it was used by four countries to procure bednets, including the Nigeria[84], and in 2010 by 16 countries, with total purchases of $436 M[85].

However, the VPP's impact on the overall bednet expenditure may be limited. First, large countries are already generally able to access lower prices. Second, differences in country preferences or funding and procurement logistics would largely eliminate the benefits of pooling. Finally, the voluntary nature of the plan, which allows participants to easily enter and leave the VPP, makes it difficult for the VPP to forecast longer-term demand and shape the market.[86]

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[82] Bonner, K.; Mwita, A.; McElroy, P. D.; Omari, S.; Mzava, A.; Lengeler, C.; Kaspar, N.; Nathan, R. et al. (2011). "Design, implementation and evaluation of a national campaign to distribute nine million free LLINs to children under five years of age in Tanzania". Malaria Journal 10: 73. doi:10.1186/1475-2875-10-73. PMC 3078903. PMID 21453519.

[83] Interview with Nick Brown of the National Malaria Control Programme, May 19, 2011

[84] Jallow, Mariatou Tala. *Procurement support services: Voluntary pooled procurement* (GFATM Slide deck). January 2010.

[85] Ha, Thuy Huong. *Les Achats Groupés Volontaires.* (GFATM Slide deck). March 2011.

[86] McKinsey (2011). "Increasing value for money in global health funding: Perspectives for discussion".

Quality Standards and Barriers to Entry

The "gold standard" of bednet quality assurance is the WHO Pesticide Evaluation Scheme certification (WHOPES), which tests nets under both simulated and actual field conditions. Though WHOPES is a certification body and not a regulator, most governments as well as PMI and the VPP require that nets have at least interim certification (based on simulated field conditions)

While WHOPES has successfully established a minimal set of standards for manufacturers to adhere to, their requirements have had the side effect of imposing a significant barrier to entry for new manufacturers.[87] Reaching interim certification takes on average two years, and full certification requires a set of large-scale three-year field trials. Moreover, though netting samples may be used for Phase I of the approval process, manufacturers are required to have factory production samples for Phases II and III, meaning they must bear the capital costs of setting up and maintaining production lines (estimated at $2.5M[88]) years before learning if their application will be successful or not.[89] New manufacturers can in some cases circumvent these processes by demonstrating that their netting material and processes replicate those of existing, approved manufacturers.

Reducing barriers to entry and streamlining/speeding the WHOPES-approval process would open the market to new products and companies, which might bring down prices. However, given that the number of manufacturers with either interim or full certification has now reached ten, there may not be big gains from increasing the number of suppliers even further.

Reducing manufacturing costs

There are few publically available data on the costs of LLIN manufacture. According to one not very recent study, yarn costs contributed 30-50% of the total, insecticides 10-15%, and manufacturing, packaging and labor another 30-50%[90]. Unfortunately, given this limited information it is difficult to judge what interventions might help to reduce manufacturing costs.

Conclusions on bednet prices

We conclude from this analysis that interventions in bednet markets are not likely to yield very large further declines in the price of this critical commodity. On the procurement side, the range of prices paid by countries for orders of different sizes is already fairly small, and larger countries are already getting better prices. Thus, potential gains from more efficient

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[87] Richard Tren, Philip Coticelli. Jumping Through WHOPES to Control Malaria; April 25, 2007. http://www.fightingmalaria.org/article.aspx?id=781 (Accessed August 2, 2011)

[88] Stannard, Paul (2011). "LLINs: Market Dynamics". Presentation given to the Global Fund Market Dynamics Ad Hoc Committee Technical Consultants Meeting, Feb 22, 2011.

[89] Tren and Coticelli (2007)

[90] MSH (2004). "Strategic Plan for Stimulating the Development, Manufacturing, and Widespread Distribution of Long-Lasting Insecticidal Nets". Management Sciences for Health—Europe, Ferney-Voltaire, France.

procurement are probably not more than 10-20%. There would be some savings, both in the short and long run, from consolidating demand on a small number of net types, but these gains must be balanced against losses in net quality or in fit to local conditions and preferences. More information on manufacturing costs is needed before estimating potential gains on the supply side. Finally, the recent expansion in the number of suppliers may eventually bring prices down, especially if it reduces Vestergaard's dominant position, but the potential for declines from competition cannot be estimated without information on profit margins.

Although the measures that we considered do not promise transformative declines in net costs, they are nonetheless worth pursuing, given the very large expenditure on bednets.

4.6 Resistance

One area of deep concern for vector control programs is insecticide resistance. Even modest resistance could make vector control measures less cost-effective, and in the extreme could render IRS useless and reduce the effectiveness of bednets dramatically, perhaps by 50%.[91] However, because controlling resistance requires already cash-strapped programs to make significant expenditures before problems become dramatic, it has historically been difficult to induce countries to take necessary steps.

The current dependence on bednets for vector control makes the problem of resistance especially acute, as only one class of insecticide, pyrethroids, is approved for use in LLINs. Moreover, because these insecticides are low-cost, long-lasting, and relatively nontoxic, they are also the chemicals of choice for IRS campaigns. The frequent use of the same insecticide in both interventions in the same geographic area results in powerful selection pressure for resistance.

Studies have found *An. gambiae* with resistance mutations to pyrethroids in several West, East, and South African countries.[92] However, the impact of these genetic changes on the effectiveness of vector control programs is not yet clear.[93] We do know that when widespread resistance does occur, the impact can be dramatic: KwaZulu-Natal's switch from DTT to deltamethrin for IRS in 1996 caused malaria rates to rise fourfold over four years.

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[91] There is no definitive data on the contribution of insecticide to the effectiveness of bednets, but several studies suggest that untreated nets might be about half as effective as treated nets. See Guyatt HL, Snow RW (2002). "The cost of not treating bednets." TrendsParasitol 2002; 18: 12–16 and Lengeler, C. (2006). "Insecticide-treated bed nets and curtains for preventing malaria (review)." The Cochrane Collaboration, John Wiley.

[92] RBM Vector Control Working Group (2010). "Current status of pyrethroid resistance in African malaria vectors and its operational significance". RBM, Geneva, Switzerland.

[93] Trape, J-F, Tall, A, Diagne, N et al (2011). Malaria morbidity and pyrethroid resistance after the introduction of insecticide-treated bednets and artemisinin-based combination therapies: a longitudinal study. Lancet Infectious Diseases. Published online August 18, 2011.

When studies showed that local *An funestus* mosquitoes were resistant to pyrethroids but still susceptible to DDT, the program switched back and experienced a 91% drop in malaria cases[94,95,96]

From a resistance perspective, the most dangerous strategy is to use the same chemical for simultaneous IRS and LLIN programs. Since there are currently no alternatives to pyrethroids for use in nets, this implies that IRS programs that overlap with net distribution should avoid using pyrethroids. Ideally, IRS programs should use several different insecticides, either in tandem or in annual rotation. But even switching to a single non-pyrethroid chemical would reduce the risk of resistance. The WHO has recently published some guidance on insecticide use to avoid resistance.[97]

Unfortunately, because of the low cost and other advantages of pyrethroids, IRS programs have historically used them despite the potential for resistance. PMI, by far the largest supporter of IRS programs in sub-Saharan Africa, states that in 2010 twelve out of sixteen country programs used exclusively pyrethroids.[98] However, the trend is encouraging: the same document notes that for 2011, four of these countries have declared an intent to switch to or add carbamates to their programs.

Each insecticide class other than pyrethroids presents its own problems. DDT, while cheap, has significant political liabilities, and countries that use it face restrictions on agricultural export to the EU. Both carbamates and organophosphates are significantly more expensive than pyrethroids, in part because more rounds of spraying per year may be necessary, and the organophosphates tend to have an unpleasant odor. However, while cost concerns are real, they should also not be overstated: a study prepared for PMI in 2008 suggested that in Ethiopia, Ghana, Benin, Mozambique, and Mali, insecticides averaged only 12.5% of IRS program costs[99]. Thus, while the price of carbamates is roughly five times that of

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[94] Sharp, B. L.; Kleinschmidt, I.; Streat, E.; Maharaj, R.; Barnes, K. I.; Durrheim, D. N.; Ridl, F. C.; Morris, N. et al. (2007). "Seven years of regional malaria control collaboration--Mozambique, South Africa, and Swaziland". The American journal of tropical medicine and hygiene 76 (1): 42–47. PMID 17255227.

[95] Maharaj, R.; Mthembu, D. J.; Sharp, B. L. (2005). "Impact of DDT re-introduction on malaria transmission in KwaZulu-Natal". South African medical journal = Suid-Afrikaanse tydskrif vir geneeskunde 95 (11): 871–874. PMID 16344885.

[96] Brooke, B. D.; Kloke, G.; Hunt, R. H.; Koekemoer, L. L.; Temu, E. A.; Taylor, M. E.; Small, G.; Hemingway, J. et al. (2001). "Bioassay and biochemical analyses of insecticide resistance in southern African Anopheles funestus (Diptera: Culicidae)". Bulletin of entomological research 91 (4): 265–272. PMID 11587622.

[97] WHO Global Malaria Programme (2011): "The technical basis for coordinated action against insecticide resistance: preserving the effectiveness of modern malaria vector control." Meeting report, 4-6 May, 2011.

[98] PMI (2011). "IRS Insecticide Procurement: Historical Trends Among PMI and USAID-Supported Countries". President's Malaria Initiative, Washington DC. http://www.pmi.gov/technical irs/ irs_procurement.pdf (Accessed August 10, 2011)

[99] Sine, J; Doherty A (2008). "Indoor Residual Spraying (IRS) for Malaria Control Indefinite Quantity Contract (IQC) Task Order 1 (TO1): Analysis of 2008 Expenditures in Five IRS TO1Countries". RTI International, North Carolina.

pyrethroids, switching would raise total program costs by about 50%, an important increase but not as overwhelming as might have been expected. (Some other studies give quite different estimates: White, et. al. (2011)'s literature survey suggests that insecticides may account for as much as 50% of program costs).[100]

Though there are as yet few clear signs of mosquito resistance to insecticides significantly dampening the effects of vector control programs, the impact should it occur could be devastating and irreversible. In the short term, donors should encourage countries to switch to alternative insecticides to pyrethroids in their IRS programs, and work to find ways to bring down the costs of existing alternatives such as carbamates. In the long run, the best hope would be to speed the development of alternative insecticides.[101]

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[100] White, M; Conteh L; Cibulskis R; Ghani A (2011). "Costs and cost-effectiveness of malaria control interventions – a systematic review." *Unpublished preprint.*

[101] Hemingway, J; Beaty, B; Rowland, M et al (2006). The Innovative Vector Control Consortium: improved control of mosquito-borne diseases. Trends in Parasitology 22: 308-12. Zaim, M & Guillet, P (2002). Alternative insecticides: an urgent need. Trends in Parasitology 18: 161-3.

5. Diagnosis and treatment

Chapter highlights

1. Expenditure on diagnostics should grow much more rapidly than treatment costs, as countries move toward universal parasitological diagnosis and as vector control measures drive down malaria incidence.

2. Increased RDT use will probably not cut total case management costs significantly, given the relative cost of drugs and tests and imperfect adherence to test results. Greater use of diagnostics will almost certainly be cost-effective in most settings, however, if the benefits of more appropriate treatment of non-malarial fevers are factored in.

3. There is little prospect of dramatic reduction in the prices of existing ACTs, as the market is already competitive and many production processes have already been optimized. But a new ACT, DHA-PPQ, is projected to cost substantially less to produce than the current leading treatment.

4. Because expenditure on diagnostics is expected to eventually exceed spending on drugs, reducing RDT costs should be a higher priority than it currently is.

5. Less is known about the manufacturing costs of RDTs, but this market is also quite competitive and many inputs are well commoditized. It will probably be difficult to reduce prices of current RDTs drastically.

6. Development of new and substantially cheaper RDT technologies should be a high research priority. Current spending on diagnostic research is too low relative to spending on other research priorities.

7. The cost of treating severe malaria, largely borne by endemic country governments and households, may be comparable to or greater than total donor spending on malaria case management. These costs could be averted by improving the current unacceptably low rate of prompt and effective treatment of uncomplicated malaria.

Diagnosis and treatment accounted for about 27% of total international spending on malaria in 2009, making this the largest broad category of expenditure after vector control.[102] Endemic country governments also spend a great deal on treating malaria—Roll Back Malaria estimates that in high-burden countries 50% of outpatient visits and 30-50% of admissions are for malaria.[103] While donors may support the purchase of ACTs and RDTs,

[102] WMR 2010.

[103] RBM. "The Economic Costs of Malaria" http://www.rollbackmalaria.org/cmc_upload/0/000/015/363/_RBMInfosheet_10.htm (Accessed August 2, 2011)

governments typically pay healthcare worker salaries and infrastructure costs from their own budgets.

Donor expenditure on treatment (primarily on ACTs) currently dwarfs spending on diagnosis: PMI and the GFATM together spent $327 million on treatment in 2009, compared to $42 M on diagnosis. On top of this, the Global Fund committed $216M to AMFm Phase 1 ACT subsidies, much of which is expected be spent by the end of 2012.[104]

The need for malaria treatment should decline as vector control is scaled up (and effective treatment itself contributes to curbing transmission). But these gains will not be realized as long as anti-malarial drugs are given "presumptively", that is, to all patients with fever, especially children. Until recently, the only definitive diagnostic tool was microscopy, which was available only at higher levels of the health system in most African countries. With the introduction of rapid diagnostic tests suitable for use at the peripheral level, and with the need to limit unnecessary expenditure on ACTs, the WHO now recommends that all suspected malaria cases be confirmed with a parasitological diagnosis before treatment. If RDTs were broadly available—and used correctly—spending on ACTs could drop very substantially, and could be considerably lower than expenditure on diagnosis. In fact, the GMAP analysis concluded that resource *needs* (as opposed to actual spending) for diagnosis are already more than twice requirements for treatment. But RDT scale-up still has a long way to go: the WHO estimates that only 45% of suspected malaria cases in Africa are currently confirmed with a test.[105]

In this chapter we consider the potential for value-for-money gains from roll-out of RDTs and from reduced prices for ACTs and RDTs. We also note the large potential savings, especially to governments, of averting severe malaria.

5.1 VfM gains from scaling up use of RDTs

The use of RDTs as a replacement for presumptive treatment offers the potential to improve patient outcomes through more appropriate treatment of non-malarial fevers while slowing the development of drug resistance. It could also substantially reduce expenditure on ACTs, but these savings must be balanced against the cost of the tests themselves. A number of studies, referenced below, including both modeling studies and analyses of actual experience in particular settings, have looked at the costs and benefits of different diagnostic strategies. These studies have generally concluded that the introduction of RDTs is likely to be cost-effective in most contexts, but not necessarily cost-saving, especially where prevalence is high.

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[104] The Global Fund To Fight AIDS, Tuberculosis and Malaria (2011). AMFm Frequently Asked Questions. Updated: July 2011. See also the 2011 World Malaria Report, p.16.

[105] WHO (2011). World Malaria Report, p. 39.

We consider first the potential for RDTs to be cost-saving. In general, the cost of a policy of universal diagnosis relative to presumptive treatment of all suspected cases depends on three factors: the relative prices of tests and treatment courses; the fraction of suspected cases tested that are in fact malaria; and the rate at which tested, non-malarial patients are still treated with ACTs, either because of false positives or because providers or patients do not adhere to test results. This last factor is especially important, as many studies show that ACTs are often provided in spite of negative test results (see below).

To illustrate the interplay of these factors, we present below results from a simple model that considers only the costs of the RDTs and ACTs themselves (not the costs of provider time or training or the cost of antibiotics to treat non-malarial illnesses). In contrast to a number of more sophisticated models that consider the cost-effectiveness of RDTs, taking into account patient outcomes,[106] [107] [108] our model focuses on the implications of RDTs for expenditure on commodities.

As Figure 5 shows, in the most optimistic scenario (full adult cost of $1.62[109] for artemether-lumefantrine (AL), only 1% of fevers malarial, no false positives, and perfect adherence to test results), RDTs are considerably cost-saving: commodity expenditures costs are nearly halved compared to presumptive treatment.

Once these stringent conditions are relaxed, however, the cost picture changes quickly. First, two thirds of patients receiving ACTs in the public sector are children or infants and therefore receive lower (and cheaper) dosages.[110] Moreover, artesunate-amodiaquine (AS-AQ), which is the ACT of choice in much of West Africa, is significantly cheaper than AL: a recent study of RDT use in Senegal estimated the average cost of ACTs at only $1.12 per course.[111] Finally, perfect adherence to test results (and RDT performance) is not likely – one study in Tanzania found that more than 50% of patients who tested negative were

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[106] Shillcutt, S.; Morel, C.; Goodman, C.; Coleman, P.; Bell, D.; Whitty, C. J.; Mills, A. (2008). "Cost-effectiveness of malaria diagnostic methods in sub-Saharan Africa in an era of combination therapy". Bulletin of the World Health Organization 86 (2): 101–110. PMC 2647374. PMID 18297164.

[107] Lubell, Y.; Hopkins, H.; Whitty, C. J.; Staedke, S. G.; Mills, A. (2008). "An interactive model for the assessment of the economic costs and benefits of different rapid diagnostic tests for malaria". Malaria Journal 7: 21. doi:10.1186/1475-2875-7-21. PMC 2266929. PMID 18226224.

[108] Zikusooka, C. M.; McIntyre, D.; Barnes, K. I. (2008). "Should countries implementing an artemisinin-based combination malaria treatment policy also introduce rapid diagnostic tests?". Malaria Journal 7: 176. doi:10.1186/1475-2875-7-176. PMC 2556342. PMID 18793410.

[109] Updated ACT Prices Under the Affordable Medicines Facility, Roll Back Malaria. March 11, 2011. (http://www.theglobalfund.org/documents/amfm/RBM_ACT_Pricing_Fact_Sheet_en.pdf; Accessed August 2, 2011)

[110] WMR 2010.

[111] Thiam, S.; Thior, M.; Faye, B.; Ndiop, M. D.; Diouf, M. L.; Diouf, M. B.; Diallo, I.; Fall, F. B. et al. (2011). Pied, Sylviane. ed. "Major Reduction in Anti-Malarial Drug Consumption in Senegal after Nation-Wide Introduction of Malaria Rapid Diagnostic Tests". PLoS ONE 6 (4): e18419. doi:10.1371/journal.pone.0018419. PMC 3071817. PMID 21494674.

nonetheless given ACTs.[112] A more realistic but perhaps still optimistic baseline might be to assume that 20% of non-malarial cases are treated with ACTs. In the Senegal study this rate was apparently achieved within the first year after the introduction of RDTs.

Under these more reasonable assumptions, RDTs are still cost-saving in low-malarial settings, but only by 10-20%. In higher-prevalence areas, universal RDT use is probably close to cost-neutral. One study recently estimated that across Sub-Saharan Africa approximately 22% of fevers are associated with *P. Falciparum*[113], while another arrived at the even higher figure of 44%.[114]

Our conclusion from this simple modeling exercise is supported by studies in the field, which have generally found that introduction of RDTs increased total case management costs.[115]

This analysis focuses on commodity costs. However, an important benefit from increased use of RDTs is the potential for better treatment of patients with non-malarial fevers. These effects are potentially decisive: Shilcutt, et. al.'s detailed analysis found that RDTs would have a 95% likelihood of being cost-effective relative to presumptive diagnosis at any prevalence below 62%.[116,117] This example illustrates the crucial difference between cost-saving and cost-effective. (We note that in this case our analysis departs from its general focus on malaria control benefits.)

Many obstacles stand in the way of universal adoption and appropriate use of effective RDTs. Among these are the relatively high cost of the tests; difficulties in reversing years of

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[112] Reyburn, H.; Mbakilwa, H.; Mwangi, R.; Mwerinde, O.; Olomi, R.; Drakeley, C.; Whitty, C. J. M. (2007). "Rapid diagnostic tests compared with malaria microscopy for guiding outpatient treatment of febrile illness in Tanzania: Randomised trial". BMJ 334 (7590): 403. doi:10.1136/bmj.39073.496829.AE. PMC 1804187. PMID 17259188.

[113] d'Acremont, V. R.; Lengeler, C.; Genton, B. (2010). "Reduction in the proportion of fevers associated with Plasmodium falciparum parasitaemia in Africa: A systematic review". Malaria Journal 9: 240. doi:10.1186/1475-2875-9-240. PMC 2936918. PMID 20727214.

[114] Gething, P. W.; Kirui, V. C.; Alegana, V. A.; Okiro, E. A.; Noor, A. M.; Snow, R. W. (2010). Whitty, Christopher J. M.. ed. "Estimating the Number of Paediatric Fevers Associated with Malaria Infection Presenting to Africa's Public Health Sector in 2007". PLoS Medicine 7 (7): e1000301. doi:10.1371/journal.pmed.1000301. PMC 2897768. PMID 20625548.

[115] Yukich J, D'Acremont V, Kahama J, Swai N, Lengeler C. (2010). "Cost savings with rapid diagnostic tests for malaria in low-transmission areas: evidence from Dar es Salaam, Tanzania." Am J Trop Med Hyg. 83(1):61-8; Lubell Y, Reyburn H, Mbakilwa H, Mwangi R, Chonya S, Whitty CJ, Mills A. (2007). "The cost-effectiveness of parasitologic diagnosis for malaria-suspected patients in an era of combination therapy." Am J Trop Med Hyg.77(6 Suppl):128-32; Hamer DH, Ndhlovu M, Zurovac D, Fox M, Yeboah-Antwi K, Chanda P, Sipilinyambe N, Simon JL, Snow RW. (2007). Improved diagnostic testing and malaria treatment practices in Zambia. JAMA. 297(20):2227-31.

[116] Samuel Shillcutt, et. al. "Cost-effectiveness of malaria diagnostic methods in sub-Saharan Africa in an era of combination therapy". *Bulletin of the World Health Organization*, 2008.

[117] WHO, based on analysis by S. Shilcutt (2008). *Determining Cost Effectiveness of Malaria Rapid Diagnostic Tests in Rural Areas with High Prevalence*.

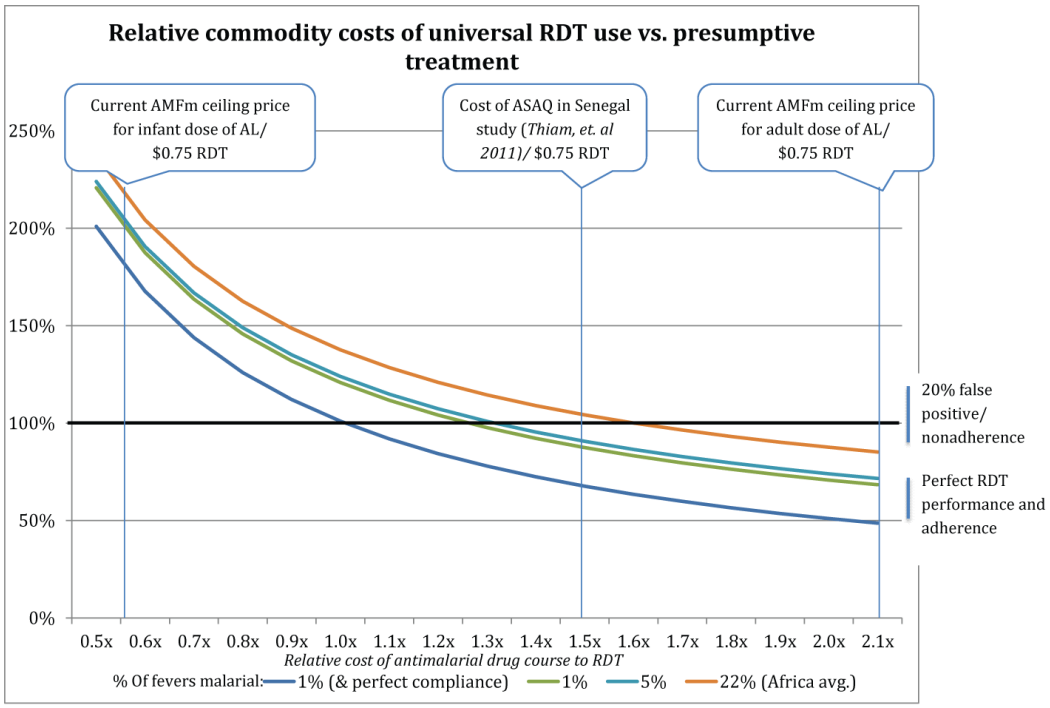

Figure 5: RDTs and commodity costs. Combined commodity costs (RDTs and antimalarial drugs) with a strategy of universal parasitological confirmation by RDT of suspected malaria cases relative to a strategy of presumptive treatment, plotted against the ratio of drug and RDT prices. Curves reflect scenarios of actual malaria prevalence in suspected cases, RDT performance (fraction of false positives) and patient/provider adherence to RDT results. ASAQ: artesunate-amodiaquine, an ACT widely used in West Africa. AL: artemether-lumefantrine, the most commonly used ACT. Source: authors' analysis.

clinician training favoring presumptive treatment; quality-control and quality-assurance issues at both the factory level and at the various stages of the supply chain; the difficulty of keeping RDTs in stock; and the challenge of ensuring correct use and adherence to results. But the experience of Senegal suggests that these challenges can be overcome. RDTs were rolled out at all levels of the public system in 2007, together with training and a revised treatment policy restricting ACT use to confirmed malaria cases when RDTs were available. Thiam et al (2010) found a dramatic increase in parasitological diagnosis and a correspondingly large decrease in ACT use.[118] They concluded that adherence to the new

[118] Thiam, S.; Thior, M.; Faye, B.; Ndiop, M. D.; Diouf, M. L.; Diouf, M. B.; Diallo, I.; Fall, F. B. et al. (2011). Pied, Sylviane. ed. "Major Reduction in Anti-Malarial Drug Consumption in Senegal after Nation-Wide Introduction of Malaria Rapid Diagnostic Tests". PLoS ONE 6 (4): e18419. doi:10.1371/journal.pone.0018419. PMC 3071817. PMID 21494674.

policy—and to test results—was high by 2009. It was not clear whether the savings in ACT expenditure offset the cost of the RDTs.

Improving malaria diagnosis in the private sector will pose more daunting challenges. Although there are important differences across sub-Saharan Africa, in most countries caregivers are more likely to seek treatment in the private sector, often from informal drug sellers, than from public-sector health facilities.[119] Since ACTs are beginning to become available at more affordable prices through these outlets as a result of AMFm,[120] finding a way to encourage appropriate RDT use in these settings will be crucial to achieving the broader goals of better diagnosis. This issue is being explored at several levels, including economic analysis and operational research.

Overall, this analysis suggests a few key conclusions. First, widespread adoption of RDTs may save money in low-endemic settings. Second, although RDTs are probably cost-neutral at best where prevalence is high, their impact on the quality of fever treatment makes them good value for money (if one considers broader health benefits). Third, strategies for improving adherence to negative results and for introducing good diagnosis in the informal private sector are the highest priorities for ensuring the greatest value-for-money gain in this area. And finally, reducing the price of RDTs would also have a great impact—probably greater than reduction in ACT costs—as expenditure on RDTs should eventually dominate case management costs. This is considered in the next section.

5.2 Commodity costs

ACTs

Spending on antimalarial drugs currently represents more than 10% of total PMI spending on malaria.[121] Two artemisinin combinations dominate the market today, Artemether-Lumefantrine (AL; primarily produced by Novartis, Cipla, Ajanta, IPCA, and Guilin) and Artesunate-Amodiaquine (AS-AQ; primarily produced by Sanofi, IPCA, and Cipla). Under

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[119] Littrell M, Gatakaa H, Evance I, Poyer S, Njogu J et al (2011). "Monitoring fever treatment behaviour and equitable access to effective medicines in the context of initiatives to improve ACT access: baseline results and implications for programming in six African countries." Malar J. 10:327; Goodman, C.; Brieger, W.; Unwin, A.; Mills, A.; Meek, S.; Greer, G. (2007). "Medicine sellers and malaria treatment in sub-Saharan Africa: What do they do and how can their practice be improved?". The American journal of tropical medicine and hygiene 77 (6 Suppl): 203–218.

[120] Global Fund to Fight AIDS, Tuberculosis and Malaria (2012). Affordable Medicines Facility – Malaria; Frequently asked questions; Health Action International (2012). "Retail prices of ACTs co-paid by the AMFm and other antimalarial medicines: Ghana, Kenya, Madagascar, Nigeria, Tanzania and Uganda .Report of price tracking surveys." (Survey date January 2012). Both available at http://www.theglobalfund.org/en/amfm/.

[121] WMR 2010

the AMFm, the maximum price manufacturers may charge for an AL fixed-dose combination (FDC) is $1.62 per treatment, while the AS-AQ limit is $0.81 for a co-blister pack and $1.09 for an FDC.[122] Despite its higher cost, AL accounted for two-thirds of ACTs procured by the public sector in 2009.[123] This was for reasons both historical and clinical: AS-AQ was introduced later, is less well-tolerated, and has cross-resistance issues with chloroquine.

The base element for all ACTs is artemisinin, a plant-derived compound whose price rose from $300/kg in 2003 to over $1000 in 2005, before dropping back down to $170 in 2007. The current price is estimated to be around $400-450/kg; however, because raw artemisinin represents only one of several cost components, this large cost increase has resulted in only a moderate increase in the price of the ACTs themselves. Moreover, achieving the 2007 price again in a sustainable way may be difficult: that level, driven by a glut on the market, was below the cost of many producers. In turn, these companies withdrew from the market, tightening supply.[124]

Two projects currently underway offer hope for some reduction in artemisinin prices. A consortium of industry and universities is working to develop semi-synthetic artemisinin, which could yield prices in the $300/kg range, while an effort by the University of York to find higher yielding varieties of artemisinin could theoretically reach $250. These efforts may result in a 10-20% reduction in the cost of ACTs in the medium term.

Unfortunately, few other promising routes to cost savings present themselves. Since 2008 low-cost generic suppliers have entered the market, the supply chain has stabilized, and global forecasts for ACT demand have been developed.[125] The chemistry for both the artemisinin-based compounds and their partner drugs has been well-optimized, though CHAI analysis suggests that some process improvements may be able to significantly reduce the cost of producing lumefantrine. Higher volumes might allow overhead costs to be spread over a larger number of pills, but there is little room for growth: worldwide production capacity for ACTs appears to be about 300-350 M treatments per year, compared to an estimate of 250 M annual cases of Malaria.[126]

The best hope for reducing the cost of ACTs may be a new drug, Dihydroartemisinin-Piperaquine (DHA-PPQ), which was approved by European regulators in late 2011. Estimates vary, but it is believed that the cost of DHA-PPQ when produced at scale should

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[122] RBM (2011), *Updated ACT Prices Under the Affordable Medicines Facility*. 1 March 2011.

[123] WMR 2010

[124] WMR 2010

[125] Clinton Health Access Initiative (2011). *Case study: Expanding the availability of high-quality, low-cost ACTs.* Clinton Health Access Initiative, Boston, MA..

[126] WHO (2010). "10 Facts on Malaria" http://www.who.int/features/ factfiles/malaria/ en/index.html, Accessed August 8, 2011.

be comparable with that of AS-AQ, or roughly one-half the cost of AL.[127] Moreover, both DHA-PPQ's biochemistry and formulation (in fixed-dose form from the start) give it an extremely favorable resistance profile. However, once DHA-PPQ is approved it will need to break into a market dominated by existing ACTs. Speeding its registration, adoption, and uptake and easing the entry of generic suppliers could help to reduce treatment costs.

In the long run, however, demand for ACTs should fall as vector control reduces malaria incidence and RDTs cut the rate of false diagnosis. Thus, while there may be some scope for decreasing ACT prices, reductions in drugs costs are not a particularly promising area for value-for-money gains.

This analysis focuses on the cost of antimalarial drugs to donors or other first-line buyers, whether these drugs are provided free to patients through public health facilities or purchased in the private sector. But of course the price to consumers matters a great deal for access and appropriate treatment, and therefore for health impact. If most patients cannot afford to buy effective antimalarials, donor expenditure on treatment is wasted. One of main goals of AMFm is to make ACTs available at affordable prices through the private sector outlets at which many African seek treatment, as well as through the public sector. The preliminary evidence from the pilot countries suggests that the initiative has had some success in achieving this, although results differ a lot among countries.[128]

RDTs

According to 2010 PQR data, the weighted average price for *P. Falciparum*-specific tests was $0.51 (range: $0.42-$0.88), compared with $0.69 ($0.58-$1.05) for multi-species tests. The weighted average prices for both types of tests fell by 11-15% annually from 2008-2010.

Little is known about the cost structure of rapid diagnostic tests for malaria. The data that are available suggest that there is no dominant contributor to cost. Rather, many components add three to five cents apiece, although labor and air transport are sometimes cited as the largest "cost drivers"[129]. With the exception of the monoclonal antibodies for detecting malaria-specific antigens, all of the components are readily available commodities, suggesting that there may be little prospect of reducing their costs.

The antibodies themselves contribute roughly as much as other relatively expensive components such as the cassette and the packaging. Two main antibodies are used. HRP2, which is *P. falciparum*-specific, is mainly produced by the South African nonprofit NBI, which

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[127] CHAI drug access team, personal communication.

[128] Global Fund to Fight AIDS, Tuberculosis and Malaria (2012). Affordable Medicines Facility – Malaria; Frequently asked questions; Health Action International (2012). "Retail prices of ACTs co-paid by the AMFm and other antimalarial medicines: Ghana, Kenya, Madagascar, Nigeria, Tanzania and Uganda .Report of price tracking surveys." (Survey date January 2012). Both available at http://www.theglobalfund.org/en/amfm/.

[129] Private communications with Jennifer Daily, independent consultant for UNITAID

because of its legal status earns only a small profit; some test manufacturers are starting to produce this antibody in-house. The state of PLDH, which detects a broad spectrum of *Plasmodium* species, is in flux: recent reports are that its developers have sold their assets to AccessBio, though the terms of the agreement have yet to be made fully available to the public.

Over 30 suppliers submitted tests for the 2008 and 2009 WHO/FIND evaluations and 8 received high marks. This suggests that the market is relatively competitive, although in practice five manufacturers dominate actual sales. It is thus likely that many, even most, opportunities for cost optimization have been explored by the manufacturers themselves. Anecdotal evidence supports this: manufacturers are already building plants in countries with low-cost labor or closer to customers to reduce shipping costs.[130]

Analysis of the Global Fund's PQR database suggests that there is some scope for reducing prices through improved procurement. Had all countries purchasing *Pf*+*Pv* or *Pf*-only tests in 2010 been able to access the lowest international price paid in 2010 for each category, they would have collectively saved approximately 15%. However, because of differences between competitors' tests, there are costs involved in switching from one product to another. In turn, this suggests that there may be gains from standardizing product interfaces and commoditizing the market, though the process of developing new standards and creating and evaluating new products could take several years. Even if countries had continued to purchase the same products but had access to the lowest international prices for each (for instance, though effective pooled procurement) they would have saved 11%.

There is a strong concern that an excessive focus on RDT prices might jeopardize product quality. While this concern may be well-founded, it is worth noting that the RDTs that score highest in the WHO assessments appear also to be among the cheapest, perhaps because their popularity has enabled their manufacturers to achieve economies of scale.

These considerations suggest that dramatic decreases in the cost of malaria diagnostics may require new technologies. But expenditure on RDT research lags far behind spending on other research priorities. A recent report by PATH noted that diagnostics research represented 4.5% of total R&D funding, compared to 31% for drugs; this amounted only to $12M in 2009.[131] Though developing new technologies for diagnostics may take five years or more, the impact could be considerable: even if RDTs were used for only one quarter of fevers in Africa, reducing their cost from $0.60 to $0.20 would save over $100M a year.[132] Moreover, cheaper diagnostics would make their use in the private sector more likely and

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[130] Communication with Jennifer Daily

[131] PATH. *Staying the Course? Malaria Research and Development in a Time of Economic Uncertainty.* Seattle: PATH; 2011.

[132] Calculation based on WHO estimate of 250M cases of malaria annually and D'Acremont (2010)'s estimate of 22% of fevers as associated with *P. falciparum.*

thereby promote more rational use of subsidized ACTs. Thus, research on low-cost diagnostic technologies could be a very good investment.

5.3 Value-for-money gains from averting severe malaria

An estimated 800,000 people die from malaria each year. Given 90% cure rates,[133] this suggests that over 8M people suffer from severe malaria annually. While this represents a fraction of the estimated 250M total cases of uncomplicated malaria, because the cost of treating severe malaria in African settings is more than $60[134], the total cost of treating all cases could reach more than $500M per year. Not all cases are treated, but this sum would be roughly twice total international donor spending on case management in 2009. These costs are in general not borne by donors, but by national governments and households.

The single best way to reduce the cost of treating severe malaria is prompt and effective treatment of uncomplicated malaria, especially in infants. In 2009, however, fewer than 65% of under-fives attending public health facilities needing antimalarial medicine received it.[135] Improving on this deplorable performance would not only prevent many if not most malaria deaths, but avert a large economic burden on health systems.

5.4. Intermittent preventive treatment

Intermittent preventative treatment (really a form of prevention) involves giving pregnant women (IPTp) and infants (IPTi) doses of relatively inexpensive antimalarials such as sulfadoxime-pyrimethamine (SP) to purge latent parasites from their system. (A third form of IPT for children, called IPTc, is still undergoing clinical efficacy trials.) IPTp has been found to cut placental malaria rates by one-third[136] to one-half[137] and decrease the prevalence

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[133] Dondorp, A. M.; Fanello, C. I.; Hendriksen, I. C.; Gomes, E.; Seni, A.; Chhaganlal, K. D.; Bojang, K.; Olaosebikan, R. et al. (2010). "Artesunate versus quinine in the treatment of severe falciparum malaria in African children (AQUAMAT): An open-label, randomised trial". The Lancet 376 (9753): 1647. doi:10.1016/S0140-6736(10)61924-1.

[134] Lubell, Y; Riewpaiboon, A; Dondorp, A (2011). Cost-effectiveness of parenteral artesunate for treating children with severe malaria in sub-Saharan Africa, WHO Bulletin 89:504-12.

[135] WMR 2010, chapter 5.

[136] Rogerson, S. J.; Chaluluka, E.; Kanjala, M.; Mkundika, P.; Mhango, C.; Molyneux, M. E. (2000). "Intermittent sulfadoxine-pyrimethamine in pregnancy: Effectiveness against malaria morbidity in Blantyre, Malawi, in 1997-99". Transactions of the Royal Society of Tropical Medicine and Hygiene 94 (5): 549–553. PMID 11132387.

[137] Parise, M. E.; Ayisi, J. G.; Nahlen, B. L.; Schultz, L. J.; Roberts, J. M.; Misore, A.; Muga, R.; Oloo, A. J. et al. (1998). "Efficacy of sulfadoxine-pyrimethamine for prevention of placental malaria in an area of Kenya with a high prevalence of malaria and human immunodeficiency virus infection". The American journal of tropical medicine and hygiene 59 (5): 813–822. PMID 9840604.

of low birth weight by one-half[138], while IPTi has been found to have a protective efficacy of 30% against clinical malaria, 21% against anemia, and 23% against all-cause hospital admissions[139]. The WHO has recommended that all pregnant women in areas of stable transmission receive two or more doses of SP and that SP be co-administered with DTP2 and DTP3 immunizations to children in areas with moderate-to-high malaria transmission.[140]

IPT is exceptionally cost-effective in areas of high transmission. Studies in Tanzania have found that IPTi delivered in concert with EPI vaccines cost just $0.68[141] and $1.57[142] per malaria case averted, and as little as $2.90 per DALY averted[143]. IPTp has been shown to have incremental cost effectiveness ratios as low as $1.02 per DALY averted[144]. Cost per case averted is higher in lower transmission areas: one study estimated the cost per cases averted in Tanzania's Kilmanjaro district, where prevalence is below 1%, at $67.[145] Although there is now significant resistance to SP in some countries, this does not seem to have substantially reduced its effectiveness in IPT.

Despite its affordability and demonstrated effectiveness, coverage of IPT is currently low: WHO estimates from household surveys that only 23% of pregnant women in sub-Saharan Africa received two doses of antimalarials in 2009-2011, in part because of low antenatal care attendance.[146] IPTi programs are still at the pilot stage.

Increasing coverage of IPTp and scaling up IPTi in high-transmission areas would be a very cost-effective investment.

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[138] Rogerson, et. al. (2000)

[139] Aponte, J. J.; Schellenberg, D.; Egan, A.; Breckenridge, A.; Carneiro, I.; Critchley, J.; Danquah, I.; Dodoo, A. et al. (2009). "Efficacy and safety of intermittent preventive treatment with sulfadoxine-pyrimethamine for malaria in African infants: A pooled analysis of six randomised, placebo-controlled trials". The Lancet 374 (9700): 1533. doi:10.1016/S0140-6736(09)61258-7.

[140] WHO (2007) "Malaria in Pregnancy: Guidelines for measuring key monitoring and evaluation indicators."; WHO (2010). "Policy recommendation on Intermittent Preventive Treatment during infancy with sulphadoxine-pyrimethamine (SP-IPTi) for Plasmodium falciparum malaria control in Africa."

[141] Conteh, L.; Sicuri, E.; Manzi, F.; Hutton, G.; Obonyo, B.; Tediosi, F.; Biao, P.; Masika, P. et al. (2010). Diemert, David Joseph. ed. "The Cost-Effectiveness of Intermittent Preventive Treatment for Malaria in Infants in Sub-Saharan Africa". PLoS ONE 5 (6): e10313. doi:10.1371/journal.pone.0010313. PMC 2886103. PMID 20559558.

[142] Hutton, G.; Schellenberg, D.; Tediosi, F.; MacEte, E.; Kahigwa, E.; Sigauque, B.; Mas, X.; Trapero, M. et al. (2009). "Cost-effectiveness of malaria internittent preventive treatment in infants (IPTi) in Mozambique and the United Republic of Tanzania". Bulletin of the World Health Organization 87 (2): 123–129. doi:10.2471/BLT.08.051961. PMC 2636201. PMID 19274364.

[143] Conteh, et. al (2010)

[144] Sicuri, E.; Bardají, A.; Nhampossa, T.; Maixenchs, M.; Nhacolo, A.; Nhalungo, D.; Alonso, P. L.; Menéndez, C. (2010). Von Seidlein, Lorenz. ed. "Cost-Effectiveness of Intermittent Preventive Treatment of Malaria in Pregnancy in Southern Mozambique". PLoS ONE 5 (10): e13407. doi:10.1371/journal.pone.0013407. PMC 2955525. PMID 20976217.

[145] Conteh et al (2010).

[146] WHO (2011), WMR, p. 35.

6. Administrative and aid efficiency

This report has focused primarily on strategic and tactical choices made by national malaria control programs and their partners—which malaria interventions to provide where and how to provide them—as well as on the prices of important malaria commodities. Clearly, however, value for money will depend ultimately on how effectively these choices are implemented. Large-scale malaria programs require planning, training and oversight, procurement, supply chain management, monitoring, and other administrative functions at central and lower levels. Yet management capacity is often weak in malaria-endemic countries, especially at the district level. These issues, which in our simple framework fall under the rubric of administrative efficiency, clearly contribute to reduced effectiveness of malaria programs, as can be seen particularly clearly by the persistent problem of stock-outs of antimalarial drugs. But it is difficult to quantify the impact on overall effectiveness and value for money.

The problem of weak management—and broader health system weakness—is not of course restricted to malaria programs, and many of the potential solutions would apply across the health system. But malaria programs differ in two important ways from many other health programs in developing countries. First, malaria programs, and especially vector control, have traditionally operated quite independently in many countries. This vertical organization, although it may not necessarily be in the best interests of the health system as a whole, does allow program managers (and donors) to exercise greater control over budgets and operations. Second, malaria programs currently rely to a greater extent than many others on the procurement and delivery of commodities rather than on the provision of services (IRS is a notable exception). Although this makes supply chain deficiencies particularly important, problems with commodity availability may be easier to track and resolve than challenges related to service delivery and quality. Even the most important malaria service, diagnosis and treatment, is far less challenging than the management of HIV or tuberculosis infection, in part because malaria infections are usually time-limited rather than chronic. In these respects, malaria control resembles childhood immunization. Together, these aspects of malaria programs may mitigate to some degree the impact of administrative and health system deficiencies.

Administrative efficiency has other dimensions as well. In addition to influencing the effectiveness of malaria programs, administrative expenditures can be an important contributor to program costs. Administrative costs are difficult to compare, as different programs use different definitions. Moreover, it is almost certainly a mistake to assume that lower administrative or overhead expenditures necessarily mean greater value for money, as hiring more staff, increasing manager salaries, or investing in information technology could in many cases increase program effectiveness.

Finally, there is no doubt that diversion of funds or commodities is a significant problem in some countries, as recent investigations by the Global Fund's Office of the Inspector

General have revealed and (high-profile articles in the press have highlighted).[147] In the case of Mali's Global Fund grants, the inspector general's report concluded that at least 42% of the grant funds had been lost to "criminal acts of fraud and misappropriation." But it would be a mistake to generalize from this case, and there is simply no good data on the overall scope of the problem.

The risk of commodity diversion is probably greatest for drugs, which have a market in the private sector, and it is clear that ACTs intended for the public sector do end up in private pharmacies and drug shops.[148] But there is not enough information on the scale of diversion to estimate the impact on value for money, in part because systems have not been created that would allow commodities to be systematically tracked through the supply chain.[149] Private-sector markets for bednets and RDTs are less well developed, so diversion is unlikely to be as important a problem for these commodities. It is possible that the advent of highly subsidized ACTs in the informal private sector through AMFm will lessen the incentive for drug diversion as well.

There is clearly no simple solution to the problem of corruption in health systems,[150] but more detailed, accurate, and timely information on commodity flows at all levels of the system would almost certainly make a difference. Mobile phone-based systems like the "SMS for life" program in Tanzania are promising. Other possible measures are the introduction of a new cadre of logistics specialists at the district level and ordering systems that bypass in part the district level, where much diversion probably occurs. A pilot project in Zambia that included district-level commodity managers as well as a new ordering system that sent tailor-made sealed packages directly from central stores to facilities increased the availability of pediatric ACTs dramatically.[151]

Just as problems in program implementation at the country level reduce value for money, current donor aid mechanisms impose their own costs and inefficiencies. The models of the Global Fund and the US government differ in important respects, with the US model's

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[147] See, for example, Global Fund Office of the Inspector General (OIG) (2011): Investigative Report on Mali Malaira (1&6) and TB (4&7) Grants; OIG (2011): Progress Report for November 2010-March 2011; Maria Cheng: "Millions in malaria drugs stolen", Associated Press, April 20, 2011; John Heilprin: "Fraud plagues celebrity-backed global health fund", Associated Press, January 23, 2011.

[148] Bate, R, Hess, K. & Mooney, L (2010). Antimalarial medicine diversion: stock-outs and other public health problems. Research and Reports in Tropical Medicine 1:19-24.

[149] Prashant Vadav, personal communication, August 15, 2011.

[150] For a variety of perspectives on this problem, see Transparency International's 2006 Global Corruption Report, which focused on corruption in health systems in countries at every level of development.

[151] World Bank (2010): Zambia study shows Zambia Study Shows Stronger Supply Chains for Key Drugs can Reduce Child Mortality. Available at http://go.worldbank.org/KYZSYO59I0. See also "Stronger drug supply chains can save thousands of children in Zambia and beyond", Available at http://siteresources.worldbank.org/INTZAMBIA/Resources/Brochure-Zambia_201004.pdf.

greater reliance on external contractors to oversee or even deliver services providing greater protection against fraud and in some cases more efficient implementation at the cost of limiting local government ownership and flexibility. These issues are not unique to malaria programs, and it is likely that the best model depends both on the setting and on the priority given to obtaining results quickly relative to operational if not financial sustainability.

These issues of administrative and aid efficiency should be a high priority for further research and analysis on value for money in malaria programs.

7. Conclusions and recommendations

1. **Malaria control is a very good investment.** Numerous studies have already established that the interventions on which malaria programs increasingly rely and which account for the great bulk of donor malaria spending—insecticide-treated bednets, indoor residual spraying, treatment with artemisinin-combination therapy—are highly cost-effective. Although it is too early in most countries for a definitive assessment, preliminary analyses of countries that have succeeded in reducing malaria burden suggest that malaria control has been and remains good value at a program level.
2. **There is little chance of *transformative* efficiency gains in the short to medium term.** This conclusion derives primarily from four features of the current malaria control landscape:
    - Commodity costs account for more than half of malaria expenditure, and there is probably little scope for more than modest reduction in the prices of key malaria commodities, including LLINs, ACTs, and RDTs.
    - Opportunities for reducing non-commodity costs of bednet programs, the largest malaria control activity, are also quite small, and these costs are already a relatively small share of total costs.
    - The need to sustain vector control even after malaria burden falls, and the lack of an adequate, cheaper alternative to nets, means that there is not much scope for reducing the need for bednets.
    - There is no evidence of gross misallocation of resources among vector-control interventions.
3. **But there are nonetheless opportunities for meaningful improvements in value for money.** In particular, our analysis highlights the following areas:
    - More efficient procurement of LLINs, including pooled procurement, could save up to 10% of bednet costs. It may also be possible to reduce manufacturing costs, but there is not enough information for specific recommendations.
    - Reducing the overlap of net and spraying programs, at least until we know more about the costs and benefits of combining the two interventions, could save 5% or more on vector control expenditure.

- Expanding the use of RDTs, including in the private sector, and strengthening adherence to test results could cut expenditure on case management commodities in some areas, but would improve the quality of fever treatment in all areas.
- Increasing coverage of IPTp and introducing IPTi on a larger scale in high-burden areas would be highly cost-effective.

4. **Some potential paths to greater value for money do not seem likely to yield big gains, although they may be worth pursuing on other grounds**
    - Reductions in ACT and RDT costs
    - Further refinement of models for initial net scale-up
    - Ensuring that vector control resources are not spend in areas where there is no malaria risk.
5. **Further research and analysis in several areas will be crucial to sustaining or increasing value for money.**
    - Practical ways to assess net durability in the field and predict net life from net properties
    - Models for continuous net replacement based on household need
    - Management of the spread of mosquito resistance to the insecticides used in bednets
    - Relative cost and effectiveness of IRS and ITN in different settings and the impact of combining the two
    - Ways to encourage appropriate use of RDTs in conjunction with AMFm-subsidized ACTs in the informal private sector
    - Better and more detailed information on the spatial distribution of intrinsic malaria transmission risk
    - Exploring the feasibility and cost-effectiveness of local malaria elimination in low-risk areas.
6. **In the long run, our analysis implies that transformative reductions in the cost of controlling malaria will require new control tools.**