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Aidspan Review of a Study by Y. Akachi and R. Atun on the Effect of Investment in Malaria Control on Child Mortality

by
Dr David McCoy

This is a review of the following study:

Effect of investment in malaria control on child mortality in sub-Saharan Africa in 2002-2008

by Y. Akachi* and R. Atun*‡.

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Preface

Aidspan (www.aidspan.org) is an NGO based in Nairobi, Kenya. Its mission is to reinforce the effectiveness of the Global Fund to Fight AIDS, Tuberculosis and Malaria. Aidspan performs this mission by serving as an independent watchdog of the Global Fund, and by providing services that can benefit all countries wishing to obtain and make effective use of Global Fund financing.

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The author of this review, Dr David McCoy (david.mccoy@aidspan.org), is a public health physician and honorary senior clinical research fellow at University College London. He serves as a consultant to Aidspan and also works part-time in the UK National Health Service.

While the authors of the original study have seen drafts of this review, the author of this review takes full responsibility for ensuring that the original study has been accurately and fairly represented, as well as for the opinions and recommendations expressed here. Aidspan is grateful for the comments and suggestions received from the authors of the original study.

Introduction

In a recently published peer-reviewed academic paper,[1] two Global Fund employees reported on their findings of an examination of the impact of official development assistance (ODA) financing for malaria control on child health in 34 sub-Saharan African (SSA) countries. This review provides a summary of the published paper ("the study") with some additional commentary.

Study design and methods

The study was designed to examine the relationship between a set of inputs, outputs and outcomes related to malaria control and child health.

The *inputs* were disbursements of official development assistance (ODA) for malaria control from 2002 to 2008. This includes financing from bilateral and multilateral donors, but not from domestic, private or philanthropic sources.[2]

The *outputs* consisted of the distribution and coverage of insecticide-treated bed nets (ITN) and indoor residual spraying (IRS).[3]

The *outcomes* were under-five mortality rates and the number of lives saved from malaria-attributed causes among children under five years of age.

Data on other variables that affect child health outcomes were also analysed. These included data on vaccine coverage;[4] vitamin A supplementation; oral rehydration solution (ORS) usage; essential care during delivery/birth; PMTCT (% pregnant women with anti-retroviral prophylaxis); antiretroviral therapy [ART] for children aged 0-15 years; access to quality water; and stunting in babies less than one month old.

Figure 1 below illustrates the full set of variables that were analysed.

To estimate the number of lives saved due to the scale-up of ITN/IRS coverage, the study made use of the Lives Saved Tool (LiST)[5], a computer-based model that allows users to set up and run multiple scenarios to estimate the impact of different intervention packages and coverage levels on maternal, neonatal and child health.

LiST works on the following data sets: (a) demographic projections; (b) cause of under-five child deaths; (c) cause of maternal deaths; (d) current levels of coverage of key health interventions; and (e) estimated effectiveness of interventions on cause-specific neonatal and child mortality. With these data, the tool calculates the association between changes in

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[1] Y. Atachi, R. Atun. Effect of investment in malaria control on child mortality in sub-Saharan Africa in 2002-2008, *PLoS ONE* (Public Library of Science) 6(6): 21309.doi:10.1371/journal.pone.0021309. Available here.

[2] Data were obtained from the Credit Reporting Systems (CRS) database of the Organization for Economic Cooperation and Development (using purpose code 12262: Malaria control) and were converted to 2008 constant US$ to control for inflation and exchange rate variations.

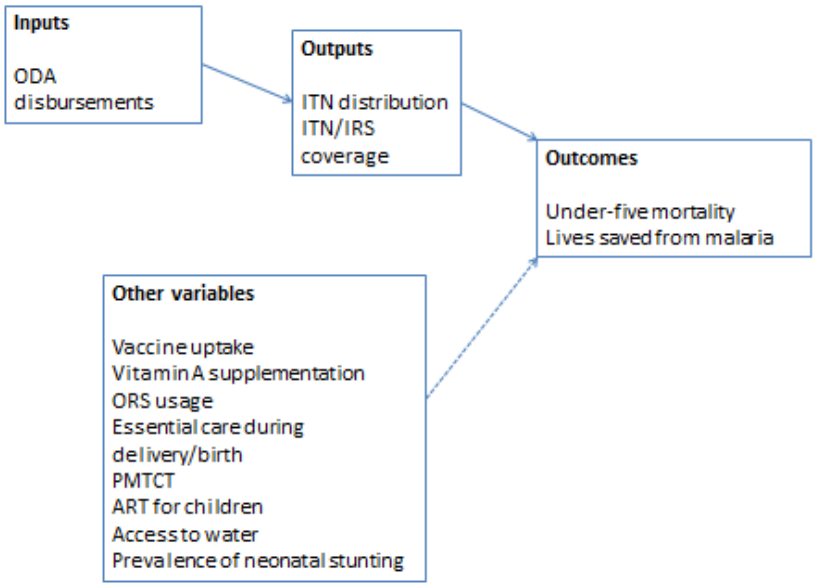
[3] Anti-malarial treatment was not analysed for various reasons, including the lack of data, changes in recommended treatment over time and limited scale-up in the period studied.

[4] Vaccine coverage included coverage rates for diphtheria-tetanus-pertussis [DTP3], measles and haemophilus influenzae type b.

[5] LiST was developed by a consortium of academic and international organisations, led by the Johns Hopkins Bloomberg School, and supported by a Gates Foundation grant to the U.S. Fund for UNICEF.

cause-specific mortality with changes in intervention coverage, while taking into account other factors such as nutritional status and breastfeeding rates, as well as changes in population trends due to fluctuations in fertility rates.

Figure 1: Variables analysed to assess the impact of malaria investment on child mortality



Much of the required data comes from various nationally representative surveys.[6] Data on the number of ITNs distributed each year were obtained from the World Health Organization (WHO) and Roll Back Malaria. Cause of death extrapolations were based on methods described elsewhere.[7] Similarly, the effect sizes used by LiST to link intervention coverage and cause-specific mortality were derived from other studies.[8, 9] Where data are missing, LiST makes linear interpolations between existing data points.

The study projected the number of deaths in children under five years of age from 2002 to 2008 and compared this to an alternative counterfactual scenario in which there was no ITN/IRS coverage. The number of lives saved by ITN/IRS coverage (defined as the household ownership of at least one ITN or a household "covered by IRS") was then estimated as the difference between the two scenarios.

[6] Of note are demographic and health surveys (DHS), malaria indicator surveys (MIS) and multiple indicator cluster surveys (MICS).

[7] R.E. Black et al. Global, regional, and national causes of child mortality in 2008: a systematic analysis, *Lancet* 375(9730): 1969-1987 (2010).

[8] J. Stover, R. McKinnon, B. Winfrey. Spectrum: a model platform for linking maternal and child survival interventions with AIDS, family planning and demographic projections, *Int J Epidemiol* 39: i7-i10 (2010).

[9] N. Walker et al. Standards for CHERG reviews of intervention effects on child survival, *Int J Epidemiol* 39: i21-i31 (2010).

Countries Studied

Thirty-four SSA countries were included in the study[10]. Countries were categorised into two disease burden groups: (a) "low-burden" countries where malaria causes less than 10% of all under-five child deaths (seven countries); and (b) high-burden countries where malaria causes 10% or more of all under-five child deaths (27 countries). Countries were also divided into four groups according to the cumulative amount of ODA disbursed for malaria control in 2002-2008 divided by the number of people at risk for malaria from year 2007.

Statistics

The statistical methods used to conduct the analysis for this study are detailed in the published paper, and include the use of regression analyses to examine the relationship between the different sets of input, output and outcome variables.

A point highlighted by the study authors is that the data on input, output and outcome from this study have two dimensions: (a) cross-sectional information which allows for a study of differences between countries; and (b) time series information which allows for a study of changes over time (2002-2008). The combination of time series and cross-sections allows for a more powerful analysis of the relationship between input and output, and between output and outcome.

Results / Findings

As mentioned earlier, the aim of this study was to examine the relationship and associations between the inputs, outputs and outcomes associated with Global Fund malaria grants. What follows is first, the study's findings on the inputs and outputs; second, the findings on the relationship between inputs and outputs; and then, the relationship between inputs/outputs and outcomes.

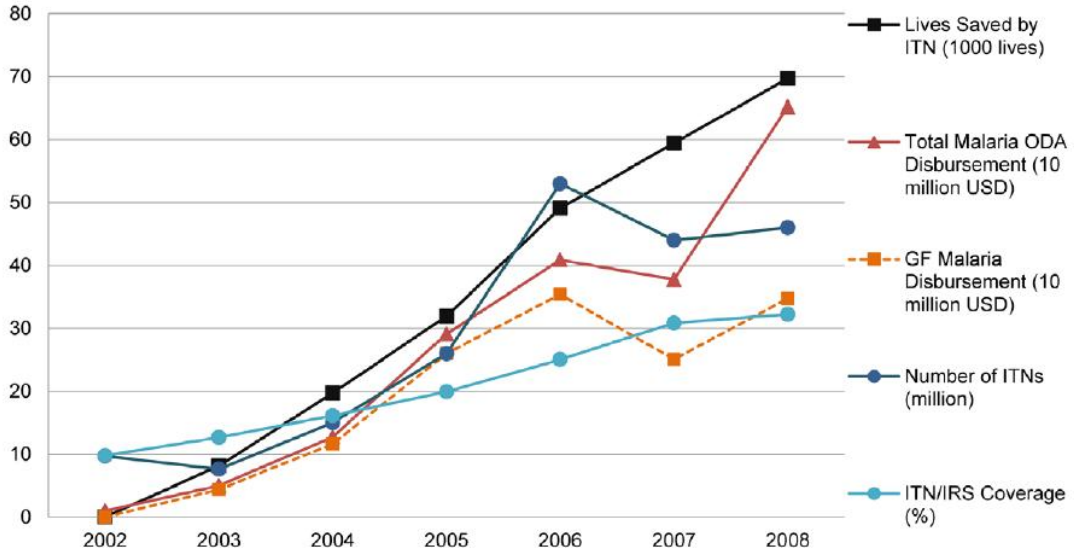
Inputs

In the 34 countries studied, the amount of ODA disbursed for malaria control increased from $9.8 million in 2002 to $651.7 million in 2008 – a 66-fold increase in funding. During this period, the Global Fund's annual share of those disbursements increased from $0 to $347.2 million. A cumulative total of $1.916 billion was disbursed, of which $1.372 billion came from the Global Fund (meaning that the Fund provided over 70% of the total ODA disbursements to those countries for malaria control).

Interestingly, the Global Fund's contribution as a percentage of total funding to these 34 countries declined annually since 2004 due to increases in malaria funding from other sources (see Figure 1 below). Global Fund funding for malaria to these 34 countries also dropped in real terms from 2006 to 2007, before recovering in 2008 to 2006 levels of funding.

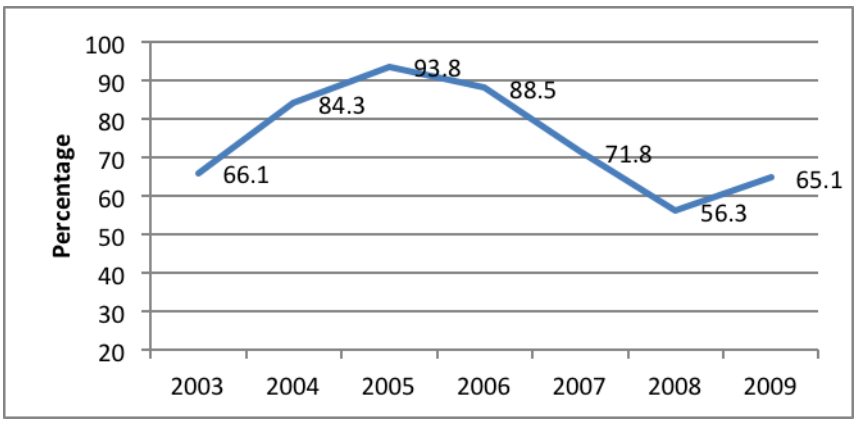
[10] Countries with small populations were excluded (Cape Verde, Comoros, Sao Tome and Principe, Mauritius, Seychelles), as were countries lacking adequate data (Gabon, Equatorial Guinea, Republic of the Congo and Namibia).

Figure 1: Input, Output and Outcome trends (34 Sub-Saharan Africa countries)



The picture of ODA malaria funding worldwide (using data from elsewhere) shows a similar pattern of the Global Fund's proportional contribution to malaria funding declining annually from 2005 to 2008. However, Global Fund disbursements for malaria in 2009 were nearly double its disbursements in 2008, with the consequence that its proportional contribution rose between 2008 and 2009 (Figure 2).

Figure 2: Global Fund Proportion of total ODA for malaria control worldwide



The study found that ODA disbursements were not related to the number of people at risk from malaria (Table 1). Several high-burden countries (Burkina Faso, Cameroon, Cote d'Ivoire, Guinea and Nigeria) received lower ODA disbursement per person-at-risk than countries where malaria is not a major cause of child deaths (Angola, Burundi, Ethiopia, Rwanda, Swaziland). The seven countries with a low burden of malaria received $7.05 ODA disbursement per person-at-risk, while countries with a high burden of malaria (10% or more of malaria attributable child deaths) received on average $3.90 per person-at-risk.

Table 1: Malaria burden and malaria control ODA disbursement per person-at-risk in 2002–2008

Malaria as a cause of all child deaths in 2000	Malaria ODA disbursement per person-at-risk in 2002–2008			
	Lowest quartile	Second quartile	Third quartile	Highest quartile
< 10%	Zimbabwe	Somalia		Angola Burundi Ethiopia Rwanda Swaziland
10-20%	Dem Rep Congo Mali	Central African Republic Mozambique Niger	Eritrea Kenya Malawi Mauritania Sierra Leone	Zambia
> 20%	Burkina Faso Cameroon Cote d'Ivoire Guinea Nigeria	Benin Ghana Guinea-Bissau Sudan Togo	Madagascar Tanzania Uganda	Gambia Liberia Senegal

Outputs

According to data from the World Malaria Report, a total of 151 million ITNs were distributed in the 34 countries between 2002 and 2008, increasing from 9.7 million in 2002 to 46 million in 2008. Interestingly, ITN distribution decreased in 2007 and 2008 compared to 2006; the reason for this is unclear. Overall, between 2002 and 2008, average ITN/IRS coverage increased from 8.3% to 33%.

Average coverage rates across the period were similar for both groups of countries: 17.4% in low-burden versus 21.2% in high-burden countries. However, ITN/IRS coverage rate in the low-burden countries increased six-fold from 5.6% in 2002 to 37.0% in 2008; while in high-burden countries it (only) increased three-fold from 9.1% in 2002 to 31.9% in 2008. This corresponds with the finding that low-burden countries had higher per capita funding than high-burden countries for persons at-risk.

Input to Output

The study found that increased ODA disbursement was significantly associated with increased ITN/IRS coverage (p,0.05). Using regression analysis, it was estimated that for every $1 million ODA disbursed for malaria control each year, about 50,000 ITNs were distributed in the same year. However, as illustrated in Figure 1 above, it should be noted that the pattern of the association between ODA disbursement and ITN distribution in the period 2002-2006 is different from that in the period 2007-2008.

Input and Output to Outcome

Using LiST, increased ITN/IRS coverage from 2002 to 2008 was estimated to have saved 240,000 lives. Using regression analysis, the study authors estimated that 0.625 lives were saved per 1,000 additional ITNs distributed. The study also found a strong statistically significant association between ODA disbursement for malaria and the number of lives saved due to ITN/IRS coverage in the same year (p,0.0001), suggesting that for every $1

million ODA disbursement for malaria control (of which about 32% may be spent on ITNs[11]), 31 under-five child lives were saved from improved ITN/IRS coverage.

The study also found that increased ITN/IRS coverage was considerably more efficient in high-burden countries compared to low-burden countries. Although there was a higher amount of ODA disbursed per person at-risk in low burden countries compared to high burden countries, the increased ITN/IRS coverage in high-burden countries led to an estimated 3,575 lives saved per one million children, compared to 914 lives saved per one million children in low-burden countries.

In absolute terms, between 2002 and 2008, a total of $512 million was disbursed to the seven low-burden countries; this expenditure was associated with an estimated 14,198 lives saved (due to expanded ITN/IRS coverage); while the $1,404 million that was disbursed to the 27 high-burden countries was associated with an estimated 223,773 lives saved (again due to expanded ITN/IRS coverage). This translates to a cost of $36,000 per life saved in low burden countries and a cost of $6,300 per life saved in high burden countries.[12] However, ODA for malaria control is also spent on malaria treatment which would save lives, and these figures therefore under-estimate the full impact of malaria investment on child health.

If however, we assume that about 40%[13] of ODA for malaria control is allocated to ITNs and IRS, one can extrapolate from the paper that ODA spending on ITN/IRS coverage translates to a cost of $14,400 per life saved in low burden countries and $2,520 per life saved in high burden countries.[14]

Other factors and variables

The study also found that reductions in under-five mortality were significantly and positively associated with improved access to quality water ($p<0.01$), increased vaccination (DTP3 and measles), increased ART provision for children ($p<0.05$), provision of medicines to pregnant women to prevent mother-to-child transmission ($p<0.05$), and lower levels of stunting ($p<0.01$). However, no significant association was found with vitamin A supplementation, ORS usage or Haemophilus influenzae vaccination coverage.

Across the period 2002-2008, panel data analysis suggested that a 10% increase in households with either ITN or IRS would prevent 1.5 child deaths per 1,000 live births. In the same model, a 10% increase in DTP3 coverage, access to quality water, measles coverage and ART for children would prevent 7.1, 6.1, 1.1, and 0.8 child deaths per 1,000 live births, respectively.[15] It was also reported that a 10% increase in stunting (at age one month) was associated with an increase of 22.4 child deaths per 1,000 live births, while a 10% decline in

[11] Using data from elsewhere, it has been estimated that about 42% of total ODA funding for malaria control has been allocated to malaria prevention (and 32% specifically to ITNs).

[12] Note however that ODA for malaria control will be combined with domestic expenditure to achieve the increases in ITN/IRS coverage; so the full costs of saving a life are higher.

[13] This is a hypothetical figure based on what is reported above in footnote 11.

[14] By way of comparison, it may be interesting to note that the Global Fund claims that Global Fund-supported programmes have saved a total of 6.5 million lives as of the end of 2010. During this time, the total value of Global Fund disbursements was about $13 billion, which would translate to about $2,000 per life saved. Global Fund-supported programmes, however, also receive funding from other sources.

[15] Note that this does not mean that increasing immunisation coverage or improving access to quality water, for example, is automatically more cost-effective than expanding ITN/IRS coverage. While the paper looked at the association between malaria ODA funding and ITN/IRS coverage, it did not look at any association between ODA and other interventions or factors related to child mortality.

population PMTCT coverage would lead to an increase of one child death per 1,000 live births.[16]

The study also threw up an unexpected finding: an increase in essential care during delivery and birth was found to be positively correlated with under-five mortality (p,0.05). In other words, more care during delivery and birth was associated with a higher death rate.

Discussion

So what can be said about this study and its findings?

It is necessary to first make a note of caution about data limitations. These include both poor data and missing data, prompting the authors to call for "more micro-level data from health surveys to improve reliability of child mortality figures and robustness of results." The LiST methodology for modelling the impact of ITN/IRS coverage on lives saved is also based on assumptions and estimations of the efficacy and effectiveness of health care interventions.[17] Finally, as the study authors themselves note, the study only describes an "association between factors" and not "explicit causal pathways".

It is hard to determine to what extent these limitations affect the results of this study. It is reasonable to conclude that improved ITN/IRS coverage has had *some* impact on reducing under-five child mortality; and it seems reasonable to conclude that increased immunisation, PMTCT coverage and improved access to quality water has also reduced child mortality. However, the finding that an increase in access to essential care during delivery and birth is associated with a worsening under-five mortality rate cannot be correct. The authors attribute this finding to poor data on the coverage of neonatal and maternal interventions.

A more general point concerns the challenge of quantifying the impact of a single downstream intervention (ITN/IRS coverage) on an outcome (the death of children) which is ultimately affected by multiple and inter-dependent social, cultural, environmental, health systems and clinical factors. Although the study investigated a number of other factors associated with child health (and found evidence that improved access to quality water, increased vaccination, increased ART provision for children, PMTCT provision for pregnant women and sound nutrition is positively associated with improved child health outcomes), many other variables were not included in the model. Put another way, other (confounding) factors may yet explain the association between ITN/IRS coverage and improved child health outcomes.

Notwithstanding these limitations, it is important to recognise that the Global Fund is leading the way in assessing the value and impact of external development assistance for health. In so doing, the Global Fund is drawing attention towards two important policy challenges. First is the need to improve the availability and quality of data through the strengthening of health information systems. And second is the need to debate the methodological challenges in understanding and quantifying the complex and dynamic interaction between health systems inputs, outputs and outcomes, as well as various other contextual variables.

While analysing aggregated data from multiple countries has some uses in providing a broad and single overview of the relationship between inputs, outputs and outcomes, it is as

[16] It should be noted that the published journal paper contains a typographical error which incorrectly states that a reduction in PMTCT and an increase in "stunting" leads to a reduction in child mortality.

[17] It is worth noting that the effectiveness of ITN/IRS coverage is not fixed and will vary from one country to another depending on a host of contextual factors.

important to acknowledge that countries and programmes vary to such a degree that there can be no universal pattern in the relationship between inputs, outputs and outcomes. In this context, it may be as useful to accept this variation and to rather study the reasons *why* there is variation (e.g. through comparative country case studies), and to use such study as a means of identifying the determinants of ITN/IRS effectiveness and how these may be optimised on a country by country basis.

Another interesting finding of this study is that the pattern of ODA disbursement for malaria control is not related to burden of disease (although this finding echoes an earlier analysis of international funding for malaria control[18]). As highlighted by the study authors, "many countries with a high burden of malaria as a cause of child deaths had limited increases in ITN/IRS coverage in 2002-2008 because of low investment per at-risk-person malaria."

Although it may be appropriate for funding per person-at-risk to be higher in low-burden countries compared to high-burden countries (because of the fewer opportunities to take advantage of economies of scale), the authors correctly suggest that further analysis is needed to understand the reasons for the allocation patterns observed. They also note that since 2008, sub-Saharan African countries with a high-burden of child deaths due to malaria have secured increased funding following support from the Roll Back Malaria Partnership and revisions in the eligibility and prioritisation criteria for Global Fund grants. An analysis of 2009 and 2010 funding patterns would soon determine if resource allocation has indeed become more needs-based.

Finally, there is an interesting point about the architecture of external funding for malaria control. In 2005, the Global Fund disbursed 94% of total malaria control worldwide; but by 2008, its proportional contribution to ODA for malaria control had decreased to 56%. One can assume that during this three-year period, recipient countries would have had to deal with other sources of ODA funding for malaria, and it may be interesting to assess the impact of a more plural external financing system on the coherence, efficiency and effectiveness of malaria programmes within recipient countries. In doing so, it would be important to include funding from private, non-ODA sources, especially the Gates Foundation.

Conclusion and recommendations

This paper illustrates the work of the Global Fund (and others) in evaluating and demonstrating the impact of external development assistance for health on the delivery of health care outputs and on health status. It is part of a trend to improve the accountability of the Global Fund and other health aid programmes.

The study found that increased ODA disbursement for malaria control is significantly associated with increased ITN/IRS coverage, and that this has in turn led to an estimated 240,000 lives saved. The study also found that investment in improving ITN/IRS coverage is generally cost-effective in terms of lives saved (especially in high burden countries), but that external funding for malaria control should be better matched to the global distribution of the malaria disease burden. However, various data quality and methodological limitations still need to be tackled before such studies can reliably measure the impact of ODA and Global Fund financing for malaria control on health outcomes.

While the LiST computer-based model that was used in this study can help policy makers and planners to make more informed decisions about resource allocation across different discrete interventions to reduce child mortality, the assumptions and limitations of such

[18] R.W. Snow et al. Equity and adequacy of international donor assistance for global malaria control: an analysis of populations at risk and external funding commitments. *Lancet* 376: 1409-16 (2010).

models must be understood. This includes recognising the variable relationship between inputs, outputs and outcomes from one setting to another.

Finally, while multi-variate analysis of aggregated data from multiple countries can play a useful role in summarising the global effort to tackle malaria, the Global Fund should also consider promoting alternative research approaches such as in-depth, mixed-method country case studies that would provide a more qualitative and contextualised understanding of the relationship between inputs, outputs and outcomes. Such studies, when conducted as part of a set of comparative country case studies, could also provide more practical insights and motivation for the improvement of malaria programmes.