Towards the Malaria End Game:
Economics and Financing of Malaria Elimination

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ABBREVIATIONS

ADB	Asian Development Bank
AFG	Afghanistan
BRA	Brazil
AIDS	Acquired Immune Deficiency Syndrome
AIM	Action and Investment to Defeat Malaria
AMC	[Sri Lanka] Antimalaria Campaign
API	Annual Parasite Index
APLMA	Asia Pacific Leaders Malaria Alliance
ASEAN	Association of Southeast Asian Nations
BCR	Benefit Cost Ratio
BDG	Bangladesh
BMGF	Bill & Melinda Gates Foundation
EMMIE	Elimination of Malaria in Mesoamerica and the Island of Hispaniola
CBA	Cost-benefit analysis
CEA	Cost-effectiveness analysis
CER	Cost-effectiveness ratio
CLM	Controlled low-endemic malaria
CHN	China
COL	Columbia
CRS	Creditor Reporting System
CSR	Corporate Social Responsibility
D	Diagnosis
DAH	Development Assistance for Health
DDT	dichloro-diphenyl-trichloroethane
E8	Elimination 8 (Block of 8 countries in southern Africa implementing regional approaches for elimination)
ETH	Ethiopia
GDP	Gross domestic product
GFATM	Global Fund to Fight AIDS, Tuberculosis, and Malaria
GHE	Government Health Expenditure
Global Fund	Global Fund to Fight AIDS, Tuberculosis and Malaria
GMS	Greater Mekong Subregion
GMEP	Global Malaria Eradication Programme
GNI	Gross National Income
GPEI	Global Polio Eradication Initiative
GTS	Global Technical Strategy
HIV	Human Immunodeficiency Virus
ICER	Incremental cost-effectiveness ratio

IDN	Indonesia
IEC	Information Education and Communication
IHME	Institute for Health Metrics & Evaluation
IMF	International Monetary Fund
IND	India
IP	Inpatient
IRN	Iran
IRQ	Iraq
IRS	Indoor residual spraying
ITN	Insecticide-treated net
JOR	Jordan
KEN	Kenya
Kg	Kilogramme
LBR	Liberia
LIC	Low-income country
LLIN	Long-lasting insecticidal net
LKA	Sri Lanka
LMIC	Lower-middle-income country
LBN	Lebanon
MAU	Mauritius
MEX	Mexico
MDA	Mass drug administration
MDB	Multilateral development bank
ME	Monitoring & Evaluation
Mg	Milligram
MOH	Ministry of Health
MUS	Mauritius
NFM	New funding model
NMCP	National malaria control programme
NPL	Nepal
NSP	National strategic plan
OECD	Organization for Economic Cooperation and Development
OOP	Out-of-pocket
OP	Outpatient
PAR	Population at risk
PHL	Philippines
PL	Palestine
PM	Program Management
PMI	Presidents' Malaria Initiative
POR	Prevention of reintroduction
PPP	Purchasing Power Parity

PRSIMA	Preferred Reporting Items for Systematic Reviews and Meta- Analyses
RAI	Regional Artemisinin-Resistance Initiative
RAI2E	Regional Artemisinin-Resistance Initiative 2 Elimination
RBM	Roll Back Malaria
SDG	Sustainable Development Goals
RDT	Rapid diagnostic test
RMO	Regional Malaria Officer
ROK	Republic of Korea
ROI	Return on investment
RWA	Rwanda
S	Supplemental
SEM	Surveillance and epidemic management
SEN	Senegal
SSA	Sub Saharan Africa
SLB	Solomon Islands
SM	Severe Malaria
STC	Sustainability, transition, and co-financing
STP	São Tomé and Principe
SWA	Swaziland
SYR	Syria
TAI	Taiwan
TB	Tuberculosis
THA	Thailand
TP	Treatment and prophylaxis
TZA	Tanzania
UM	Uncomplicated Malaria
UMIC	Upper-Middle-Income Country
UK	United Kingdom
UN	United Nations
USA	United States of America
USD	United States dollar
VC	Vector Control
VLY	Value of additional life year
VUT	Vanuatu
WHO	World Health Organization
WMR	World Malaria Report

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SUMMARY

Background

In the past fifteen years, the world has made substantial progress towards reducing malaria mortality and morbidity. Global malaria incidence and deaths have declined by 41 and 62%, respectively, between 2000 and 2016. 17 countries have eliminated malaria, six of which have been certified as malaria-free by the World Health Organization (WHO). According to the WHO, an additional 21 countries are in a position to achieve at least one year of zero indigenous cases of malaria by 2020. Achieving the malaria elimination goals will require sustained financial and political commitment at the global and domestic levels. However, external funding is on the decline particularly for the subset of malaria eliminating countries which tend to be low burden and middle income countries. The malaria landscape is further complicated by the emergence and spread of antimalarial drug resistance arising from the Greater Mekong Subregion (GMS). Failure to maintain resources for malaria elimination and the health systems that support it has the potential to reverse the impressive gains made.

Aim and objectives

The aim of thesis is to examine the economic evidence for malaria elimination and generate results relevant to policy for continued investment for malaria elimination. Specifically:

- To review and interpret the existing information on the costs and benefits of malaria elimination from published and unpublished sources of literature
- To estimate the costs and benefits and develop a national investment case for malaria elimination in Sri Lanka
- To estimate the costs and benefits and develop a regional investment case for malaria elimination in the Asia Pacific region
- To track and interpret trends in development assistance and government financing for malaria from 1990-2017
- To assess the implications of changing donor policies on financing for malaria programmes and their potential impact on malaria elimination targets

Methodology

A variety of quantitative and qualitative methods were used. A systematic review of published and grey literature was conducted to gain an understanding of the current evidence on the costs and benefits of malaria elimination. The cost of malaria elimination and prevention of reintroduction (POR) at the national level was estimated using ingredients based costing methodology. A hypothetical resurgence scenario was modeled as the counterfactual scenario using historical data. The total income approach was used to quantify the benefits of elimination and the return on investment was computed. The cost of maintaining elimination activities was compared to the financing available to estimate the funding gap. To develop the regional investment case in the Asia Pacific, a mathematical transmission model coupled with a cost model was used to estimate the

minimum set of interventions to reach elimination on or before 2030 and the regional cost of these interventions. An investment case was generated using the outputs of these models compared to a scenario of maintaining the status quo. The benefits of elimination were quantified using the total income approach and a return on investment was computed as with the national investment case.

Building on the Institute for Health Metrics and Evaluation's (IHME) annual Financing Global Health research methodology, data were collected from organizations that channel development assistance for health to the 35 countries actively pursuing malaria elimination and categorized by type of expenditure. A diverse set of data points were used to estimate government health expenditure on malaria, including World Malaria Reports and government reports when available. Projections were made using regression analyses taking recipient country averages and earmarked funding into account.

Lastly, average annual Global Fund allocations for eligible malaria-eliminating countries for the period of 2014–2017 were computed. Estimated funding ranges were calculated using the proposed national allocation plus any possible adjustments and additional funding. The minimum and maximum funding estimates were compared to average annual disbursements under the previous funding model to determine the impact of the allocation model on funding for malaria elimination. A qualitative analysis of the new Global Fund transition policy was conducted and interpreted for challenges for malaria elimination programmes. Policy recommendations were developed for donors and countries to ensure uninterrupted service delivery.

Principal findings

Of the 54 studies included in the systematic review, twenty-two were focused on elimination or eradication. The annual per capita cost of malaria control to a health system ranged from USD0.11 to USD 39.06, while that for malaria elimination ranged from USD 0.18 to USD 27. Overall, the investments needed for malaria control and elimination varied greatly amongst the various countries and contexts. However, the findings illustrated that while the cost of elimination in most cases was greater than the cost of control, the benefits greatly outweighed the cost.

The total current economic cost of the elimination and POR program in Sri Lanka was estimated at USD 0.57 per capita per year with a financial cost of USD 0.37 per capita in 2014. The cost of potential malaria resurgence was, however, much higher providing an economic return on investment of 13 times or a financial return on investment of 21. Despite the phenomenal returns, current financing for malaria elimination in Sri Lanka meets only 53 % of needs leaving a significant funding gap.

The investment case generated for the Asia Pacific region demonstrated a median return of about six times the investment for malaria elimination. The cost of elimination was estimated at USD 29.02 billion between 2017-2030. Malaria elimination was shown to save about 400,000 lives and

avert 123 million malaria cases, translating to almost USD 90 billion in economic benefits. Total financing for malaria in the Asia Pacific however, covered only 30% of the estimated annual cost of elimination between 2018-2020.

Despite these demonstrated returns on investment from malaria elimination, external financing declined by about 65% since 2010 from USD 176 million in 2010 to USD 62 million in 2013 for the 35 countries actively pursuing malaria elimination. Government expenditures on malaria, while increasing, have not kept pace with diminishing external funding. The Global Fund to Fight AIDS, Tuberculosis and Malaria, the largest external financier for malaria, provided 96% of the total external funding for malaria in 2013. Under the allocation model, there was a cumulative 31 % decrease in financing for malaria elimination. Even if countries received the maximum possible funding allowable, 46 % of the countries included in the analysis would receive less than they received under the previous funding model, potentially leaving critical gaps in essential program activities.

Eight key challenges are faced by countries undergoing transition from donor financing: challenges in management capacity; lack of financial planning data; diminishing political will; concurrent epidemiological changes and changing priorities after elimination; parallel donor and government systems; integration of vertical programs; procurement pricing and quality commodities and; strategic program delivery and management. Policy recommendations for donors and national malaria programs to facilitate a more successful transition process included the need for adequate time and resources for transition, the consideration of strategic investments of the transitional financing for health for capacity building in information systems and management and a robust transition plan that allows for sustainability of core functions of the program.

Conclusion

This body of work provides strong evidence on the uncertainty about the future availability of financing for malaria elimination. It also demonstrates that malaria elimination is a worthwhile investment providing robust health and economic returns at the national and regional level. A concerted effort is needed to use the generated evidence to build an advocacy strategy to ensure that financing for malaria elimination is maintained until the end game. Anything less will undermine decades of investment and the unprecedented gains achieved towards achieving a global public good - a world free of malaria.

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CHAPTER 1

Background and Introduction

1.1 Global epidemiological and economic burden of malaria

The launch of the Roll Back Malaria Partnership (RBM) in 1998 and the Millennium Development Goals in 2000 catalyzed unprecedented political and financial commitment for malaria from donors, such as the Global Fund, the United States President's Malaria Initiative (PMI), the World Bank, and others as well as endemic countries themselves. As a result, global malaria incidence and deaths have dramatically declined by 41 and 62%, respectively, between 2000 and 2015 [1]. During this period, 17 countries eliminated malaria, six of which have been certified as malaria-free by the World Health Organization (WHO) [2]. Thirty-five countries are currently actively pursuing malaria elimination, with elimination goals ranging from 2018 to 2035 [3]. In 2016, 44 countries reported fewer than 10 000 malaria cases. According to WHO, 21 countries are in a position to achieve at least one year of zero indigenous cases of malaria by 2020 [4]. Of the 106 countries with ongoing malaria transmission in 2000, 57 reduced malaria incidence more than 75 % by 2015 and an additional 18 countries reduced incidence by more than 50 % [2].

Bolstered by these successes, the idea of malaria eradication is once again on the global health agenda. Many countries have developed national elimination goals, and regional networks have been formed to facilitate collaboration [3, 5]. Leaders from the Asia Pacific Leaders Malaria Alliance (APLMA) and the African Leaders Malaria Alliance (ALMA) have endorsed regional goals for malaria elimination by 2030 in November 2014 and January 2015, respectively, galvanizing support for elimination and eradication [6, 7].

Despite this progress, malaria continues to place a heavy toll on the world. In 2016, 216 million cases occurred globally, leading to 445,000 deaths, most of which occurred in children under age five years in Africa [8]. These estimates are likely to be conservative, as adult cases and deaths from

malaria might well be underestimated in much of Africa and Asia due to the high proportion of treatment seeking behavior in the private sector [9-12].

Furthermore, global progress in malaria control and elimination is marked by vast disparities between and within countries, with vulnerable groups that have poor access to health services continuing to be marginalized. A few countries that have successfully reduced malaria transmission are struggling to maintain their gains. An increased number of cases have recently been reported from a number of countries, including Cambodia, Djibouti, Rwanda, Madagascar, Uganda, and República Bolivariana de Venezuela [13] The WHO reported that between 2014 and 2016, case incidence increased in the Americas, South-East Asia and the Western Pacific and in Africa [8].

Some of the challenges impeding countries' abilities to maintain their gains and advance towards malaria elimination include a lack of sustainable and predictable international and domestic funding. This is compounded by the emergence of parasite resistance to antimalarial medicines and mosquito resistance to insecticides, posing a serious threat to global health security. Since 2010, donor funding for malaria has plateaued and is projected to continue to decline [14]. These reductions in external financing are even greater for the sub-set of malaria eliminating countries despite demonstrated evidence on the returns on investment from elimination [15,16]. By nature, these countries have lower disease burdens and are often lower-middle or middle-income countries and therefore a lesser priority for donors [17,18]. In some cases, donors are moving away from disease-based funding to general system strengthening to address Universal Health Coverage or concerns of global health security [19]. While integrated systems might help countries in the final push to malaria elimination and prevent reintroduction of malaria, a well-funded malaria programme, maintaining a level of vertical oversight, is crucial in the short to medium term. At the same time, as the disease becomes less "visible", government funds for malaria are often diverted to other health priorities that are perceived to be greater health threats, risking a reversal of the recent gains made in malaria elimination [15, 20, 21].

The Global Fund, which has been the largest external financing channel supporting eliminating nations representing more than half (57%) of the total resources for malaria control and elimination, has historically dispersed about 7% of its total portfolio to eligible malaria-eliminating countries. However, under the New Funding Model adopted in 2012, resources for this sub- set of countries declined to less than 5% [22] and have declined further under a revised allocation-based model adopted by the Global Fund Board in November 2016 [23]. Other bilateral and multilateral donors are similarly diverting resources to higher-burden countries with the least ability to pay as measured by their Gross National Income (GNI). For example, PMI launched in 2005, focuses on reducing malaria-related mortality in 24 high burden countries in sub-Saharan Africa in addition to targeted support in the Greater Mekong Subregion in Asia, aimed at combating antimalarial drug resistance [24].

The reductions in financing for countries eliminating malaria comes at a critical time—WHO's Global Technical Strategy (GTS) for Malaria 2016–2030 [25] and the Roll Back Malaria Partnership's Action and Investment to Defeat Malaria 2016–2030 (AIM) [26] together with the recently endorsed Sustainable Development Goals, have set their sights on rapid progress with malaria elimination towards attainment of malaria free status in 35 countries by 2030. The GTS estimated that USD 6.4 billion will be needed annually to achieve a reduction of at least 40% in malaria case incidence and mortality by 2020 compared to 2015 levels. However, total funding for malaria control and elimination was estimated at USD 2.7 billion in 2016 [25], representing just 42% of the annual need.

Table 1.1. Global malaria goals and targets

Goal	Milestones		Target
	2020	2025	2030
Reduce malaria mortality rates globally compared with 2015	At least 40%	At least 75%	At least 90%
Reduce malaria case incidence globally compared with 2015	At least 40%	At least 75%	At least 90%
Eliminate malaria from countries in which malaria was transmitted in 2015	At least 10 countries	At least 20 countries	At least 35 countries
Prevent the reestablishment of malaria in all countries that are malaria free	Reestablishment prevented	Reestablishment prevented	Reestablishment prevented

Source: [25]

Achieving the global goals will require sustained financial and political commitment at the global and domestic levels. These investments have the potential to deliver strong health benefits through fewer deaths and less illness valued at over USD 49 billion, exceeding investment costs by a factor of 40 between 2015 and 2030 [26].

Although the contribution of malaria elimination to the colossal health and development returns of global eradication is implicitly recognized [15, 16, 21], malaria elimination requires additional front-loading of investments into robust surveillance-response systems to detect and respond to remaining cases. While socio-economic and other structural changes will eventually change the intrinsic baseline potential for transmission in countries such that active measures are no longer required [27], the decision facing policymakers is how to best allocate finite resources in the short term. Countries who have successfully lowered their malaria burden are faced with the risk of losing or severely reducing their recurrent expenditure for elimination and preventing the re-introduction of malaria at a critical period in the malaria elimination efforts [3, 18]. At the same

time, they face the risk of resurgence due to the persistent importation of new cases which will not only have devastating effects on the health and welfare of individuals, but will also place an additional economic burden on the health system. A review on malaria resurgence occurring from the 1930s through to the 2000s demonstrated that almost all resurgence events could be attributed, at least in part, to the weakening of malaria control programmes for a variety of reasons, of which resource constraints were the most common [28]. In addition, lessons learned from the Global Malaria Eradication Programme (GMEP), which ended in 1969, affirm that while well-funded interventions can have a major impact on the disease, such gains are fragile and can easily be reversed particularly in the short term in areas that continue to be epidemiologically and entomologically receptive and vulnerable [29].

1.2 Malaria elimination and eradication

Malaria elimination is defined as the reduction to zero of the incidence of infection caused by a specified agent in a defined geographical area as a result of deliberate efforts. Global eradication of malaria is the permanent reduction to zero of the worldwide incidence of infections caused by the malaria parasite as a result of deliverable efforts [30].

In areas of moderate to high transmission that are implementing malaria control, interventions are deployed on a large scale to reduce the public health burden of the disease. In elimination settings, targeted interventions aim to interrupt local transmission in the specific places where it becomes increasingly concentrated, that is, small geographic areas or special subpopulations that may be harder and costlier to reach. The key decisions facing policy makers in low- and moderate-transmission settings are when to embark on malaria elimination [31,32]; which interventions to implement and where and when; and at what levels of intensity and reach. Critical to this debate are the political and financial commitments that are needed long after the disease stops being a public health burden.

Malaria elimination involves stopping indigenous transmission through active control measures. The complete absence of local incidence is very unlikely to be achieved in places with high intrinsic potential for transmission and elevated importation of cases [33]. For example, even the United States, a relatively low transmission risk area, identified 156 locally acquired cases between 1957 and 2003 [34]. Even countries that do not contiguously border endemic neighbors experience considerable importation annually: Sri Lanka reported 49 confirmed imported malaria cases in 2014, and in Tanzania, Zanzibar's estimated importation of 1.6 cases per 1,000 residents could potentially produce 1,300 incident cases [35]. Transmission from imported cases may lead to first degree *introduced* cases; a second degree of transmission from an introduced case produces an *indigenous* case: both are products of *local* transmission. Elimination accordingly requires preventing all indigenous cases, but introduced cases may continue to occur sporadically. As more

countries and regions eliminate malaria and implement measures to prevent reintroduction, fewer imported infections will occur, and eradication will become increasingly feasible.

The first malaria eradication attempt was made as part of the Global Malaria Eradication Programme, or the GMEP, which ran from 1955-1970. Until the mid-nineteenth century, malaria was endemic in most countries across the globe. Between 1900 and 1945, only nine countries in Europe eliminated malaria [20,21]. Sparked by the availability of chloroquine for treatment and dichloro-diphenyl-trichloroethane (DDT) for vector control, WHO launched the GMEP in 1955 to interrupt transmission in all endemic areas outside of Africa [29]. The programme relied on vector control—mainly indoor residual spraying—and systematic detection and treatment of cases. The campaign which targeted elimination in countries with low or intermediate malaria intensity, succeeded in eliminating malaria in 37 of the 143 countries or economies where it was endemic in 1950 [36], including some lower-income areas with tropical climates such as Maldives; Mauritius; Réunion; Taiwan, China; much of the Caribbean; Brunei Darussalam; most of China; Hong Kong SAR, China; Singapore [20,21,36]. In many other countries, such as Sri Lanka, the burden of disease and deaths from malaria was greatly reduced [37]. However, failure to sustain strong funding for the program, particularly in the face of increasing costs due to mounting drug and insecticide resistance, led to the end of the GMEP in 1969 [38] when the World Health Assembly recommended that countries not yet ready for “eradication” focus on controlling malaria as a first step toward the ultimate goal of elimination. Multilateral agencies withdrew their support for malaria programmes in favor of general health programmes. In the ensuing years, although most countries that had eliminated malaria continued to remain malaria free, the scaling back of control efforts in malarious countries led to a global resurgence of the disease during the 1970s and 1980s and a complete reversal of progress in some countries, such as Sri Lanka and Pakistan [28,39]. The experience of the GMEP provides critical lessons for contemporary elimination programmes about the need to maintain vigilance and sustain investments during the latter stages of elimination efforts.

1.3 Malaria elimination and health security

As countries become more interconnected through increased infrastructure and air links, health security is also becoming a major concern. Recent outbreaks of severe acute respiratory syndrome, H5N1 (“avian flu”) and H1N1 (“swine flu”) influenza, Middle Eastern respiratory syndrome coronavirus, Ebola, and more recently the Zika virus have highlighted the need for governments to invest in health security to tackle emerging and re-emerging infectious diseases. Artemisinin resistance similarly poses a risk to health security. Investing in malaria elimination has a direct positive contribution to the health security of the countries and communities involved. Malaria’s key interventions—including strengthened surveillance, health information systems, disease surveillance, and preparedness—provides a platform to tackle other emerging infectious diseases by improving the capacity to detect and report disease outbreaks, respond faster to public health

emergencies, and collaborate across borders [40,41].

Across most malaria endemic countries, weak health systems are a major constraint to the planning, implementation, monitoring, and sustainability of effective interventions. Malaria elimination can be viewed as an entry point to strengthen health systems and has the potential to highlight how elimination can lead to increased equity. In low transmission settings, where cases cluster among high-risk populations, programs must tackle areas and communities that lack access to critical health services. These systems will also be able to deliver universal health coverage, and the funds no longer needed for malaria, can be redirected to tackle other pressing health challenges. The malERA Refresh research agenda has highlighted the role of health systems improvement for the continuous and timely delivery of malaria interventions [42]. Given the context of declining malaria case numbers across the region, malaria advocacy is increasingly being tied to a wider narrative that includes other communicable diseases such as dengue, which has seen a dramatic resurgence in recent years, and Zika as part of a regional health security response.

1.4 Malaria in the Asia Pacific Region

Malaria remains a major cause of death and illness in the region with an estimated 1.72 billion people at risk of the disease [8] About 20 different Anopheles vectors have been implicated in malaria transmission in the Asia Pacific. Some of these vectors bite outdoors, between early evening to the early hours of the morning, and exhibit zoophilic biting—behaviors that require expanded vector control interventions beyond long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) and improved targeting of high risk populations [40].

Approximately 260 million people live in high-transmission areas. In 2016, among the 21 countries in the region with ongoing malaria transmission or working towards POR, there were 6,345,208 presumed and confirmed cases of malaria according to the World Malaria Repot of the World Health Organization (WHO) of which 53% of cases were due to *Plasmodium falciparum (P. falciparum)* and 41% due to *Plasmodium vivax* (*P. vivax)* cases. The remaining infections (6%) are mixed. Of this total, 14,729 cases were imported. India, South Asia carries the highest burden of disease with India alone accounting for 49% of global *P. vivax* malaria cases and 51% of global *P. vivax* malaria deaths in 2015 [8].

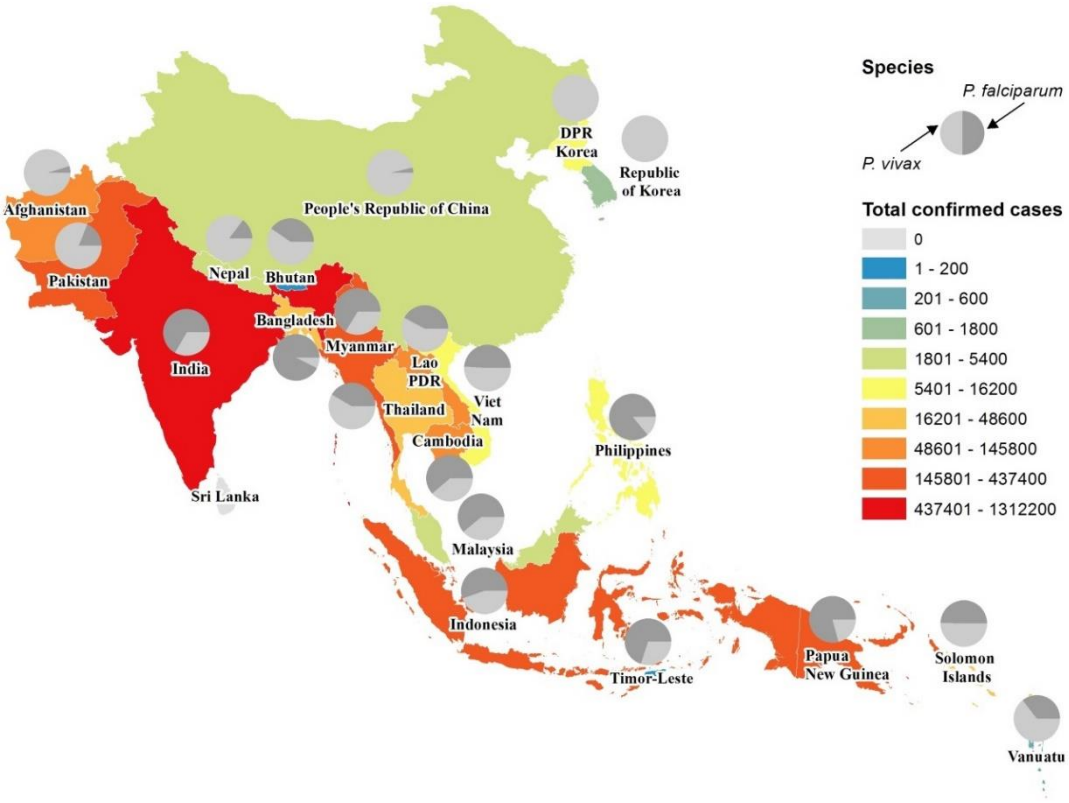
The Asia Pacific region has achieved significant gains against malaria over the last 15 years. Malaria cases and deaths have been reduced by more than 50% between 2010 and 2015 in the region's 22 malaria-endemic countries.[1] Sri Lanka was declared malaria-free in 2016, becoming only the second

[1] The Asia Pacific region in this report encompasses the 22 malaria-endemic countries as defined by APLMA. Sri Lanka has since been declared as malaria free but still implements prevention of reintroduction activities. Countries include: Afghanistan, Bangladesh, Bhutan, Cambodia, Democratic People's Republic of Korea (DPRK), India, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea (PNG), People's republic of China, Philippines, Republic of Korea (ROK), Solomon Islands, Sri Lanka, Thailand, Timor Leste, Vanuatu and Vietnam.

country in Southeast Asia (after the Maldives) to successfully eliminate malaria [43,44]. Apart from India, Indonesia, Myanmar, and Thailand, malaria-endemic countries reported decreases of malaria incidence of more than 75% since 2000. Cases and deaths declined by more than 50% between 2010 and 2015 in the majority of the countries in the region, surpassing the WHO milestone of a 40% reduction by 2015 [1]. In some cases, they have declined by almost 100%, with Bhutan, China, and Timor-Leste reporting less than 200 cases in 2016 [8]. Progress in driving down malaria is attributed to the scale-up of effective interventions to prevent, diagnose, and treat malaria, facilitated by strong political and financial support from governments and donors like the Global Fund to Fight AIDS, Tuberculosis and Malaria (the Global Fund).

The numbers of confirmed cases by country and species are shown in Figure 1.1.

Figure 1.1. Confirmed *P. falciparum* and *P. vivax* malaria cases in Asia Pacific, 2015



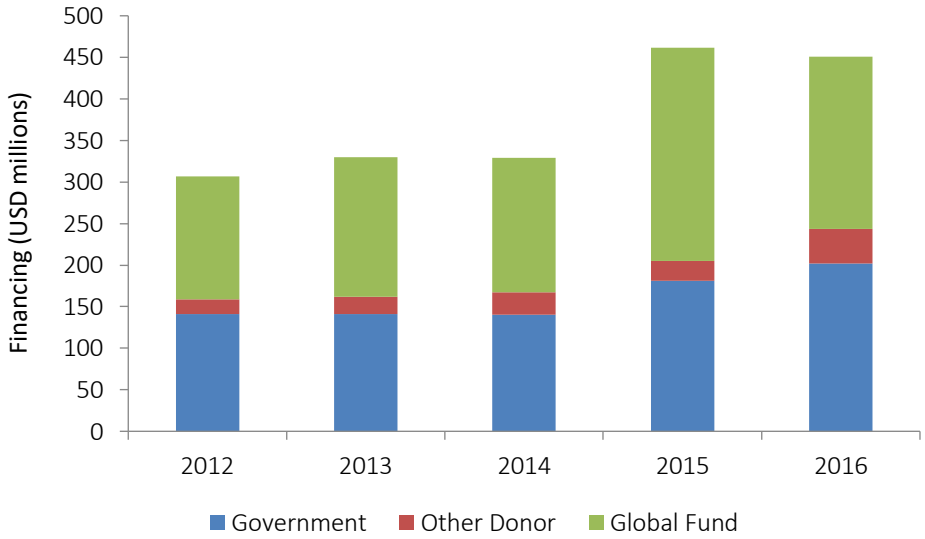
Source: [1,45]

1.5 Financing for Malaria in the Asia Pacific Region

Over the past decade and a half, the Asia Pacific region has invested in excess of USD 3 billion in malaria control interventions [40]. Annual financing for malaria in the region increased exponentially from less than USD 100 million in 2000 to about USD 415 million in 2016 [41,46].

The main sources of financing are domestic government resources and external financing from donors. Most national malaria control programs (NMCPs) in the region continue to be highly reliant on external financing, particularly from the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund). As Figure 4 illustrates, almost 50% of the total funding for malaria in Asia Pacific in 2016 was from the Global Fund. This dependence on external financing is projected to continue beyond 2017.

Figure 1.2. Financing for malaria in the Asia Pacific region



Source: [46]

However, there has been a plateau in external financing for malaria, particularly for countries that have middle-income status and experience relatively lower transmission of malaria. Between 2006-2010, the Asia Pacific region attracted between 12% and 21% of global malaria funding from the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) [22]. Although domestic financing for malaria has increased in many countries in the last decade, the need for malaria control and elimination far exceeds the available resources. This is particularly important in the context of elimination where malaria is no longer perceived as a threat with countries simultaneously facing competing disease priorities. At the same time, the region has experienced unprecedented economic growth, providing unparalleled opportunities to reach and sustain resources for malaria elimination.

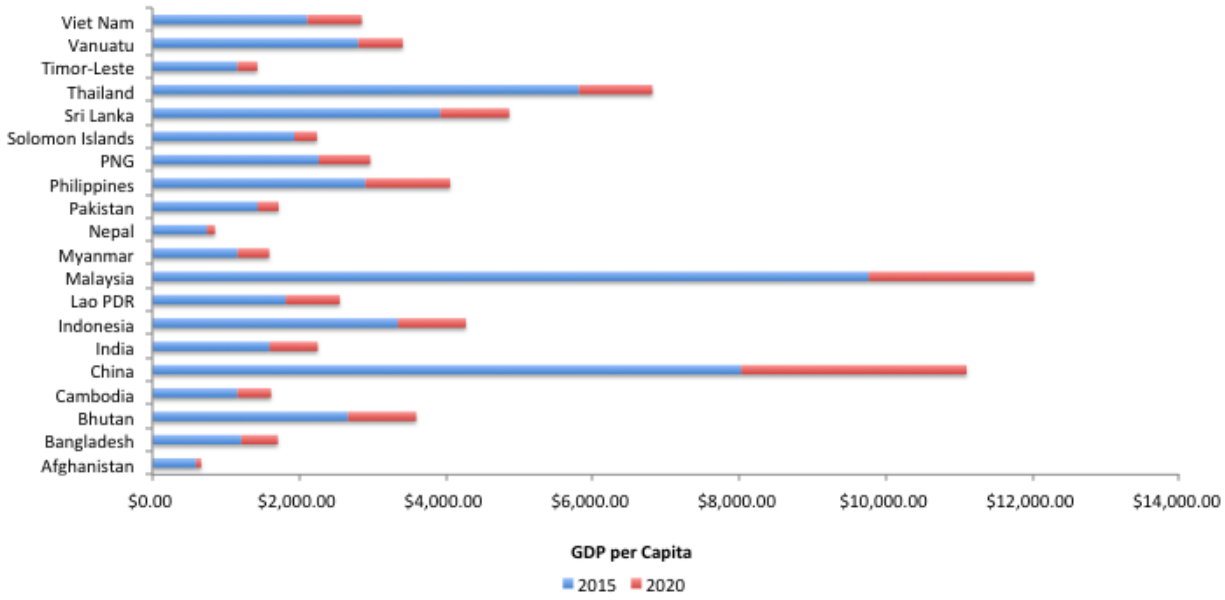
With the growing threat of antimalarial drug resistance arising from the Greater Mekong Subregion (GMS) and the urgent need to contain its spread, the case for malaria elimination has never been stronger [47]. However, in order to achieve a malaria-free Asia Pacific – a goal endorsed by leaders at the highest levels though the Asia Pacific Leaders Malaria Alliance (APLMA)[2] – financial resources will need to be sustained [48]. Failure to maintain resources for malaria elimination has the potential to reverse the impressive gains made [16,28].

1.6 Economic transition of countries in the Asia Pacific Region

Asia Pacific economies have been growing by approximately 6.5% over the past five years, and although the International Monetary Fund (IMF) expects the region's growth to decelerate to 5.3% in 2017, the Asia Pacific is still the world's fastest growing region [49]. The growth in wealth is however, unequally distributed between and within countries, but in some cases it has increased countries' fiscal space to invest in socio-economic development. This strong economic growth has also led to changes in the way economies are classified by the World Bank. In 2001, the World Bank classified 14 countries in the region as low-income countries (LICs), 13 as lower-middle-income countries (LMICs), and only three as upper-middle-income countries (UMICs) [50]. In 2016, only three countries were classified as LIC, 21 as LMIC, and eight as UMIC. The income classification dictates countries' abilities to attract development financing, including grants and concessional loans from donors and multilateral development banks (MDBs). In the coming years, external donors like the Global Fund will increasingly focus on sustainability, transition, and co-financing (STC). The Global Fund's new STC policy [51] emphasizes long-term sustainability as a key aspect of health financing and that all countries, regardless of their economic capacity and disease burden, should embed sustainability considerations within national strategies, program design, and implementation. This focus will be particularly relevant for UMICs and LMICs in the Asia Pacific, with moderate disease burdens, such as Malaysia, the Philippines, Sri Lanka, and Thailand. Figure 1.4 illustrates the projected growth of select economies in the region to 2020.

[2] At the 2013 East Asia Summit (EAS), the Asia Pacific Leaders Malaria Alliance (APLMA) was established to accelerate progress towards a reduction in malaria cases and deaths. In 2014 at the ninth EAS, the APLMA Co- Chairs (the Prime Ministers of Viet Nam and Australia) tabled a recommendation for the Asia Pacific region to become free of malaria by 2030. EAS Heads of Government agreed to the goal, and tasked APLMA Co- Chairs to present a plan to reach malaria elimination through a "Leaders Malaria Elimination Roadmap". The APLMA roadmap was presented to Heads of Government during the 10th EAS Meeting in 2015.

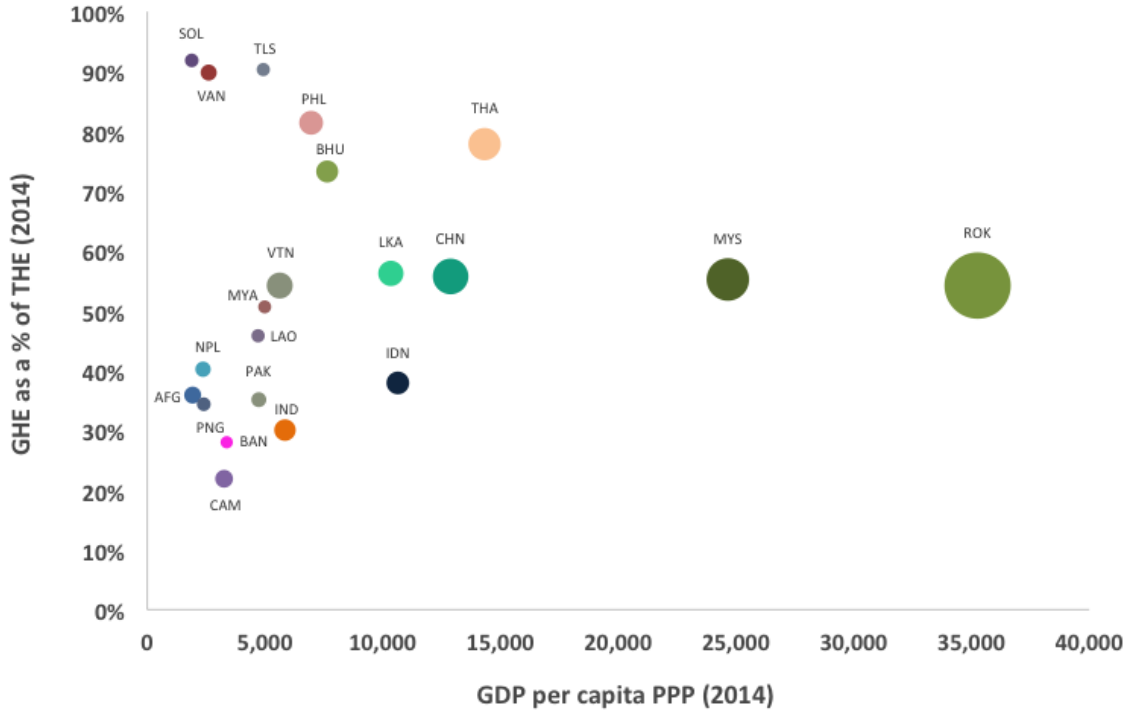
Figure 1.4. GDP per capita in 2015 and 2020 (projected) for select Asia Pacific countries



The 22 countries in the Asia Pacific region have collectively reported domestic financing levels of USD 267.6 million for malaria to the Global Fund in 2016 [45]. This amount mostly refers to funding directly available for vertical malaria control activities. Government commitments for 2015-2017 have seen an overall 46% increase compared to 2012-2014 levels. Nevertheless, there is still an estimated funding gap of about 50% of the total need, as estimated through expressions of need in the National Strategic Plans (NSPs) for malaria [53].

The premise of the health financing transition, which forms the basis of donor policies is that as countries develop as measured by their Gross Domestic Product (GDP) or Gross National Income (GNI), government contributions will correspondingly increase. However, in most countries, these increases are not proportional or immediate. Figure 1.5 illustrates the variation in the proportion of Government Health Expenditure (GHE) as a function of the GDP per capita. The Pacific Islands of Vanuatu and the Solomon Islands as well as Timor Leste have a high proportion of government financing despite the relatively low GDP while Malaysia and the Republic of Korea have lower contributions by the government despite having a higher GDP.

Figure 1.5. Government Health Expenditure as a percentage of Total Health Expenditure and Gross Domestic Product in the Asia Pacific countries



1.7 Rationale for PhD thesis

The economic impact of malaria has been studied for well over a century. While there is a plethora of literature on the economics and financing of malaria control there is little information on the economics of malaria elimination including information on the marginal costs of elimination or the economic returns that can be used by policymakers for decision-making. Policymakers need to know how much it costs to achieve reductions in malaria burden and elimination, whether the cost savings of elimination will offset the initial investment and what are the financial returns of elimination versus maintaining the status quo. In addition, there are major gaps in the published literature about the sources of funding for malaria elimination efforts and about how these funds are spent. The Institute for Health Metrics and Evaluation (IHME) [54, 55] has been tracking Development Assistance for Health (DAH) from 1990 onwards, disaggregating spending by the source of funding, intermediary channel and recipient country while others have concentrated on specific health focus areas, such as HIV and maternal, child and newborn health [56]. WHO annually publishes a World Malaria Report [8], which includes government expenditure information obtained from countries' national malaria control programmes. However, expenditure data are often unavailable and replaced by budget information. Past analyses have either focused on single countries and/or disease programmes or across multiple countries aimed at measuring the

effectiveness of funding. To better understand past and future trends in financing for malaria elimination, a better tracking of malaria-specific estimates expenditures from all sources is needed. A clear perspective on where resources have been and will be available will uncover critical investment gaps and investment opportunities.

In order to fill these gaps, this research and thesis seeks to accomplish four aims. The first aim is to review the existing literature on the costs and benefits of malaria elimination. The second aim is to estimate the costs and benefits and develop regional and national investment cases for malaria elimination in the Asia Pacific. The third is to track development assistance and government financing for health and the forth is to discuss the implications of the changing financing landscape and opportunities for resource mobilization.

For the first aim, a systematic literature review on the costs and benefits of malaria elimination was conducted. For the second objective, methods to collect data on the costs of malaria elimination were developed as well as two different methodologies for developing regional and national investment cases for malaria elimination. Both quantitative and qualitative data collection and analysis was conducted. Ingredients based costing methodology was developed and the full-income approach to estimating the benefits of elimination were employed.

For the third aim, financing flows for malaria elimination were collected from various sources from 1990 through 2013. Building on the Institute for Health Metrics and Evaluation's annual Financing Global Health research, data were collected from primary agencies and organizations that channel DAH or third party organizations or private organizations that collect such data [55] and split into categories identifying the type of investment. The Organization for Economic Cooperation's (OECD) Creditor Reporting System (CRS) database [57] was used to collect information on financing channeled through bilateral agencies and budget data from the Global Fund malaria grants were extracted by service delivery areas. A diverse set of data points and reports were used to estimate the share of domestic government health budgets spent on malaria from 2000 through 2014 including the World Malaria Report (WMR).

For the fourth aim, data from Global Fund disbursements and allocation were compared across years and a quantitative analysis was performed. A qualitative analysis was use to determine the effect of Global Fund transitions and provide policy recommendations.

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CHAPTER 2

Aims and Objectives

2.1 General Aims

The overall aim of this PhD thesis is to provide the economic evidence for continued investment for malaria elimination. The first approach was to gain an understanding of the costs and benefits of malaria elimination. The second approach was to estimate the cost of malaria elimination at the national and regional level and develop investment cases using various methodologies that can be used for advocacy for continued financing for malaria elimination. The third approach was to the understand sources of financing for malaria elimination. The fourth approach was to understand the implications of the changing financing landscape on malaria elimination and to identify new opportunities for resource mobilization.

2.2 Specific Objectives

In order to fill these gaps, this research and thesis seeks to accomplish five specific objectives: The first objective is to understand the existing information on the costs and benefits of malaria elimination from published and unpublished sources of literature. The second objective is to estimate the costs and benefits and develop a national investment case for malaria elimination in Sri Lanka. The third aim is to estimate the costs and benefits and develop a regional investment case for malaria elimination in the Asia Pacific region. The fourth is to track development assistance and government financing for malaria from 1990-2017. The fifth objective is to understand the implications of changing donor policies on malaria elimination programmes.

A. To understand the existing information on the costs and benefits of malaria elimination from published and unpublished sources of literature (Paper 1, Chapter 4).

   The objective of this paper was to review the existing literature and evidence on the costs and benefits of malaria elimination. Specifically, this paper presents a comprehensive review of literature on the cost of malaria control as well as those of achieving and of sustaining elimination and the benefits generated by malaria elimination compared to the cost of malaria control. The review was intended to elicit evidence along the various phases of the programme: control, elimination and Prevention of Reintroduction (POR).

B. To estimate the costs and benefits and develop a national investment case for malaria elimination in Sri Lanka. (Paper 2, Chapter 5).

   The purpose of this study was to estimate the current costs of the malaria programme and to develop an investment case for malaria POR in Sri Lanka. In addition, the paper reviewed the funding landscape for malaria in the country and identified anticipated gaps in the near future. The findings provides the AMC with an estimate of the resources required to prevent the reintroduction of malaria, as well as robust evidence to advocate for sustained funding from both domestic and external sources.

C. To estimate the costs and benefits and develop a regional investment cases for malaria elimination in the Asia Pacific. (Paper 3, Chapter 6).

   The purpose of this study was to model the cost of achieving malaria elimination in all the malaria endemic countries of the Asia Pacific on or before 2030 and to develop an investment case for malaria elimination that advocates can use to advocate for sustained resources. The study also assessed current and future sources of financing to estimate the gaps in funding and potential opportunities for resource mobilization.

D. To track development assistance and government financing for malaria elimination from 1990 through 2017 (Paper 4, Chapter 7).

   To better understand past and future trends in financing for malaria elimination, this paper systematically tracks development assistance for the prevention and treatment of malaria from channel to recipient country or region, for 1990– 2013; generates lower-bound estimates of how development assistance for the prevention and treatment of malaria was used by activity or intervention area for the same time period; estimates government health expenditures (GHE) for malaria from 2000 to 2014; and, projected Development Assistance for Health (DAH) from 2014 to 2017 in 35 eliminating countries.

E. To understand the implications of the changing donor policies by assessing the impact of the Global Fund allocation model on funding for malaria elimination programmes (Paper 5, Chapter 8).

   In 2011, the Global Fund transitioned to a new funding model (NFM), which prioritizes grants to high burden, lower income countries. Many low transmission countries, dependent on GFATM financing to achieve their malaria elimination goals, would receive less funding under the NFM. This study aims to understand the projected increase or decrease in national and regional funding from the GFATM's NFM to the 34 malaria-eliminating countries.

F. To understand the implications of the changing donor policies by understanding the challenges of Global Fund transitions for malaria elimination programmes (Paper 6, Chapter 9).

   Seven malaria-eliminating countries are in their final round of Global Fund Support or will reach the Global Fund's eligibility thresholds in the next five years. This paper outlines the key challenges faced by countries undergoing this transition, explore gaps that exist in current evidence, and highlight policy recommendations for donors and national malaria programmes to facilitate a more successful transition process.

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CHAPTER 3

Methods

3.1 Literature review

A systematic search of peer-reviewed literature in English, French and Spanish, pertaining to economics of malaria, published on or before September 2014 was conducted. Databases searched were MEDLINE via PubMed, SCOPUS and Google Scholar using MeSH terms as well as other key-words. The term 'malaria' was combined with 'elimination' and 'eradication' and the following search terms: 'economics', 'cost', 'cost analysis', 'cost allocation', 'cost apportionment', 'cost control', 'cost of illness', 'employer health costs', 'hospital costs', 'health care costs', 'drug costs', 'direct service costs', 'health expenditures', 'financing', and 'cost-benefit analysis'. A detailed list of search terms and corresponding results are available upon request. Two independent database searches were carried out to ensure an exhaustive search of the literature. The two lists of papers were subsequently merged and duplicates were removed. Reference lists of papers that met the inclusion criteria were also screened. Titles and abstracts of all initial search results were reviewed for relevance, and those that included some form of economic analysis were assessed further for eligibility. Articles that did not have abstracts available online but were thought to be relevant based on their titles alone were included in the full-text assessment. Articles were excluded during full-text assessment if they did not meet the inclusion criteria or if their full-text versions could not be located after multiple attempts. A full description of the inclusion and exclusion criteria is contained in Chapter 4.

A comprehensive literature review was conducted for the Sri Lanka investment case to gain an understanding of the current and historical structure, activities, and financing of the malaria program. A search was conducted using Google, Google Scholar, Pubmed, World Health Organization Library (WHOSIS) [1], World Health Organization (WHO) Office of the South-East Asia Region [2], and the Global Fund website using the search terms "Sri Lanka" AND "malaria" AND "cost" OR "burden" OR "elimination. References were also identified by cross-referencing bibliographies of relevant publications. The inclusion criteria included any articles that included the above key words and were in English.

3.2 National investment case in Sri Lanka

3.2.1 History of malaria control and elimination in Sri Lanka

Sri Lanka has made extraordinary gains in reducing the burden of malaria in the last decade. Between 2000 and 2011, the number of malaria cases declined by more than 99% [6, 7]. With zero locally transmitted malaria cases recorded since November 2012 and no indigenous deaths since 2007, Sri Lanka received the World Health Organization (WHO) certification of elimination in September 2016, an official recognition of its malaria-free status [6, 7, 8]. This period of progress coincided with increased political and financial commitment from the government and external donors, particularly the Global Fund to Fight AIDS, Tuberculosis and Malaria [9].

However, funding for malaria from the Global Fund is declining and being prioritized for high-burden, low-income countries and there is waning political interest and a rising disinterest toward malaria among health workers within the country as the disease is no longer considered a major public health threat. At the same time, the country continues to face a significant risk of resurgence especially in areas of high receptivity and vulnerability [10].

In 1963, malaria elimination was on the horizon with only 17 cases recorded in public facilities, of which only six were locally transmitted [11]. However, a severe cutback in political and financial support for malaria control, led to the withdrawal of malaria control measures and rapid resurgence of malaria [12]. To implement its new strategy for the POR of malaria, the Antimalaria Campaign (AMC) needs continued resources particularly in the short- to medium-term until the intrinsic transmission potential is sufficiently altered to make elimination stable.

3.2.2 Ingredients based costing and quantitative cost data extraction in Sri Lanka

A micro-costing approach was used to calculate the costs of POR in Sri Lanka. A detailed cost analysis was conducted for ongoing program activities from expenditure and financial records, historical record reviews as well as extraction from existing reports and key informant interviews. Available information was obtained from existing reports and grey and published literature, including AMC Directorate records at the national and regional levels.

All fixed and recurrent costs incurred by the health system for malaria activities including resources received as donations and other in-kind or indirect expenditures were captured. Costs were categorized by source of funding, type of cost input, and by activity or intervention. Benefits were measured as the averted costs of resurgence were estimated under a hypothetical scenario of resurgence, which was constructed based on historical data and expert opinion in the country. Under this counterfactual scenario, it was assumed that all POR activities would be halted in 2014 resulting in an increase in malaria cases between 2015 and 2020 with a peak in 2017, mimicking the magnitude and trend of the malaria epidemic between 1997 and 2002, adjusted for population growth. The cost of resurgence was estimated as the direct and indirect cost incurred by the health

system to prevent and treat the increased cases as well as the direct and indirect cost incurred by individual households and the society.

3.2.3 Study setting and sampling

Sri Lanka is divided into nine provinces and 25 administrative districts. Five districts were purposively sampled in five different provinces to collect data on the cost of the malaria activities for POR: Hambantota (Southern Province), Ampara (Eastern Province), Anuradhapura (North Central Province), Puttalam (North Western Province), and Jaffna (Northern Province). The sampled districts represented regions where recent cases had been identified and included a range of previously endemic regions that used different mixes of interventions. Based on input from the AMC and other in-country experts, these sampled districts were deemed to be representative of the remaining 20 districts with respect to programmatic costs and levels of receptivity and vulnerability to malaria trans- mission. In addition, cost data were also collected from the AMC at the national level.

Financial costs of malaria: The financial costs of malaria POR were obtained from the estimates of economic costs without accounting for capital costs or the cost of the general health system or personnel that are financed through integrated national and provincial health budgets not specific to malaria.

Data collection: Data collection for this study took place between February and July 2015. Data on the costs of malaria POR activities for 2014 were obtained from inter- views and a review of the most recent budget and expenditure records. Staff at the regional malaria offices (RMOs) in each of the sampled districts was interviewed in a semi- structured format. The time spent on each activity was recorded based on self-reporting by the RMOs and other interviewees triangulated with interviews with the AMC director. At the central level, officers at the AMC including the AMC director, director of finance and accounting, surveillance, and monitoring and evaluation unit staff, and the Global Fund project finance manager were interviewed.

Data analysis: Estimating cost of POR. Primary data on costs collected from each sample district and the AMC were aggregated based on three dimensions—funding source, activity or intervention, and input type—to identify the cost drivers for malaria POR activities. All costs were expressed in 2013 U.S. dollars (USD), using a mid-year exchange rate of 131.5 Sri Lankan rupees per USD [3].

3.2.4 Estimating cost of resurgence

The benefit of sustained investments in malaria and hence the corresponding cost saving from POR activities was obtained by estimating the cost of potential malaria resurgence. A hypothetical resurgence scenario was constructed based on the assumption that all POR activities would have been halted in 2014 resulting in an increase in malaria cases between 2015 and 2020 similar to that observed during the epidemic between 1997 and 2002, after adjusting for population growth. The

cases and deaths averted in the elimination scenario were used to calculate the cost savings or benefits from POR activities.

3.2.5 Economic benefits estimation

The health benefits were then monetized by looking at the averted cost to the health system, averted cost to individual households, and averted cost to society.

1. Cost averted to the health system includes costs associated with diagnosis and treatment costs of IPs and Ops;
2. Cost averted to the individual households is out-of-pocket (OOP) expenditures for seeking care; and
3. Cost averted to the society includes patients' lost productivity due to premature death and morbidity and caregivers' reduced economic output.

Unit costs for case management included costs for OP visits, diagnostic tests, and drug treatments for OP malaria cases, as well as hospital hotel costs and drug treatments for IP malaria cases. OOP expenditures were estimated by applying country-specific OOP expenditure per capita separately for OP and IP cases. Productivity losses among patients and caretakers were calculated by multiplying an estimate of daily productivity by the number of days lost due to illness or care seeking.

The full-income approach was used to estimate the economic impact of lost productivity due to premature death from malaria. The numbers of averted deaths were multiplied by the value of additional life years (VLYs) and life expectancies at age 40 among males and females, which was the assumed average age of death due to malaria. One VLY was estimated to be 2.8 times the GDP per capita for Sri Lanka, as suggested by the *Lancet Commission on Investing in Health* [4].

3.2.6 Uncertainty analysis

To test the sensitivity of the costs to discounting, the discount rate used for capital goods was varied between 1% and 7% for the Sri Lanka study. In addition, to assess the robustness of our estimates with regard to the uncertain risk of resurgence, we conducted a sensitivity analysis by generating several alternative scenarios of resurgence with varying assumptions of severity and probability based on historical data. Following the application in the insurance industry and recent literature on pandemic influenza risk, we used the notion of "exceedance probability" to test probability of a resurgence with a certain thresh- old severity. Using historical data on malaria incidence, the maximum annual growth rate and the maximum total growth rate (between trough years) were used to vary the severity levels. Additional probabilities for the risk of resurgence were based on available historical data in the literature. Cohen and others [5] noted that 75 malaria resurgence events occurred over 70 years in 61 different countries, which translates to a 2% probability of resurgence. We used this as a lower bound estimate to analyze the sensitivity of the

ROI to varying probabilities of resurgence between 2% and 100%.

The detailed methodology used to estimate costs is provided in chapter 5.

3.3 Regional investment case for the Asia Pacific

3.3.1 Developing a transmission model

We used outputs from a mathematical transmission model to estimate the costs and benefits of malaria elimination in the Asia Pacific. The model estimated the impact of several intervention scenarios on the transmission of *P. falciparum* and *P. vivax* malaria from 2016 to 2030 in each of the 22 countries and is described elsewhere [6].

The elimination scenarios modeled were categorized into two groups: “Accelerate” includes scaling up existing malaria control and elimination interventions while “Innovate” explores new and emerging interventions (Figure 3.1).

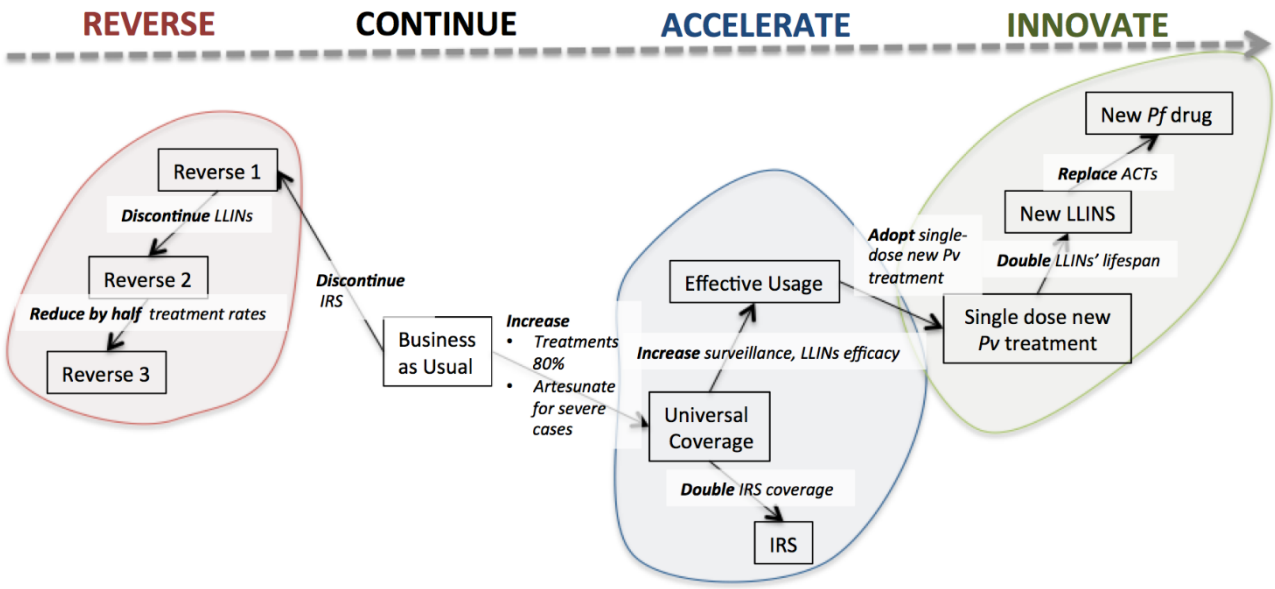
Elimination was defined as the first year in which less than one reported clinical case is achieved. Note that the model does not distinguish between indigenous and imported cases; hence, we estimated malaria elimination thresholds using a regression model of indigenous and imported cases from countries that have recently eliminated malaria. The scenario that allowed attainment of the elimination threshold was considered the elimination scenario. The scenarios used are described in detail in Table 3.1. The outputs of averted mortality and morbidity under the elimination scenarios were then used to estimate the cost, benefits, and return on investment (ROI).

Counterfactual scenarios

Two scenarios were used as the counterfactuals to malaria elimination: business as usual and reverse scenarios (see “Reverse” and “Continue” in Figure 3.1).

- *Business as usual*
  This scenario projects the malaria burden in 2016-2030 based on continuing the mix and scale of malaria interventions implemented in 2015.
- *Reverse scenario*
  This scenario projects the malaria burden in 2016-2030 assuming that LLIN distribution ceases and treatment rates fall by 50%

Figure 3.1. Scenarios used in the transmission model



3.3.2 Cost projections for Asia Pacific

A cost estimation model aligned with the outputs of the transmission model was developed to estimate the total costs associated with implementing each of the scenarios above. Program costs included the costs of testing and treating uncomplicated or outpatient (OP) and severe or inpatient (IP) malaria cases; vector control (i.e., LLIN distribution and IRS); supply chains; surveillance through community health workers; information, education, communication; training; MDA; new treatments (e.g., tafenoquine for *P. vivax*); and rollout of new LLINs. Unit costs for each activity were obtained using a combination of empirical data collected in various Asia Pacific countries by the MEI, literature reviews, and proxies when the previous options were unavailable.

The total cost of the elimination scenarios was used to in this investment case. The costs to reach elimination were calculated separately for each country and then summed them to obtain the total cost for elimination in the Asia Pacific region. To calculate the incremental or additional costs of malaria elimination, the estimated costs of the business as usual and reverse scenarios were subtracted from the elimination scenario. All monetary figures are expressed in 2015 constant USD.

Table 3.1. Modeled scenarios

	Scenario	Description
1	Business as usual	Continue all interventions at 2014 levels from 2016 through 2030
2	Reverse scenario 1	• Business as usual • IRS activities ceased
3	Reverse scenario 2	• Reverse scenario 1 • Distribution of new LLINs ceased
4	Reverse scenario 3	• Reverse scenario 2 • Treatment rates reduced by 50%
5	Universal coverage	• Business as usual • Coverage test and treat increased from 2017 onwards in a linear fashion over eight years to 80% by 2025 • Quinine is switched to injectable artesunate for management of severe disease in 2017
6	IRS	• Universal coverage • IRS coverage in 2017 doubled in a linear fashion over eight years
7	Effective usage	• Universal coverage • Effectiveness of LLINs increased • Surveillance increased
8	New *P. vivax* treatment	• Effective usage • Replace primaquine with a new *P. vivax* treatment
9	New LLINs	• New *P. vivax* treatment • Life of LLINs doubled
10	New *P. falciparum* treatment	• New LLINs • First-line ACT replaced with new candidate for *P. falciparum* treatment
	Assumption	**Description**
A	Artemisinin resistance	5% probability of treatment failure from ACTs across all countries is constant until 2018 and then increased to 30% through 2025
B	MDA	Five annual rounds of MDA at 50% coverage from 2018 starting four months before the peak of the transmission season
C	LLINs	Scaling up LLINs to 80% effective coverage deployed in a 3-year cycle (50%, 25% and 25%)

3.3.3 Economic benefits estimation

Using outputs from the model for the Asia Pacific, the estimated the mortality and morbidity averted from malaria elimination was estimated by subtracting the estimated cases and deaths of the elimination scenario from the corresponding outputs of the business as usual and reverse scenarios.

For the Sri Lanka benefits estimation, the cases and deaths averted in the elimination scenario were used to calculate the cost savings from POR.

The health benefits were then monetized by looking at the averted cost to the health system, averted cost to individual households, and averted cost to society.

- Cost averted to the health system includes costs associated with diagnosis and treatment costs of IPs and Ops;
- Cost averted to the individual households is out-of-pocket (OOP) expenditures for seeking care; and
- Cost averted to the society includes patients' lost productivity due to premature death and morbidity and caregivers' reduced economic output.

The same cost inputs used in the cost estimation were used for calculating the economic benefits. Unit costs for case management included costs for OP visits, diagnostic tests, and drug treatments for OP malaria cases, as well as hospital hotel costs and drug treatments for IP malaria cases. OOP expenditures were estimated by applying country-specific OOP expenditure per capita separately for OP and IP cases. Productivity losses among patients and caretakers were calculated by multiplying an estimate of daily productivity by the number of days lost due to illness or care seeking.

The full-income approach was used to estimate the economic impact of lost productivity due to premature death from malaria. The number of deaths averted, were multiplied by the country-specific values of additional life years (VLYs) and life expectancies at age 40 among males and females, which was the assumed average age of death due to malaria. One VLY was estimated to be 2.2 times the GDP per capita for each of the countries in South East Asia and the Pacific and 2.8 times the GDP per capita for each of the countries in South Asia, as suggested by the *Lancet Commission on Investing in Health* [4].

All costs and economic benefits were discounted at 3%.

3.3.4 Return on investment

The Return on Investment (ROI) was calculated by subtracting the incremental cost of elimination from the economic benefits, and dividing the resulting figure by the incremental cost of

elimination. The ROI is interpreted as the economic return from every additional dollar spent on malaria elimination and prevention of reintroduction.

For the Asia Pacific investment case, we performed the ROI analysis for 2016-2030 by comparing the elimination scenario with the business as usual and reverse scenarios under the stable and increasing resistance assumptions.

3.3.5. Uncertainty analysis

For the Asia Pacific costing, to assess the robustness of our estimates with regard to the uncertain risk of resurgence, we conducted a sensitivity analysis by generating several alternative scenarios of resurgence with varying assumptions of severity and probability based on historical data. We performed stochastic sensitivity analysis on the epidemiological and cost outputs of the malaria transmission model. The minimum, median, and maximum malaria cases and deaths predicted by the model for each scenario were used to calculate the minimum, median, and maximum economic benefits. For the costs, we assigned an uncertainty interval of +/-25% on the value of the input costs used. Three hundred random samples were drawn, which generated a range of costs. From the range of costs generated, we determined the minimum, maximum, median, mean, and other measures (e.g., percentiles).

3.4 Finance Tracking

Building on the Institute for Health Metrics and Evaluation's annual Financing Global Health research, data were collected from primary agencies and organizations that channel DAH or third party organizations or private organizations that collect such data [REF] and split into categories identifying the type of investment. The Organization for Economic Cooperation's (OECD) Creditor Reporting System (CRS) database was used to collect information on financing channeled through bilateral agencies and budget data from the Global Fund malaria grants were extracted by service delivery areas [7]. A diverse set of data points and reports were used to estimate the share of domestic government health budgets spent on malaria from 2000 through 2014 including the World Malaria Report (WMR). To track development assistance and government financing for health financing flows for malaria elimination were collected from various sources from 1990 through 2013.

3.4.1 The 35 Malaria Eliminating Countries

Of the approximate 100 countries with endemic malaria, 35 have been identified as malaria-eliminating defined here as a country that has a national or subnational evidence-based elimination goal and/or is actively pursuing elimination (zero malaria transmission) within its borders (Fig 3.2) [4,5].

Fig. 3.2. List of malaria eliminating countries included in this analysis

Asia Pacific	***Latin America and Caribbean***
• Bhutan	• Belize
• China	• Costa Rica
• Democratic People's Republic of Korea	• Dominican Republic
• Malaysia	• El Salvador
• Nepal	• Guatemala
• Philippines	• Honduras
• Republic of Korea (ROK)	• Mexico
• Solomon Islands	• Nicaragua
• Sri Lanka	• Panama
• Thailand	• Paraguay
• Vanuatu	
• Vietnam	***Sub-Saharan Africa***
	• Botswana
North Africa, Europe, Middle East, Central	• Cape Verde
Asia	• Mayotte*
• Algeria	• Namibia
• Azerbaijan	• São Tomé and Príncipe
• Iran	• South Africa
• Saudi Arabia	• Swaziland
• Tajikistan	
• Turkey	

*No data available

3.5 Global Fund financing to the malaria-eliminating countries under the new funding model

This analysis was conducted on nineteen of the eliminating countries that were eligible for an allocation. Five countries were not eligible for national malaria grants, but were expected to receive funds through regional grants: Belize, Costa Rica, Dominican Republic, Panama, and South Africa.

Publicly available GFATM grant data [8, 9] was collated in Microsoft Excel 2010. The average annual funding from the old funding model was calculated using the total disbursed amounts from each country's most recent active malaria grant(s) averaged over the respective grant start date through to December 2013, the Global Fund specified cut-off date for the round based system. Disbursed amounts rather than the signed amounts in grant agreements were used in order to avoid "double counting" of money not yet disbursed that will later be incorporated into the national allocation. Regional grant amounts were excluded from this portion of the analysis and analyzed separately. Average annual grant amounts disbursed under the old funding model were compared to average annual national allocated amounts under the NFM to determine the percent change between old and new average annual funding.

3.5.1 Regional grants

Funding channeled to malaria-eliminating countries through the E8, EMMIE, and RAI GF regional malaria grants was included. While the RAI grant has a predetermined country-level breakdown of funding, country shares for EMMIE and E8 was assumed to be divided equally among the countries involved. For eliminating countries included in a regional grant, the country share of regional grant funding was added to the national allocations and a new percent change of funding from the previous funding model compared to the NFM was calculated.

3.5.2 Funding ranges under new allocation model

The minimum and maximum funding range that each country could receive was estimated to include potential variations in allocation should a country not meet their willingness to pay criteria and to account for any changes in national disease split, incentive funding or other qualitative adjustments that may be applied. The minimum and maximum amounts were averaged over the 4-year period (2014–2017) and compared to the average annual disbursements under the previous funding model to determine the range of percent change in funding for eligible countries. More details are available in Chapter 8.

3.5.3 Ethical clearance

The Sri Lanka costing study was approved by the institutional review boards of the University of California, San Francisco Committee on Human Research (Study no. 14-14546, Reference no. 093635) and the Ethics Review Committee of the Faculty of Medicine, University of Kelaniya, Sri Lanka (Reference no. P/209/10/2014). Verbal informed consent procedures were conducted before each interview. Ethical clearance was not needed for the other studies.

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CHAPTER 4

The Economics of Malaria Control and Elimination: A Systematic Review

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4.1 Abstract

Background: Declining donor funding and competing health priorities threaten the sustainability of malaria programmes. Elucidating the cost and benefits of continued investments in malaria could encourage sustained political and financial commitments. The evidence, although available, remains disparate. This paper reviews the existing literature on the economic and financial cost and return of malaria control, elimination and eradication.

Methods: A review of articles that were published on or before September 2014 on the cost and benefits of malaria control and elimination was performed. Studies were classified based on their scope and were analysed according to two major categories: cost of malaria control and elimination to a health system, and cost-benefit studies. Only studies involving more than two control or elimination interventions were included. Outcomes of interest were total programmatic cost, cost per capita, and benefit-cost ratios (BCRs). All costs were converted to 2013 USD for standardization.

Results: Of the 6425 articles identified, 54 studies were included in this review. Twenty-two were focused on elimination or eradication while 32 focused on intensive control. Forty-eight per cent of studies included in this review were published on or after 2000. Overall, the annual per capita cost of malaria control to a health system ranged from USD 0.11 to USD 39.06 (median: USD 2.21) while that for malaria elimination ranged from USD 0.18 to USD 27 (median: USD 3.00). BCRs of investing in malaria control and elimination ranged from 2.4 to over 145.

Conclusion: Overall, investments needed for malaria control and elimination varied greatly amongst the various countries and contexts. While the cost of elimination in most cases was greater than the cost of control, the benefits greatly outweighed the cost. Information from this review provides guidance to national malaria programmes on the cost and benefits of malaria elimination in the absence of data. Importantly, the review highlights the need for more robust economic analyses using standard inputs and methods to strengthen the evidence needed for sustained financing for malaria elimination.

4.2 Background

In the past decade and a half, remarkable progress in malaria control has been achieved with a 37% decline in malaria incidence and 60% reduction in malaria deaths globally [1]. Almost half of the world's nations are now malaria free [2] and several countries have reduced malaria transmission to levels low enough to allow them to embark on, and in many cases achieve, elimination [3].

Despite international consensus that malaria elimination leading to global eradication is a worthwhile goal [2], sustaining domestic and international funding as the malaria burden declines is a serious concern for many countries. External aid is on the decline [4] and multilateral and bilateral donor funds are increasingly shifting away from disease-specific financing or being targeted towards low-income, high-burden countries. At the same time, domestically there is mounting competition for limited resources from other pressing disease priorities.

There is little disagreement that elimination is an attractive investment in the long term due to its ability to pay for itself through future reductions in spending and its generation of broader economic benefits. The contribution of malaria elimination to colossal health and development returns of global eradication is also implicitly recognized [5, 6]. Notwithstanding, malaria elimination requires additional front-loading of investments into robust surveillance systems to detect and respond to remaining cases. While socio-economic and other structural changes will eventually change the intrinsic baseline potential for transmission in countries such that active measures are no longer required [7], the decision facing policymakers is how to best allocate finite resources in the short term. Countries who have successfully lowered their malaria burden are faced with the risk of losing or severely reducing their recurrent expenditure for elimination and

preventing the re-introduction of malaria at a critical period in the malaria elimination efforts [8]. At the same time, they face the risk of resurgence due to the persistent importation of new cases which will not only have devastating effects on the health and welfare of individuals, but will also place an additional economic burden on the health system. A review on malaria resurgence occurring from the 1930s through to the 2000s demonstrated that almost all resurgence events could be attributed, at least in part, to the weakening of malaria control programmes for a variety of reasons, of which resource constraints were the most common [9]. In addition, lessons learned from the Global Malaria Eradication Programme (GMEP), which ended in 1969, affirm that while well-funded interventions can have a major impact on the disease, such gains are fragile and can easily be reversed particularly in the short term in areas that continue to be epidemiologically and entomologically receptive and vulnerable.

The economic impact of malaria has been studied for well over a century. The numbers of such studies have escalated since the conclusion of the GMEP in the late 1960s and more so starting early 2000. Many of these studies have reported data on the economic burden of malaria and the cost of malaria programmes. However, evidence on the economics of malaria elimination remains disparate without a comprehensive synthesis of the marginal costs of elimination that can be used by policymakers for decision-making. Policymakers need to know how much it costs to achieve reductions in malaria burden and elimination, whether the cost savings of elimination will offset the initial investment given that elimination requires, to avert the last few cases, and what are the financial returns of elimination versus maintaining the status quo.

Economic methods such as cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA) have commonly been used to assess the comparative value of investing in malaria control interventions. CEA, which calculates the amount of funding an intervention needs to prevent loss of a standard unit of disease burden, is the most commonly used approach to compare the economic attractiveness of health programmes. In an elimination context, CEA is relevant for identifying the optimum mix of interventions needed to sustain elimination. However, it does not help drive decisions on the economic appeal of malaria elimination as a whole [10]. In addition, as the burden of malaria diminishes, elimination interventions become less cost-effective because the incremental health gains are significantly smaller compared to programme costs. Furthermore, malaria transmission becomes increasingly concentrated in small geographic areas that are often difficult, and more expensive to reach such that a simple cost-effectiveness ratio (CER) is unlikely to be favourable [11]. When evaluated as a CER, the health and economic gains associated with elimination may already be captured by control [12]. Lastly, CERs may not fully capture all the benefits and positive externalities that malaria elimination and prevention of re-introduction (POR) may bring, particularly when considering the cost of malaria resurgence [9, 13].

To generate results most relevant to policy, malaria elimination requires a comparison of cost with a counterfactual scenario of malaria control to reflect programmatic realities. In practice, most

economic analyses in malaria use a loosely defined status quo, which varies substantially but is most often that of partial control. WHO recommends a null state of disease without intervention as the counterfactual scenario. Used in several analyses, this alternative is neither pragmatic nor sustainable but can provide information to understand the benefits of continued investment in malaria when the disease is greatly reduced or absent. Others have recommended the use of controlled low-endemic malaria as the most policy-relevant alternative for economic analyses of elimination [13]. However, the threats of drug and insecticide resistance and the instability of international financing mean that malaria control may not be sustained in the long term. In addition, elimination delivers additional indirect benefits outside of health. As a country approaches and reaches elimination, other countries benefit from reduced importation of malaria conferring positive externalities to neighbouring countries as well. A comprehensive CBA enables these broader benefits to be translated into a common metric and is therefore a more effective means to inform strategic decisions.

The aim of this paper is to review the existing literature and evidence on the costs and benefits of malaria elimination. Specifically, this paper presents a comprehensive review of literature on the cost of malaria control as well as those of achieving and of sustaining elimination and the benefits generated by malaria elimination compared to the cost of malaria control. The review intends to elicit evidence along the various phases of the programme: control, elimination and POR [14].

4.3 Methods

4.3.1 Search strategy

Following PRISMA guidelines [15], a systematic search of peer-reviewed literature in English, French and Spanish, pertaining to economics of malaria, published on or before September 2014 was conducted. Databases searched were MEDLINE via PubMed, SCOPUS and Google Scholar using MeSH terms as well as other keywords. The term ‘malaria’ was combined with ‘elimination’ and ‘eradication’ and the following search terms: ‘economics’, ‘cost’, ‘cost analysis’, ‘cost allocation’, ‘cost apportionment’, ‘cost control’, ‘cost of illness’, ‘employer health costs’, ‘hospital costs’, ‘health care costs’, ‘drug costs’, ‘direct service costs’, ‘health expenditures’, ‘financing’, and ‘cost-benefit analysis’. A detailed list of search terms and corresponding results are available upon request.

Two independent database searches were carried out to ensure an exhaustive search of the literature. AA, who conducted the literature search, was blinded to the initial search strategy but used the same databases and publication timeframe. The two lists of papers were subsequently merged and duplicates were removed. Reference lists of papers that met the inclusion criteria were also screened and included 13 additional articles that were deemed relevant.

4.3.2 Article screening and selection

Titles and abstracts of all initial search results were reviewed for relevance, and those that included some form of economic analysis were assessed further for eligibility. Articles that did not have abstracts available online but were thought to be relevant based on their titles alone were included in the full-text assessment. Articles were excluded during full-text assessment if they did not meet the inclusion criteria or if their full-text versions could not be located after multiple attempts. In case of a disagreement during article selection, inclusion and exclusion, data extraction, article categorization and quality appraisal, the authors discussed each case separately until a consensus was reached.

4.3.3 Inclusion criteria

Articles were included if they: (a) evaluated at least three interventions, suggesting intensive control or elimination rather than individual or limited interventions; (b) presented final costs and benefits in economic or monetary terms; and, (c) provided a clear description of data sources and methodology. Micro-economic studies that assessed the cost of delivering malaria interventions to the health system were included and economic evaluations that included cost-benefit type analyses on malaria interventions were also included.

4.3.4 Exclusion criteria

Studies that used preference approaches (e.g., willingness to pay) for valuing costs and benefits were excluded as a way to limit the analysis to studies that used empirical or secondary cost data rather than elicitation methods. Papers that only presented descriptive statistics or reiterated findings from other studies already included in the review were also excluded. However, any review papers that either conducted any primary analysis on scientific literature were included [10, 16].

4.3.5 Data abstraction, standardization and qualitative synthesis

A standard Microsoft Excel® template was used to abstract detailed information about each study's publication year, study setting, study period, sources of data, and the outcomes of interest. Monetary data were first adjusted to USD in the year of the initial study (if the authors had not already done so) using historical exchange rates provided in the article. If the article did not provide exchange rates, historical exchange rates were obtained from the World Bank official exchange rate database for year 1981 onwards [17] and other online sources such as OANDA [18]. For studies where the currency year was not provided, the publication date or date of article submission was used for the currency conversion. All monetary data were standardized to 2013 USD using consumer price index conversion factors published by Oregon State University, USA [19].

Studies that assessed health system costs of malaria control and elimination were abstracted for total costs, cost per population at risk (PAR), and cost per capita. When total costs only were provided, the annual cost per capita was calculated by dividing the annual aggregate or total cost by either the PAR or total population numbers reported in the articles or their supplements

published online. Similarly, the authors attempted to convert other averaged costs (e.g., cost per person protected, cost per suspected case, cost per case treated) into cost per capita whenever possible to help account for differences in intended programme coverage. It is important to note, however, that a standardized way to measure or calculate PAR does not exist [20–22] making comparisons among such reported costs potentially problematic.

For CBAs, net benefits (also referred to as net present value or net social benefit) and benefit-cost ratios (BCRs) were extracted. If net benefits or BCRs were not calculated in the original study, they were computed based on total benefits and total costs reported in the study whenever possible to facilitate comparisons among CBA.

4.3.6 Quality assessment and critical appraisal

The quality of the included studies was assessed using two checklists published in the literature. For CBAs, the ten-point Drummond checklist first developed by Drummond and colleagues in 1997 [23, 24] was adapted. Each study was assigned a total score equal to the number of 'yes' ratings it received out of ten questions in the checklist. For cost analysis studies, the two-point evaluation criteria developed by Fukuda and Imanaka was adapted to assess the quality and transparency of costing exercises [25]. The Fukuda and Imanaka criteria evaluated each costing study based on its clarity of scope and accuracy of costing methodology, with activity-based micro costing getting the highest score.

4.4 Results

4.4.1 Literature search

A total of 6425 articles were identified through database searches. After removal of duplicates, 5505 titles and abstracts were initially screened, and 390 full-text articles were reviewed further for eligibility. After reviewing full text articles, 40 from the database searches and 14 from citation snowballing were included in the final qualitative analysis (Fig. 4.1). Most of the studies conducted more than one type of economic analysis and therefore are not classified into mutually exclusive categories.

Of the 54 articles in this review, 22 were focused on elimination while the remaining 32 were on intensive control. Fifty-three studies estimated the programmatic costs of malaria control and elimination, and ten studies estimated both costs and benefits (Table 4.1).

Figure 4.1. PRISMA diagram

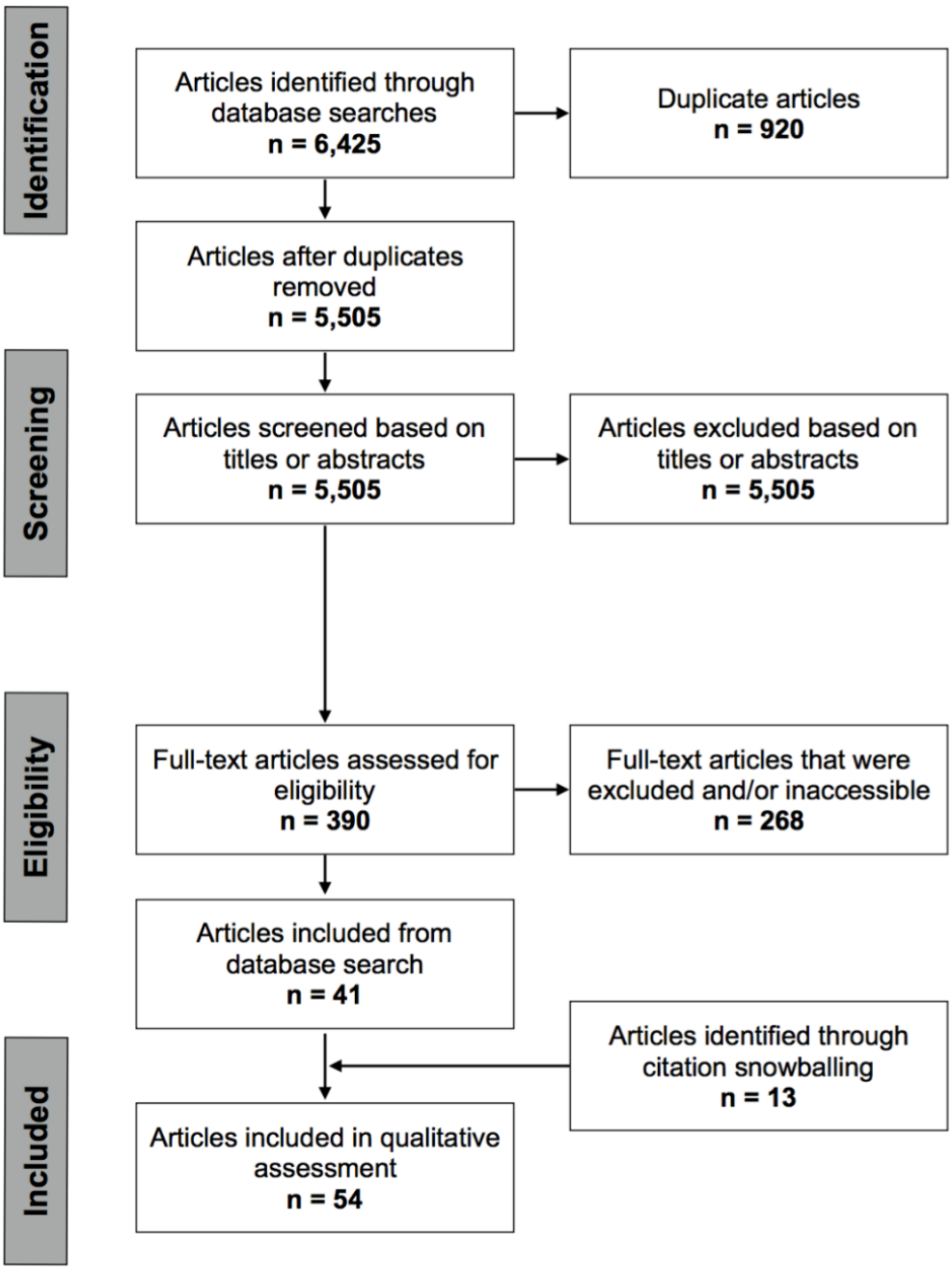


Table 4.1. Summary of included articles

Total number of studies included in qualitative review	**54**	
Number of studies with more than one economic outcome reported	9	
Type of study	**Total number**	**Percent (%)**
Cost to health systems	53	98.1
Cost-benefit analyses	10	18.5
Focus of study	**Total number**	**Percent (%)**
Elimination	22	40.7
Control	32	59.3
Publication date	**Total number**	**Percent (%)**
On or after 2000	26	48.1
Before 2000	28	51.9

4.4.2 Cost to the health system

Among the 53 studies that reported the cost of malaria on health systems, 32 were on the cost of control (Table 4.2; Table S4.1) and 21 on elimination and eradication (Table 4.3; Table S4.1). These studies reported direct costs associated with an entire malaria programme or a set of control and elimination interventions. The earliest study was published in 1903, with about 47% of studies being published on or after 2000. Seven studies looked at the costs of malaria control and elimination during the GMEP era (1955–1969). More than half (27) of the studies were on Asian countries, such as India, Sri Lanka and Thailand, and a number of states in western Asia. Eight studies were in African countries, while another 12 had a global, regional or multi-country focus. Five studies were in South American countries and only one was in Europe. Overall, programmatic costs varied immensely from a few hundred dollars to a several hundred million, owing to heterogeneity in study setting or geographic reach, study period, mix and scale of interventions, and costing methodology, among others. Tables 4.2 and 4.3 summarize the findings by country, region, focus (malaria control and elimination), and study period.

Table 4.2. Cost of malaria control to the health system

Country or region	Study period	Cost per capita (2013 USD)[a]	Cost per PAR (2013 USD)	Source
Global	2006-2015	2.50	Not provided	[25]
	2003-2009	Not provided	1.42-11.13	[26]
	2002-2007	Not provided	0.47-0.80	[27]
Africa				
Ethiopia	2011-2015	1.67	2.94	[28]
Kenya	1990	0.28	Not provided	[29]
Liberia	1953-1961	31.25-39.06	Not provided	[30]
Mauritius	10-year time horizon	2.37	2.37	[13]
Rwanda	2011-2015	4.76	6.64	[28]

Country or region	Study period	Cost per capita (2013 USD)[a]	Cost per PAR (2013 USD)	Source
Senegal	2011-2015	4.26	4.26	[28]
Sub-Saharan	2003	1.21-2.22	1.76-2.61	[31]
Africa	2006-2015	3.47	4.65	[32]
Swaziland	10-year time horizon	0.94	4.88	[13]
Tanzania	2011-2015	2.14-2.21	2.14-2.21	[28]
	10-year time horizon	3.26	3.26	[13]
	2011-2015	2.87	2.87	[28]
Zambia	1929-1949	11.86	Not provided	[33]
Americas				
Brazil	1989-1996	2.15	6.60	[34]
Colombia	1993-1998	0.54-3.48	Not provided	[35]
Asia				
Afghanistan	1953	1.34	Not provided	[36]
Bangladesh	2008-2012	Not provided	0.40	[37]
	1990	Not provided	0.02	[38]
China	10-year time horizon	0.12-0.21	0.16-0.22	[13]
India	1953	0.30	Not provided	[36]
	1990	Not provided	0.12	[38]
	1953-1977	0.36	Not provided	[39]
	1989	9.39	Not provided	[40]
Indonesia	1990	Not provided	2.16	[38]
Nepal	1990	Not provided	0.52	[38]
	Unspecified	0.11-1.21	Not provided	[41]
	1984-1985	0.45-1.36	Not provided	[42]
Palestine	1921-1922	19-32	Not provided	[43]
Sri Lanka	2009	Not provided	1.95	[44]
	2004	Not provided	0.87-2.06	[44]
	1994-1995	Not provided	0.36-4.26 per person protected[c]	[45]
	1977-1981	1.71	Not provided	[46]
	1953	0.80	Not provided	[36]
	1934-1955	0.63-5.22	Not provided	[47]
Thailand	1995	Not provided	12.94-15.40 per case[b]	[48]
	1990	Not provided	1.59	[38]

[a] Unless otherwise stated, the costs reported here are costs per capita, computed by dividing total program costs by the total population in the area of implementation.

[b] These costs represent the costs for detecting and treating cases and may not include prevention costs.

[c] These costs reflect the cost of selected interventions and not the entire program.

Table 4.3. Cost of malaria elimination to the health system

Country or region	Study period	Cost per capita (2013 USD)[a]	Cost per PAR (2013 USD)	Source
Africa				
Mauritius	10-year time horizon	4.63	4.63	[13]
	1955-2008	3.03-6.22	Not provided	[49]
São Tomé and Principe	2007 (modeled over 20 years)	12	Not provided	[50]
Swaziland	2007 (modeled over 20 years)	3.00	Not provided	[50]
	10-year time horizon	2.65	13.77	[13]
Tanzania	10-year time horizon	4.22	4.22	[13]
Americas				
Mexico	1971-1976	0.18	Not provided	[51]
	1970	0.54	Not provided	[52]
Asia				
China	1994-1995	1.23 per suspected case[b]	0.05	[53]
	2007 (modeled over 20 years)	0.27	2	[50]
	2007 (modeled over 20 years)	0.27	2.17	[54]
	10-year time horizon	0.23-0.54	0.30-0.55	[13]
India	Unspecified	Not provided	0.58 per person protected	[10]
Indonesia	Unspecified	Not provided	0.97 per person protected	[10]
Iran	Unspecified	20.95	Not provided	[55]
Iraq	1964-1970	2.96	Not provided	[56]
Jordan	1964-1970	0.95	Not provided	[56]
Lebanon	1964-1970	1.68	Not provided	[56]
Philippines	1998-2010	Not provided	0.67-13.08	[57]
Solomon Islands	2008	1.60	Not provided	[58]
	2007 (modeled over 20 years)	20	Not provided	[50]
Sri Lanka	2007 (modeled over 20 years)	1.00	Not provided	[50]
	Unspecified	Not provided	0.86 per person protected[c]	[10]
Syria	1964-1970	0.73	Not provided	[56]
Taiwan	Unspecified	Not provided	0.52 per person protected[c]	[10]
	1952-1957	15.06	Not provided	[59]
Thailand	Unspecified	Not provided	1.54 per person protected[c]	[10]
Vanuatu	2008	3.34	Not provided	[58]
	2007 (modeled over 20	27	Not provided	[50]

Country or region	Study period	Cost per capita (2013 USD)[a]	Cost per PAR (2013 USD)	Source
	years)			
	1991	18.44	Not provided	[60]

[a] Unless otherwise stated, the costs reported here are costs per capita, computed by dividing total program costs by the total population in the area of implementation.

[b] These costs represent the costs for detecting and treating cases and may not include prevention costs.

[c] These costs reflect the cost of selected interventions and not the entire program.

4.4.3 Health system costs of malaria control

Of the 32 studies on costs of malaria control, only 24 (45%) used empirical data such as public and private expenditure reports or survey data. Eight studies used historical expenditures and budgets to extrapolate the costs of intensive control in Africa [29, 32, 33, 61], India [62], Thailand [48], Nepal [41], and globally using varying time periods [63].

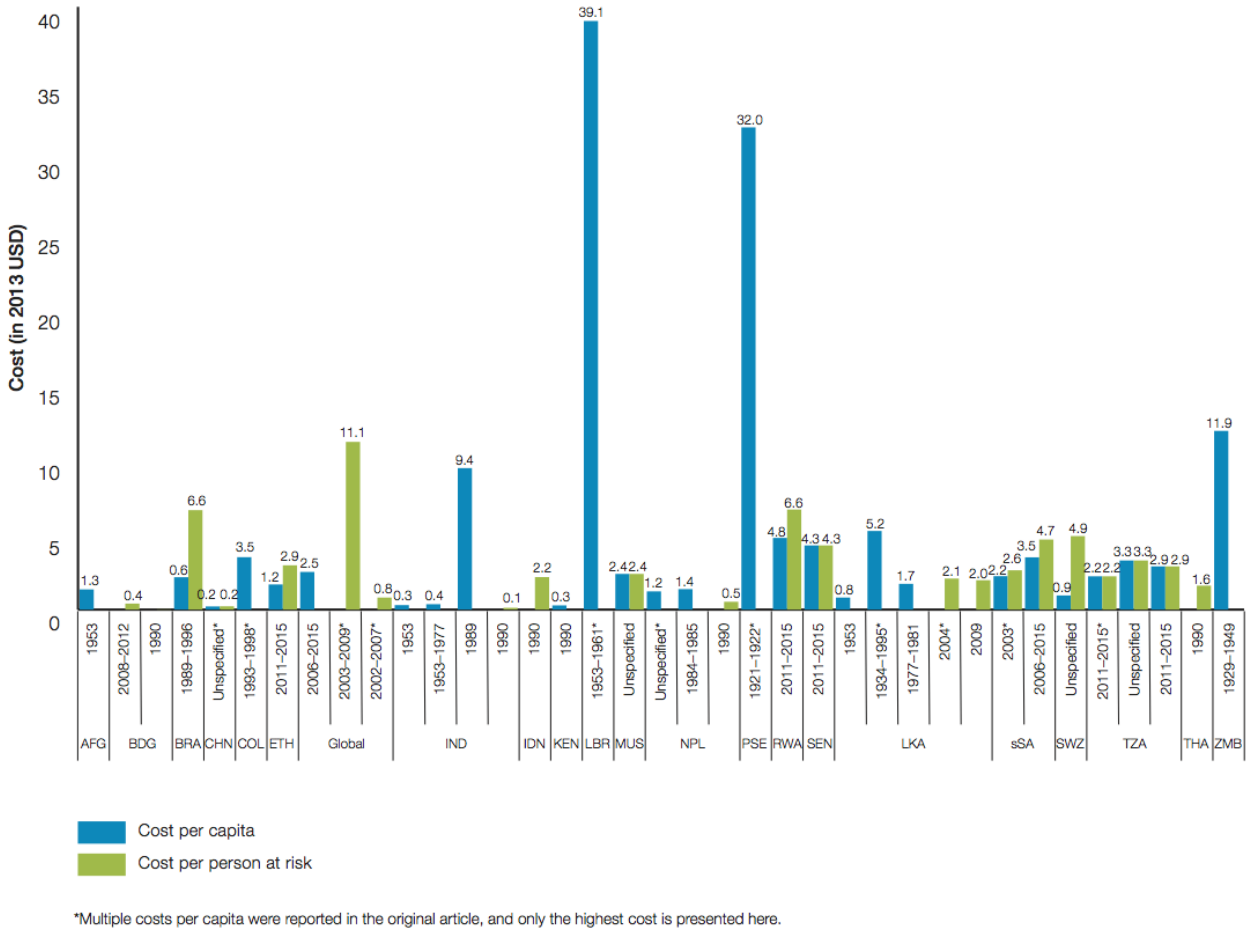
The median annual cost per capita for malaria control across all studies was USD 2.21 (range USD 0.11–USD 234.17). Sabot et al. (China), Some et al. (Kenya), Ramaiah (India), and Haque et al. (Bangladesh) reported some of the lowest per capita costs at USD 0.12–USD 0.21, USD 0.28, USD 0.36, and USD 0.40, respectively (Table 2; Fig. 2) [13, 30, 37, 39]. Two studies by Mills showed comparatively low per capita costs for malaria control in Nepal across several districts, ranging USD 0.11–USD 1.36 [41, 42]. Control costs ranged from USD 0.11 in Nepal [38] to USD 9.39 in India [40], USD 32 in Palestine [43] to USD 39.06 in Liberia [31]. In Nepal and India, the costs included interventions such as testing and treatment, indoor residual spraying (IRS), and bed nets, while in Palestine and Liberia they included community education, environmental management and chemoprophylaxis. Costs also varied within countries over time, partly due to the mix of interventions that were included in the costing. For example, in India, control costs were reported at USD 0.36–USD 0.58 during the GMEP era. Costs were generally lower in Asia compared to Africa.

In a subset of 13 studies conducted after 2000, of which only ten were conducted in Africa, control costs ranged from USD 0.94 in Swaziland and USD 4.75 per capita in Rwanda (median USD 2.30 per capita). In Asia costs ranged from 0.40 per capita in Bangladesh and USD 2.06 per capita in Sri Lanka (median USD 0.64). Most of these studies did not use the full package of WHO recommendations for malaria control at scale. None of the studies in the Americas has been conducted since 2000. Stuckey et al. [61] modeled the cost of implementing distribution of long-lasting insecticidal nets (LLINs), IRS, and intermittent screening and treatment among school children twice per year at 80–90% coverage in Nyanza Province of western Kenya at USD 179.50–USD 234.17 annually per capita. However, these costs were based on modeled coverage of interventions rather than actual scales.

With respect to cost per PAR, the overall median cost per PAR for malaria control, across all studies was USD 2.15 (range USD 0.02–USD 11.13). Kondrashin reported the lowest cost per PAR at USD 0.02 in Bangladesh, followed by USD 0.12 in India and USD 0.52 in Nepal (Fig. 2) [38]. Snow et al.

[28] also reported low cost per PAR (USD 0.47–USD 0.80) for Plasmodium falciparum infections across 87 countries. These two studies used aggregated budget data from WHO, Global Fund and the World Bank. Only two studies that used empirical data reported cost per PAR, which ranged from USD 0.87 to USD 1.95 in Sri Lanka [44] and USD 6.64 in Rwanda [29].

Fig. 4.2. Cost per capita and cost per population at risk of malaria control.



*Multiple costs per capita were reported in the original article, and only the highest cost is presented here.

AFG Afghanistan, *BDG* Bangladesh, *BRA* Brazil, *CHN* China, *COL* Columbia, *ETH* Ethiopia, *IND* India, *IDN* Indonesia, *KEN* Kenya, *LBR* Liberia, *MUS* Mauritius, *NPL* Nepal, *PSE* Palestine, *RWA* Rwanda, *SEN* Senegal, *LKA* Sri Lanka, *sSA* Sub-Saharan Africa, *SWZ* Swaziland, *TZA* Tanzania, *THA* Thailand, *ZMB* Zambia

4.4.4 Health system costs of malaria elimination

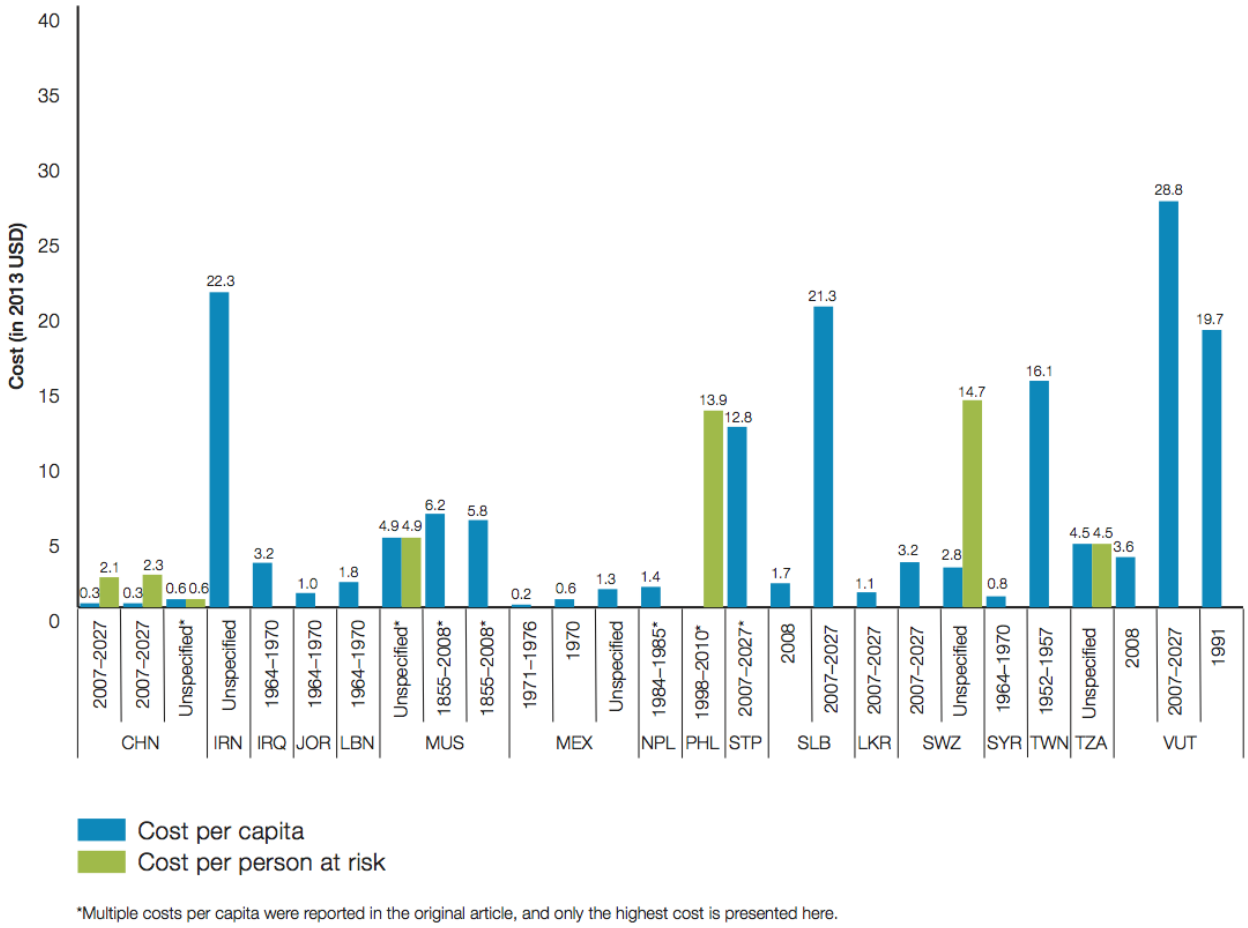
Analyses of actual expenditures for programmes that have recently or are currently eliminating malaria have been conducted in only a few selected places, primarily in Asia and Africa with some work in South America and Europe (Table 4.2; Table S4.1). Of the 21 studies on costs of malaria elimination with known data sources, only 11 used empirical data. Eight of the 21 studies looked at the prospective costs of elimination and eradication while the rest used retrospective costs.

Total programmatic costs of malaria elimination ranged from USD 10,472 in Iran per 500 population (or USD 20.95 per capita) [55] to USD 27 million per year in South Africa [64] (or USD 0.52 per capita) (Table S1). The median annual cost per capita for malaria elimination across all studies was USD 3.00 (range USD 0.10–USD 20.95) In Iran the assumptions for each type of intervention included were not uniform. Larviciding and IRS were implemented annually, however it is unclear if the costs for insecticide treated nets (ITNs) and treatment were yearly. In terms of cost per capita, the range of reported costs was USD 0.18 in Mexico in 1971 [51] to USD 0.27 in China [65], USD 15.06 in Taiwan [59], USD 20.95 in Iran [66], and USD 27 in Vanuatu [50] (Table 2; Fig. 3). A study in the Aneityum Island of Vanuatu reported the second highest cost per capita at USD 18.44 [60]. This 1991 campaign included weekly mass drug administration (MDA), ITN distribution, and the use of larvivorous fish in breeding sites and was successful in ending local transmission. Barring a few exceptions, reported elimination costs per capita were generally lowest in the Asian countries (i.e., China [13, 50, 53, 54], India [10], Indonesia [10], Philippines [57], Taiwan [10], Thailand [10], Sri Lanka [50], and Vanuatu [58]) and Mexico [51, 52]. Costs were generally highest in African nations, such as Mauritius [49], São Tomé and Principe [50], Swaziland [13, 50], and Tanzania (Zanzibar) [13].

Assessing a sub-set of 12 studies carried out after 2000, five were carried out in Africa, eight in Asia including one carried out in the Philippines between 1998 and 2010 and six with unspecified dates. In the eight studies carried out in the Asia Pacific, costs ranged from USD 0.27 per capita in China to USD 27 in Vanuatu (median USD 1.30). Elimination costs were higher in Africa, with costs ranged from USD 2.65 in Swaziland to USD 4.22 in Tanzania and USD 12 in Sao Tome (median USD 4.22 per capita).

In terms of cost per PAR, elimination in China has the lowest average annual cost of USD 0.05 [53] (Table 4.2; Fig. 4.3). Similarly, modeled costs per PAR for elimination in China were USD 0.30 in Jiangsu and USD 0.50 in Hainan, while POR is estimated to be USD 0.13 per PAR in both provinces [13]. Other countries report much higher cost per PAR. For example, the cost of Mauritius's second elimination campaign in 1975–1990 was approximately USD 4.63 per PAR per year, even though several economic costs and contributions by external partners were not included [9, 49]. Costs per PAR in different provinces in the Philippines ranged from USD 2.77 to USD 4.33 (excluding outbreak years) [57]. Four countries in the Middle East reported similar costs per PAR in 1970 ranging from USD 0.73 to USD 2.96 [56].

Fig. 4.3. Cost per capita and cost per population at risk of malaria elimination.



CHN China, *IRN* Iran, *IRQ* Iraq, *JOR* Jordan, *LBN* Lebanon, *MUS* Mauritius, *MEX* Mexico, *NPL* Nepal, *PHL* Philippines, *STP* São Tomé and Principe, *SLB* Solomon Islands, *LKR* Sri Lanka, *SWZ* Swaziland, *SYR* Syria, *TWN* Taiwan, *TZA* Tanzania, *VUT* Vanuatu

4.4.5 Economic benefits

Several studies explored the other economic benefits of investing in malaria control and elimination without a cost component. Two studies found that a reduction in malaria burden was associated with increased household spending in India [67] and increased household consumption in Vietnam [68]. In the USA and Latin American countries, exposure to malaria elimination programmes was associated with less work disability [69] and higher incomes [70] in adulthood. In a widely cited study, Gallup et al. [71] found that a 10% reduction in malaria burden was associated with as much as 0.3% in gross domestic product (GDP) growth. Finally, Hong found that between 1850 and 1860 in the USA, people who migrated from one area to another place with less malaria accumulated greater real estate wealth compared to those who relocated to a more malarious area [72].

4.4.6 Cost-benefit analyses

Of the ten CBAs identified (Table 4.4; Table S4.2), three were conducted during the GMEP era [39, 73, 74] and five were on malaria elimination. Eight were original studies while two articles were reviews with overlapping studies included [10, 16] and only two used empirical data [39, 74]. The main type of economic benefit identified in the studies was increased labour productivity due to reductions in morbidity and absenteeism. Other benefits included reductions in treatment costs and gains from the migration of labour into previously malarial areas.

All but one study in Zambia [34] showed a positive BCR, with BCRs for control ranging from 2.4 in the Philippines [10], 4.14 and 9.22 in India [39, 75] and 17.09 in Greece [76], to over almost 150 for elimination in Sri Lanka [16] (Table 4.3).

Table 4.4. Cost-benefit analyses

Country or setting	Study period	Focus (control or elimination)	Benefit-cost ratio	Source	Quality assessment score (out of 10)
Global	2010-2030	Elimination	6.11	[73]	7
Greece	1946-1949	Elimination	17.09[a]	[74]	1
India	1953-1954, 1976-1977	Control	9.27	[39]	6
	2000-2001	Control	4.14[a]	[75]	3
Iraq	1958-1967	Elimination	6.3[a]	[71]	3
Paraguay	1965	Elimination	2.6-3.3	[72]	3
Philippines	Unspecified	Control	2.4	[15]	NA
Sri Lanka	1947-1955	Control	146.3	[15]	NA
Sub-Saharan Africa	Varies by study	Control	1.9-17.1	[10]	NA
Sudan	1977-1984	Control	4.6	[15]	NA
Thailand	Unspecified	Control	6.5	[15]	NA
West Pakistan	1960	Control	4.9	[15]	NA
Zambia	1929-1949	Control	0.57[a]	[33]	9
	2006-2015	Control	40	[28]	6

[a] Calculated by authors based on reported benefits and costs

4.4.7 Quality assessment and critical appraisal

The results of the quality assessment of CBAs using the Drummond ten-point checklist are in Table S4.3. Out of a possible ten points, the average score for CBAs was 4.8 (range 0–9). Several CBA studies scored poorly for failing to discount future benefits, identify alternative scenarios and conduct incremental analyses, carry out sensitivity analyses, and address key issues related to resource allocation in the country or setting where the study was situated. Table S4.4 shows the

results of quality evaluation of the cost studies. Over half of studies that evaluated programmatic costs described their cost inputs and thus scored high on the scope of costing metric of the Fukuda and Imanaka criteria. Although a total of 54 studies were evaluated in this review, strong conclusions cannot be drawn and the findings should be interpreted with caution.

4.5. Discussion

Summarizing evidence on economics of malaria from heterogeneous studies, sources, inputs, methods, time, and geography is challenging. While total costs were corrected for population size by presenting them as cost per capita or cost per PAR, other factors contributed to the magnitude of the costs. The methodologies and cost inputs used were not standard and many studies used secondary data. In some cases, the cost inputs, cost categories, interventions, and assumptions that were included were not stated explicitly. Some studies provided coverage inputs, such as total population or PAR, while others presented a simple total programmatic cost. Among the studies included in the review, discount rates when specified, ranged from 3 to 16%. Many of the studies included used a public sector perspective for economic analysis. However, these costs represent only part of the equation. While most malaria control efforts are largely government-led public health initiatives, programmatic costs are only part of the picture as individuals, households and employers from the private sector may also incur costs for malaria treatment and prevention. It is unclear to what extent these direct and indirect costs were included in the literature examined. Out-of-pocket expenditures for treatment as well as transport to health facilities, as well as any indirect opportunity cost of lost wages and absenteeism may have substantial consequences. Other studies have shown that up to 6% of a household's total spending on health, even when public sector primary health care is free and indirect costs can translate to USD 150 in lost earnings per malaria episode [77].

Numerous caveats with respect to the relevance and extrapolation of the results exist and findings should be used cautiously. First, programme costs depend largely on the mix and scale of interventions, which differ from country to country, or even among districts or provinces in countries with decentralized systems. Mauritius, for example, employs a more costly border-screening programme for visitors from malaria-endemic countries. Some earlier studies did not incorporate post-elimination costs of surveillance and other interventions to prevent re-introduction of the disease, as the expectation at the time was that malaria-related expenditure would stop after elimination. In the early studies that did actually demonstrate reductions in post-elimination expenditures, the value of these savings were diminished due to discounting, preventing them from fully offsetting the initial increased investments to reach elimination. Second, cost is affected by the size and programme efficiency of a health system used to implement interventions, as well as the coverage rates employed. Smaller countries such as Swaziland potentially due diseconomies of scale appear to have higher costs. Sri Lanka on the other hand, has one of the earliest and effective public health systems with generally low levels of health

expenditures. Costs also differed by the region (Africa or Asia) with costs in Asia much lower than in Africa, possibly due to higher use of vector control in Africa, as well as size and development status of the country evaluated. Fourth, timing plays an important role in determining the price of consumables, services and labour. Estimates from earlier years were generally lower than that from the contemporary studies due to the difference between the relative prices of physical and human inputs to malaria control. In addition, the current menu of tools and interventions for malaria is broader and more costly, encompassing LLINs, intermittent preventive therapy for pregnant women and children, artemisinin-combination therapy, and rapid diagnostic tests, as well as innovative delivery models. Lastly, there are wide variations in regional, epidemiological and economic contexts. The presence of the more tenacious *Plasmodium vivax* could have substantial cost implications during the elimination phase. Barring a few studies based on mathematical models, few measured the cost of the full spectrum of WHO recommendations for the control of malaria. For elimination, there is currently no recommended optimal package as the interventions are often context specific and tailored to the particular landscape of the country. While some of these programmatic, temporal, spatial, and methodological differences are expected in costing studies; future studies should attempt to standardize methodologies to facilitate meaningful comparisons of cost estimates.

Despite the challenges in directly comparing costs in the studies reviewed, some trends can be observed. While the investment needed to achieve elimination varied greatly between countries and contexts, it is likely that the immediate costs for elimination will initially be equal to, or higher than those of a control programme, as indicated by data from Swaziland [13], due to initial investments in programme re- orientation to strengthen surveillance systems. This cost however tend to decrease as the focus progresses to the POR phase [42–44] due to streamlining of surveillance activities, reductions in commodity expenditures and in some cases, integration of supporting health system activities [13, 78]. Two studies that collected empirical data on actual expenditures over multiple programmatic phases support this claim. In Sri Lanka, expenditures per PAR declined when moving from a high level of control to controlled low-endemic malaria [44]. In the Philippines declining marginal expenditures were observed from control to POR, where costs per PAR were more than halved [57]. Similar findings have been reported in three Namibian regions in a recent study published after the initial search was conducted [79]. In contrast, Ruberu's analysis in Sri Lanka suggested that the high short-term cost of elimination is exceeded by long-term investments in control and the resulting consequences of productivity losses [46]. This is supported by the Eighth Report of the Expert Committee on Malaria which suggested that the cost of a well-operated programme to consolidate and sustain elimination would be only 65–75% that of operating an 'all-out' or intensive malaria control programme [80].

The bulk of the CBAs dated from the GMEP era. Several of these studies focused on periods of relatively high transmission (i.e., control), even though elimination or eradication was mentioned in the title or body of articles, emphasizing the need to standardize the use of malaria terminology.

Most of these studies were prospective in design and suggest that the benefits of intensive control and elimination exceed costs. However, these studies have not been followed up subsequently to assess the validity of their conclusions. The main type of economic benefit identified in the studies was increased labour productivity due to reductions in morbidity and absenteeism. Other benefits included reductions in treatment costs and gains from the migration of labour into previously malarial areas. Factors such as school absenteeism due to malaria and its effect on cognitive development and educational outcomes have also been reported by several studies, for example, Lucas reported that in Sri Lanka ending malaria in the most heavily affected region led to an estimated 17% increase in literacy [81]. Similarly, Bleakley *et al*. [82] examined the effects of malaria on female educational attainment in Paraguay and found that every 10% decrease in malaria incidence led to 0.1 years of additional schooling, and increased the chance of being literate by one to two percentage points. While an important factor on human capital accumulation, these were not included in this review as they did not present costs in economic terms, an important element in order to be comparable and used in economic analyses.

As with cost estimates, the heterogeneity in cost-benefit estimates can be explained largely by the lack of standardization in calculating BCRs, particularly on how benefits were defined, categorized or estimated. Some studies used a broad definition of benefits from a societal perspective, while others used a narrow definition of outputs. Some studies also made wide-ranging assumptions about the effect of malaria on labour, tourism and the larger economy and attempted to include their effect into their metric. The studies also use varying time periods of analysis and a variety of discount rates ranging from 3 to 10% to obtain present values. A complete economic assessment of elimination should include direct and indirect benefits, some of which are difficult to measure. The economics of malaria elimination are complicated because most of the benefits of elimination are typically realized only when an absolute threshold of malaria-free status is achieved, by conferring indirect benefits such as economic development [83]. While it is expected that one of the benefits of malaria is likely to be a positive effect on tourism, two studies carried out in an area of South Africa and Mauritius [84, 66] reported that tourists' perceptions of risk were highly unresponsive to actual changes in malaria transmission. A comprehensive CBA should compare the potential net benefits of elimination with those of control. Ideally, such as exercise should begin with cost-minimization analysis to establish the optimum package of interventions with which to achieve control and elimination. Nevertheless, the overall favourable BCR of investing in malaria supports the case for continued investment in malaria elimination within individual countries and globally.

Few studies have looked at the relative returns to elimination versus long-term control. The Eighth Report of the Expert Committee on Malaria (1961) suggested that experience indicated that a well-operated consolidation mechanism costs per annum 65–75% of an attack mechanism [80], and there is some evidence that the costs for elimination are likely to be equal to or higher than those of a control programme [50, 85]. Indeed, one of the strongest arguments against elimination is the increasing cost associated with finding and treating decreasing numbers of cases, since the final few

cases require an enormous outlay of resources that may be considered disproportionate to the marginal return [86]. This discussion around the financing of malaria elimination is no different to that of other elimination and eradications programmes. Since the start of the Global Polio Eradication Initiative (GPEI), the burden has been reduced by over 99%. Twenty-seven cases of wild polio have been diagnosed this year, all in Afghanistan, Pakistan and Nigeria. Finishing the job of eradicating polio will cost an additional USD 1.5 billion to enhance vaccination and surveillance efforts in hard to-reach places. This translates into a cost of about USD 0.5 billion a year or USD 18 million per case averted. However, eradicating polio will have saved at least USD 40–50 billion between 1988 and 2035. In the USA alone, eradicating polio is estimated to have saved about USD 220 billion since 1955. Nevertheless, some public health advocates continue to question whether polio should be merely managed rather than eliminated and the money be allocated to fighting other diseases. However, withdrawing support will have devastating health, social and economic effects. In 2003, certain states in Nigeria briefly stopped delivering vaccines in 2003 and as a result, GPEI spent USD 220 million dealing with the resultant outbreak. Equatorial Guinea also recently saw its first reported polio case since 1999, when a virus from Cameroon exploited a drop in the routine vaccination of children [87, 88].

Similarly, while the literature supports the claim that investment in malaria elimination provides generous benefits, the challenge is sustaining financial support. Donor funding is on the decline in favour of programmes with seemingly greater potential impact on mortality and morbidly. Although many of the countries currently attempting to eliminate malaria are middle-income countries and will eventually be able to fund their programmes domestically, they are faced with competing priorities for finite amounts of financing. In addition, the long-term nature of elimination programmes contrasts with governments' and donors' typical short-term funding cycles and goals. As a result, elimination programmes become victims of their own success and risk the withdrawal of funding at a critical time in their malaria epidemiology.

The review identified several gaps in the literature on the economics of malaria elimination. Firstly, there is no standard methodology or guidance for computing the cost of malaria control and elimination. The studies in this review employed a wide range of inputs to compute the cost of malaria control and elimination to arrive at the costs, making meaningful comparisons difficult. For elimination, this standardization needs to include the cost likely to be incurred in a post-elimination scenario to allow appropriate budgeting and planning. Secondly, while comprehensive WHO guidance exists on interventions for the control of malaria, there is little direction on the epidemiological and economic efficiencies of various mixes of interventions utilized for malaria elimination. The start-up costs of malaria elimination, particularly the cost of strengthening surveillance systems for enhanced case identification are also largely unknown. A country embarking on elimination will need to plan for the additional resources needed in its transition from control to elimination. Most of the studies in this review used financial costs and therefore, the true cost of the human resources and programmatic management and health system

strengthening are largely unknown. Lastly, malaria elimination confers several non-health benefits to the economy. Methods to comprehensively quantify these benefits will greatly enable stakeholders to strengthen the elimination argument.

4.6 Conclusion

The evidence documented in this review is important in answering key questions on resource allocation and financial planning by malaria programme managers and policymakers serving as an interim guide for countries until they are able to undertake more robust economic analyses in their own contexts. The investment needed to achieve elimination is likely to initially be equal to or higher than that of a control programme, particularly in the short term. As with any disease elimination programme, the cost of 'finishing the job' is likely to be higher than merely controlling the disease. This higher cost must be built into programme budgets with appropriate advocacy actions to ensure that financing is maintained well after elimination is achieved. At the same time, it should be tacit that, the total benefits of elimination, many immeasurable, vastly outweigh its cost. Nevertheless, there is a need for thorough research into the comprehensive benefits of elimination to guide relevant policy decisions. At the same time, malaria-related expenditure is not likely to stop as soon as elimination is achieved. Malaria interventions need to be viewed as a continuous expenditure even when the disease is absent, such as with routine immunization, until global eradication is achieved. Elucidating the health and economic costs and comprehensive benefits of continuing spending will facilitate such a policy shift.

4.7 Acknowledgements

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Additional files

Table S4.1. Cost of malaria to the health system.
Table S4.2. Cost-benefit analyses of malaria control and elimination.
Table S4.3. Quality assessment of CBAs.
Table S4.4. Quality assessment of costing analyses.

4.8 References

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Table S4.1. Cost of malaria to the health system

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
Abeyasinghe et al. (2012) [1]	Sri Lanka (Kurunegala and Anuradhapura districts)	Retrospective/ Cost analysis	2004 and 2009	Literature search, public sector expenditure records, informant interviews	Prevention, diagnosis, treatment and prophylaxis, surveillance and response, education and communication, and program management	No total cost provided	No total population provided	Anuradhapura: 0.87 (2004) and 1.95 (2009) Kurunegala: 2.06 (2004) and 1.95 (2009)
Akhavan et al. (1999) [2]	Brazil (Amazon basin)	Retrospective/ Cost analysis and CEA	1989-1996	Literature for epidemiological data, unclear for cost data	Prevention and treatment	914 M (780 M prevention, 134 M treatment)	2.57 (2.18 prevention, 0.38 treatment)[7]	2.57 (2.18 prevention, 0.38 treatment)[7]
Clinton Health Access Initiative, et al. (2011) [3]	Ethiopia, Rwanda, Zambia, Tanzania (Mainland and Zanzibar)	Prospective/ Cost analysis and CEA	2011-2015	Malaria specific expenditures from government and active partners	Diagnosis and treatment	Ethiopia: 148 M Rwanda: 55 M Senegal: 55.4 M Mainland Tanzania: 88-91 M Zanzibar: 4 M	Ethiopia: 1.67[7] Rwanda: 4.78[7] Senegal: 4.26[7] Mainland Tanzania: 2.14-2.21[7] Zanzibar: 2.87[7]	Ethiopia: 2.94[7] Rwanda: 6.64[7] Senegal: 4.26[7] Mainland Tanzania: 2.14-2.21[7] Zanzibar: 2.87[7]
Dua et al. (1997) [4]	India (one industrial setting)	Prospective and retrospective/ Cost analysis	1987-1995	Entomological and parasitological surveys, hospital budgets	Direct cost to health facilities	112,000 (1985) 684,000 (1986-1995)	No total population provided	No PAR provided
Dy (1954) [5]	Various	Retrospective/	1953	Public sector	Personnel, supplies,	Afghanistan: 726,000	Afghanistan: 1.34	No PAR provided

[3] Asterisks in this column describe whether a study explicitly considered malaria severity, where * = uncomplicated and ** = uncomplicated and severe.

[4] Unless otherwise stated, the total costs are based on the study period.

[5] Unless otherwise stated, the costs reported here are the annual costs per capita (i.e., annual total costs of program divided by total population in area of implementation).

[6] Unless otherwise stated, the costs reported here are the annual costs per PAR (i.e., annual total costs of program divided by PAR in area of implementation). For many studies, the cost per PAR is the same as the cost per capita because the entire population is deemed at risk for malaria.

[7] Calculated by authors based on total population or PAR reported in the original study.

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
	countries in Asia	Cost analysis		expenditure records	equipment, transport, and other miscellaneous expenses	Burma: 284,000 Ceylon: 6.1 M China: 205,000 India: 10.9 M Indonesia: 160,401 Malaya: 24,900 Portuguese India (Goa): 64,700 Thailand: 1.8 M Vietnam: 3.2 M	Ceylon: 0.80 India: 0.30 *Cost per person protected* Afghanistan: 1.74 Burma: 2.74 Ceylon: 1.98 China: 1.37 India: 0.61 Indonesia: 1.88 Malaya: 5.80 Portuguese India (Goa): 2.32 Philippines: 4.25 Thailand: 9.71 Vietnam: 1.06	
Ebi (2008) [6]	Global	Prospective/ Cost analysis	2000-2030	WHO database, Disease Control Priorities II project cost data	ITNs, case management with ACT, IPTp, and IRS	1.701 M-9.503 M[8]	No total population provided	No PAR provided
Giron et al. (2006) [7]	Colombia	Retrospective/ Cost analysis and CEA	1993-1998	Public sector expenditure records, household interviews	Fumigation, spraying, bednet treatment, elimination of breeding sites, IEC on environmental factors, and malaria tests	National program: 5,380 per 10,000 persons Integrated alternative: 34,847 per 10,000 persons	National program: 0.54 Integrated alternative: 3.48	No PAR provided
Gunaratna (1956) [8]	Ceylon (Sri Lanka)	Retrospective/ Cost analysis	1934-1955	Unspecified	Spraying, case detection, and treatment	98,000-7.3 M	0.63-5.22	No PAR provided
Haque et al. (2014) [9]	Bangladesh	Retrospective/ Cost analysis	2008-2012	Public sector expenditure	Equipment, infrastructure, training,	No total cost provided	0.40	No PAR provided

[8] Estimated under different scenarios

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
				record	operational research, transportation, and supplies such as drugs, diagnostics, LLINs, and insecticides for retreatment of nets			
Hedman et al. (1979) [10]	Liberia (Yekepa, Nimba County)	Retrospective/ Cost analysis	1953-1961	Unspecified	Vector control measures (including personnel, chemicals, equipment) and chemoprophylaxis with amodiaquine	504,969	31.25-39.06	No PAR provided
James (1903) [11]	India (Mian Mir cantonment)	Retrospective/ Cost analysis	1901-1903	Unspecified	Personnel, environmental management for vector control, and miscellaneous expenses	7,217 rupees[9] (1901-1902)	4.70 rupees[9]	No PAR provided
Jowett et al. (2005)** [12]	Tanzania	Retrospective/ Cost analysis	1998	Literature, donor and public sector expenditure records, manufacturer's pricing for drug prices	Prevention and treatment activities	93 M	3.14 (government 0.63, donors 0.30, private 2.21)	No PAR provided
Kaewsonthi et al. (1989) [13]	Thailand	Unclear/ Cost analysis	Unspecified	Unspecified	Surveillance, vector control, and malaria clinics	123 M (24.3 M government, 98.7 M private)	No total population provided	No PAR provided
Kamolratanakul et al. (1999) [14]	Thailand	Prospective/ Costs analysis	1995	Unspecified	Personnel, materials, and capital	88,737	Cost per *Pv* case: 12.94 Cost per *Pf* case: 15.40	No PAR provided

[9] No reliable exchange rate could be found for Indian rupees for the years 1901-1902

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
							Cost per visit: 2.59, Cost per case: 11.48 Cost per house sprayed: 3.13 Cost per impregnated net: 2.15	
Kiszewski et al. (2007)** [15]	81 high-burden malaria countries	Retrospective/ Cost analysis	2006-2015	WHO database, UNDP projections, public sector expenditure record	Commodities and distribution, health system strengthening activities, training, communication, operational research, M&E, and technical assistance	4.4 B-5.2 B per year (2 B-2.5 B Africa, 2.4 B-2.8 B rest of the world)	Africa: 2.81 Asia and Oceania: 1.34 Americas: 0.99 Global: 2.50	No PAR provided
Kligler (1924) [16]	Palestine	Retrospective/ Cost analysis	1921-1922	Unspecified	Case detection and treatment, vector control, prophylaxis, and education	Migdal: 434 Kinnereth: 677 Yemma: 812	Migdal: 24 Kinnereth: 32 Yemma: 22 Menachamia: 19 Um-Ul-Alex: 32	No PAR provided
Kondrashin (1992) [17]	WHO SEARO region	Retrospective/ Cost analysis	1990	WHO SEARO and New Delhi budget data	Unspecified	No total cost provided	No total population provided	Bangladesh: 0.02 India: 0.12 Indonesia: 2.16 Nepal: 0.52 Thailand: 1.59
Konradsen et al. (1999) [18]	Sri Lanka (one area in Anuradhapura district)	Retrospective/ Cost analysis	1994-1995	MOH, Anti Malaria Campaign, Kekirawa government hospital, survey data	Salaries, transport and storage, chemicals, capital investments and maintenance for IRS, bednet impregnation, larviciding, water management, and diagnosis and	No total cost provided	*Cost per person protected per year* Spraying: 3.13-4.26 Bednet impregnation: 1.29 Larviciding: 0.73 Water management: 0.36	No PAR provided

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
					treatment		*Cost per positive case* Diagnosis: 1.45-2.39 Treatment: 1.91-4.12	
Korenromp et al. (2013)* [19]	90 countries	Retrospective/ Cost analysis	2003-2009	Disbursement reports from donors, WHO database, household surveys, manufacturer cost reports	Unspecified	No total cost provided	78-5,749 per case prevented[10] 57,654-3,903,107 per death prevented[10]	1.42-11.13[7]
Mills (1992)* [20]	Nepal (5 districts)	Prospective/ Cost analysis and CEA	Unspecified	Surveys, government control program	Diagnosis and prevention	No total cost provided	0.11-1.21	No PAR provided
Mills (1993b) [21]	Nepal	Retrospective/ Cost analysis and CEA	1984-1985	Survey data, malaria program budgets and accounts, surveillance data	NMCP costs	Morang: 174,877 and 112,567[11] Ilam: 57,938 and 31,134 Rupandehi: 186,546 and 139,037	Morang: 0.45 and 0.97 Ilam: 1.35 and 1.36 Rupandehi: 0.81 and 0.87[7]	No PAR provided
Morel et al. (2005) [22]	Sub-Saharan Africa	Prospective/ CEA	2003 population data as baseline, modeled over 10 years	Literature review, expert opinion, WHO-CHOICE database	Unspecified	Southern and Eastern Africa: 597,045,946-598,568,437 Western Africa: 426,990,689-632,846,172	Southern and Eastern Africa: 2.22 Western Africa: 1.21-1.80	Southern and Eastern Africa: 2.26-2.27 Western Africa: 1.76-2.61
Prakash et al. (2003)** [23]	India (Jorajan camp of Oil India, upper	Retrospective/ Cost analysis and CBA	April 2000-May 2001	Oil India Limited records	Personnel, transportation, and antimalarial measures	2,746	Cost of hospitalization per case: 264.89	No PAR provided

[10] Cost analyses limited to 49 countries outside Africa

[11] Higher costs are from lower receptive areas (API of 10 and 40 per 1000) while lower costs are from moderate receptive areas (API of 50 and 250 per 1000).

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
	Assam)							
Ramaiah (1980) [24]	India	Retrospective/ Cost analysis and CBA	1953-1977	Literature, public sector expenditure reports	Treatment and transportation	4.274 M	0.36[7]	No PAR provided
Ruberu (1977) [25]	Sri Lanka	Retrospective/ Cost analysis	1977-1981	Malaria program expenditures and reports, source of historical epidemiological data unclear	NMCP costs	7.2 M-13.2 M (1977-1986) Attack phase (1977-1981): 120.5 M	Attack phase: 1.71	No PAR provided
Sharma (1996) [26]	India	Retrospective/ Cost analysis	1991	Literature, public sector expenditure reports	NMCP expenditures, transportation, personal protection methods, and treatment	330,464,252-542,423,009	No total population provided	No PAR provided
Snow et al. (2008)* [27]	87 countries	Retrospective/ Cost analysis	2002-2007	GFATM, WHO, World Bank, unilateral and bilateral organizations	Approved fund distributions	1,114,044,944	No total population provided	Any risk for *Pf*: 0.47 Stable risk for *Pf*: 0.80
Some (1994)** [28]	Kenya (Uasin Gishu district)	Retrospective/ Cost analysis	Jan-Sep 1990	Hospital record, absenteeism data from 6 primary schools, routine and verbal reports	Accommodations, vehicle use and maintenance, supplies, printing, equipment and maintenance, and miscellaneous expenses	Additional cost of controlling the malaria epidemic (June 1990): 142,665	0.28[7]	No PAR provided
Stuckey et al. (2014) [29]	Kenya (Rachuonyo South district, Homa Bay county, Nyanza	Prospective and retrospective/ Cost analysis and CEA	2011-2012 data as baseline, modeled over 5 years	GFATM, WHO-CHOICE, and Malaria Transmission Consortium	Health system resources, treatment, supplies, personnel, and direct patient costs (travel and	89,749,493-117,078,093	897.49-1170.78 over five years (179.50-234.17 per year[5])	No PAR provided

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
	province)			databases, literature review, demographic and health survey	consumables)			
Teklehaimanot et al. (2007)** [30]	Africa	Prospective/ Cost analysis	2006-2015	Literature, UNDP database, UN data on malaria	Prevention, diagnosis, treatment, M&E, and overhead	3.5 B	3.47	4.65
Utzinger et al. (2002) [31]	Zambia (four communities)	Retrospective/ Cost analysis	1929-1949	Census data, life tables, literature search, program budgets for control	Prevention, diagnosis, and treatment	17,078,703	11.86[7]	No PAR provided
Yadav et al. (1991) [32]	India (two mining settlements in Orissa)	Retrospective/ Cost analysis	May 1989	Hospital records, survey, expenditure data from mining companies	Treatment, antilarvals, and IRS	128,109	9.39[7]	No PAR provided
Beaver (2011) [33]	Solomon Islands, Vanuatu	Retrospective/ Cost analysis	2008	Government budget projection reports, GFATM, AusAID, WHO, and Rotary Against Malaria data	Projected budgets for case management, diagnosis, prevention, and M&E	No total cost provided	Vanuatu: 1.60 Solomon Islands: 3.34[12]	No PAR provided
Cohn (1973) [34]	India	Retrospective/ Cost analysis	1952-1971	National malaria program expenditure data	Materials, equipment, and operations	Control (1951-1958): 150 M Elimination (1958-1971): 1.3 B	No total population provided	No PAR provided
de Zulueta et al. (1972) [35]	Iraq, Lebanon, Syria, Jordan	Retrospective/ Cost analysis	1964-1970	Unspecified	NMCP costs	Iraq: 77,083,000 Jordan: 17,699,000 Lebanon: 5,174,000 Syria: 22,067,000	No total population provided	Iraq (1970): 2.96 Jordan (1970): 1.68 Lebanon (1970):

[12] Values deflated by remoteness and incapacity indices

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
								0.73 Syria (1970): 0.95
Jackson et al. (2002) [36]	China (Gushi and Shangcheng, in Henan province)	Prospective/ Cost analysis	1994-1995	Budget for administrative costs, community costs based on sample of suspected cases, government health records	Vector surveillance, population blood surveys, case management, personnel, administration, training, drugs, blood testing, and miscellaneous expenses	175,340	1.23 per suspected case	0.05
Kahn et al. (2009a) [37]	China (Jiangsu, and Hainan Island), Sao Tome and Principe, Solomon Islands, Sri Lanka, Swaziland, Vanuatu	Prospective/ Cost analysis and CEA	2007 (modeled over 20 years)	Public sector expenditure reports and budgets, GFATM proposals, expert opinions	NMCP costs	*Jiangsu, China* Control: 9.9 M Elimination: 6.66 M *Hainan, China* Control: 3.2 M Elimination: 2.6 M *Swaziland* Control: 0.8 M Elimination 1.36 M	Using GMAP figures (1950s-1960s): 3-14 Hainan, China: 0.27 Sao Tome and Principe: 12 Solomon Islands: 20 Vanuatu: 27 Sri Lanka: 1 Swaziland: 3	Hainan, China: 2 Sri Lanka: 5 Swaziland: 8
Kahn et al. (2009b) [38]	China (Jiangsu, and Hainan Island), Swaziland	Prospective/ Cost analysis and CEA	2007 (modeled over 20 years)	China: MOH expenditures and budgets, GFATM proposals, expert opinion Swaziland: government budgets and GFATM proposals	NMCP costs	*Jiangsu, China* Control: 9.9 M Elimination: 6.66 M *Hainan, China* Control: 3.2 M *Swaziland* Annual cost: 430,000 Budgeted amount for elimination: 2.6 M	*Hainan, China* Elimination: 0.27	*Hainan, China* Elimination: 2.17
Kaneko et al. (2000)* [39]	Vanuatu (Aneityum)	Retrospective/ Cost analysis	Sept-Nov 1991	Unspecified	ITNs, antimalarials, microscopy, transportation, and	No total cost provided	18.44	No PAR provided

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
					travel allowances			
Liu et al. (2013) [40]	Philippines (4 provinces)	Retrospective/ Cost analysis	1998-2010 (varies by province)	Subnational historical records, key interviews, Public sector expenditure reports	Diagnosis, treatment, prevention, surveillance, and M&E	Apayao: 384,737-798,470 Laguna: 29,748-117,621 Cavite: 7,464-45,389 Benguet: 17,020-17, 292	No total population provided	Apayao: 3.50-7.70 Laguna: 3.48-13.08 Cavite: 0.67-4.63 Benguet: 2.69-2.96
Livadas et al. (1963) [41]	Greece	Retrospective/ Cost analysis	1946-1949	Unspecified	Direct and indirect cost	11 M	No total population provided	No PAR provided
Lok (1979)* [42]	Singapore	Retrospective/ Cost analyses	1974-1978	Unspecified	Program implementation, drugs, and medical care	3.5 M	No total population provided	No PAR provided
Mills (2008) [43]	Multiple countries	Retrospective and prospective/ Cost analysis	Varies by country	Literature	Various	No total cost provided	*Cost per person protected*[13] Taiwan: 0.52 India: 0.58 Sri Lanka: 0.86 Indonesia: 0.97 Thailand: 1.54	No PAR provided
Moonasar et al. (2013) [44]	South Africa	Prospective/ Cost analysis	2012-2018	Public sector expenditure reports and budgets	Surveillance, vector control, health promotion, case management, and program management	190 M (2012-2018)	No total population provided	No PAR provided
Niazi (1969) [45]	Iraq	Retrospective/ Cost analysis and CBA	1958-1967	Unspecified	Treatment and medical care, antilarval measures, and insecticidal spraying	86,653,366	No total population provided	No PAR provided

[13] Updated costs from (1) Griffith ME. Financial implications of surveillance in India and other countries. *Bulletin of the National Society of India for Malaria and Other Mosquito-borne Diseases* 1961;9:385-411 and (2) Kaewsonthi S, Harding AG. Cost and performance of malaria surveillance in Thailand. *Soc Sci Med* 1992;34(9):1081-1097.

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
Ortiz (1968) [46]	Paraguay (agricultural, cattle farming, and forestry industries)	Retrospective/ Cost analysis and CBA	1965	Servicio Nacional de Erradicación del Paludismo	NMCP costs	Actual value: 38,414,815 Annual disbursement: 51,466,667	No total population provided	No PAR provided
Purdy et al. (2013) [47]	WHO regions	Prospective/ Cost analysis and CBA	2013-2035	GMAP	GMAP costs	7.534 M (2010) 7.163 M (2015) 6.338 M (2020) 6.036 M (2025) 4.167 M (2030) 2.877 M (2035)	No total population provided	No PAR provided
Rezaei-Hemami et al. (2014)* [48]	Iran	Retrospective/ Cost analysis and CEA	Unspecified (pre-elimination to elimination phases)	Iranian Ministry of Health and Medical Education	Utilities, capital, operations, personnel, and transportation	10,472	20.95	No PAR provided
Sabot et al. (2010) [49]	China (Hainan and Jiangsu), Mauritius, Swaziland, and Tanzania (Zanzibar)	Retrospective and prospective/ Cost analysis	Varies by country (10-year time horizon for elimination plus 15 years post-elimination)	Public sector expenditure reports and annual health reports, yearly country program data, national health accounts, donor proposals, informant interviews	NMCP costs	*Hainan, China*: Control (2007-2009): 1.766 M Elimination (2010-2014): 4.72 M POR (2020-2029): 1.197 M *Jiangsu, China* Control (2007-2009): 9.169 M Elimination (2010-2014): 17.966 M POR (2020-2029): 8.218 M *Mauritius* Control (1982): 2.673 M Elimination (1983-	*Hainan, China* Control: 0.21 Elimination: 0.54 POR: 0.13 *Jiangsu, China* Control: 0.12 Elimination: 0.23 POR: 0.10 *Mauritius* Control: 2.37 Elimination: 4.63 POR: 2.62 *Swaziland* Control: 0.94 Elimination: 2.65 POR: 1.67 *Tanzania*	*Hainan, China* Control: 0.22 Elimination: 0.55 POR: 0.13 *Jiangsu, China*: Control 0.16 Elimination 0.30 POR: 0.13 *Mauritius* Control: 2.37 Elimination: 4.63 POR: 4.63 *Swaziland* Control: 4.88 Elimination: 13.77 POR: 8.65 *Tanzania*

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
						1988): 4.71 M POR (1990-2008): 2.999 M *Swaziland* Control (2004-2008): 1.068 M Elimination (2009-2013): 3.22 M POR (2020-2029): 2.452 M *Tanzania*: Control (2009) 4.229 M Elimination (2010-2019): 5.31 M POR (2020-2029): 4.220 M	Control: 3.26 Elimination: 4.22 POR: 2.18	Control: 3.26 Elimination: 4.22 POR: 2.18
Suarez Torres (1970a)** [50]	Mexico	Prospective/ Cost analysis	1971-1976	Unspecified	IRS, surveillance, case investigation and management, education campaign, entomological surveillance, research, program management, public relations, logistics, and administration	National plan (1971): 856,874 National plan with regional expansion (1971): 1,578,216 National plan with implementation in all malarious areas (1971): 4,057,006 Six-year plan: 21,608,204	Cost of national plan with implementation in all malarious areas (1971): 0.18	No PAR provided
Suarez Torres (1970b) [51]	Mexico (Gulf of Mexico, Yucatan Peninsula)	Prospective/ Cost analysis	July to Dec 1970	National Commission for the Eradication of Malaria and federal government	Personnel, supplies, communication, transportation, maintenance, spraying, and vehicles	537,425	0.54	No PAR provided

Source[3]	Country or region	Study type/ Study method	Study period	Data source	Costs and interventions included	Total cost of program (2013 USD)[4]	Cost per capita per year (2013 USD)[5]	Cost per PAR per year (2013 USD)[6]
Taiwan Provincial Malaria Research Institute et al. (1958)** [52]	Taiwan	Retrospective/ Cost analysis	1952-1957	Taiwan Provincial Malaria Research Institute	NMCP costs	Total funds for malaria (1952-1956) [14]: 242,705,049	15.06[7] (1956)	No PAR provided
Tatarsky et al. (2011) [53]	Mauritius	Retrospective/ Cost analysis	1855-2008	Peer-reviewed literature, WHO and government reports, gray literature, expert interviews, budgets, technical reports, program reviews, expenditure data	Surveillance, diagnosis, treatment, prevention, and program management	First elimination (1948-1951): 2.3 M-2.7 M First POR program (1969-1974): 2 M Second elimination (1982-1991): 3 M-5.6M Current program (2008): 2.7M	First elimination: 4.83 and 6.22 First POR: 3.24 Second elimination: 3.03-5.83 Current POR: 2.23	No PAR provided

Note: The color scheme in the table represents the focus of each study, where intensive malaria control is white and malaria elimination and eradication are in grey.

[14] 2013 costs are based on the exchange rate for New Taiwan dollars (TWD) in the 1950s, which was 5 TWD to 1 USD (see Li K-T. *The evolution of policy behind Taiwan's development success*. Singapore: World Scientific Publishing Co. Pte. Ltd.)

Acronyms used in Table S4.1

ACT – Artemisinin combination therapy
API – annual parasite index
AusAID – Australian Agency for International Development (now under the Department of Foreign Affairs and Trade)
B – Billion
CBA – Cost-benefit analysis
CEA – Cost-effectiveness analysis
IEC – Information, education and communication
IPTp – Intermittent preventive treatment in pregnancy
IRS – Indoor residual spraying
ITN – Insecticide-treated bednet
GFATM – Global Fund to Fight AIDS, Tuberculosis and Malaria
GMAP – Global Malaria Action Plan
LLIN – Long-lasting insecticidal bednet
M – Million
M&E – Monitoring and evaluation
MOH – Ministry of Health
NMCP – National malaria control program
PAR – population at risk
Pf – Plasmodium facliparum
POR – Prevention of reintroduction
Pv – Plasmodium vivax
SEARO – Southeast Asia Regional Office
TWD – New Taiwan dollars
UN – United Nations
UNDP – United Nations Development Programme
WHO – World Health Organization
WHO-CHOICE – WHO cost-effectiveness and strategic planning

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Table S4.2. Cost-benefit analyses of malaria control and elimination

Source[15]	Country or region	Study period	Perspective/ Data sources	Costs included	Benefits included	Total cost (2013 USD)	Total benefits (2013 USD)	Net benefits (NB, in 2013 USD) or benefit to cost ratio (BCR)
Barlow et al. (1986)**[16] [1]	Multiple countries	Varies by country	Societal/ Published literature	Direct cost of control interventions	Economic benefit of increased labor productivity	None	None	*BCR* Pakistan: 4.9 Philippines: 2.4 Sri Lanka: 146.3 Sudan: 4.6 Thailand: 6.5
Clinton Health Access Initiative, et al. (2011) [2]	Zambia (Konkola copper industry)	2006-2015	Societal/ Published data	Direct cost of control interventions	Cost savings	4,180,249	167,733,891	NB: 163,653,642 BCR: 40
Prakash et al. (2003)** [3]	India (Jorajan camp of Oil India, upper Assam)	April 2000-May 2001	Societal/ Oil India data	Direct cost of control interventions	Cases averted	2,746	11,387	NB: 8,644 BCR: 4.14[17]
Ramaiah (1980) [4]	India	1953-1954, 1976-1977	Societal/ Literature, public sector expenditure reports	Direct and indirect costs of control interventions	Cost savings	4.274 M	NPV: 39.628 M	BCR: 9.27
Utzinger et al. (2002) [5]	Zambia (4 communities)	1929-1949	Societal/ Census data, life tables, literature search, program budgets for	Direct and indirect costs of control interventions	DALYs averted	17.1 M	9.9 M	BCR: 0.57[17]

[15] Asterisks in this column describe whether a study considered malaria severity, where * = uncomplicated and ** = uncomplicated and severe.

[16] Review article – only selected studies or findings were extracted and included here

[17] Calculated by authors based on reported benefits and costs

Source[15]	Country or region	Study period	Perspective/ Data sources	Costs included	Benefits included	Total cost (2013 USD)	Total benefits (2013 USD)	Net benefits (NB, in 2013 USD) or benefit to cost ratio (BCR)
			control					
Livadas et al. (1963) [6]	Greece	1946-1949	Societal/ Unspecified	Direct cost of elimination interventions	Cost savings	11 M	199 M	NB: 188 M BCR: 17.09[17]
Mills (2008)[16] [7]	Sub-Saharan Africa[18]	Varies	Societal/ Published literature	Direct cost of intensified control interventions	Macro-economic benefits and monetized value of averted DALYs	None	None	*BCR* Based on macroeconomic benefit: 1.9-4.7 Based on averted DALYs: 17.1
Niazi (1969) [8]	Iraq	1958-1967	Societal/ Unspecified	Direct cost of elimination interventions	Cost savings	86,653,366	548,383,410	NB: 461,425,993 BCR: 6.3[17]
Ortiz (1968) [9]	Paraguay (agricultural and forestry industries)	1965	Societal/ Data from Servicio Nacional de Erradicación del Paludismo	Direct and indirect costs of elimination interventions	Increased productivity	48 M	139.7 M-220.8 M	BCR: 2.6-3.3[17]
Purdy et al. (2013) [10]	WHO regions	2010-2030	Societal/ GMAP	GMAP costs including prevention, case management, program, and R&D	DALYs averted, work years saved, and projected productivity growth	7.534 M (2010) 7.163 M (2015) 6.338 M (2020) 6.036 M (2025)	Several reported based on GDP per person and projected productivity growth	NB (2013-2035): 208.6 B BCR (2035): 6.11[17]

[18] More studies conducted in other studies are included in the original review article, but only the BCRs from Sub-Saharan Africa are reported here. Findings from other studies in Sudan, Thailand, Pakistan, Greece, Sri Lanka, Iraq, Paraguay, and India are reported separately in this table or are included in the Barlow et al. (1986) entry.

Source[15]	Country or region	Study period	Perspective/ Data sources	Costs included	Benefits included	Total cost (2013 USD)	Total benefits (2013 USD)	Net benefits (NB, in 2013 USD) or benefit to cost ratio (BCR)
						4.167 M (2030) 2.877 M (2035)		

Note: The color scheme in the table represents the focus of each study, where intensive malaria control is white and malaria elimination and eradication are in grey.

Acronyms used in Table S4.2

B – Billion
BCR – Benefit-cost ratio
DALY – Disability-adjusted life year
M – Million
NB – Net benefit
NPV – Net present value
GDP – Gross domestic product
GMAP – Global Malaria Action Plan
R&D – Research and development
WHO – World Health Organization

References used in Table S4.2

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4. Ramaiah T. 1980. C*ost benefit analysis of malaria control and eradication programme in India*. Ahmedabad: Public Systems Group, Indian Institute of Management.
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Table S4.3. Quality assessment of cost-benefit analyses using the 10-point Drummond checklist

Article	Q1 Was a well-defined question posed in answerable form?	Q2 Was a comprehensive description of the competing alternatives given?	Q3 Was the effectiveness of the programmes or services established?	Q4 Were all the important and relevant costs and consequences for each alternative identified?	Q5 Were costs and consequences measured accurately in appropriate physical units?	Q6 Were costs and consequences valued credibly?	Q7 Were costs and consequences adjusted for differential timing?	Q8 Was an incremental analysis of costs and consequences of alternatives performed?	Q9 Was allowance made for uncertainty in the estimates of costs and consequences?	Q10 Did the presentation and discussion of study results include all issues of concern to users?	**TOTAL SCORE**
Barlow et al. (1986)* [1]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Clinton Health Access Initiative, et al. (2011) [2]	Y	Y	Y	N	Y	Y	N	Y	N	N	6
Prakash et al. (2003) [3]	Y	Y	Y	N	N	N	N	N	N	N	3
Ramaiah (1980) [4]	Y	Y	Y	N	Y	Y	N	Y	N	N	6
Utzinger et al. (2002) [5]	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	9
Livadas et al. (1963) [6]	N	Y	N	N	N	N	N	N	N	N	1
Mills (2008)* [7]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Niazi (1969) [8]	Y	Y	N	N	N	N	N	Y	N	N	3
Ortiz (1968) [9]	N	Y	Y	N	N	Y	N	N	N	N	3
Purdy et al. (2013) [10]	Y	Y	Y	N	Y	Y	Y	Y	N	N	7

Note: The color scheme in the table represents the focus of each study, where intensive malaria control is white and malaria elimination and eradication are in grey.

* These articles are reviews, which could not be assessed for quality using the Drummond checklist.

References used in Table S4.3

1. Barlow R and Grobar LM. 1986. C*osts and benefits of controlling parasitic diseases*. Ann Arbor: University of Michigan.
2. Clinton Health Access Initiative, Evidence to Policy Initiative, African Leaders Malaria Alliance. 2011. *Maintaining the gains: the health and economic benefits of sustaining control measures*. San Francisco: UCSF Global Health Group.. Available from: http://globalhealthsciences.ucsf.edu/sites/default/files/content/ghg/e2pi-maintaining-the-gains.pdf.
3. Prakash A, Bhattacharyya DR, Mohapatra PK, Barua U, Phukan A and Mahanta J.2003. Malaria control in a forest camp in an oil exploration area of Upper Assam. *Natl Med J India* 16(3):135-8.
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Table S4.4. Quality assessment of costing studies

Reference	Scope of costing		Accuracy of method evaluating cost	
Abeyasinghe et al. (2012) [1]	B	All components of costs were described and data for costs in each component were reported.	α	Micro-costing estimates based on individual item expenses and/or detailed data sets
Akhavan et al. (1999) [2]	B	All components of costs were described and data for costs in each component were reported.	γ	Use of charge data as a proxy
Beaver (2011) [3]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Clinton Health Access Initiative, et al. (2011) [4]	A	All components of costs were described and data for both quantity and unit price of resources were reported for each component.	γ	Use of charge data as a proxy
Cohn (1973) [5]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
de Zulueta et al. (1972) [6]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Dua et al. (1997) [7]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Dy (1954) [8]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Ebi (2008) [9]	C	All components of costs were described but costs in each component were not reported.	γ	Use of charge data as a proxy
Giron et al. (2006) [10]	C	All components of costs were described but costs in each component were not reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from

				budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Gunaratna (1956) [11]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Haque et al. (2014) [12]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Hedman et al. (1979) [13]	A	All components of costs were described and data for both quantity and unit price of resources were reported for each component.	β	Estimates based on relative value units (RVUs) or ratio of costs to charges (RCCs)
Jackson et al. (2002) [14]	B	All components of costs were described and data for costs in each component were reported.	α	Micro-costing estimates based on individual item expenses and/or detailed data sets
James (1903) [15]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Jowett et al. (2005) [16]	B	All components of costs were described and data for costs in each component were reported.	γ	Use of charge data as a proxy
Kaewsonthi et al. (1989) [17]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Kahn et al. (2009a) [18]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Kahn et al. (2009b) [19]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or

				unpublished literature, personal communication, and other secondary sources)
Kamolratanakul et al. (1999) [20]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Kaneko et al. (2000) [21]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Kiszewski et al. (2007) [22]	A	All components of costs were described and data for both quantity and unit price of resources were reported for each component.	γ	Use of charge data as a proxy
Kligler (1924) [23]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Kondrashin (1992) [24]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Konradsen et al. (1999) [25]	B	All components of costs were described and data for costs in each component were reported.	α	Micro-costing estimates based on individual item expenses and/or detailed data sets
Korenromp et al. (2013) [26]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Liu et al. (2013) [27]	A	All components of costs were described and data for both quantity and unit price of resources were reported for each component.	α	Micro-costing estimates based on individual item expenses and/or detailed data sets
Livadas et al. (1963) [28]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or

				unpublished literature, personal communication, and other secondary sources)
Lok (1979) [29]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Mills (1992) [30]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Mills (1993b) [31]	B	All components of costs were described and data for costs in each component were reported.	β	Estimates based on relative value units (RVUs) or ratio of costs to charges (RCCs)
Mills (2008)* [32]	NA	Assessment not applicable	NA	Assessment not applicable
Moonasar et al. (2013) [33]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Morel et al. (2005) [34]	B	All components of costs were described and data for costs in each component were reported.	β	Estimates based on relative value units (RVUs) or ratio of costs to charges (RCCs)
Niazi (1969) [35]	A	All components of costs were described and data for both quantity and unit price of resources were reported for each component.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Ortiz (1968) [36]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Prakash et al. (2003) [37]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Purdy et al.	D	Only scope of costing was described but	δ	No clear description of cost accounting

(2013) [38]		components of costs were not described.		methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Ramaiah (1980) [39]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Rezaei-Hemami et al. (2014) [40]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Ruberu (1977) [41]	B	All components of costs were described and data for costs in each component were reported.	γ	Use of charge data as a proxy
Sabot et al. (2010) [42]	A	All components of costs were described and data for both quantity and unit price of resources were reported for each component.	α	Micro-costing estimates based on individual item expenses and/or detailed data sets
Sharma (1996) [43]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Snow et al. (2008) [44]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Some (1994) [45]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Stuckey et al. (2014) [46]	A	All components of costs were described and data for both quantity and unit price of resources were reported for each component.	γ	Use of charge data as a proxy
Suarez Torres	B	All components of costs were described	δ	No clear description of cost accounting

(1970a) [47]		and data for costs in each component were reported.		methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Suarez Torres (1970b) [48]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Taiwan Provincial Malaria Research Institute et al. (1958) [49]	D	Only scope of costing was described but components of costs were not described.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Tatarsky et al. (2011) [50]	A	All components of costs were described and data for both quantity and unit price of resources were reported for each component.	α	Micro-costing estimates based on individual item expenses and/or detailed data sets
Teklehaimanot et al. (2007) [51]	B	All components of costs were described and data for costs in each component were reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Utzinger et al. (2002) [52]	C	All components of costs were described but costs in each component were not reported.	δ	No clear description of cost accounting methods or inability to confirm the method easily (i.e., data are taken from budget or financial reports, published or unpublished literature, personal communication, and other secondary sources)
Yadav et al. (1991) [53]	B	All components of costs were described and data for costs in each component were reported.	γ	Use of charge data as a proxy

Note: References in RED are in Spanish or French.

* These articles are reviews, which could not be assessed for quality using the Fukuda and Imanaka checklist.

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CHAPTER 5

An Investment Case to Prevent the Reintroduction of Malaria in Sri Lanka

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5.1 Abstract

Sri Lanka has made remarkable gains in reducing the burden of malaria, recording no locally transmitted malaria cases since November 2012 and zero deaths since 2007. The country was recently certified as malaria free by World Health Organization in September 2016. Sri Lanka, however, continues to face a risk of resurgence due to persistent receptivity and vulnerability to malaria transmission. Maintaining the gains will require continued financing to the malaria program to maintain the activities aimed at preventing reintroduction. This article presents an investment case for malaria in Sri Lanka by estimating the costs and benefits of sustaining investments to prevent the reintroduction of the disease. An ingredient-based approach was used to estimate cost of the existing program. The cost of potential resurgence was estimated using a hypothetical scenario in which resurgence

assumed to occur, if all prevention of reintroduction activities were halted. These estimates were used to compute a benefit–cost ratio and a return on investment. The total economic cost of the malaria program in 2014 was estimated at U.S. dollars (USD) 0.57 per capita per year with a financial cost of USD 0.37 per capita. The cost of potential malaria resurgence was, however, much higher estimated at 13 times the cost of maintaining existing activities or 21 times based on financial costs alone. This evidence suggests a substantial return on investment providing a compelling argument for advocacy for continued prioritization of funding for the prevention of reintroduction of malaria in Sri Lanka.

5.2 Introduction

Sri Lanka has made extraordinary gains in reducing the burden of malaria in the last decade. Between 2000 and 2011, the number of malaria cases declined by more than 99% [1,2]. With zero locally transmitted malaria cases recorded since November 2012 and no indigenous deaths since 2007, Sri Lanka received the World Health Organization (WHO) certification of elimination in September 2016, an official recognition of its malaria-free status [1,3,4]. This period of progress coincided with increased political and financial commitment from the government and external donors, particularly the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund).

As Sri Lanka's national malaria program, the Anti Malaria Campaign (AMC), shifts its programmatic focus toward prevention of reintroduction (POR), it faces a new set of strategic and financial challenges [5]. Funding for malaria from the Global Fund is declining and being prioritized for high- burden, low-income countries [6]. At the same time, there is waning political interest and a rising disinterest toward malaria among health workers within the country as the disease is no longer considered a major public health threat and other health issues such as dengue fever and non- communicable diseases have become more pressing national health priorities [5].

Abruptly shifting focus away from the malaria program at this critical juncture is a conceivable risk to malaria resurgence in Sri Lanka. Scaling down of malaria efforts due to funding withdrawal in Sri Lanka in the 1960s is arguably the most cited resurgence story in history [7]. In 1963, malaria elimination was on the horizon with only 17 cases recorded in public facilities, of which only six were autochthonous (locally transmitted) [2, 8]. Following this success, there was a severe cutback in political and financial support for malaria control, leading to the withdrawal of malaria control measures, weakened surveillance and programmatic support, and growing insecticide resistance. Rapid resurgence of malaria soon followed with confirmed malaria cases rising to more than half a million in 1969 [8]. Between 1970 and 1999, malaria control interventions were resumed; however, frequent epidemics continued to occur during the 1980s and early 1990s.

The country continues to face a significant risk of resurgence especially in areas of high receptivity and vulnerability. Increased levels of tourism, migration, poor infrastructure in some areas, and the presence of vectors contribute to vulnerability to autochthonous transmission triggered by imported malaria [9,10]. In 2013, 95 imported cases of malaria were reported throughout the year. 60 % of the imported cases occurred among Sri Lankans returning from travel overseas, most being diagnosed and reported by public sector hospitals in the Western Province, an area not traditionally endemic for malaria.

To counter these challenges, Sri Lanka embarked on a new national strategic plan (NSP) for the elimination and POR of malaria for 2014–2018 [5]. The key focus of this strategy was to reorient and focus the program to strengthen surveillance systems for malaria, to facilitate rapid detection and response to emergent cases, and to eliminate parasite reservoirs and transmission foci. To implement this strategy, the AMC needs continued resources particularly in the short- to medium-term until the intrinsic transmission potential is sufficiently altered to make elimination stable.

The purpose of this study was to develop an investment case for malaria POR in Sri Lanka. In addition, it reviews the funding landscape for malaria in the country and identifies anticipated gaps in the near future. The findings will provide the AMC with an estimate of the resources required to prevent the reintroduction of malaria, as well as robust evidence to advocate for sustained funding from both domestic and external sources.

5.3 Methods

5.3.1 Study design

This study used a cost–benefit approach in which the cost of current malaria program activities was computed against the economic benefits of maintaining the program. A comprehensive literature review was initially conducted to gain an understanding of the current and historical structure, activities, and financing of the malaria program.

A micro-costing approach was used to obtain data on the costs of POR. A detailed cost analysis was conducted for ongoing program activities from expenditure and financial records, historical record reviews as well as extraction from existing reports and key informant interviews. Available information was obtained from existing reports and grey and published literature, including AMC records at the national and regional levels.

All fixed and recurrent costs incurred by the health system for malaria activities including resources received as donations and other in-kind or indirect expenditures were captured. Costs were categorized by source of funding, type of cost input, and by activity or intervention. Benefits were measured as the averted costs of resurgence were estimated

under a hypothetical scenario of resurgence, which was constructed based on historical data and expert opinion in the country. Under this counterfactual scenario, it was assumed that all POR activities would be halted in 2014 resulting in an increase in malaria cases between 2015 and 2020 with a peak in 2017, mimicking the magnitude and trend of the malaria epidemic between 1997 and 2002, adjusted for population growth. The cost of resurgence was estimated as the direct and indirect cost incurred by the health system to prevent and treat the increased cases as well as the direct and indirect cost incurred by individual households and the society.

The framework presented in Figure 5.1 was used to develop the cost–benefit analysis using an ingredient-based micro- costing analysis for estimating cost and a corresponding counterfactual scenario analysis for estimating benefits.

5.3.2 Study setting and sampling

Sri Lanka is divided into nine provinces and 25 administrative districts. We purposively sampled five districts in five different provinces to collect data on the cost of the malaria activities for POR: Hambantota (Southern Province), Ampara (Eastern Province), Anuradhapura (North Central Province), Puttalam (North Western Province), and Jaffna (Northern Province). The sampled districts represented regions where recent cases had been identified and included a range of previously endemic regions that used different mixes of interventions. Based on input from the AMC and other in-country experts, these sampled districts were deemed to be representative of the remaining 20 districts with respect to programmatic costs and levels of receptivity and vulnerability to malaria transmission. In addition, cost data were also collected from the AMC at the national level.

5.3.3 Data collection

Data collection for this study took place between February and July 2015. Data on the costs of malaria POR activities for 2014 were obtained from interviews and a review of the most recent budget and expenditure records. Staff at the regional malaria offices (RMOs) in each of the sampled districts was interviewed in a semi- structured format. The time spent on each activity was recorded based on self-reporting by the RMOs and other interviewees triangulated with interviews with the AMC director. At the central level, officers at the AMC including the AMC director, director of finance and accounting, surveillance, and monitoring and evaluation unit staff, and the Global Fund project finance manager were interviewed.

Data for the cost of resurgence were retrieved from published and unpublished literature and described in detail under “data analysis” below. Key informant interviews with AMC staff were also conducted to obtain consensus on the assumptions used and to fill any outstanding data gaps. The data on financing for malaria were extracted from existing

reports and grey and published literature including, but not limited to, Internet-based searches and AMC records at the national and regional levels.

This study was approved by the institutional review boards of the University of California, San Francisco Committee on Human Research (Study no. 14-14546, Reference no. 093635) and the Ethics Review Committee of the Faculty of Medicine, University of Kelaniya, Sri Lanka (Reference no. P/209/10/2014). Verbal informed consent procedures were conducted before each interview.

5.3.4 Data analysis

Estimating cost of POR. Primary data on costs collected from each sample district and the AMC were aggregated based on three dimensions—funding source, activity or intervention, and input type—to identify the cost drivers for malaria POR activities. All costs were expressed in 2013 U.S. dollars (USD), using a mid-year exchange rate of 131.5 Sri Lankan rupees per USD.

Cost by source. The two main sources of funding for malaria activities in Sri Lanka were 1) domestic funding, in the form of direct government allocations from the national health budget to the AMC and to the provinces, and 2) external funding, primarily from the Global Fund provided to the government for malaria activities. Government resources were disbursed to provinces and districts for all integrated health activities including malaria prevention and control separately from the resources provided to the AMC specifically for malaria activities. The explicit source of funding for malaria activities for each line item was identified to the extent possible.

Cost by input. Costs were categorized by four major inputs of production: capital, personnel, consumables, and services. Capital costs included vehicles, buildings and office space, furniture, computers, and other durable sup- plies. Personnel costs included salaries, allowances, and any other compensation to staff involved in malaria activities. Consumable costs included office and laboratory sup- plies, medicines, insecticides, and other products. Service costs included utilities, transport (domestic and international), training, maintenance, and security.

Capital goods were annualized based on their useful life years and a standard discount rate of 3%. Maintenance costs for equipment, vehicles, or buildings were calculated using actual information on the expenditure of maintaining these resources. No replacement costs were used for capital resources when their current value had already depreciated to zero, assuming that replacement would not occur in the near future. For all inputs shared across multiple programs, only the cost attributed to malaria activities was included based on the %age of time spent on malaria-specific activities. Shared resources such as staff time spent

on each activity were self-reported and determined through interviews and triangulated using multiple sources.

Cost by activity or intervention. All costs were divided across seven different activity groups for malaria: vector control (VC); diagnosis (D); treatment and prophylaxis (TP); surveillance and epidemic management (SEM); monitoring and evaluation (ME); information, education, and communication (IEC); and program management (PM). Although the implementation of most of these activities was integrated, the activity groups were created to facilitate analysis for the purpose of this study. Resources were apportioned across the activities based on self-reporting during interviews. Table 5.1 details the inputs for each of these interventions.

Estimating cost of POR at the national level. To obtain national-level estimates of cost of POR, data from the five sampled districts were extrapolated to the entire country by matching each non-sampled district to a representative sampled district. District matching was based on the size of the malaria program and the mix of activities implemented by the sampled and non-sampled districts. The number of staff and the size of the district measured by area in square kilometers were used as proxies for the size of the malaria program for the purpose of matching for cost extrapolation. Districts in the Western Province (i.e., Colombo, Gampaha, and Kalutara) were not matched in the same way because the AMC serves as the RMO for this region and their costs were already incorporated into AMC costs.

To estimate the national cost of POR, the total cost incurred by each sample district in 2014 was divided by its respective population to get the average cost per capita. The population of each non-sampled district was multiplied by the average cost per capita from the corresponding matched sample district. Costs across all districts were then summed together with the central level costs from the AMC to estimate the total cost of POR for the country for 2014. The AMC anticipated that the activities and, therefore, the cost of continuing POR over the next 3–5 years is likely to be similar to the cost of the program in 2014. The NSP (2014–2018) prioritizes strengthening of the existing interventions for malaria, particularly surveillance and response for the early detection of cases and their effective treatment, maintaining skills for diagnosis and treatment, strengthening preparedness for epidemic and outbreak response, and entomological surveillance through integrated vector management. The cost data estimated for 2014 were thus projected linearly to obtain cost estimates for 2015–2020, assuming a steady economic growth rate [11].

Figure 5.1. Framework for cost and benefit analysis

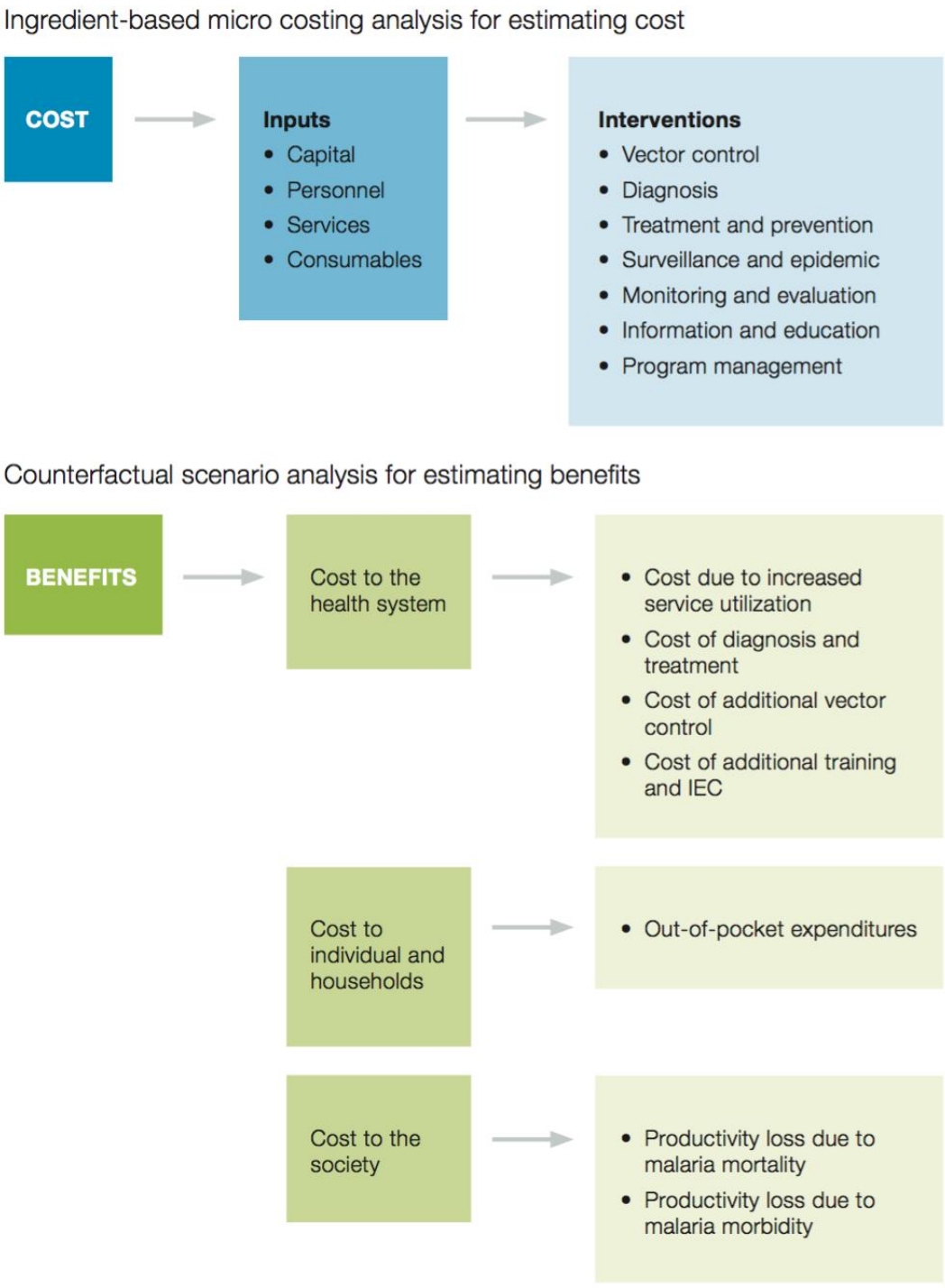


Table 5.1. Detailed explanation of cost categories

Vector control (VC)	Environmental management Targeted biological control Personal and community protection (LLINs and IRS) Chemical larviciding
Diagnosis (D)	Rapid diagnostic test Molecular diagnosis and confirmation Quality assurance
Treatment and prophylaxis (TP)	Chemoprophylaxis Passive case detection and treatment Provider training
Surveillance and epidemic management (SEM)	Active case detection Activated passive case detection Entomological surveillance Case investigation and response Epidemic response Surveillance training Private sector surveillance
Monitoring and evaluation (ME)	Internal ME External ME Health information system Periodic surveys
Information, education, and communication (IEC)	Private sector engagement Partnership development Behavior change communication programs Policy advocacy School-based education Operational research
Program management (PM)	Administrative training Capacity building Staff placement and recruitment Meetings Supervision and monitoring General administration

* Each of the categories above includes the human resources, consumables and utility costs associated with implementing the activit

5.4 Estimating cost of resurgence

The benefit of sustained investments in malaria and hence the corresponding cost saving from POR activities was obtained by estimating the cost of potential malaria resurgence. A hypothetical resurgence scenario was constructed based on the assumption that all POR activities would have been halted in 2014, resulting in an increase in malaria cases between 2015 and 2020 similar to that observed during the epidemic between 1997 and 2002, after adjusting for population growth. In this scenario, the peak number of malaria cases was assumed to be 324,371 with 122 deaths with a total epidemic size of 1,241,776 cases. The detailed parameters used to estimate the cost of resurgence and their data sources are listed in Table 5.2. As shown in Figure 5.1, the costs of resurgence were categorized based on three broad dimensions: 1) cost to the health system, 2) cost to the individual households, and 3) cost to the society.

Cost to the health system. Cost due to increased health service utilization. The potential cost of malaria resurgence to the health system was calculated separately for uncomplicated malaria (UM) and severe malaria (SM). Of the UM cases, Plasmodium vivax cases were presumed to be treated with primaquine for 14 days and chloroquine for 3 days according to the national treatment guidelines, and *Plasmodium falciparum* cases with artemether–lumefantrine as inpatients. Table 5.3 outlines the malaria treatment guidelines in Sri Lanka.

Table 5.2. Input parameters, and the data sources

Parameter	Values	Source	Comments
Population	18.75 million (year 1999) 20.96 million (year 2015)	[15]	Projected for 2015 based on population growth rates from UN[20]
GDP per capita	Year 1999: 2135.7 (in 2005 USD) Year 2015: 3839		
GDP growth rate	Year 2015: 7.4%	[11]	
Malaria			
Number of cases	264,549 (year 1999) 324,371 (year 2017)	[11]	Projected for 2015 based on population growth rates from UN
Distribution of cases by gender	Male: 54% (1999); 90%(2015) Female: 46% (1999); 10%(2015)	AMC	Distribution for year 2015 based on that for 2011
Distribution of cases by age	<15 years: 41% (1999): 6%	AMC	Distribution for year

Parameter	Values	Source	Comments
	(2015) >15 Years: 59% (1999): 94% (2015)		2015 based on that for 2011
Number of deaths	102 (1999) 122.3 (2015)	AMC	Projected for 2015
Proportion of uncomplicated cases	75%	AMC	
Proportion of severe cases	25%	AMC	
Proportion *vivax*	76%	AMC	
Proportion *falciparum*	24%	AMC	
Slide positivity rate	16.72%	AMC	
Total blood films	1.58 million	AMC	
% population protected by IRS	4% twice a year	AMC	
# of LLINs needed	1 LLIN per 1.8 population in "at risk areas"	[16]	
Cost and related parameters			
# days lost due to a malaria illness	9.3 days	[17]	
Cost of OP illness	USD 1.68	[12]	
Cost of IP admittance	USD 24.49	[12]	
Cost of malaria medicines (OP)	USD 1.00	AMC	
Cost of malaria medicines (IP)	USD 8.5	AMC	
Cost of IRS per person protected	USD 4.37	[17]	
Cost of LLIN distributed	USD 6.87	AMC	
Cost of testing non-malaria fevers	USD 1.12 per RDT USD 0.86 per microscopy slide	[12]	
Cost for SP during pregnancy	USD 0.5	AMC	
Cost of household consumption goods for malaria	USD 7.31	[17]	
Tourism			
Number of tourists (in million)	0.44 million (1999) 1.89 million (2015)	[18]	
Average nights spent by tourist	8.6 (1999) 9.25 (2015)	[18]	2015 data is based on author's projection based on previous trends
Average revenue per tourist per day	USD 158.65	[18]	
%age of tourists from Europe and North America	67	[18]	

Table 5.3. Treatment guidelines for malaria treatment in Sri Lanka

Uncomplicated malaria (*P. falciparum*)	Hospitalization for 3 days with immediate dose of primaquine (0.75 mg/kg body weight) plus artemether-lumefantrine (20/120 mg)
Severe malaria (*P. falciparum*)	Hospitalization with injectable artesunate until patient can take medication orally (usually 3 days) after which a complete course of artemether-lumefantrine (20/120 mg) is given
Military	*P. vivax* patients hospitalized for 3 days in military medical facilities; patients are kept within their barracks for two weeks for 14- day primaquine regimen (0.25 mg/kg body weight) in addition to chloroquine for 3 days
Non-military	Primaquine for 14 days (0.25 mg/kg body weight) plus chloroquine for 3 days
Mixed infections	Artemether-lumefantrine (20/120 mg) for 3 days plus primaquine for 14 days as an inpatient for 3 days

The unit costs of malaria treatment were multiplied by the number of potential cases to estimate the total cost of treatment to the health system. Actual health system costs for both inpatient and outpatient treatment of malaria were not available as malaria services are integrated with general health services. Therefore, secondary data from a separate micro-costing database from a teaching hospital in Kurunegala, Sri Lanka, were used to approximate service delivery costs, which included the average cost of out- patient care (including consultation and diagnostic tests) and the average cost of hospital admission for all patients regardless of original complaint or final diagnosis [12]. The cost of inpatient care thus includes the length of a hospital stay multiplied by the average cost of a hospital bed per day. The cost of an average course of antimalarials as reported by the AMC was added to this to obtain the total cost of malaria treatment (AMC, personal communication). Supply chain costs were estimated as 25% of the acquisition cost of the product and added to the unit cost of the medicine [13].

Cost of vector control. The cost of indoor residual spraying (IRS) and distribution of long-lasting insecticidal nets (LLINs) were used to estimate the cost of vector control under the resurgence scenario. Under this scenario, we assumed that the country would resume IRS at a coverage rate of 4 % of the total population, similar to the coverage rate during the 1999 resurgence (AMC, personal communication).

In addition, LLIN coverage of 1 net per 1.8 people was assumed based on WHO recommendations for the population at risk [14]. The total population at risk was identified in collaboration with the AMC based on the receptivity and vulnerability for malaria transmission in the country. Costs for

procurement, distribution, and delivery of LLINs and IRS were obtained from WHO Global Malaria Program and added to the cost of vector control as these costs were not available in country (Patouillard, E., personal communication).

Cost of increased diagnosis of fever cases for malaria. Under the resurgence scenario, it was assumed that more fever cases would be tested for malaria, leading to increased spending on rapid diagnostic tests (RDTs) and microscopy. Using the slide positivity rates from 1999 of 16.72% and the expected number of positive malaria cases in 2015, we estimated the total number of potential non-malaria cases assuming that 83.28% of the cases would be non-malarial fevers. The excess cost of diagnosing non-malaria fever cases was obtained by multiplying the number of potential non-malarial fevers by the average cost of diagnosis (average of RDT and microscopy) plus the cost of administering the test (AMC, personal communication).

Cost of training and IEC. In the event of malaria resurgence, it was assumed that there will be additional training for providers of all cadres, as well as additional IEC-related activities directed at the community.

Cost to the individual household. Out-of-pocket (OOP) expenditures incurred due to malaria. All malaria cases are treated in the public sector free of charge. They do not incur any user fees and there are no social health insurance schemes covering malaria. OOP expenditures due to malaria include both direct and indirect cost incurred by the house- hold for preventing or seeking care for malaria. These included transport costs as well as expenditures on other products for prevention, such as LLINs, mosquito coils, and repellents. These expenditures were extrapolated from secondary data from a study done in Sri Lanka in 1994 and inflated to reflect current costs [17].

Cost to society. Cost due to loss of life to malaria. The full income approach (see equation below) was used to estimate the potential social value of life lost due to malaria mortality as proposed by the Lancet Commission on Investing in Health [19]. This approach combines growth in national income with the value of additional life years (VLYs) due to malaria, which accounts for an individual's willingness to trade off income, pleasure, or convenience for an increase in life expectancy.

$$\boldsymbol{Income\ Growth + Value\ \ of\ life\ years\ gained\ in\ that\ period} \\ \boldsymbol{= Change\ in\ country's\ full\ income\ \ over\ a\ time\ period}$$

The (potential) number of adult deaths due to malaria in the resurgence scenario was multiplied by the remaining life years at death and the VLYs. The number of excess deaths among adults (persons age 15 years and above) in the hypothetical scenario was projected based on deaths between 1997 and 2002. The average life expectancy at age 40 years (separately for male and female) obtained from World Bank data was used as a proxy for the remaining life years at death due to malaria [11].

The Lancet Commission estimates the VLY average across low- and middle-income countries to be 2.3 times the income per capita at a 3% discount rate [19]. Sri Lanka's gross domestic product (GDP) per capita at 7.4%for 2015 was obtained from the World Bank database [11,17].

Cost due to loss of productivity to malaria morbidity. The reduced productivity or lost earnings due to malaria morbidity in adults was estimated by multiplying the potential malaria cases among the adult population, average days lost to one malaria episode (estimated at 9.3 days from previous research), and the average income (GDP) per capita per day obtained from World Bank data [14,16].

Estimating the return on investment. The return on investment (ROI) to the health system was calculated as the difference in total cost of POR and total cost of potential resurgence, also known as the net gain, divided by the total cost of POR. The cost of POR was computed from an input perspective using data from the costing portion of this study, whereas the cost of resurgence was computed from an output perspective, where the output costs were multi- plied by the potential number of cases under resurgence.

Uncertainty analysis. As with any cost and benefit estimation, our estimates relied on various assumptions about the input parameters, such as discount rates. To test the sensitivity of the cost of POR to discounting, the discount rate used for capital goods was varied between 1% and 7%. Another key underlying assumption in this analysis is that withdrawal of all malaria interventions will result in resurgence. The risk of resurgence in the future primarily hinges on two key parameters: the probability of resurgence and the severity of resurgence. In our construction, we assumed that future resurgence would be as severe as that experienced during the most recent epidemic between 1997 and 2002 (with a peak in year 1999). We also assumed that the resurgence would follow a similar distribution pattern and that a resurgence of this severity would occur with 100% probability.

To assess the robustness of our estimates with regard to the uncertain risk of resurgence, we conducted a sensitivity analysis by generating several alternative scenarios of resurgence with varying assumptions of severity and probability based on historical data. Following the application in the insurance industry and recent literature on pandemic influenza risk, we used the notion of "exceedance probability" to test probability of a resurgence with a certain thresh- old severity. Using historical data on malaria incidence, the maximum annual growth rate and the maximum total growth rate (between trough years) were used to vary the severity levels. Additional probabilities for the risk of resurgence were based on available historical data in the literature. Cohen and others (2012) [7] noted that 75 malaria resurgence events occurred over 70 years in 61 different countries, which translates to a 2% probability of resurgence. We used this as a lower bound estimate to analyze the sensitivity of the ROI to varying probabilities of resurgence between 2 and 100%.

Table 5.4 includes the various parameters that were varied and scenarios that were generated to assess the uncertainty of the cost and ROI estimates. Figure 5.2 illustrates the scenarios that were as translated into incidence projections. Financial costs of malaria. The financial costs of malaria POR were obtained from the estimates of economic costs without accounting for capital costs or the cost of the general health system or personnel that are financed through integrated national and provincial health budgets not specific to malaria.

Table 5.4. Scenarios for uncertainty analysis

Severity of resurgence	Scenarios
Incidence rate similar to historical rates between 1997-2002	Baseline
Maximum annual growth rate observed between two peak years	I
Maximum total growth rate observed between two peak years	II
Growth rate in 1975 from previous trough year	III
Growth rate in 1987 from previous trough year	IV
Growth rate in 1991 from previous trough year	V
Growth rate in 1999 from previous trough year	VI
Growth rate required to reach number of cases in year 1968 from 2012 level	VII
Growth rate required to reach number of cases in year 1975 from 2012 level	VIII
Growth rate required to reach number of cases in year 1987 from 2012 level	IX
Growth rate required to reach number of cases in year 1991 from 2012 level	X
Growth rate required to reach number of cases in year 1999 from 2012 level	XI
Probability of resurgence	
100%	Severe
51%	Median
2%	Mild

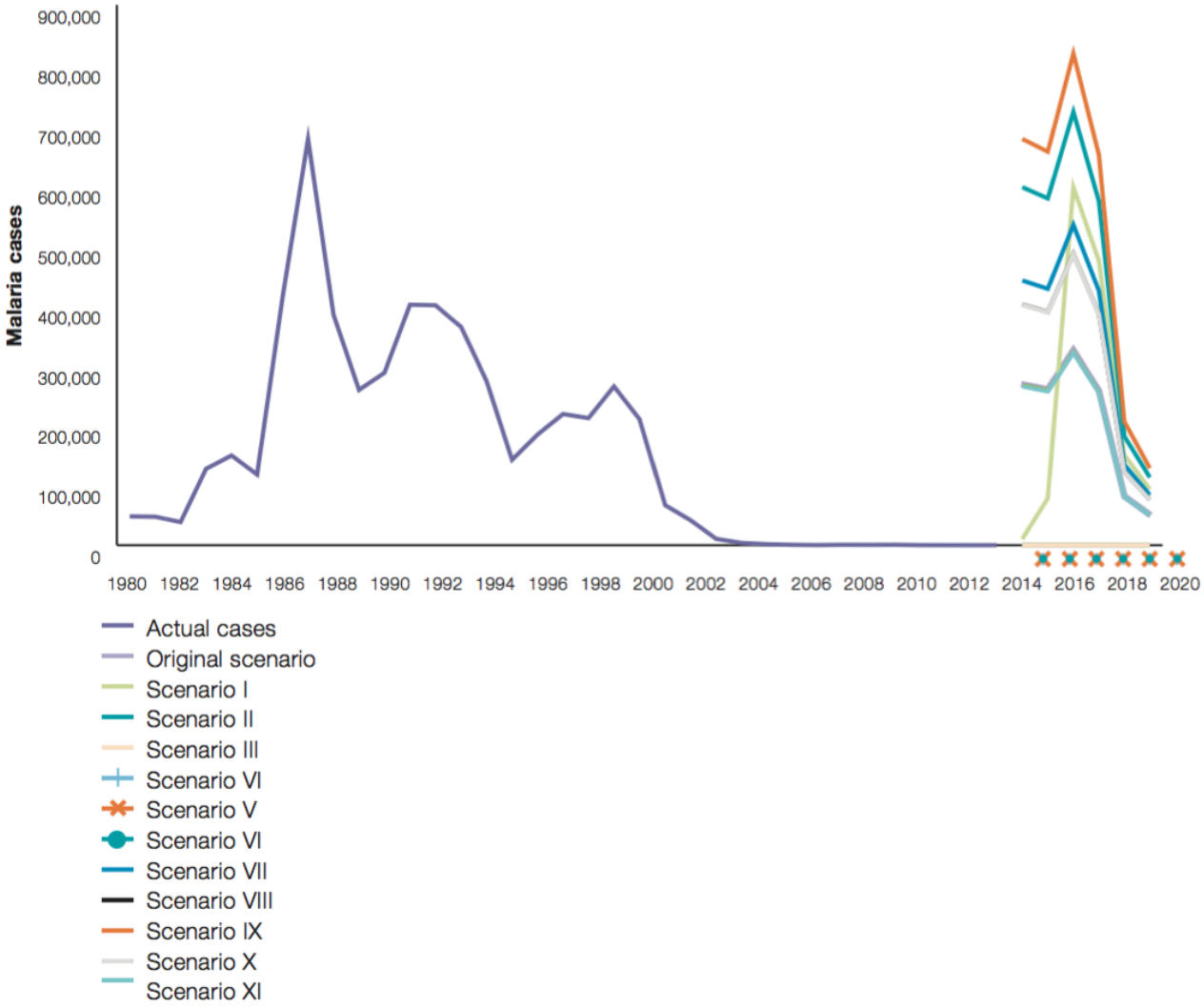
Note: The severity of resurgence is determined based on a combination of historical growth rates since 1950 in order to reach the peak level of resurgence from the base year 2012 (when only 23 cases were observed). The distribution of cases during hypothetical resurgence years (2015-2010) followed the actual case distribution observed between years 1997-2002.

5.5 Results

5.4.1 Cost of POR

The total economic cost of the malaria program in Sri Lanka for 2015 was estimated to be USD 11.85 million (Table 5.5). 58 % of the total cost was incurred by the AMC, whereas the provincial level incurred the remaining 42 %. Cost estimates varied widely across the districts from less than USD 30,000 to about USD 0.5 million per year with a median cost of USD 197,252. The average economic cost per capita for POR was estimated to be USD 0.57 and the corresponding financial cost was USD 0.37 for 2015.

Figure 5.2. Framework for uncertainty analysis



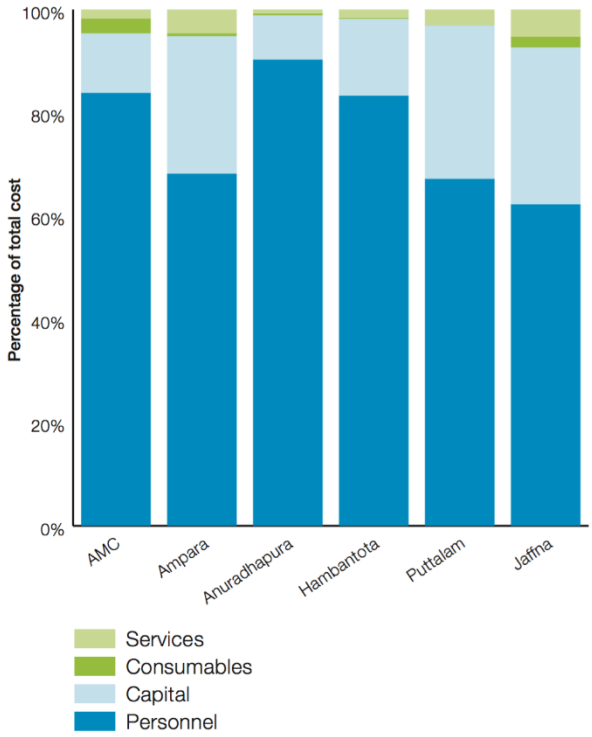
Scenarios	Severity of resurgence
Original	Incidence rate similar to historical rates between 1997–2002
I	Maximum annual growth rate observed between two peak years
II	Maximum total growth rate observed between two peak years
III	Growth rate in 1975 from previous trough year
IV	Growth rate in 1987 from previous trough year
V	Growth rate in 1991 from previous trough year
VI	Growth rate in 1999 from previous trough year
VII	Growth rate required to reach number of cases in year 1968 from 2012 level
VIII	Growth rate required to reach number of cases in year 1975 from 2012 level
IX	Growth rate required to reach number of cases in year 1987 from 2012 level
X	Growth rate required to reach number of cases in year 1991 from 2012 level
XI	Growth rate required to reach number of cases in year 1999 from 2012 level

About 80 % of the total cost was funded domestically, of which 8 % was from provincial funds and 72 % was from national government. The Global Fund financed the remaining 20 %. Funding for the AMC was primarily domestic (82 %) and the remaining 18% from the Global Fund. Across the districts, the source of funding varied largely with an average of 70 % domestic (of which 9 % was national and 62 % was provincial) and 29 % from donors.

Table 5.5. Projected cost for malaria POR

Year	Estimated annual cost (millions USD)	Cumulative cost (millions USD)
2015	11.86	11.86
2016	12.62	24.48
2017	13.43	37.90
2018	14.28	52.19
2019	15.20	67.39
2020	16.17	83.56

Figure 5.3. Distribution of input cost across sample districts

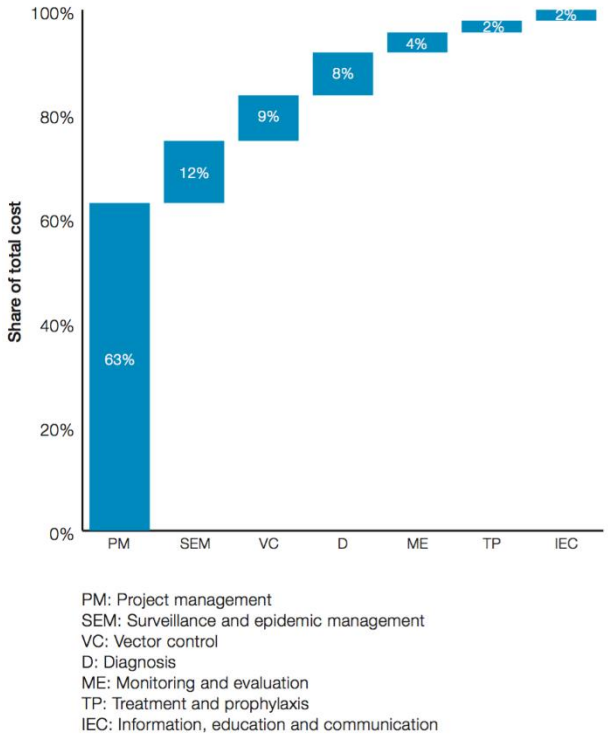


Among the inputs, human resources constituted the largest share at about 83% of the total cost, followed by capital costs at about 13%. Consumables and services together constituted about 5% of total cost of malaria POR. There was considerable heterogeneity in the mix of inputs across the

district and the national levels (Figure 5.3). In all instances, however, human resources were the main cost driver at 62– 90% of total cost among the districts. The share of capital cost was, on average, 22% (range: 8–30%). Consumables constituted < 1% of the total cost (range: < 1–3%), and services constituted approximately 3% of the total cost (range: < 1–5%).

Among the activities, the major cost drivers at all levels were project management and surveillance and epidemic management, followed by VC and D. Figure 5.4 illustrates the distribution of total costs across all activities in Sri Lanka. At a national level, PM consisted of about 63% of the total cost, followed by SEM at about 12%, and VC at 9%.

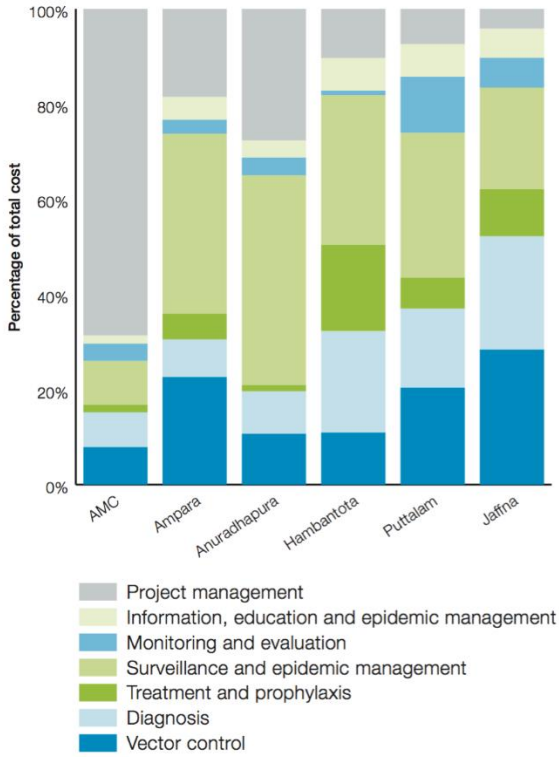
Figure 5.4. Distribution of total cost of POR across interventions



PM: Project management
SEM: Surveillance and epidemic management
VC: Vector control
D: Diagnosis
ME: Monitoring and evaluation
TP: Treatment and prophylaxis
IEC: Information, education and communication

The cost of activities also varied widely across districts (Figure 5.5). At the district level, SEM constituted an average of 33% of the cost (range: 21–44%). Across the districts, the cost share for VC averaged 19% (range: 11–28%). Similarly, the cost share of D ranged between 8% and 24% with an average of 16%. The cost share of IEC was fairly stable across districts at approximately 5% of the total cost.

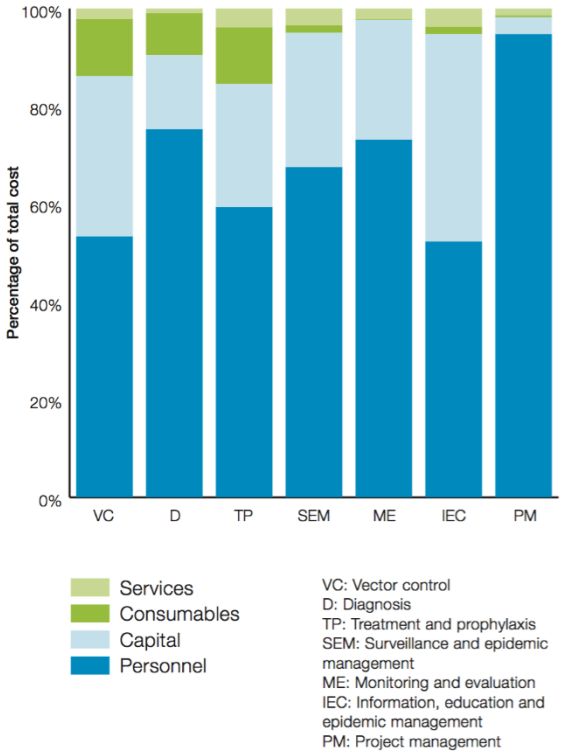
Figure 5.5. Distribution of cost of POR by intervention across districts



Across all activities, human resources constituted the highest share, followed by capital costs. The most human resource-intensive interventions were PM, SEM, and ME. IEC was the most capital-intensive intervention. As expected, TP followed by VC and D constituted relatively higher shares of consumable costs than other interventions. These differences in inputs across interventions are illustrated in Figure 5.6.

Cost of POR activities over time. The future cost of POR was extrapolated using the costs for 2014 adjusting for economic growth under the assumption that most of the activities and interventions for POR will remain constant over the next 5 years. The estimated cost to sustain the current level of activities for malaria between 2015 and 2020 was estimated at USD 83 million (Table 5.4).

Figure 5.6. Distribution of input cost across interventions



5.4.2 Cost of resurgence

Figure 5.7 illustrates this cost of resurgence between 2015 and 2020 broken down by the cost to household, the health system, and society.

Table 5.6. Cost of resurgence of malaria for year 2015

Cost of resurgence in 2015	**Best estimate (in millions USD)**
Direct cost to the health system	
Cost due to increased health service utilization	14.63
Cost of vector control to control resurgence	104.08
Cost of increased diagnosis	1.30
Cost of training human resources and educating community	1.31
Direct cost to the individual household	
Out of pocket expenditure due to malaria	1.96
Indirect cost to the society	
Cost due to loss of life to malaria	21.13
Cost due to loss of productivity to malaria morbidity	24.54
Total cost of resurgence in 2015	**168.96**

The total cost of resurgence was estimated at approximately USD 169 million. Within this cost, the direct cost to the health system was USD 121 million, the cost to households was USD1.95 million, and the cost to society totaled USD 45.66 million (Table 5.6).

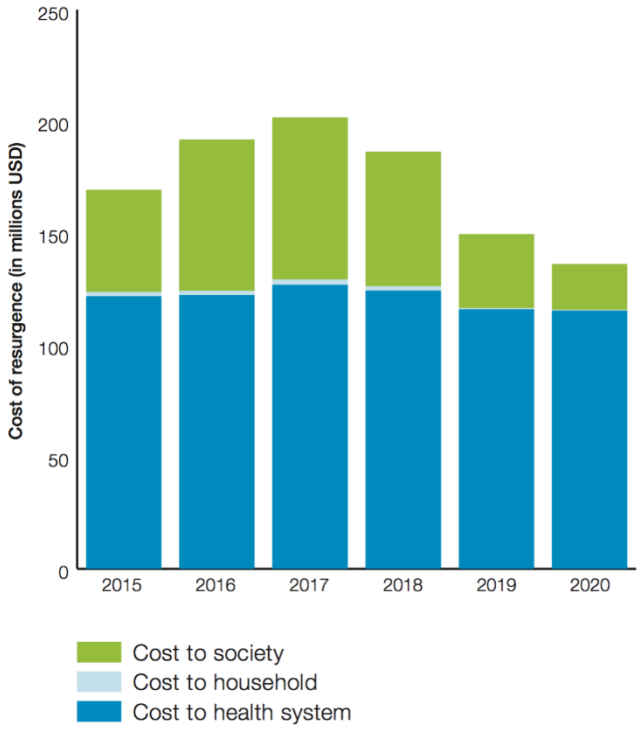
The cost of resurgence was estimated to be the highest for year 2017 when the incident cases peak and started declining following the trajectory of malaria incidence. The majority of the cost of resurgence is incurred by the health system, followed by the cost to society. As the majority of malaria interventions are publicly funded, out-of-pocket expenditures or household did not constitute a large portion of the cost.

5.4.3 Return on investment

The total cost of malaria POR in Sri Lanka for 2015 was estimated to be USD11.86 million, whereas the total cost of resurgence for the corresponding year was USD168.96 million yielding a ROI of more than 13 to 1. When considering the financial costs only (without capital cost and non-malaria-specific cost incurred by the integrated health system), the ROI was estimated at more than 21 to 1.

Similarly, when considering only the financial cost to the health system (without individual or societal costs), the cost of resurgence is estimated to be about 10 times the cost of maintaining the activities yielding a ROI of 10 to 1.

Figure 5.7. Cost of resurgence of malaria in Sri Lanka



5.4.4 Uncertainty analysis

An uncertainty analysis was carried out using a variety of discount rates to test the robust- ness of the results. The results did not vary significantly with the discount rates used—the difference in the cost estimate between the highest and the lowest discount rates was less than USD 0.2 million in 2015. A discount rate of 3 % produced the median cost estimates and was retained for this analysis.

In addition, a sensitivity analysis was performed on the cost of resurgence by varying the risk and probability of a hypothetical resurgence scenario. Figure 5.8 illustrates the ROI obtained under the various scenarios. Under these resurgence scenarios, the cost of resurgence was estimated at between USD 78 and 208 million.

The ROI, in turn was found to be between 6 and 16 under various severity and probabilities of resurgence. As expected, the cost of resurgence starts declining as the resurgence is contained after the peak year in 2017, resulting in a subsequent reduction in ROI. Figure 5.8 illustrates the sensitivity of the ROI using economic cost to varying levels of risk and probability of resurgence. Eleven scenarios of incidence were used in the sensitivity analysis denoting risk at three levels of probability: 100 %, 51 %, and 2 % for a total 33 scenarios (Table 5.4).

Figure 5.9 illustrates the sensitivity of the ROI using financial cost to varying levels of risk and probability of resurgence. Eleven scenarios of incidence were used in the sensitivity analysis denoting risk at three levels of probability, 100 %, 51 %, and 2 % for a total 33 scenarios (Table 5.4).

Figure 5.8. Sensitivity analysis of the estimates of return on investment in malaria using economic costs

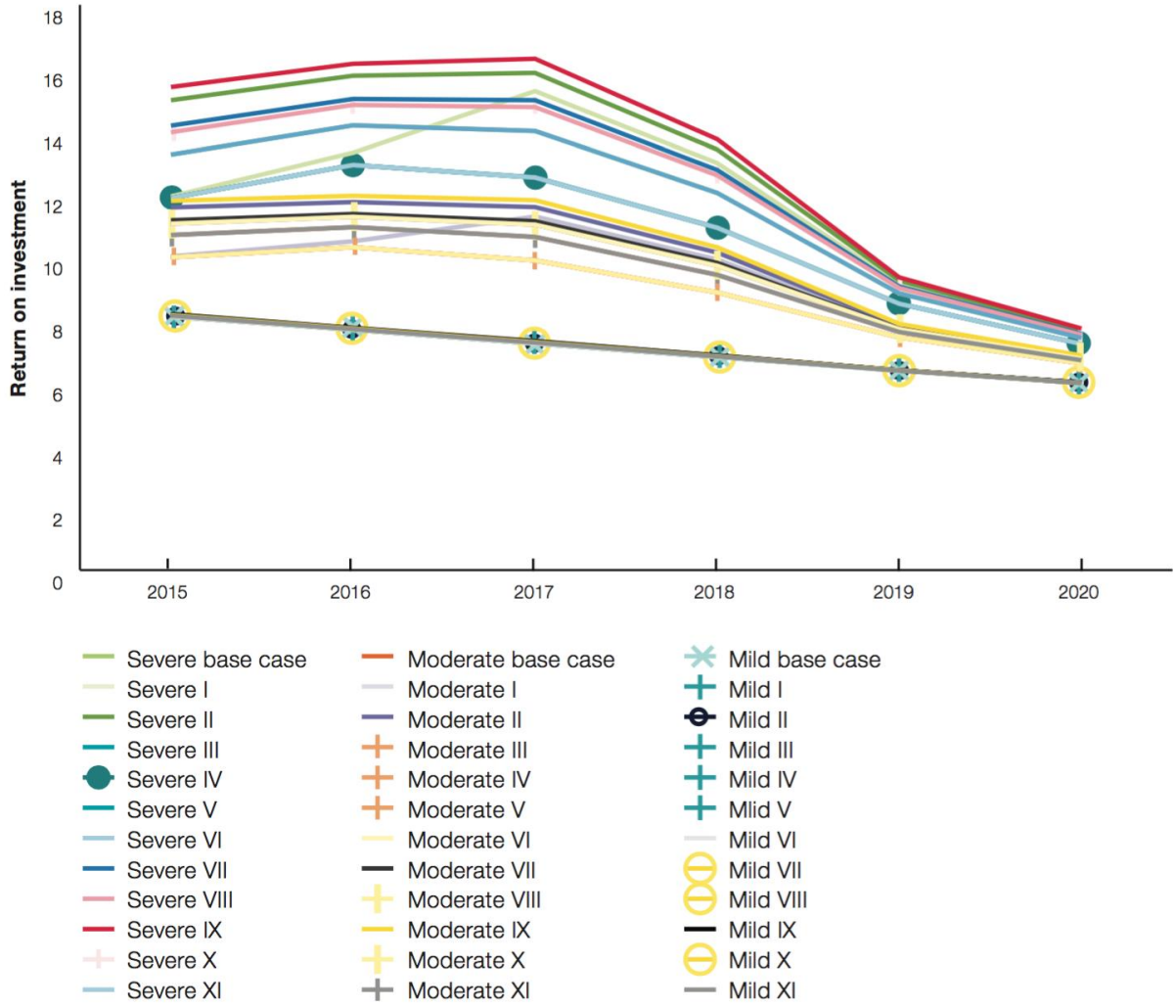
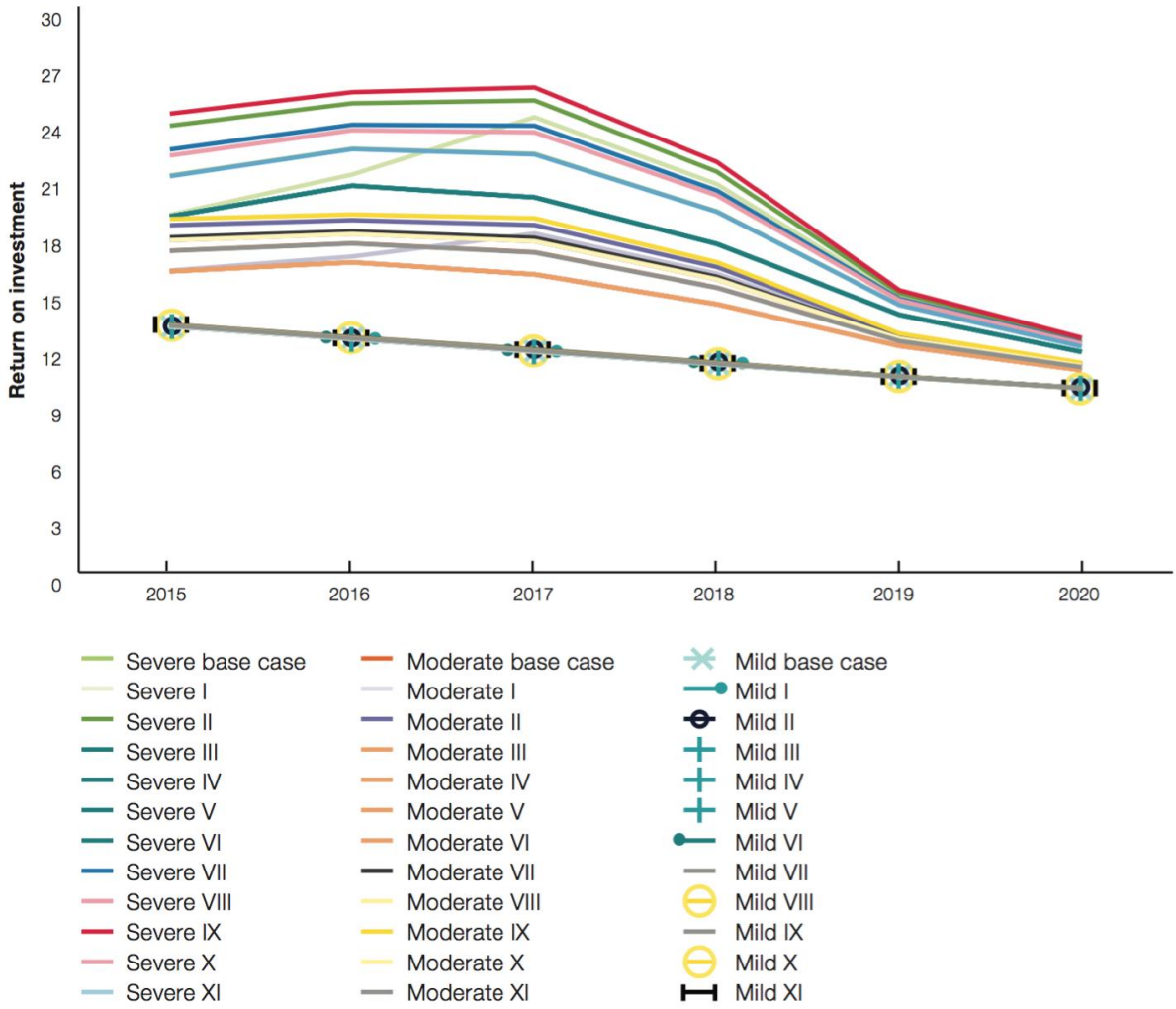


Figure 5.9. Sensitivity analysis of the estimates of return on investment in malaria using financial costs



5.4.5 Financing for malaria

In 2014, total funding for malaria activities from all sources was USD 8.7 million, which accounted for about 1 % of the overall government spending on health in Sri Lanka [5]. Domestic funding accounted for about 58 % of the expenditure on malaria in the country in 2014, whereas the remaining 42 % of the funding for malaria came from the Global Fund at USD 3.7 million [5]. Table 5.7 provides the actual and the projected expenditures on malaria from 2012 to 2017.

Table 5.7. Actual and projected expenditures for the malaria program in Sri Lanka 2012-2017

Source of Funding	Actual funds spent (millions USD)			Projected funds (USD)		
	2012	2013	2014	2015	2016	2017
Domestic spending [1]	3.26	3.63	5.06	5.49	6.12	6.77
Global Fund support [2]	2.91	3,.13	3.72	2.47	2.47	2.47
Total budget for malaria control	6.17	6.76	8.78	7.95	8.58	9.23
Total domestic spending on health	7.58	8.41	9.34	1,037	1,151	1,277
% of domestic funding for malaria	53	54	58	69	71	73
% of domestic health budget allocated for malaria	0.43	0.43	0.54	0.53	0.53	0.53
Total budget for malaria as a %age of total domestic spending on health	0.81	0.80	0.94	0.77	0.75	0.72

[1] Based on data published by the Central Bank of Sri Lanka (www.cbsl.gov.lk)

[2] Global Fund support amounting to USD 9.6 million has been requested for the period 2014-2017. Given that this grant was not approved until 2015, it has been allocated to 2015-2017 projected costs and has been split evenly among the three years.

The financial cost required to maintain the current level of malaria activities in Sri Lanka in 2015 was estimated to be on average about USD 7,673,961 million annually. Domestic financing covered approximately 53 % at USD 4,054,878. Even with resources from the Global Fund at approximately USD 2.3 million, Sri Lanka still faces a financial gap of about USD 1.7 million annually.

5.6 Discussion

This study found that the economic cost of maintaining malaria POR in Sri Lanka was approximately USD 0.57 per capita in 2015 and the corresponding financial cost was USD 0.37 per capita. In contrast, the cost of resurgence in 2015 was estimated to be USD 169 million or USD 8.07 per capita in a single year, yielding an economic ROI of 13.29 to 1 and a financial return of 21 to 1. This by far exceeds the threshold on returns that are considered to be high- impact investments [20].

The estimates of cost of resurgence in this study are likely to be undervalued as they exclude several macro- economic costs of malaria far beyond the health system. Studies have shown that indirect costs of malaria account for a large share of societal costs due to its debilitating physical impact leading to cognitive disability in children and later productivity as adults, as well as impeding macro-economic development by limiting foreign investments and tourism [21-27]. These macroeconomic impacts have not been included in these estimates, primarily due to the lack of

accurate data to quantify these effects and to directly attribute them to malaria. Other costs to the health system such as cost of drug and insecticide resistance, the cost of higher price alternatives, the cost associated with their implementation, and the cost of research and development have also been omitted.

There are several limitations to the data and methods used in this study. Obtaining accurate data on the cost of program operations, particularly in an integrated health system, is challenging. Several malaria program resources were shared across other public health programs. Peripheral level staff is often designated to perform other public health functions such as dengue surveillance following the decline in malaria burden leading to difficulties in attributing specific resources to malaria alone. Furthermore, activities for malaria were paid for through a combination of government and external resources. Although most provincial level staff was paid using government funds, several central AMC staff was funded through the Global Fund grants. In addition, resources for malaria control were spread across interventions and activities. Costs for malaria in this study were estimated using self-reported hours during the interview process and apportioned to the respective malaria activities. While this is a common methodology used in other studies, the authors acknowledge the potential reporting bias in the estimates. Ideally, a protracted period of time would be spent in the field to closely monitor and record the time and resources spent on each activity. However, such an approach would require a considerably more resources than those available for this work.

The perspective used for estimating the cost of POR was the public sector provider perspective as the majority of costs incurred for malaria are from the public sector with prevention and treatment provided free by the government at the time of this analysis.

The findings of this work are based on a hypothetical resurgence scenario. Although the probability and magnitude of resurgence are difficult to predict, historical evidence from Sri Lanka and other countries suggests that weakening vigilance and waning financing provide a high risk for malaria resurgence [7]. In this study, the cost of resurgence was over 14 times the cost of POR with a healthy ROI of 13 to 1. Varying the risk and probability of resurgence consistently outweighs the cost of investing in POR.

The major cost driver in the resurgence scenario was vector control. The analysis used conservative estimates of vector control coverage of 4% for IRS and targeted LLIN coverage to populations at risk. The authors recognize that the resulting ROI is based on these assumptions; however, historical evidence from Sri Lanka, experience from other countries, and expert consultations on the intervention cover- age in a potential resurgence scenario were used to inform these assumptions.

The total income approach was used to compute income losses from malaria mortality. Although this methodology provides more generous estimates of losses than other methods, given the small number of deaths in the resurgence scenario, the use of this method is not likely to have resulted in a significantly higher than expected ROI.

There are currently no global recommendations on the specific mixes of interventions needed for elimination and POR, and little data on the effectiveness and cost-effectiveness of the various strategies for POR. The AMC has largely suspended vector control activities in favor of rigorous epidemiological and entomological surveillance. Decisions on intervention selection were made by experts with in-depth historical knowledge of malaria epidemiology in Sri Lanka, bolstered by pragmatic decision-making. These cost estimates are largely founded on the assumption that the current strategy in Sri Lanka will continue to succeed in preventing POR. Nevertheless, without a transmission model or comparative trial data to assess the epidemiological and economic efficiency of the intervention mix, it is difficult to recommend optimal strategies or to judge if further cost savings can be accrued through technical and programmatic efficiencies.

When compared with projected "top-down" cost estimates from the NSP, the economic cost is approximately 43% higher as our estimates include societal costs to the health system including health worker salaries in the integrated health system. Using financial costs only demonstrated similar estimates to the NSP projections with a financial cost of 7% less than the top-town budget projections. In addition, the NSP projections do not include the savings that the AMC had accrued from insecticide procurement from targeting IRS to high-risk areas.

Despite the robust benefits associated with investing in malaria POR, Sri Lanka's program is likely to face a gap in funding in the immediate future. Funding for malaria from government sources met only 53% of the total needs in the country, as estimated by this study. This gap is likely to be much higher after 2018 when the Global Fund grant ends, which unless bridged by domestic resources will result in a severe funding cliff with potential devastating effects on the malaria program.

Despite the waning commitment from donors and shifting of government priorities, there are several opportunities within the country to mobilize additional resources for POR. Sri Lanka currently allocates only about 0.43% of their total domestic expenditure on health to malaria [5]. A recent analysis by Jha and colleagues suggest that if Asian countries were to allocate 2 % of their health budgets to malaria, the funding gap would be reduced significantly [28]. Increasing the funding domestically or identifying alternative financing mechanisms is imperative to sustaining the gains in malaria control and elimination in Sri Lanka.

Sri Lanka's economy has experienced strong growth rates in recent years. The flourishing economy presents an opportunity for the government to increase its domestic allocations for health and hence funding for malaria. Tax revenues constitute only around 13.1% of Sri Lanka's total GDP in

2013, although the government of Sri Lanka has recently announced new adjusted tax proposals [29,30]. Raising tax revenues to amount to 20% of GDP as recommended by the Addis Ababa accord for the Sustainable Development Goals would generate an additional revenue of USD4.35 million per year—a potential funding source for malaria POR [31]. The private sector is also a major player in Sri Lanka's economy. A total of 40 companies collectively spend about USD 30.5 million annually on corporate social responsibility (CSR) covering a wide range of development issues [32]. The CSR consortia in Sri Lanka has recently partnered with Sri Lanka's Public Health Department for dengue eradication. Tapping into the resources from CSR programs of large multinational firms operating in Sri Lanka to fight malaria may also be a potential resource for POR. Sri Lanka has already adopted a policy for discouraging alcohol consumption and smoking by raising taxes on both products in recent years providing additional government revenue. Exploration of other means of augmenting domestic financing using innovative approaches such as health and diaspora bonds and airline and financial transaction taxes have the potential to supplement government revenue, which can be used for health including malaria [22].

High-level advocacy to policy makers and donors is needed to ensure sustained financing for malaria. This study provides compelling evidence on the economic benefits of continued prioritization of funding for malaria, which can be used to strengthen the advocacy argument for increased domestic and external funding to keep Sri Lanka malaria free.

5.7 Acknowledgments

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CHAPTER 6

An Investment Case for Eliminating Malaria in the Asia Pacific Region

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6.1 Abstract

Background: The Asia Pacific region has made significant progress against malaria, reducing cases and deaths by more than 50% between 2010 and 2015. Multiple factors have contributed to these reductions including strong political and financial commitment of governments, donors, and partners. However, the region continues to face a high burden of malaria. Gains made against the disease are fragile, threatened by declining funding and persistent health system challenges, particularly the risk and spread of antimalarial drug resistance. To address these challenges, leaders in the region have committed to a goal of malaria elimination by 2030, endorsing a detailed plan to accelerate progress as outlined in

the Asia Pacific Leaders Malaria Alliance (APLMA) Malaria Elimination Roadmap. Achieving this will require an intensification of efforts accompanied by a plan for sustainable financing for the region. This article presents an investment case for malaria in Asia Pacific by estimating the costs and benefits of sustaining investments until elimination is achieved in the region.

Methods: A mathematical transmission model was developed to project rates of decline of malaria and determine the associated costs of the interventions that would need to be undertaken to reach elimination on or before 2030. 80 scenarios were modeled under various assumptions of resistance, MDA and LLIN coverage. The scenario that allowed attainment of the elimination threshold was considered the elimination scenario. Using outputs from the model, the mortality and morbidity averted from malaria elimination were estimated and health benefits were monetized by calculating the averted cost to the health system, averted cost to individual households, and averted cost to society. The full-income approach was used to estimate the economic impact of lost productivity due to premature death and illness and a return on investment was computed.

Findings: The study estimated that by using a variety of interventions, all 22 countries in the Asia Pacific region could achieve elimination of *Plasmodium falciparum* and *Plasmodium vivax* malaria, up to two years before the regional 2030 target and at a cost of USD 29.02 billion between 2017-2030. Approximately 80 per cent of the cost will be incurred in South Asia. Compared to a business as usual scenario, interrupting local transmission can save over 400,000 lives and avert 123 million malaria cases, translating to almost USD 90 billion in economic benefits. Discontinuing vector control interventions and reducing treatment coverage rates to 50% will reverse the gains made, resulting in an additional 845 million cases, 3.5 million deaths, and excess costs of USD 7 billion. Malaria elimination in the Asia Pacific region has a return on investment of 6:1. Despite this evidence, there remains a significant annual gap in funding of about 80% of the estimated cost of elimination between 2018-2020 in the region, emphasizing the need for sustained financial resources.

Interpretation*:* This investment case provides compelling evidence for the benefits of continued prioritization of funding for malaria and can be used to develop an advocacy strategy for increased domestic and external funding for the region to reach its goal to be malaria-free by 2030.

6.2 Introduction

The Asia Pacific region has achieved significant gains against malaria over the last decade. Malaria cases and deaths have declined by more than 50% between 2010 and 2015 in the region's 22 malaria-endemic countries.[19] Sri Lanka was declared malaria-free in 2016, becoming only the second country in Southeast Asia, after the Maldives, to successfully eliminate malaria. Apart from India, Indonesia, Myanmar, and Thailand, malaria-endemic countries have reported reductions in malaria incidence of more than 75% since 2000. In Bhutan, China, and Timor-Leste, cases have declined by almost 100%, with less than 200 cases in 2016 [1].

Progress in driving down malaria may be attributed to a number of factors; strong political and financial support from governments and donors like the Global Fund to Fight AIDS, Tuberculosis and Malaria (the Global Fund) has enabled the scale-up of effective interventions to prevent, diagnose, and treat malaria. Financing for malaria in the Asia Pacific region increased from less than USD 100 million in 2000 to about USD 415 million in 2016. Between 2006-2010, the Asia Pacific region attracted between 12% and 21% of global malaria funding from the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) [2]. However, there has been a steady decline in external financing for malaria, particularly for middle-income status countries that experience relatively lower malaria transmission [3].[20] Although domestic financing for malaria has increased in many countries in the last decade, the need for malaria control and elimination far exceeds the available resources, particularly in the context of elimination where malaria is no longer perceived as a priority disease.

Despite the progress and opportunities for elimination, malaria remains a major cause of death and illness in the region with an estimated 1.72 billion people at risk of the disease in 2016 [4]. The recent gains made are fragile and investments could be lost if malaria resurges. The case for malaria elimination has never been stronger, particularly with the growing threat of antimalarial drug resistance arising from the Greater Mekong Subregion (GMS) and the risk of it spreading to other regions. Reduced funding or political commitment has historically been linked to 75 resurgences of malaria in 61 countries since the 1930s [6]. However, in order to achieve a malaria-free Asia Pacific – a goal endorsed by

[19] The Asia Pacific region in this report encompasses the 22 malaria-endemic countries as defined by APLMA. Sri Lanka has since been declared as malaria free but still implements prevention of reintroduction activities. Countries include: Afghanistan, Bangladesh, Bhutan, Cambodia, Democratic People's Republic of Korea (DPRK), India, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea (PNG), People's republic of China, Philippines, Republic of Korea (ROK), Solomon Islands, Sri Lanka, Thailand, Timor Leste, Vanuatu and Vietnam.

[20] Low transmission refers to low-burden, pre-elimination, and elimination settings.

leaders at the highest levels though the Asia Pacific Leaders Malaria Alliance (APLMA)[21] – financial resources will need to be sustained [5].

Countries and partners need better estimates of the resources required to eliminate malaria in the long term, as well as evidence on the financial and economic benefits of investing in malaria elimination in order to advocate for more resources. The objectives of this study were to estimate the cost to achieve malaria elimination in the Asia Pacific region by 2030; generate an investment case for malaria by estimating the economic benefits of malaria elimination and prevention of reintroduction (POR) and; identify the funding gaps and explore the potential opportunities for generating financial resources for achieving malaria elimination goals.

6.3 Financing for malaria in the Asia Pacific region

The main sources of financing for malaria in Asia Pacific are domestic government resources and external financing from donors. Although domestic financing for malaria has increased by over 40% in Asia Pacific between 2015-2017 compared to 2012-2014 [5], most national malaria control programs (NMCPs) in the region continue to be highly reliant on external financing, particularly from the Global Fund. As Figure 1 illustrates, almost 50% of the total funding for malaria in Asia Pacific in 2016 was from the Global Fund. This dependence on external financing is projected to continue [7].

6.4 Methods

We used outputs from a mathematical transmission model to estimate the costs and benefits of malaria elimination. The model estimated the impact of several intervention scenarios on the transmission of *P. falciparum* and *P. vivax* malaria from 2016 to 2030 in each of the 22 countries. Data used to calibrate and validate the model were sourced from World Malaria Reports [1, 4. 9-15], peer reviewed literature on G6PDd prevalence and the Earth System Research Laboratory website for El Niño Southern Oscillation time series [16. 17]. This data was used to build ranges of plausible estimates of several malaria-related indicators including estimated cases [18].

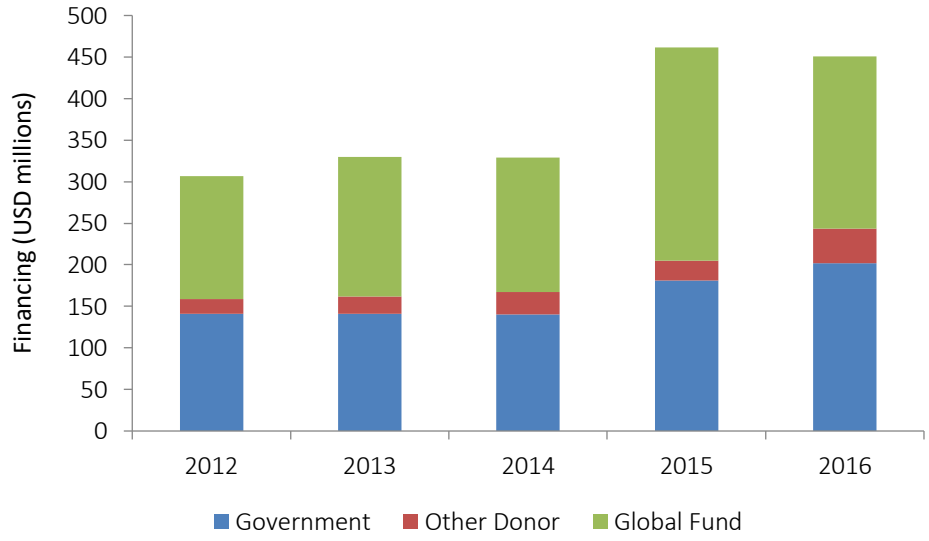
The model was validated separately against the estimated burden of disease for *P. falciparum* and *P. vivax* and accumulated case mortality. Several indicators (such as the

[21] At the 2013 East Asia Summit (EAS), the Asia Pacific Leaders Malaria Alliance (APLMA) was established to accelerate progress towards a reduction in malaria cases and deaths. In 2014 at the ninth EAS, the APLMA Co-Chairs (the Prime Ministers of Viet Nam and Australia) tabled a recommendation for the Asia Pacific region to become free of malaria by 2030. EAS Heads of Government agreed to the goal, and tasked APLMA Co- Chairs to present a plan to reach malaria elimination through a "Leaders Malaria Elimination Roadmap". The APLMA roadmap was presented to Heads of Government during the 10th EAS Meeting in 2015.

estimated incidence of all malaria species and reported fatalities) were modeled for each country between 2016 and 2030, under scenario-specific assumptions. Eighty (80) scenarios were simulated, based on 10 different sets of packages of interventions. These ranged from discontinuing most malaria activities to a very substantial scale-up of interventions, which could be supplemented by mass drug administration (MDA) or an increase in the coverage of Long-lasting Insecticide Treated Nets (LLINs), at either a stable or increasing trajectory of drug resistance [19]. The last component was a full costing of each scenario by computing the costs of interventions per country, year and component and developing an investment case.

While the reported coverage of interventions (particularly long lasting insecticide-treat nets (LLINs) and indoor residual spraying (IRS)) were included in the model to inform changes in incidence, there was little available data on coverage of other interventions between 2000 and 2015, such as the introduction of community health workers). These coverage statistics were therefore imputed based on observed changes in reported incidence. The mortality predicted by the model was validated against reported deaths. A full description of the model is available elsewhere [19].

Figure 6.1. Financing for malaria in the Asia Pacific region



Source: [8]

6.4.1 Elimination scenarios

A total of 80 (eighty) scenarios were generated. We modeled four counterfactual scenarios (Nos. 1-4 in Table 6.1) including one “business as usual scenario” in which coverage remained the same as for 2015 (the last data point for which covariate rates were available for all 22 countries), and three reverse scenarios that simulated the potential impact of

scaling down the malaria program. The six elimination scenarios (No. 5-10 in Table 6.1 were modeled sequentially to increase in complexity and in the number of interventions included.

Table 6.1. Modeled scenarios

	Scenario	Description
1	Business as usual	• Continue all interventions at 2015 levels from 2016 through 2030
2	Reverse scenario 1	• Business as usual • IRS activities ceased
3	Reverse scenario 2	• Reverse scenario 1 • Distribution of new LLINs ceased
4	Reverse scenario 3	• Reverse scenario 2 • Treatment rates reduced by 50%
5	Universal coverage	• Business as usual • Coverage of population at risk with test and treat increased from 2017 onwards in a linear fashion over eight years to 80% by 2025 • Quinine is switched to injectable artesunate for management of severe disease in 2017
6	IRS	• Universal coverage • IRS coverage in 2017 doubled in a linear fashion over eight years
7	Effective usage	• Universal coverage • Effectiveness of LLINs increased • Surveillance increased
8	New *P. vivax* treatment	• Effective usage • Replace primaquine with a new *P. vivax* treatment
9	New LLINs	• New *P. vivax* treatment • Life of LLINs doubled
10	New *P. falciparum* treatment	• New LLINs • First-line Artemisinin based Combination Therapy (ACT) replaced with new candidate for *P. falciparum* treatment
	Assumption	**Description**
A	Artemisinin resistance	5% probability of treatment failure from ACTs across all countries is constant until 2018 and then increased to 30% through 2025
B	MDA	Five annual rounds of MDA at 50% coverage from 2018 starting four months before the peak of the transmission season targeted at both species
C	LLINs	Scaling up LLINs to 80% effective coverage deployed in a 3-year cycle (50%, 25% and 25%)

For each country, we determined the minimum package of interventions that would achieve malaria elimination, defined here as one year with less than one reported clinical case. This was taken to be the minimum elimination scenario for that particular country. Since the model did not distinguish between indigenous and imported cases, we assumed that certain thresholds of cases are imported, which we subtracted from the model outputs. In addition, we simulated the effect of improved targeting of malaria interventions on both costs and epidemiological outputs. We did this by reducing intervention coverage by 30% among the population at risk (PAR) for all scenarios, with and without the resistance and mass drug administration (MDA) assumptions.

The outputs of averted mortality and morbidity under the elimination scenarios were expressed as reported cases and deaths (projected from reported cases) and estimated cases and deaths projected from a range of estimates. Averted cases and deaths were then used to estimate the cost, benefits, and returns on investment (ROIs).

6.4.2 Additional assumptions

We applied additional assumptions to simulate various possible outcomes across all 10 scenarios: (i) the first was around the occurrence of artemisinin resistance; across all scenarios, a baseline treatment failure rate of 5% was applied in all countries from 2016-2030. Under the resistance assumption, the probability of treatment failure was kept constant at 5% through 2018 and increased to 30% between 2018 and 2025; (ii) the second assumption concerned the use of MDA. MDA was simulated as five annual rounds of dihydroartemisinin-piperaquine at 50% coverage of the population at risk from 2018 onwards, starting four months before the peak of the malaria transmission season; (iii) n a third set of simulations, LLIN scale-up was added to all the elimination scenarios in accordance with WHO guidelines for vector control, if malaria elimination was not achieved by 2030. LLIN scale-up was defined as LLIN coverage of up to 80% coverage achieved through three-year distribution cycles from 2017 to 2026. These additional rates of decline were projected separately.

These additional scenarios produced a total of 80 scenarios: with and without resistance; with and without MDA; and with and without LLIN scale up to 80%.

6.4.3 Population at risk

For all the scenarios, a declining population at risk (PAR) was assumed in the model. PAR values used to estimate costs in the model were adjusted to reflect the decreases in incidence predicted from the implementation of elimination-focused interventions. Historical incidence and PAR data were analysed statistically to infer a predicted change in PAR for a given change in incidence. This relationship was applied to the 2015 PAR data and

updated every year until 2030 as interventions were applied in the modeled scenarios. This method has limitations, including a non-standardized definition of PAR.

6.4.4 Cost projections

We built a cost estimation model aligned with the outputs of the transmission model to estimate the total costs associated with implementing each of the scenarios above. Program costs included the costs of testing and treating uncomplicated or outpatient (OP) and severe or inpatient (IP) malaria cases; vector control (i.e., LLIN distribution and IRS); supply chains; surveillance through community health workers; information, education, communication; training; MDA; new treatments (e.g., tafenoquine for *P. vivax*); and rollout of new LLINs. Unit costs for each activity were obtained using a combination of empirical data collected in various Asia Pacific countries by the authors, literature reviews, and proxies when the previous options were unavailable (Table S1).

In addition, we simulated the effect of improved targeting of malaria interventions on both costs and epidemiological outputs on cost. We did this by reducing intervention coverage by 30% year-to-year among the PAR for all three scenarios with and without the resistance assumption.

The total cost of the elimination scenarios was used to build this investment case. We calculated the costs to reach elimination separately for each country and then summed them to obtain the total cost for elimination in the Asia Pacific region. To calculate the incremental or additional costs of malaria elimination (which were used to calculate ROIs), we subtracted the estimated costs of the business as usual and reverse scenarios from the elimination scenario. All monetary figures are expressed in 2015 constant USD.

6.4.5 Economic benefits estimation

Using outputs from the model, we estimated the mortality and morbidity averted from malaria elimination by subtracting the estimated cases and deaths of the elimination scenario from the corresponding outputs of the “business as usual” and “reverse” scenarios. We then monetized these health benefits by looking at the averted cost to the health system, averted cost to individual households, and averted cost to society:

- Cost averted to the health system includes costs associated with diagnosis and treatment costs of IPs and OPs;
- Cost averted to the individual households is out-of-pocket (OOP) expenditures for seeking care; and
- Cost averted to the society due to patients’ lost productivity due to premature death and morbidity and caregivers’ reduced economic output.

The same cost inputs used in the cost estimation were used for calculating the economic benefits. Unit costs for case management included costs for OP visits, diagnostic tests, and drug treatments for OP malaria cases, as well as hospital hotel costs and drug treatments for IP malaria cases. OOP expenditures were estimated by applying country-specific OOP expenditure per capita separately for OP and IP cases. We calculated productivity losses among patients and caretakers by multiplying an estimate of daily productivity by the number of days lost due to illness or care seeking.

We used the full-income approach to estimate the economic impact of lost productivity due to premature death from malaria. We multiplied the number of averted deaths for each country by the country-specific values of additional life years (VLYs) and life expectancies at age 40 among males and females, which was the assumed average age of death due to malaria. One VLY was estimated to be 2.2 times the gross domestic product (GDP) per capita for each of the countries in South East Asia and the Pacific and 2.8 times the GDP per capita for each of the countries in South Asia, as suggested by the *Lancet Commission on Investing in Health* [20].

All costs and economic benefits were discounted at 3%.

6.4.6 Return on investment

The ROI was calculated by subtracting the incremental cost of elimination from the economic benefits, and dividing the resulting figure by the incremental cost of elimination. The ROI is interpreted as the economic return from every additional dollar spent on malaria elimination. We performed the analysis for 2017-2030 by comparing the elimination scenario with the business as usual and reverse scenarios under the stable and increasing resistance assumptions.

6.4.7 Uncertainty analysis

We performed stochastic sensitivity analysis on the epidemiological and cost outputs of the malaria transmission model. The minimum, median, and maximum malaria cases and deaths predicted by the model for each scenario were used to calculate the minimum, median, and maximum economic benefits. For the costs, we assigned an uncertainty interval of +/-25% on the value of the input costs used. Three hundred random samples were drawn, which generated a range of costs. From the range of costs generated, we determined the minimum, maximum, median, mean, and other percentiles.

6.4.9 Gap analysis and opportunities for resource mobilization

Using available malaria financing data in the region (donor and domestic), between 2017-2020, we estimated the potential gap in financing assuming the total funding envelope would remain as projected. We also assessed potential opportunities for resource

mobilization to fill financing gaps by mapping private sector investors and analysing the domestic funding landscape.

Research in context

Evidence before this study: Several attempts have been made to forecast the financing needs for countries to reach elimination and to determine the economic benefits of these efforts in the Asia Pacific. In 2015, APLMA estimated that just over USD 1 billion per year would need to be spent in the first five-year phase of Asia Pacific malaria elimination, and just under USD 2 billion per year in subsequent phases leading to over 200 million preventable malaria cases and 1.3 million deaths averted by 2030 [21]. These estimates, however utilized the outputs of a transmission model developed for the Global Technical Strategy for Malaria 2016–2030, which is almost exclusively focused on *P*. *falciparum* malaria transmission dynamics from Sub-Saharan African countries. This makes the model of limited usefulness for Asia, which has higher proportions of *P. vivax* and a lower overall burden. Furthermore, the model forecasts the cost of reducing malaria morbidity and mortality by 90% between 2015 and 2030 and not elimination *per se*. Costed National Malaria Strategic Plans (NSPs) for malaria in each of the 22 malaria-endemic countries have also be used as an indicator of financial need. However, the cost estimates in the NSPs are often shorter-term and are not purposefully calibrated for elimination. In addition, they do not build in efficiency measures and are therefore likely to be overestimates.

Added value of this study: This is the first investment case developed using the output of a multispecies transmission model developed specifically for malaria elimination in the Asia Pacific region. In most cases, costs were obtained directly from the countries, making the estimates more plausible. The investment case, gap analysis and potential resource mobilization strategies presented are context specific making the evidence more likely to be used by policy makers in the region.

Implications of all the available evidence: Declining financing for malaria is an imminent threat to malaria elimination. The investment case for malaria elimination is robust. Malaria elimination will cost USD 29.02 billion between 2017-2030. Although the short-term investment needed may seem substantial, these are time-limited as costs taper off significantly as more countries eliminate the disease. Interrupting local transmission can save over 400,000 lives and avert 123 million malaria cases, translating to almost USD 90 billion in economic benefits. This study provides compelling evidence for the benefits of continued prioritization of funding for malaria, and can be used to develop an advocacy strategy for increased domestic and external funding for the region to reach its goal to be malaria-free by 2030. Gaps in financing could potentially be filled using innovative health financing mechanisms to boost domestic spending as well as by mechanisms to increase efficiency and value for money.

6.5 Findings

6.5.1 Projected declines in transmission

The transmission model predicted that malaria elimination can be achieved by all the countries in the Asia Pacific region by 2030 by implementing a variety of scenarios.

Table 6.2. Scenarios and predicted elimination dates

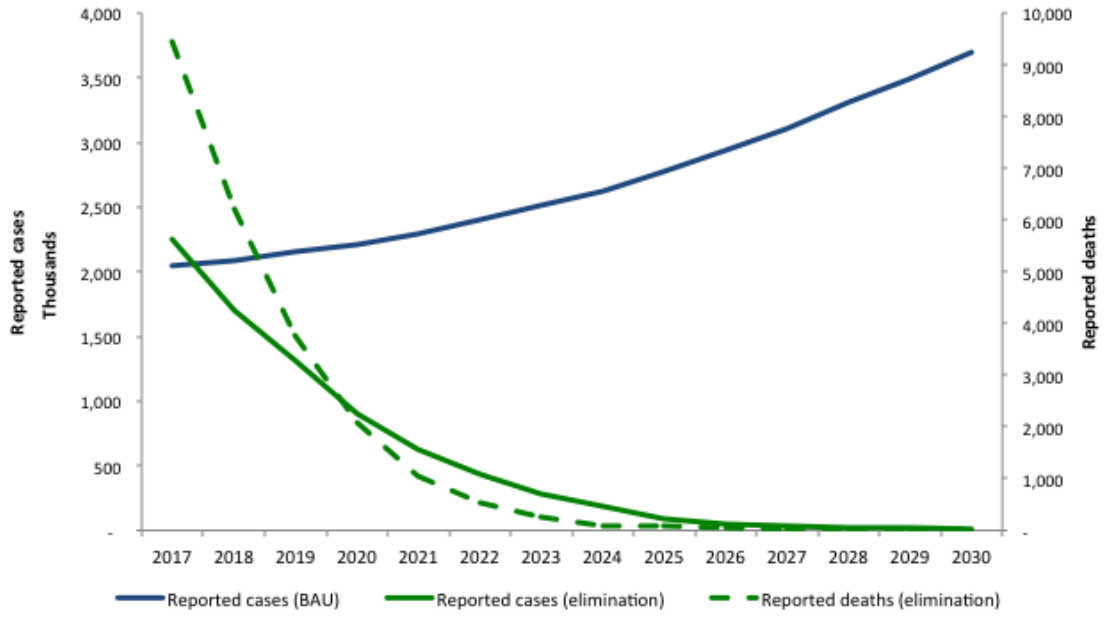
Country	Minimum elimination scenario and interventions	MDA	LLIN	Elimination date (predicted range)	National elimination goal
Afghanistan	Effective usage	Yes	Yes	2025 (2025,2027)	None
Bangladesh	Effective usage	No	No	2025 (2024,2029)	2035
Bhutan	Effective usage	No	No	2024 (2023, 2025)	2018
Cambodia	New LLINs	Yes	No	2023 (2022, 2030)	2025
China	Business as usual (already eliminated by 2017)	No	No	2017	2020
DPRK	New *P. vivax* treatment	No	Yes	2028 (2027, 2030)	2025
India	New LLINs	No	Yes	2028 (2026, 2030)	2030
Indonesia	Effective usage	Yes	No	2025 (2022,2028)	None
Lao PDR	New *P. falciparum* treatment	Yes	Yes	2025 (2022,>2030)	
Malaysia	IRS	No	No No	2023 (2019, 2029)	2020
Myanmar	New *P. falciparum* treatment	Yes	Yes	2025 (2024,>2030)	None
Nepal	Effective usage	No	No	2022 (2017, 2026)	2026
Pakistan	Effective usage	Yes	Yes	2022 (2021, 2030)	None
PNG	Effective usage	Yes	No	2025 (2025,2028)	
Philippines	Effective usage	No	No	2021 (2017,2023)	2030
ROK	Business as usual	No	No	2017 (2017,2019)	2017
Solomon Islands	New LLINs	Yes	No	2028(2026, 2029)	
Sri Lanka	Business as usual (already eliminated by 2017)	No	No	Already eliminated in 2013	2012
Thailand	New *P. vivax* treatment	No	No	2026 (2025, 2029)	2024
Timor-Leste	Universal coverage	No	No	2019 (2017,2024)	
Vanuatu	Effective usage	Yes	No	2021 (2021, 2024)	2025
Viet Nam	Effective usage	No	No	2024 (2022, 2027)	2030

Table 6.2 illustrates the predicted output of the transmission model under an assumption of increasing artemisinin resistance and identifies the minimum elimination scenario defined as the scenario under which the country can achieve elimination on or before 2030 with the least amount of effort.

The model predicted that it is possible for all 22 countries to achieve elimination of *P. falciparum* and *P. vivax* by 2030. China, ROK, and Sri Lanka[22] are the only countries predicted to achieve elimination without scaling up current interventions. Elimination is possible in Cambodia, DPRK, India, Lao PDR, Myanmar, Solomon Islands, and Thailand by 2030 using new tools and technological innovation. Elimination is predicted to be possible by 2030 only through the addition of MDA in Afghanistan, Cambodia, Indonesia, Lao, Myanmar, Pakistan, PNG, Solomon Islands, and Vanuatu. In all other countries, elimination is possible with the scale up of existing interventions.

Figure 6.2 illustrates the median reported cases and deaths between 2017-30 under the "business as usual" scenario and minimum elimination scenarios for the region. These are predictions projected from the *reported* cases in 2015. Figure 3. Illustrates the median estimated cases and deaths between 2017-30 under the "business as usual" scenario and minimum elimination scenarios for the region. These are predictions projected from the *estimated* cases in 2015.

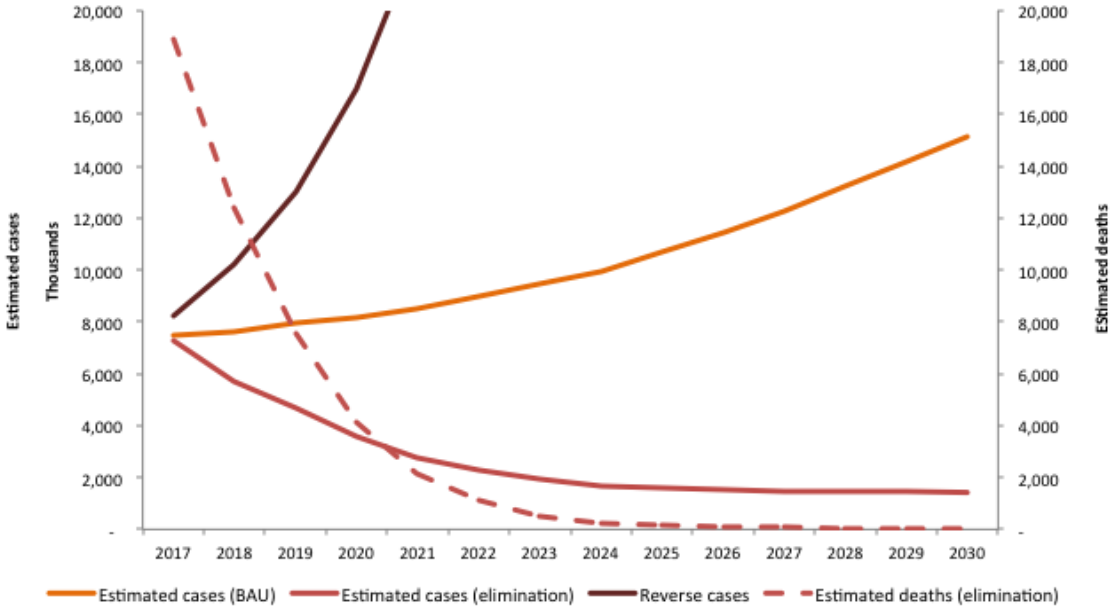
Figure 6.2. Transmission prediction for the Asia Pacific region, 2016-2030 (reported cases and deaths)



BAU – Business as usual scenario; Elimination – elimination scenario

[22] Sri Lanka saw its last indigenous case in 2012 and obtained WHO certification in 2016.

Figure 6.3. Transmission prediction for the Asia Pacific region, 2016-2030 (estimated cases and deaths)



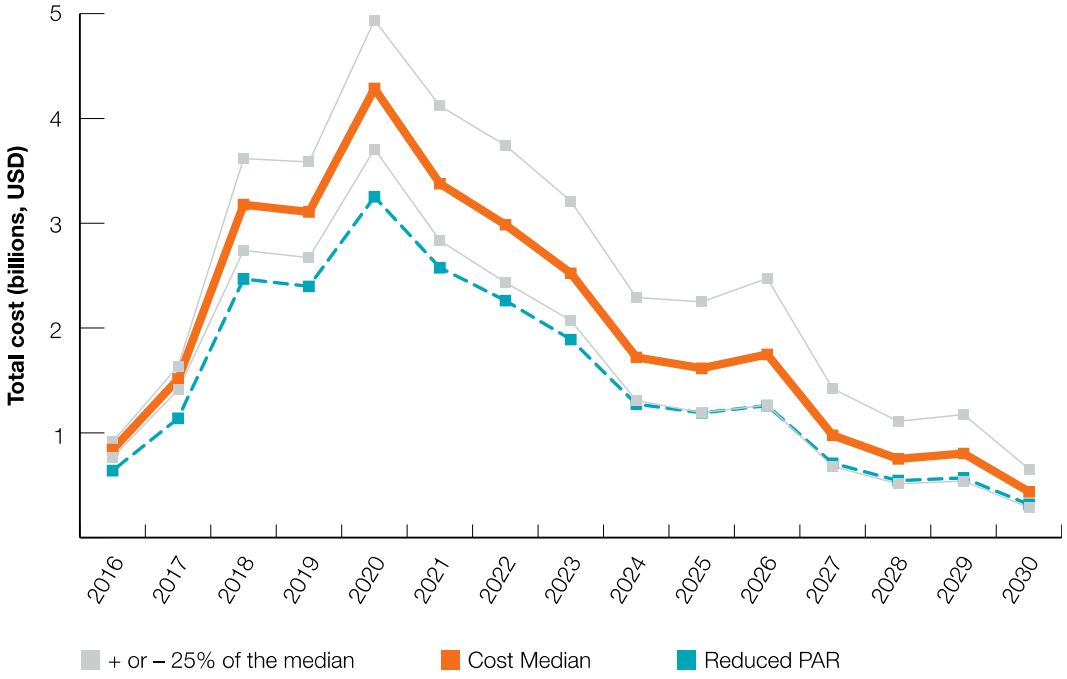
In the business as usual scenario for all countries in the region, clinical cases rose from an estimated 7 million in 2016 to 15 million in 2030. Implementing the elimination scenario in each country will avert a total of over 123 million clinical cases and approximately 3.5 million deaths in the region over 14 years. In a "reverse" or worst case scenario, where interventions are halted and reduced (reverse scenario), cases increase to about 180 million by 2030. There would be about 1 billion additional cases and 3.5 million additional deaths, costing an excess of USD 7 billion between 2016-2030.

6.5.2 Cost of malaria elimination through 2030

The cost of malaria elimination is shown in Figure 4 and Table 3 The total cost to achieve malaria elimination in the Asia Pacific between 2017-2030 was estimated to be USD 29.024 billion (range: USD 23.65-36.23 million). The median cost in 2017 for the elimination scenarios was about USD 1.5 billion. Costs peak in 2020 at USD 4.29 billion, then decrease to less than USD 1 billion in 2027 and less than USD 450 million in 2030 when elimination is expected to be achieved in all 22 countries. Lower costs incurred are expected to continue after the elimination date as POR of malaria interventions continue.

The reverse scenario would cost an excess of USD 7 billion between 2017-2030. If interventions were only applied to 70% of the PAR in the low transmission areas (a crude proxy for the effect of improved targeting of interventions), the total cost would be about USD 22.49 billion.

Figure 6.4. Modeled costs of the elimination scenario, 2016-2030



	Median cost of elimination scenarios (USD)	
2017-2020: 12,085,202,018	2021-2025: 12,221,791,374	2026-2030: 4,716,224,691

Figure 6.5. Modeled regional and country level costs of the elimination scenario until 2030

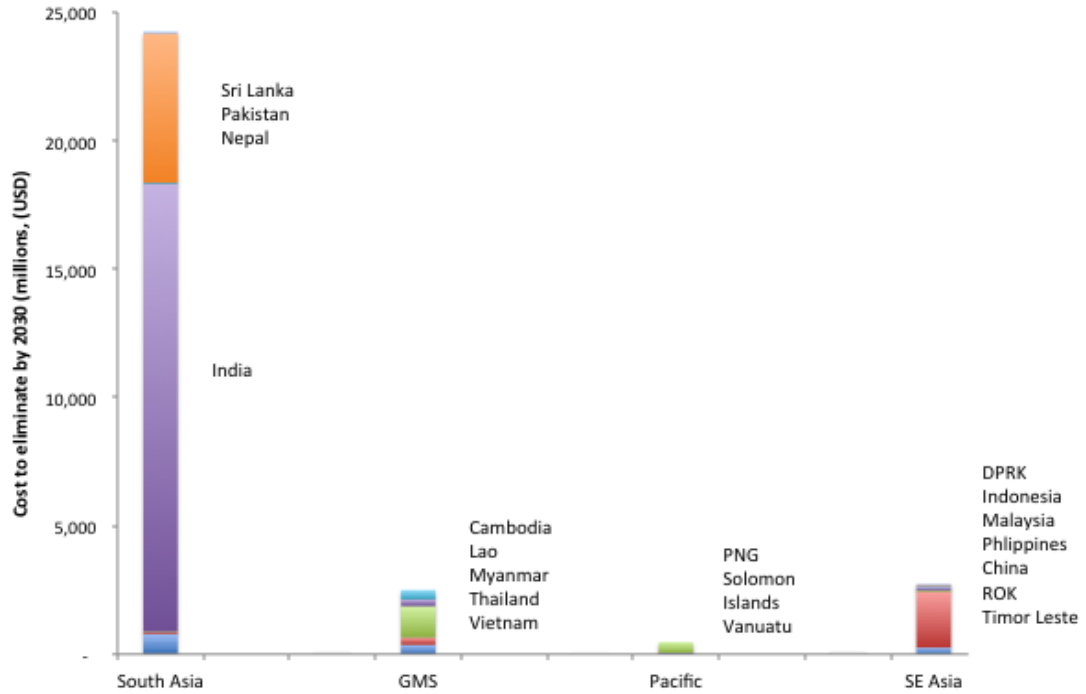


Figure 6.5 illustrates the regional and country level costs for the total PAR for 2017-2030. The figure illustrates how the relative costs are skewed by sub region and country with over 80 per cent of the costs expecting to be incurred in South Asia – most notably, India.

6.5.3 Economic benefits estimation

Compared to a business as usual scenario, interrupting local transmission can save over 400,000 lives and avert 123 million malaria cases, translating to almost USD 90 billion in economic benefits. The economic benefits included costs averted for diagnosis and treatment costs as inpatients and outpatients, costs averted to individual and households and the monetized value of lost productivity due to premature death and morbidity and caretaker's reduced economic output as a result of taking care of patients. Discontinuing vector control interventions and reducing treatment coverage rates to 50% will reverse the gains made, resulting in an additional 845 million cases, 3.5 million deaths, and excess costs of USD 7 billion.

6.5.4 Return on investment

The cost of malaria elimination should be weighed against the epidemiological and economic costs of inaction. When the net benefits of elimination compared to the cases and costs averted in the business as usual scenario of the transmission model for the period of 2017 to 2030, the median ROI for each additional dollar invested in malaria elimination was calculated to be 6:1. This increases to 7:1 if interventions are better targeted in low risk areas.

Table 6.3. Summary of costs and benefits, 2017-2030

Scenarios compared	Total cost (USD)	Estimated clinical cases averted	Deaths averted	Economic benefits (USD)	Incremental cost (USD)	ROI
Business as usual vs. elimination (with resistance assumption)	29.024 billion (range: 23.64-36.23) 21.85 billion	123.14 million (estimated) [23] 16.54 million (reported)[24]	386,167 (estimated) 193,084 (reported)	87.73 billion	14.05 billion	6:1
Business as usual	28.953	92.23	264,322	72.90	13.79 billion	5:1

[23] Projected from estimated cases

[24] Projected from reported cases

Scenarios compared	Total cost (USD)	Estimated clinical cases averted	Deaths averted	Economic benefits (USD)	Incremental cost (USD)	ROI
vs. elimination (baseline)	billion (IQR: 23.38-35.72)	million (estimated clinical) 11.68 million (reported)	(estimated clinical) 132,161 (reported)	billion		
Reverse vs. elimination (with resistance assumption)	NA	845.73 million	3.487 million	N/A	6.693 billion	N/A

6.5.5 Financial gap

A median resource envelope of about USD 3 billion is needed annually to achieve elimination between 2018-2020. Total financing for the region is projected to be USD 0.5 billion annually for 2018-2020. Therefore, the anticipated gap is therefore likely to be over 80% of the resources required for elimination between 2018-2020.

3.5.6 Sensitivity analysis

Figure 6.7. Sensitivity analysis of cost of elimination (2016-2030)

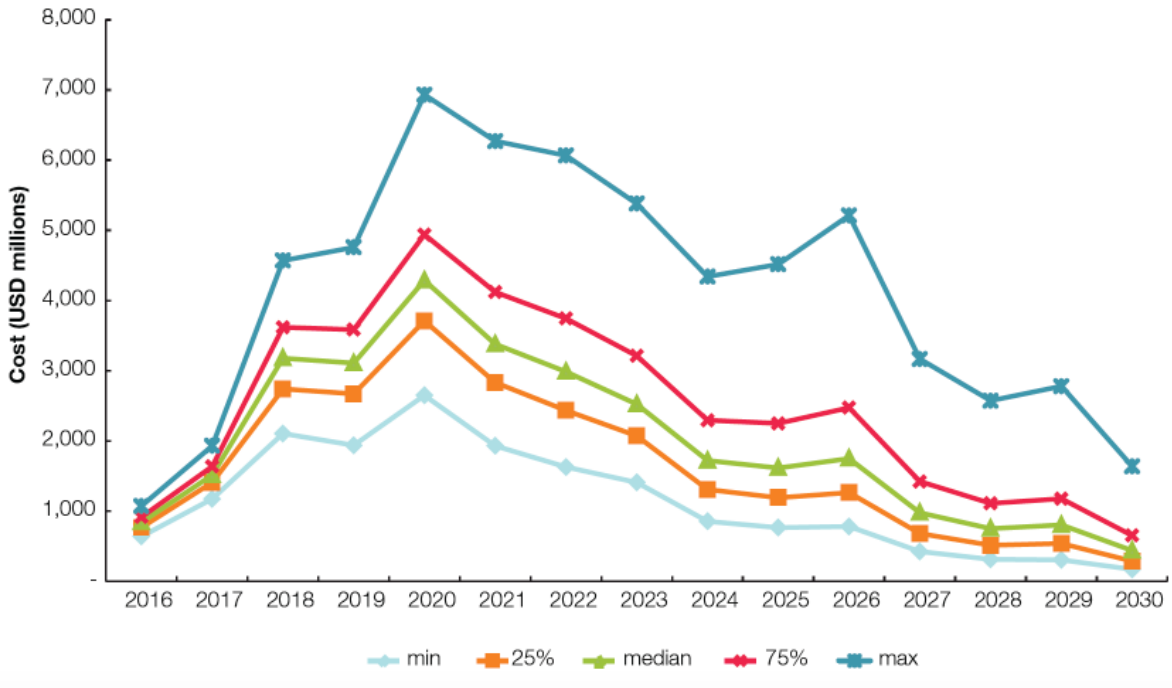
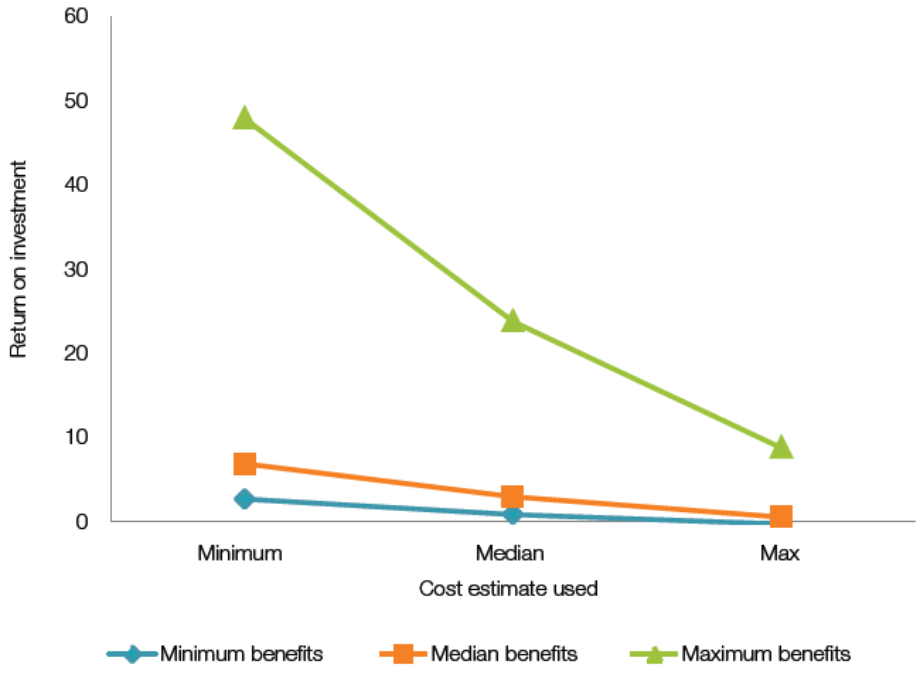


Figure 6.7 illustrates the sensitivity of the total cost to the individual cost inputs. At the peak in 2020, costs vary from USD 2.5 billion to USD 7 billion. Figure 6. 8 illustrates that using minimum values of the benefits will still produce a positive ROI.

Figure 6.8. ROI estimates for malaria elimination using outputs of sensitivity analysis



6.6 Discussion

This analysis compared the monetized value of expected benefits from malaria elimination to the investment costs over a 14-year investment period (2017–2030) in the 22 malaria endemic countries of the Asia Pacific, demonstrating a robust median return of about six times the incremental investment.

The study found that by employing a variety of existing and new interventions, all countries in the Asia Pacific could eliminate malaria by 2028 – two years before the 2030 APLMA regional goal. The health, social, and economic returns are potentially formidable. Malaria elimination will save over 400,000 lives and avert over 123 million cases, translating to economic benefits of almost USD 90 billion.

Successfully achieving elimination, however, will require sustained financial resources. Our model estimates that the total cost of achieving elimination and POR is about USD 29.02 billion (range: USD 23.64-36.23 billion) over 14 years or USD 12 billion between 2017-2020. Total financing for malaria in the Asia Pacific in 2016 was estimated at USD 415 million.

Using co-financing data from Global Fund concept notes, total financing for malaria was projected at USD 1.4 billion between 2018-2020, leaving an annual gap of about USD 2.5 billion or 80% of the estimated cost of elimination.

Numerous countries in the region continue to rely on Global Fund resources to provide up to 50% of their total financing for malaria elimination. However, the allocation methodology adopted by the Global Fund in 2012, utilizes a combination of disease burden and gross national income (GNI) per capita to determine the financing that countries will receive. By definition, malaria-eliminating countries have lower disease burdens, have higher incomes and are therefore a lessor priority for donors. Country-specific funding from the Global Fund to the sub-set of countries attempting to eliminate malaria has declined by over 30% [2]. Further declines in allocations have been noted under a subsequently revised model adopted in November 2016 [22]. Given the downward trend in malaria burden and the region's rising economic status, this level of support is likely to be even more diminished in subsequent years.

Many malaria-eliminating countries are Middle Income Countries (MICs) as defined by the World Bank [23]. The International Monetary Fund (IMF) projects average annual GDP growth rates of 3-10%, which means that economies in Asia will double or triple in size in the next decade. By 2020, four countries in Asia that are currently Lower-Middle Income Countries (LMICs); Bhutan, Indonesia, the Philippines, Sri Lanka, will surpass the World Bank threshold for MICs of USD 4,125 GDP per capita. This means that while there is increased potential for domestic financing, more countries will also start to graduate out of aid eligibility. Of the 22 countries in the Asia Pacific region, three are currently LICs, 15 are LMICs, and three are UMICs and one is an UIC. Eighteen are currently eligible for Global Fund financing [24] – out of which an additional two countries will be receiving the final transitional grants in the next two years (the Philippines and Sri Lanka). Political and policy changes in other donor constituencies also pose similar risks.

These changing polices have major implications for the financing and delivery of health services, for malaria elimination. Malaria financing will therefore need to depend on larger contributions from government budgets. Indeed, the expectation of the economic and health financing transition suggests that as countries develop they will spend more on health than they did before. Although domestic financing for malaria has increased by over 40% in the Asia Pacific between 2015-2017 compared to 2012-2014 [7], the resources required far exceed the amounts available.

The potential consequences of funding gaps at this critical juncture can be serious. This analysis estimates that scaling back interventions in the Asia Pacific could lead to an additional 3.5 million deaths, almost 1 billion cases, and economic costs of almost USD 7

billion. Emerging artemisinin resistance further threatens the gains made against malaria and regional health security with estimates of 9,560 excess deaths and USD 51 million in productivity losses annually [25].

To ensure an uninterrupted availability of key malaria interventions, mechanisms to augment and prioritize domestic funding and improve efficiencies in the existing malaria envelope will need to be explored. The Addis Ababa Action Agenda calls on a number of resource mobilization efforts encompassing aid, domestic public resources, and support from the private sector [26].

Many national governments are considering raising health budgets by improving the capacity to raise tax revenue including the implementation of Pigovian or sin taxes. In the Philippines, increased taxes on tobacco and alcohol generated USD 2.3 billion within just 2 years, increasing the Department of Health budget by 63% in 2015 [27]. This revenue has freed up resources, which would have otherwise been used for social protection of the poor. Indonesia and Vietnam have similarly implemented such revenue generating structures.

The diversification of Asia Pacific countries' economies, present a unique opportunity to engage the private sector in malaria elimination [28]. Private Asian companies such as AirAsia, Samsung, the Tata group, and Alibaba have become internationally recognizable brands. Government incentives for the private sector engagement could include tax relief or tax credit schemes and policies that promote expansion or diversification of programs. For example, the Cambodian Ministry of Health has developed a policy framework for public-private partnerships in the health sector. Similarly, an airline levy such as the UNITAID model could raise more than USD 300 million per year [29].

Multilateral Development Banks (MDBs) and partners can provide new financing opportunities to governments and the private sector, including cross-sectoral financing for health programs, incentivizing companies to invest in health interventions [30]. Countries can seek out additional grants and soft-loans from MDBs to help frontload the costs of elimination. Several MDBs are currently engaged in innovative models including ADB, the Inter-American Development Bank, the Islamic Development Bank, and others in collaboration with the Bill & Melinda Gates Foundation, the Global Fund and other partners [31-33].

Innovative financing options can also fill the gap between needs and resources until government budgets catch up with the financing transition. These may include health bonds, debt swaps, and blended financing mechanisms. Social impact bonds and development impact bonds are other types of instruments that have been implemented in

selected settings. One example is the Mozambique Malaria Performance Bond, which is being used to raise funding from investors interested in both financial and social returns [34-36]. Such innovative instruments have been used to raise financing for health and other sectors, such as education and environment.

In addition to increasing available health revenue and allocating additional resources, improved efficiencies can generate cost-savings, freeing up resources to cover financing gaps. Assessing and identifying current inefficacies and drivers of inefficiency can increase utilization of current funds.

Many countries will graduate in income status and will graduate from donor financing. Malaria programs, given the low disease burden, may lose eligibility before then. In addition to pursuing additional domestic financing and meeting current co-financing requirements of existing grants, countries should appropriately plan the transition from donor to domestic funding sources 3-5-years in advance of the actual transition [37].

A number of unknown factors and limitations impact the findings of this report. The costs of medicines and other interventions have been estimated based on available data and proxies were used when data were unavailable. The cost of new interventions such as new LLINs and new treatments such as tafenoquine were based on historical estimates of the cost of new tools when they were first adopted rather than actual costs. In particular, separating out the cost of interventions in integrated systems is challenging and the analysts have relied on country-level partners to apportion the amounts spent on each intervention to arrive at disaggregated costs.

The cost estimates produced are highly dependent on the output of the transmission model, which was designed with a single homogeneous patch for the whole of each country, using national level data on incidence and intervention coverage. Treating the whole country as a single unit in this way is likely to lead to over-estimates in costs of elimination. Furthermore, spatial heterogeneity within each country was not modeled. These estimates are therefore subject to error, particularly in countries with heterogeneous transmission patterns. Population movement was not included in the model and this is likely to have reduced the predicted costs. Additionally, elimination often requires targeted interventions to risk areas or populations, rather than ubiquitous coverage to an entire country. Without subnational estimates of incidence and coverage, targeted interventions are difficult to estimate and cost.

We were unable to predict the impact that economic development and housing improvements may have on malaria transmission or how the costs of commodities or interventions may change at the global or national levels. While we modeled for a declining

PAR based on historical changes in PAR compared to changes in incidence, this method has limitations including a non-standardized definition of PAR.

While we have tried to estimate the effect that drug and insecticide resistance would have on cost, it is impossible at this stage to predict accurately the future extent and effect of drug and insecticide resistance and the actual interventions that would be implemented to address these. In addition, the impact and cost of known tools in the innovation pipeline have been modeled, however, the impact of new tools and approaches not yet developed is unknown and will be likely to decrease costs in the long term given that the cost of new tools is greatest at the time of adoption with economies of scale and competition driving costs down over time. It is also difficult to predict how the costs of interventions may change at the regional or national levels over time.

Lastly, current assessments of reported malaria incidence have limitations. Research suggests that there may be significant under-reporting in the scale of global malaria incidence and mortality due to the weakness of health reporting and information management systems as well as widespread and undocumented use of the private sector in many endemic countries. For example, the Institute for Health Metrics and Evaluation estimated a figure of 1.2 million malaria deaths in 2010—almost double the WHO's figure of 655,000 [38]. Similarly, a widely quoted study in the *Lancet* estimated that in India, 205,000 deaths per year could be attributed directly to malaria, which differed by more than ten times the numbers reported by the malaria program in the same year [39].

There have been various attempts at quantifying the true burden of malaria and more recent publications of the World Malaria Reports contain data on reported cases to health facilities as well as estimated cases based on a number of assumptions. This report utilized reported cases from the World Malaria Reports as well as estimated cases for the Asia Pacific countries derived by the Mahidol-Oxford Tropical Medicine Research Unit in collaboration with a number of partners including the WHO [18]. These estimates were obtained by combining and triangulating data from a variety of data sources. Both reported and estimated cases are depicted in the graphs. Nevertheless, the wide variation in estimates of burden makes it harder to be sure of the resources required to eliminate the disease. Without an informed and complete understanding of the current cartography of malaria risk and prevalence, future projections of the cost of eliminating malaria face an overwhelming uncertainty.

We believe that the estimated benefits of elimination are conservative. Beyond the benefits of achieving malaria elimination as explained in this report, other benefits are likely, but are harder to quantify as there are no reliable quantitative estimates on how malaria may impact these. As a by-product of national elimination, other positive externalities are

increased tourism, a strengthened health system, better cognitive development, and improved regional health security. In addition, elimination may bring significant benefits to other regional public goods including opportunities to create stronger cross-border disease coordination. These estimates can therefore be considered conservative.

Because of these uncertainties, estimated costs can only provide an indicative guide or baseline to help determine financing needs. It is therefore important that economic estimates are constantly reviewed in the light of new information, through to 2030. Importantly, due to the diversity of the region, further analysis is required to adapt the model to individual country settings and develop country-level estimates based on the national context. This, however, makes it even more important that funds can be put in place quickly to match currently expected costs.

Despite limitations above, this investment case provides robust evidence of the benefits of continued prioritization of funding for malaria. The ROIs remain robust, comparable to those obtained for other high impact investments such as immunization programs and cardiovascular disease research [40].

Focused advocacy at all levels is needed to reach key decision-makers in order to highlight the social and economic benefits of investing in malaria elimination and the risks of not doing so. In particular, emphasis on the threat of drug resistance in undermining success and posing a risk of regional health security is needed. Continued engagement is needed with governments to focus attention on increased domestic budgets to reach the regional goal of a malaria-free Asia Pacific by 2030.

6.7 Conclusion

Global progress against malaria has been dramatic over the past decade. These gains, however, have been driven by substantial political and financial commitments that must be sustained to avoid a resurgence of malaria. There are several critical reasons why malaria elimination should receive a special focus for financing. Malaria is a major ongoing cost driver burdening national health systems and eliminating the disease will confer public health benefits as well as major cost savings to national health systems. Although the short-term investment needed may seem substantial, these are time-limited as costs taper off significantly as more countries eliminate the disease. Secondly, there is a strong correlation between the decline in malaria burden and financing. Declining financing for malaria is an imminent threat to malaria elimination, the spread of drug resistance, and regional health security in the Asia Pacific region. This investment case provides compelling evidence for the benefits of continued prioritization of funding for malaria, and can be used to develop an

advocacy strategy for increased domestic and external funding for the region to reach its goal to be malaria-free by 2030.

6.8 Abbreviations

ACT: Artemisinin-based Combination Therapy; ADB: Asian Development Bank; APLMA: Asia Pacific Leaders Malaria Alliance; ASEAN: Association of Southeast Asian Nations; GDP: Gross domestic product; Global Fund: Global Fund to Fight AIDS, Tuberculosis and Malaria; GMS: Greater Mekong Subregion; IMF: International Monetary Fund; IP: Inpatient; IRS: Indoor residual spraying; LIC: Low-income country; LLIN: Long-lasting insecticidal net; LMIC: Lower-middle-income country; MDA: Mass drug administration; MDB: Multilateral development bank; MOH: Ministry of Health; NMCP: National malaria control program; NSP: National strategic plan; OECD: Organization for Economic Cooperation and Development; OOP: Out-of-pocket; OP: Outpatient; PAR: Population at risk; PPP: Purchasing Power Parity; POR : Prevention of reintroduction; RDT: Rapid diagnostic test; ROI: Return on investment; STC: Sustainability, transition, and co-financing; UMIC: Upper-middle-income country; USD: United States dollar; VLY: Value of additional life year; WHO: World Health Organization.

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CHAPTER 7

Tracking Development Assistance and Government Health Expenditures for 35 Malaria-Eliminating Countries: 1990-2017

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7.1 Abstract

Background: Donor financing for malaria has declined since 2010 and this trend is projected to continue for the foreseeable future. These reductions have a significant impact on lower burden countries actively pursuing elimination, which are usually a lesser priority for donors. While domestic spending on malaria has been growing, it varies substantially in speed and magnitude across countries. A clear understanding of spending patterns and trends in donor and domestic financing is needed to uncover critical investment gaps and opportunities.

Methods: Building on the Institute for Health Metrics and Evaluation's annual Financing Global Health research, data were collected from organizations that channel development assistance for health to the 35 countries actively pursuing malaria elimination. Where possible, development assistance for health (DAH) was categorized by spend on malaria intervention. A diverse set of data points were used to estimate government health expenditure on malaria, including World Malaria Reports and government reports when available. Projections were done using regression analyses taking recipient country averages and earmarked funding into account.

Results: Since 2010, DAH for malaria has been declining for the 35 countries actively pursuing malaria elimination (from USD176 million in 2010 to 62 million in 2013). The Global Fund to Fight AIDS, Tuberculosis and Malaria is the largest external financial fund for malaria providing 96% of the total external funding for malaria in 2013, with vector control interventions being the highest cost driver in all regions. Government expenditure on malaria, while increasing, has not kept pace with diminishing DAH or rising national GDP rates, leading to a potential gap in service delivery needed to attain elimination.

Conclusion: Despite past gains, total financing available for malaria in elimination settings is declining. Health financing trends suggest that substantive policy interventions will be needed to ensure that malaria elimination is adequately financed and that available financing is effectively targeted to interventions that provide the best value for money.

7.2 Background

The launch of the Roll Back Malaria Partnership (RBM) in 1998 and the Millennium Development Goals in 2000 catalysed unprecedented political and financial commitment for malaria from donors, such as the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund), the US President's Malaria Initiative (PMI), the World Bank, and others as well as endemic countries themselves. As a result, global malaria incidence and deaths have dramatically declined by 41 and 62%, respectively, between 2000 and 2015 [3]. Between 2000 and 2015, 17 countries eliminated malaria, six of which have been certified as malaria-free by the World Health Organization (WHO) [1]. Thirty-five countries are currently actively pursuing malaria elimination, with elimination goals ranging from 2016 to 2035 [2]. According to WHO, 21 countries are in a position to achieve at least one year of zero indigenous cases of malaria by 2020 [3].

Despite this unprecedented progress, donor funding for malaria has declined since 2010 and is projected to continue to decline [4, 5]. These reductions in external financing are even greater for the sub-set of malaria eliminating countries despite demonstrated evidence on the returns on investment from elimination [6]. By nature, these countries have lower disease burdens and are often lower-middle or middle-income countries and therefore a lesser priority for donors [5].

The Global Fund, which has been the largest external financier supporting eliminating nations, has historically dispersed about 7% of its total portfolio to eligible malaria-eliminating countries. However, under the New Funding Model adopted in 2012, resources for this subset of countries declined to less than 5% [5] and have declined further under a revised allocation-based model adopted by the Global Fund Board in November 2016 [7]. Other bilateral and multilateral donors are similarly diverting resources to higher-burden countries with the least ability to pay as measured by their Gross National Income (GNI) [8, 9]. In some cases, donors are entirely moving away from disease-based funding to general system strengthening to address concerns of global health security [10]. While integrated systems might help countries in the final push to malaria elimination and prevent reintroduction of malaria, a well-funded malaria programme, maintaining a level of vertical oversight, is crucial in the short to medium term [10]. At the same time, as the disease becomes less "visible", government funds for malaria are often diverted to other health priorities that are perceived to be greater health threats, risking a reversal of the recent gains made in malaria elimination [11].

Reductions in financing for countries eliminating malaria comes at a critical time—WHO's Global Technical Strategy (GTS) for Malaria 2016–2030 and the Roll Back Malaria Partnership's Action and Investment to Defeat Malaria 2016–2030 (AIM) together with the recently endorsed Sustainable Development Goals, set their sights on rapid progress with malaria elimination towards attainment of malaria free status in 35 countries by 2030. Total funding for malaria control and elimination was estimated at USD 2.9 billion in 2015 [1], representing just 46% of the GTS 2020 milestone of USD 6.4 billion. Achieving the global goals will require sustained financial and political commitment at the global and domestic levels [2]. The investments have the potential to deliver strong health benefits through fewer deaths and less illness valued at over USD 49 billion, exceeding investment costs by a factor of 40 between 2015 and 2030 [12].

There is little published information about the international resources funding malaria elimination efforts, how these funds are spent and their association with domestic financing. Several published studies describe disbursements of development assistance for health (DAH) and government health expenditure (GHE). The Institute for Health Metrics and Evaluation (IHME) [13] has been tracking DAH from 1990 onwards, disaggregating spending by the source of funding, intermediary channel, recipient country, and health focus area. Some studies have concentrated on specific health focus areas, such as HIV and the estimates produced by Countdown to 2015 [14], which focused on maternal, child and newborn health. WHO annually publishes a World Malaria Report [3], which includes government expenditure information obtained from countries' national malaria control programmes. However, expenditure data are often unavailable and replaced by budget information. Pigott et al. [15] collated co-financing data from the Global Fund grant proposals to obtain government budgets on malaria interventions. The system of national health accounts, available in a limited number of countries, provide valuable information about financing flows, but are limited by issues of comparability, timeliness and level of reporting. Past analyses have either

focused on single countries and/or disease programmes or across multiple countries aimed at measuring the effectiveness of DAH by exploring how DAH is allocated across recipient countries and/ or health focus areas or interventions.

To better understand past and future trends in financing for malaria elimination, this paper systematically tracks malaria-specific estimates of DAH expenditures from all major international development agencies from 1990 to 2013 with projections up to 2017, and splits this spending into 13 malaria activities or intervention areas that describe how the resources were used. In addition, GHE as a source for malaria financing was tracked from 2000 to 2014 to explore associations between DAH and GHE to inform future decision-making and better align need with actual resource allocation. A clear perspective on where resources have been and will be available will uncover critical investment gaps and investment opportunities.

Specifically, the paper aims to: (a) track development assistance for the prevention and treatment of malaria from channel to recipient country or region, for 1990– 2013; (b) generate lower-bound estimates of how development assistance for the prevention and treatment of malaria was used by activity or intervention area for the same time period; (c) estimate GHE for malaria from 2000 to 2014; and, (d) estimate DAH projected financing from 2014 to 2017 in the 35 eliminating countries.

7.3 Methods

This analysis was conducted in 35 malaria-eliminating countries defined in 2015 as countries that have a national or sub-national evidence-based elimination goal and/or are actively pursuing elimination (zero malaria transmission) within its borders [16] (see Figure. 7.1).

7.3.1 DAH

DAH is defined as the financial and in-kind contributions for maintaining or improving health in low and middle-income countries. This analysis focuses on financial contributions, as there is no reliable database that captures in-kind contributions. Disbursement of development assistance for malaria was estimated to the 35 countries for 1990 through 2013. Building on the IHME's annual Financing Global Health research, data were collected from primary agencies and organizations that channel DAH or third party organizations or private organizations that collect such data [13]. Detailed methodology is described elsewhere [17], however, in brief, resources were tracked from the channel back to the source (original donor) where possible, and further forward to the country or region recipient. This permits disaggregation of data into categories such as private or specific public sources, bilateral and multilateral agencies, and recipient countries. When underlying disbursement data were not available, disbursements were estimated using econometric time-series methodologies and appropriations or commitment data. Double counting generated by transfers among channels was removed manually in order to estimate a total envelope without

exaggerating the true amount of resources provided. Throughout this analysis, figures are standardized to USD 2014 to allow for uniform comparisons.

Fig 7.1. List of malaria-eliminating countries included in this analysis

Asia Pacific

- Bhutan
- China
- Democratic People's Republic of Korea
- Malaysia
- Nepal
- Philippines
- Republic of Korea (ROK)
- Solomon Islands
- Sri Lanka
- Thailand
- Vanuatu
- Vietnam

North Africa, Europe, Middle East, Central Asia

- Algeria
- Azerbaijan
- Iran
- Saudi Arabia
- Tajikistan
- Turkey

Latin America and Caribbean

- Belize
- Costa Rica
- Dominican Republic
- El Salvador
- Guatemala
- Honduras
- Mexico
- Nicaragua
- Panama
- Paraguay

Sub-Saharan Africa

- Botswana
- Cape Verde
- Mayotte*
- Namibia
- São Tomé and Príncipe
- South Africa
- Swaziland

*No data available

7.3.2 DAH by service delivery area

DAH for malaria elimination was split into categories identifying the type of investment. The Organization for Economic Cooperation's (OECD) Creditor Reporting System (CRS) database contains information on DAH that has been channeled through bilateral agencies [18]. From the CRS data, the amount of DAH disbursed per project, the recipient country, the project title, and the project description was collated. A keyword search was run to further disaggregate malaria DAH into intervention or activity categories. For Global Fund malaria grants, budget data were extracted by service delivery areas from programme grant agreements. The fraction of aid allocated to every service delivery area for each year in a grant was calculated, and the budgeted malaria aid fractions to actual DAH for each year of a grant were applied. When budget information was missing from a programme grant agreement, DAH was distributed to the service categories based on service delivery areas that were listed in the Global Fund online grants portfolio for the specific grant. Some funders, such as the World Bank, did not have this kind of information and therefore, funding by service delivery areas was unable to be disaggregated.

7.3.3 GHE

A diverse set of data points and reports were used to estimate the share of domestic government health budgets spent on malaria from 2000 through 2014. The WHO annually publishes a World Malaria Report (WMR), which includes government expenditure (or budget information when expenditures are unavailable) obtained from countries' national malaria control programmes. GHE as source data were extracted from these reports from 2008 to 2015 and from Pigott *et al*. [15], which collated co-financing data from the Global Fund grant proposals to obtain government budgets on malaria treatment. Each data source has its own concerns. Government expenditure published in the WMR does not generally provide comprehensive tracking of spending on healthcare workers and capital costs. In addition, reports from different years are inconsistent, mostly due to weak or non-existing expenditure tracking systems, impeding any temporal comparisons. Pigott *et al*. reports government expenditure that includes spending on human resources, but these numbers are from government budgets rather than actual expenditure. If budgets and spending differ in a non-random manner these estimates will be biased. To estimate government expenditure that is comprehensive of all public spending on malaria, a linear regression on data from both sources was performed. Country-specific regression analyses took into account country, the year the data were published, whether the data were comprehensive of human resources and capital costs, whether the data were expenditure or budget, and time. These were modeled using basis splines to avoid assuming linear growth.

7.3.4 Estimates of DAH projected financing from 2014 to 2017

To estimate projected DAH spending, a regression that took into account DAH averages to recipient countries and budgeted or earmarked funding was used. The dataset used to train the model was tailored to reflect the data available for each forecast. These individual training sets were made in order to take into account future malaria projects for which financial commitment data was not available at the time of writing this paper.

7.3.5 Uncertainty estimates

Uncertainty intervals for government health expenditure and DAH projected financing from 2014 to 2017 were calculated by sampling the variance–covariance matrix generated by each linear regression 1000 times.

7.3.6 GHE as a function of GDP and disease burden

To assess the association between GHE and a country's income as measured by the Gross Domestic Product (GDP) per capita, GHE for malaria as a %age of total health expenditure was plotted against GDP and further analysed by malaria disease burden as measured by Annual Parasite Index (API).

7.4 Results

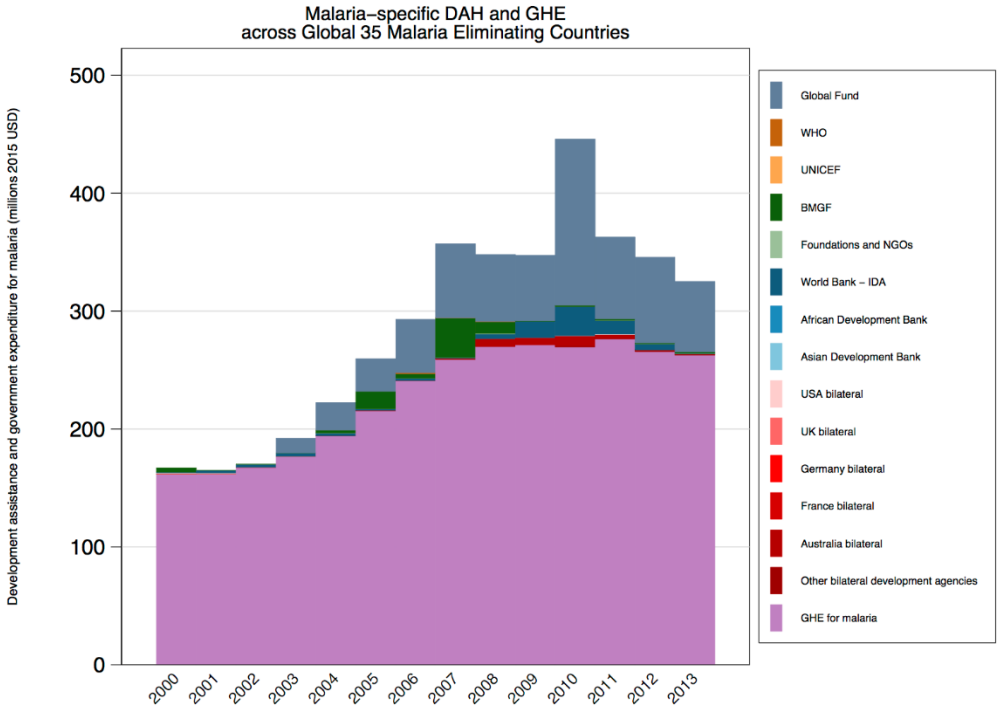
7.4.1 Funding landscape for malaria elimination

Between 2000 and 2010, the overall funding for malaria for the 35 malaria-eliminating countries grew 2.5-fold from USD 179 million in 2000 to over USD 458 million. Despite a reduction in overall funding after 2010, total funding to these countries amounted to over USD 335 million in 2013 of which 81% was from domestic resources and 19% from donors. South Africa was later excluded in subsequent analysis as it had significant GHE for malaria until 2009, thereby skewing the results of the underlying trend in GHE by the remaining 34 countries. Without South Africa, total financing amounted to USD 430 million in 2010 (see Figure. 7.2).

7.4.2 DAH

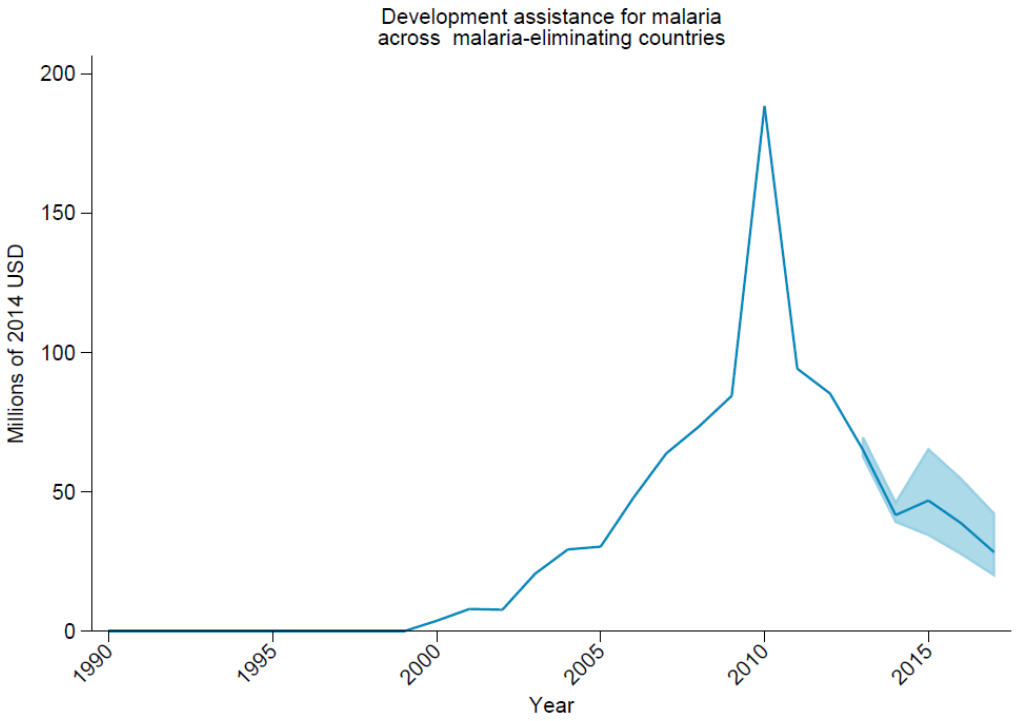
DAH increased 33-fold between 2000 and 2010 for the 35 malaria-eliminating countries from just over USD 5 million in 2000, accelerating after 2007, and peaking at over USD 176 million in 2010. However, DAH sharply declined by over 65% between 2010 and 2013 to about USD 60 million. The largest declines in DAH were seen in China which was 90% externally financed in 2010 compared to only 10% in 2013 and in Democratic People's Republic of Korea and the Solomon Islands with declines of over 25%. Nonetheless, external funding was 11.5-fold higher in 2013 than in 2000. In 2013, DAH accounted for less than 10% in Azerbaijan and Belize. Overall financing trends are projected to continue to decrease between 2014 and 2017 with a low of USD 28 million in 2017 (uncertainty interval USD 9.6 million to USD 66.4 million). Figure 7.3 illustrates malaria expenditure by donors (by the primary sources or intermediary channels) from 1990 and projected to 2017, and government from 2000 (when data was available from) for the 34 malaria-eliminating countries (excluding South Africa).

Fig. 7.2. Development Assistance for Health (DAH) and Government Health Expenditure (GHE) by funding channel graph for 34 countries (excluding South Africa). GHE data only available after 2000



The Global Fund was the largest source of external funding for malaria-eliminating countries, providing 96% of the total DAH in the 35 countries in 2013. However after peak funding in 2011, Global Fund resources for these countries decreased by approximately 58% from over USD 140 million in 2011 to approximately USD 60 million in 2013. Other donors that provided funding to malaria-eliminating countries over the period 2007– 2011 included the World Bank, the Australian government (particularly for the Pacific islands), and the Bill & Melinda Gates Foundation (BMGF). Malaria-specific funding from the World Bank halted in 2012 with the conclusion of the World Bank Booster Programme for Malaria. Similarly bilateral funding from Australia decreased sharply in 2011 by 64% decreasing further with the integration of Australia's aid programme into the Department of Foreign Affairs and Trade.

Fig. 7.3. Development Assistance for Health (DAH): past and future projections for 35 malaria eliminating countries



7.4.3 DAH by service delivery area

Figure 7.4 illustrates the trend in spending by service delivery area in the 35 malaria-eliminating countries. The graph indicates that DAH channels prioritise various service delivery areas at different times. In general, DAH increased along all interventions starting in 2003 and peaking in 2010 at over USD 176 million. Treatment, diagnosis and vector control [indoor residual spraying (IRS) and bed nets], and to a lesser extent, health system strengthening and surveillance grew at faster rates than other service delivery areas, consistent with recommendations for malaria elimination. Exceptions included the Dominican Republic where surveillance accounted for 40% of expenditures in 2009 declining to less than 10% in 2013. Expenditures for malaria treatment increased between 2003 and 2007 but have declined since 2010. At the same time, DAH expenditures on diagnosis increased gradually, consistent with WHO recommendations on testing before treatment, peaking in 2010, but decreasing thereafter. In most countries, the ratio of DAH expenditure on diagnosis versus treatment increased after 2008, reaching a 50:50 split in Bhutan and Costa Rica by 2013.

A notable exception is Thailand with 25% of total expenditure on treatment but very little on diagnosis. There was a high growth in vector control spend particularly on bed nets as well as other undefined vector control interventions peaking in 2010 and declining thereafter. By 2012, expenditures on bed nets were less than other vector control interventions. However, bed nets still accounted for 80% of expenditure in Bhutan. Other vector control interventions accounted for over

80% of total expenditure in Nepal, and up to 50% in Sao Tome and Nicaragua. There was some growth in community outreach and strengthening of surveillance systems, however, this growth was not uniform; with surveillance expenditure actually decreasing overall between 2010 and 2012. A large proportion of funds could not be allocated over any of the service delivery areas particularly between 2008 and 2011 (14%).

7.4.4 GHE for malaria

For the 35 malaria-eliminating countries in aggregate (excluding South Africa as an outlier), GHE as source for malaria elimination steadily increased since 2000 from about USD 131 million per year to about USD 250 million in 2014, outpacing DAH. In 2010, at the peak of external finding, government spending was 1.4 times higher than the donor resources available.

Table 7.1 shows the growth rates across various time periods for both GHE and DAH for the 35 malaria-eliminating countries.

7.4.5 GHE as a function of GDP and API

Figure 7.5 illustrates government health expenditure for malaria as a function of GDP and API. There is a wide variation in the GHE on malaria uncorrelated with GDP indicating that GDP is not directly associated with increased domestic spending in malaria. Higher GDP countries with low government expenditure on malaria include several countries in Latin America (Costa Rica, Panama, Belize) as well as Swaziland and Thailand. Most of the countries spent less than 0.05% on malaria with the exception of Vanuatu (0.1%). Furthermore, the Figure illustrates that malaria expenditure is also not directly associated with disease risk as measured by API.

Fig. 7.4. Development Assistance for Health (DAH) by service delivery area for 35 countries

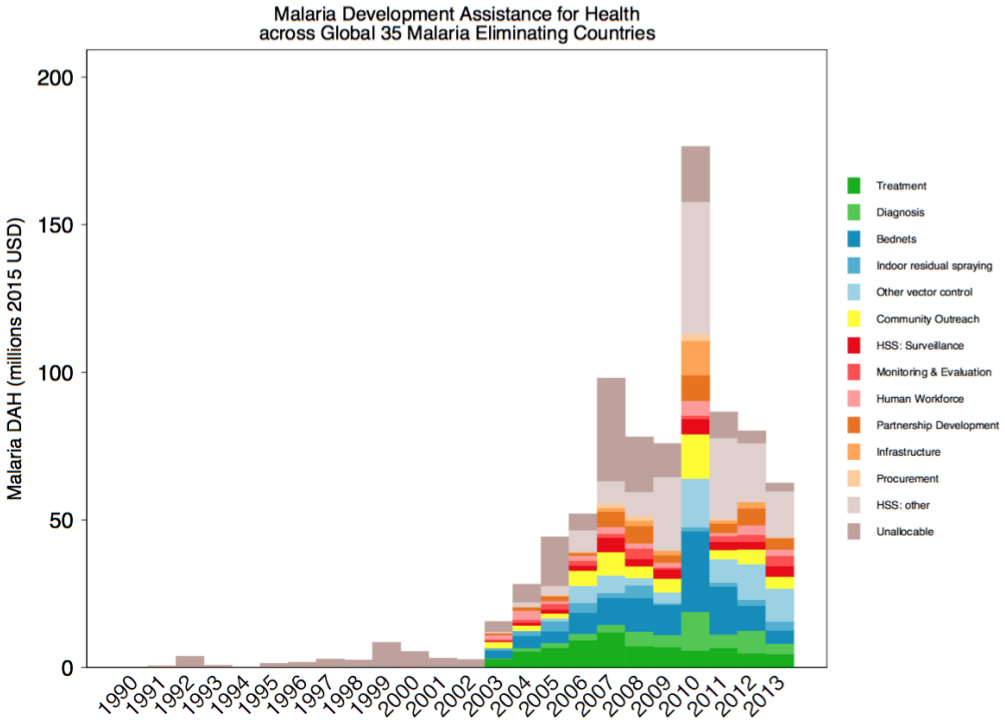
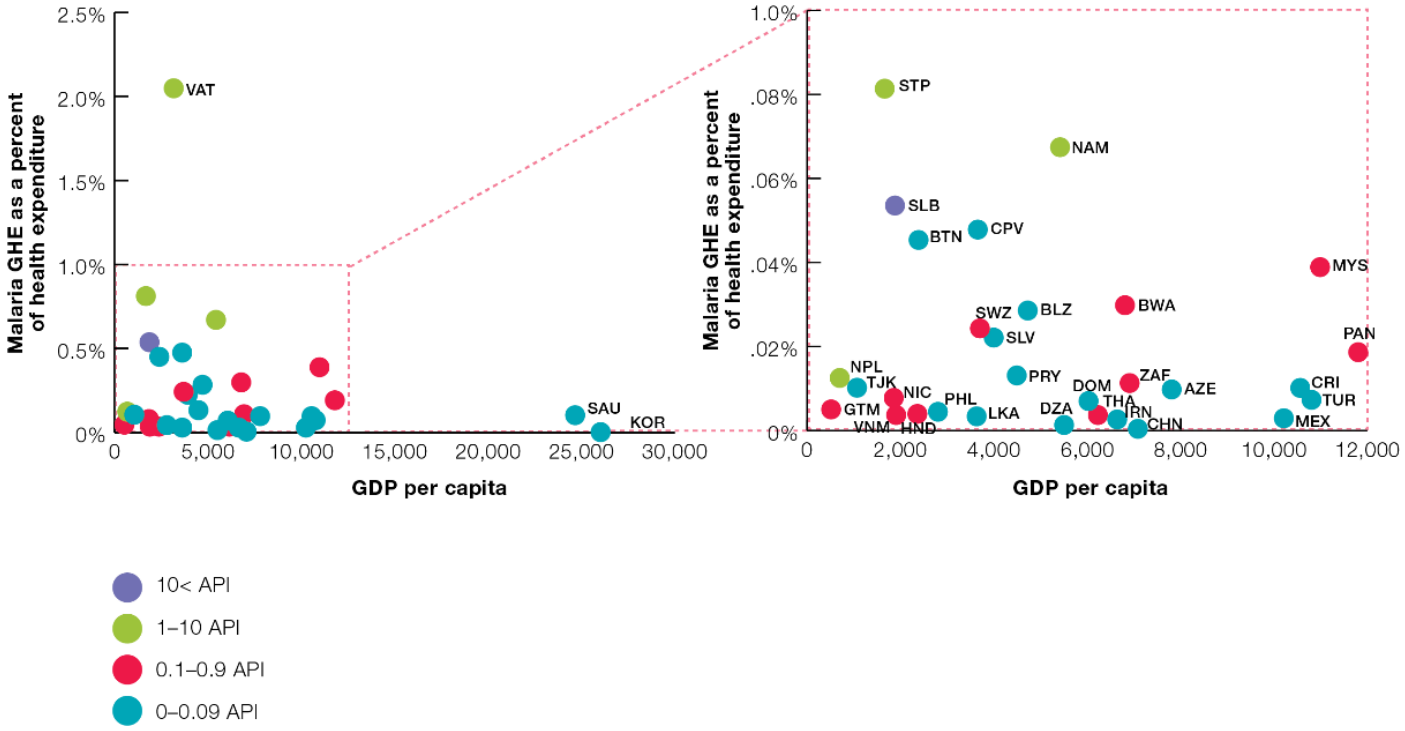


Fig. 7.5. GHE for malaria as a % of health expenditure by GDP and API



7.5 Discussion

This is the first study that tracks DAH and GHE specifically for malaria eliminating countries from 1990 to 2014 with projections to 2017. This study also makes use of enhanced methods providing a more comprehensive tracking of DAH and GHE than has previously been utilized in other studies. The findings clearly demonstrate a growing uncertainty about the future availability of DAH for malaria elimination. At the same time, while government health expenditures have steadily increased, they have not kept pace with the declining DAH. Many malaria-eliminating countries could risk facing significant funding gaps, which can increase the risk of malaria resurgence highlighting the need for an interim solution until the economies of these countries have sufficiently grown to fill the gap.

The findings demonstrate three periods for DAH for malaria: a period of moderate growth in the 1990s, accelerated growth in the first decade of the 2000s of 97%, and a decline of 65% since 2010. In the 35 countries included in this review, total financing for malaria grew from USD 179.5 million to USD 301.7 million between 2000 and 2013 of which DAH accounted for 19% in 2013. DAH began to decline in 2011, coinciding with the Global Fund's decision to halt its 11th grant cycle. During this period, DAH declined by 65% in the 35 malaria-eliminating countries overall and is projected to further decline through 2017.

Table 7.1. DAH and GHE annualized growth rates for the 35 malaria eliminating countries

	2000-2004		2005-2009		2010-2013 or 2014	
Countries	**DAH**	**GHE**	**DAH**	**GHE**	**DAH**	**GHE**
Afghanistan	-42.25	11.10	115.97	11.21	74.73	-25.84
Algeria	0	1.25	0	-0.17	0	-74.68
Angola	52.77	23.42	-20.30	19.66	27.14	24.27
Azerbaijan	-100.00	7.38	306.69	27.84	-19.43	7.20
Bangladesh	-46.18	3.15	48.74	23.54	18.47	31.14
Belize	0	2.27	0	9.93	0	4.896
Bhutan	-100.000	4.053	2.841	-0.720	-6.907	-2.74
Bolivia	100.615	-6.049	4.214	7.651	4.132	-15.55
Botswana		-6.070		29.333	-100.000	9.107
Cambodia	-21.264	13.611	-3.17	12.08	-24.696	-10.42
Cape Verde	0	3.48	-100.00	7.71	0	-15.88
China	51.187	6.21	49.758	31.03	-67.35	37.58
Colombia	-100.00	2.66	5.002	3.239	-16.60	-7.16
Costa Rica	0	2.322	0	7.284	0	-9.15
Democratic People's Republic of Korea (DPRK)	-100.00	8.16	-100.00	5.94	-31.51	-0.16
Dominican Republic	0	-26.33	0	15.53	-2.53	3.56

	2000-2004		2005-2009		2010-2013 or 2014	
Countries	**DAH**	**GHE**	**DAH**	**GHE**	**DAH**	**GHE**
Ecuador	0	5.91	0	4.67	-26.95	-17.79
El Salvador	0	-9.52	0	31.83	0	14.23
French Guiana	0	-2.04	0	-0.17	0	-22.20
Guatemala	0	15.87	-29.73	17.16	0	-46.02
Guyana	0	-26.57	6.85	6.59	-1.47	13.09
Haití	0	-3.65	-7.65	-22.95	0	28.09
Honduras	176.03	-1.35	-14.49	-12.500	-13.18	-14.51
India	-5.40	-1.48	-36.41	4.10	-24.09	-13.52
Indonesia	59.17	2.38	37.71	2.16	-8.92	30.63
Iran	-100.00	7.45	18.18	4.83	10.72	-15.12
Lao (PDR)	21.86	-4.73	-8.64	-17.92	5.48	2.14
Malaysia	0	-0.74	0	16.46	0	10.78
Mexico	0	0.29	0	2.96	0	-6.74
Mozambique	61.40	7.17	1.42	10.25	-14.49	-2.07
Myanmar	-50.36	10.35	-44.94	36.76	1.76	7.13
Namibia	92.00	11.86	24.49	-0.63	43.21	5.17
Nepal	65.01	4.46	42.31	1.62	-22.15	14.02
Nicaragua	0	-4.90	21.38	-7.11	3.83	-17.16
Pakistan	181.89	0.82	34.03	6.74	16.25	6.58
Panama	0	-23.04	0	17.00	0	38.53
Papua New Guinea	0	-17.63	53.74	17.80	86.62	9.95
Paraguay	0	1.53	0	11.23	0	13.13
Perú	0	12.59	-100.00	35.43	-58.07	-49.57
Philippines	74.09	-12.26	-17.26	50.41	-43.70	18.03
Republic of Korea	0	-2.19	0	13.51	0	-13.39
Saudi Arabia	0	1.97	0	7.574	0	-2.27
Solomon Islands	78.20	11.23	56.29	37.85	-45.71	-27.87
South Africa	-12.90	5.08	-34.73	-1.80	31.62	-5.85
Sri Lanka	101.76	12.98	53.20	1.63	-12.84	-34.37
Surinam	0	27.36	1.08	5.57	-6.62	35.38
Swaziland	0	-1.48	74.44	8.64	-2.69	-8.91
São Tomé and Príncipe	6.33	2.00	-49.88	28.57	49.09	37.10
Tajikistan	-54.13	5.01	99.02	21.17	-12.23	32.21
Thailand	-17.24	-5.61	-7.23	-14.26	46.57	6.53
Timor Leste	129.50	23.91	8.16	22.15	-3.30	44.30
Turkey	0	79.47	0	12.76	0	-2.86
Vanuatu	0	-0.47	-25.54	6.61	-11.60	-8.42
Venezuela	0	31.54	5.00	-10.89	-100.00	-36.29
Vietnam	61.06	-0.22	8.58	0.35	-45.99	-11.48
Zambia	28.36	38.63	-1.25	7.69	40.13	29.53
Zimbabwe	144.84	-13.97	55.68	-16.02	3.75	-22.49

The allocation methodology adopted by the Global Fund in 2012, uses a combination of disease burden and GNI per capita to determine the financing that countries will receive for the three diseases. Under this New Funding Model, country-specific funding to the sub-set of countries attempting to eliminate malaria has declined by over 30% [5]. Further declines in allocations have been noted under a revised model adopted in November 2016. These changing polices have major implications for the financing and delivery of health services, particularly for malaria elimination. Eliminating countries typically have lower disease burdens and are often middle-income countries and therefore tend to be less attractive investments for donors looking for easy to measure high impact results. Of the 35 countries included in this review, 2 are high-income countries, 15 are upper middle income, 14 are lower middle income, and 3 are lower income (no data was available on Mayotte). 18 of these countries are ineligible to receive Global Fund financing. Three countries have graduated from Global Fund malaria financing in the past 6 years: China (2011), Dominican Republic (2013) and Iran (2012) and one country transitioned out of Global Fund support in 2016 (Paraguay). Sri Lanka, which attained malaria-free certification by WHO in September 2016 and Botswana, will receive one more transitional grant from the Global Fund. The Philippines submitted their final proposal for funding in the first quarter of 2017 together with a transition plan for sustainable financing. Several other countries are approaching one or more donor eligibility thresholds in the next few years. Although the majority of funding in these countries comes from domestic sources, DAH still plays an important role in the delivery of health interventions, particularly to vulnerable populations that are often underserved by the government health system. Donors such as the Global Fund will need to continue to prioritize these populations to deliver on its 2017–2022 Global Fund Strategy, which aims to achieve progress toward a world free of the burden of HIV/AIDS, tuberculosis, and malaria.

The Global Fund continued to provide the largest source of DAH to malaria-endemic countries accounting for over 90% of all external financing. It is not possible to unpack donor contributions specifically to malaria disbursed by the Global Fund, however, in general, the US government provides 35% of all funding, the United Kingdom, 16%, France, 9% and non-official sources including foundations and charities, 6%. A more diverse set of donors including the World Bank and various bilateral donors played a larger role in the malaria agenda prior to the establishment of the Global Fund. For example, Australia played a major role in funding malaria control in the Pacific Islands; however, this funding has been drastically reduced since with the creation of the Department of Foreign Affairs and Trade replacing Australian Aid whose new Health for Development Strategy 2015–2020 [9] focuses on health as development with little on disease-specific funding.

Across the 35 countries included in this review, GHE almost doubled between 2000 and 2010, ultimately resulting in about USD 249 million in 2014 (excluding South Africa as an outlier). In most countries, the upward GHE trend between 2008 and 2014 has been maintained or increased. Nine

countries included in the review (Algeria, El Salvador, Guatemala, Malaysia, Mexico, Panama, Paraguay, ROK, Saudi Arabia) are entirely domestically financed.

DAH was disaggregated into 13 service delivery areas allowing for cross-country and regional comparisons. The observed trends in spending or allocation by service delivery area are not uniform or consistent with epidemiological profiles or regional policies demonstrating the need for greater emphasis on allocative efficiency. Vector control, mostly bed nets continues to be the largest cost driver across all regions, followed predominately by treatment costs.

Thirty-one of 35 countries spent less than 10% of their malaria DAH funding on surveillance, a key malaria elimination intervention between 2010 and 2013. The ratio of DAH expenditure on diagnosis versus treatment increased after 2008 reaching a 50% split in most countries by 2013 bringing countries closer to compliance with WHO's Test: Treat: Track policy. Notable exceptions are Honduras, Tajikistan, and Thailand with minimal expenditure on diagnosis. As actual cases decrease, expenditure on diagnosis is expected to be at least twice the spending on treatment. However, discrepancies between use of DAH for certain service delivery areas and strategy for malaria elimination could be explained by governments using DAH to fund allowable expenses and GHE to pay for the rest, for example procurement of diagnostics. Nevertheless, the analysis does raise the question on whether DAH is being spent on the most effective strategies for malaria elimination.

Morel and colleagues noted, "it is important to ask whether current interventions are used appropriately and what is the most cost-effective way to scale up activities to the levels needed" [19]. With declining DAH, available resource will need to be used more efficiently. This would include focusing the needs of the malaria programme on the most effective interventions coupled with better targeting of intervention delivery to strategic populations to maximize value-for-money and prevent drug and insecticide resistance and from available resources [20]. At the same time, there is a need to move donor funding for malaria control away from an input model that mostly focuses on the procurement and distribution of key inputs (most notably mosquito nets) towards more support for operational improvements, capacity building in programme management, improved disease and intervention surveillance as well as knowledge generation and sharing to strengthen the impact of elimination interventions.

The WHO Global Technical Strategy for Malaria estimated that USD 6.8 billion will be needed annually to reduce malaria related morbidity and mortality by 90% between 2015 and 2030 and projected gaps of more than half of this financing need. Although gains in health system efficiency can be used to make reduce the discrepancy between available finances and need, current trends suggest that many countries may face gaps in financing for malaria elimination. If increasing domestic health financing is the solution, countries will need to increase their own spending on malaria beyond historical trends. The expectation of the economic and health financing transition

suggests that as countries develop they spend more on health than they did before. Of 35 currently low income and middle-income countries, included in this review, 22 countries currently meet the Chatham House goal of spending 5% of GDP or USD 86 per capita on health [21].

There are several complementary ways for countries to fill the gap between needs and resources until government allocations catch up with the financing transition. The Addis Ababa Action Agenda calls on a number of resource mobilization efforts encompassing aid, domestic public resources, and support from the private sector. Many national governments are considering raising health budgets by improving the capacity to raise tax revenue including the implementation of Pigovian or sin taxes. In the Philippines, the Sin Tax Reform Bill, passed in 2012, increased taxes on tobacco and alcohol, generating USD 2.3 billion within 2 years increasing the Department of Health budget by 63% in 2015. This revenue has freed up resources, which would have otherwise been used for social protection of the poor and has trickled down for use for malaria and other diseases targeted for elimination.

Two other areas of resource mobilization which have had limited traction are better harnessing of private financing as well as innovative approaches, such as social impact bonds, airline and financial transactions taxes. Blended approaches which refer to the use of funds to leverage or de-risk private investment in development are increasingly being explored. Although there are no current estimates on their scale, these financing instruments have been used with success in other sectors within and outside of health and have the potential to catalyse future additional private sector support.

The Roll Back Malaria Action for Investment in Malaria (AIM) suggests that investment in malaria could deliver strong health benefits through fewer deaths and less illness that can be valued at over USD 49 billion. These benefits exceed investment costs by a factor of 40 over the period to 2030 [12]. Focused advocacy at all levels is needed to reach key decision-makers in order to highlight the social and economic benefits of investing in malaria elimination and the risks of not doing so. In particular, emphasis on the threat of drug resistance in undermining success and posing a risk of regional health security is needed. Continued engagement is needed with governments to focus attention on increased domestic budgets.

This analysis has several limitations. Many of the DAH expenditures could not be allocated to specific interventions, therefore introducing a potential bias. In addition, the spending by governments could not be further disaggregated by intervention area and it is possible that DAH was spent on particular interventions due to co-financing of others through domestic sources. Estimates of domestic expenditures on malaria were obtained from sources, which relied on self-reporting by countries with little triangulation of data and the findings should therefore be interpreted as such.

Nevertheless, the findings provide strong evidence on the uncertainty about the future availability of DAH in malaria elimination settings and the wide variation in support for malaria programmes by governments [12]. Many malaria-eliminating countries could risk facing funding gaps, which could be compounded if countries face funding cliffs with multiple donors phasing out simultaneously. These disruptions in service delivery could also confer negative cross-border externalities to neighbouring countries, compromising regional elimination targets and ultimately global eradication.

7.6 Conclusion

Financing for malaria elimination is declining at a time when commitment to elimination will be crucial to paving the way to global malaria eradication. While government health expenditure has steadily increased in most countries, this increase has not been proportional to the rate of waning external funding, particularly in middle-income countries, increasing the risk of deadly and costly malaria resurgences. Notwithstanding, existing financing has not been used in the most cost-effective or efficient manner. Mechanisms to increase efficiency and value for money are urgently needed as well as further analysis on the extent to which expenditures are in line with the interventions recommended by the WHO. Innovative health financing mechanisms may provide a respite—until domestic financing is able to fi the gap created by diminishing donor resources.

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CHAPTER 8

Global Fund Financing to the 34 Malaria-eliminating Countries under the New Funding Model 2014–2017: An Analysis of National Allocations and Regional Grants

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8.1 Abstract

Background: The Global Fund to Fight AIDS, Tuberculosis, and Malaria (GFATM) has been the largest financial supporter of malaria since 2002. In 2011, the GFATM transitioned to a new funding model (NFM), which prioritizes grants to high burden, lower income countries. This shift raises concerns that some low endemic countries, dependent on GFATM financing to achieve their malaria elimination goals, would receive less funding under the NFM. This study aims to understand the projected increase or decrease in national and regional funding from the GFATM's NFM to the 34 malaria-eliminating countries.

Methods: Average annual disbursements under the old funding model were compared to average annual national allocations for all eligible 34 malaria-eliminating countries for the period of 2014–2017. Regional grant funding to countries that are due to receive additional support was then

included in the comparison and analysed. Estimated funding ranges for the countries under the NFM were calculated using the proposed national allocation plus the possible adjustments and additional funding. Finally, the minimum and maximum funding estimates were compared to average annual disbursements under the old funding model.

Results: A cumulative 31 % decrease in national financing from the GFATM is expected for the countries included in this analysis. Regional grants augment funding for almost half of the eliminating countries, and increase the cumulative % change in GTFAM funding to 32 %, though proposed activities may not be funded directly through national malaria programmes. However, if countries receive the maximum possible funding, 46 % of the countries included in this analysis would receive less than they received under the previous funding model.

Conclusions: Many malaria-eliminating countries have projected national declines in funding from the GFATM under the NFM. While regional grants enhance funding for eliminating countries, they may not be able to fill country-level funding gaps for local commodities and implementation. If the GFATM is able to nuance its allocation methodology to mitigate drastic funding declines for malaria investments in low transmission countries, the GFATM can ensure previous investments are not lost. By aligning with WHO's Global Technical Strategy for Malaria and investing in both high and low-endemic countries, the Global Fund can tip the scale on a global health threat and contribute toward the goal of eventual malaria eradication.

8.2 Background

Of the approximate 100 countries with endemic malaria, 34 were defined in 2010 as malaria-eliminating (see Table 8.1), defined here as a country that has a national or subnational evidence-based elimination goal and/or is actively pursuing elimination (zero malaria transmission) within its borders [1]. Among these 34 countries, 78% of financing for malaria programmes has been provided by governments themselves [2]; however, the %age of domestic funding can vary widely from country to country, ranging from under 10 % in some low and lower–middle-income countries (LMICs) such as the Philippines and Tajikistan, and up to 100 % in upper–middle to high-income countries such Costa Rica, South Korea, and Turkey [3].

As the largest international financier to national malaria programmes, the Global Fund to Fight AIDS, Tuberculosis, and Malaria (GFATM) has played a critical role in reducing global malaria burden. Between 2000 and 2011, global financing for malaria increased 18-fold, largely due to the creation of the GFATM in 2002 [4]. From inception until 2011, the GFATM granted funding through a "round" system whereby countries would submit proposals that were evaluated based on technical soundness, alignment with national strategy, and capacity for implementation [5]. Under this old funding model, a total of USD 8.65 billion had been disbursed for malaria, 93 % of which

was spent on high burden countries [2]. The remaining 7 % disbursed by the GFATM accounted for the largest source of donor assistance for 19 of the 34 malaria-eliminating countries that received support from the GFATM. Although it is a small %age of the overall GFATM malaria portfolio, this amount has catalyzed national progress toward elimination [2], helping to reduce malaria cases in the 34 malaria-eliminating countries collectively by 85 % between 2000 and 2013 [6].

In an effort to become more transparent and systematic, the GFATM created the new funding model (NFM) in 2012 to increase value for money and focus investments to hardest hit countries with fewer available financial resources [7]. With the NFM, the GFATM formalized their allocation methodology, largely determined by disease burden and gross national income (GNI) per capita, which emphasized their priority on investments in higher burden, lower income countries [8]. Implemented during the 2014–2016 funding cycle, the NFM offers a pre-calculated allocation to each country for human immunodeficiency virus (HIV), tuberculosis (TB), and malaria.

Under the NFM, countries are first assigned to one of four bands based on their disease burden and income level (Table 8.2). Then, the allocation formula is applied to determine the country's national allocation, which includes any unspent money left over from grants under the old funding model, plus a new allocation amount.

Table 8.1. 34 malaria-eliminating countries, national elimination goals (as of 2015), and study inclusion status

Country	National elimination goal	Eligible for national funding in 2014	Eligible for funding through a regional initiative	Meets inclusion criteria for this analysis?
Eastern Mediterranean and Europe				
Algeria	2015	not eligible	n/a	no
Azerbaijan	2013	not eligible	n/a	yes
Iran (Islamic Rep.)*	2025	not eligible	n/a	yes
Kyrgyzstan	2015	yes	n/a	yes
Saudi Arabia	2015	not eligible	n/a	no
Tajikistan	2015	yes	n/a	yes
Turkey	2015	not eligible	n/a	no
Uzbekistan	2015	yes	n/a	yes
The Americas				
Argentina	NNEG	not eligible	n/a	no
Belize[1]	2020	not eligible	yes	yes
Costa Rica[1]	2020	not eligible	yes	yes

Country	National elimination goal	Eligible for national funding in 2014	Eligible for funding through a regional initiative	Meets inclusion criteria for this analysis?
Dominican Republic[1]	2020	not eligible	yes	yes
El Salvador[1]	2020	yes	yes	yes
Mexico[1]	2020	not eligible	n/a	no
Nicaragua[1]	2020	yes	yes	yes
Panama[1]	2020	not eligible	yes	yes
Paraguay	2015	yes	n/a	yes
South-East Asia and Western Pacific				
Bhutan	2018	yes	n/a	yes
China	2020	not eligible	n/a	no
Korea, Dem. Rep.	2025	yes	n/a	yes
Malaysia	2020	not eligible	n/a	no
Philippines	2030	yes	n/a	yes
Republic of Korea	2017	not eligible	n/a	no
Solomon Islands	2035	yes	n/a	yes
Sri Lanka	2014	yes	n/a	yes
Thailand	2030	yes	yes	yes
Vanuatu	2025	yes	n/a	yes
Vietnam	2030	yes	yes	yes
Sub-Saharan Africa				
Botswana	2018	yes	yes	yes
Cape Verde	2020	yes	n/a	yes
Namibia	2020	yes	yes	yes
Sao Tome and Principe	2020	yes	n/a	yes
South Africa	2018	not eligible	yes	yes
Swaziland	2015	yes	yes	yes

Notes: Although these 34 malaria-eliminating countries form the basis of this review, the UCSF Global Health Group's Malaria Elimination Initiative now identifies 35 malaria-eliminating countries based on progress around the world over the last five years. [23]

NNEG: No National Elimination Goal.

[a] While not eligible for a new allocation under the NFM, Iran has funding through the Global Fund from a previous five-year grant signed in 2011.

[b] Elimination goal of 2020 declared under the EMMIE regional initiative.

Once the national allocation is determined and publicly announced, countries can develop a concept note for submission to the GFATM. During concept note development and revisions, the country dialogue process is open and countries can make additional modifications to the allocation. Such adjustments include changes to the disease allocation split between HIV, TB, and malaria or

other adjustments based on the willingness to pay criteria, defined by the amount the country is willing to invest in their own programmes beyond the required counterpart financing.

The final concept note is then reviewed by the GFATM's Grant Approvals Committee. The committee can approve eligible countries for additional incentive funding, defined by the GFATM as "a special reserve of funding available on a competitive basis awarded to applications that demonstrate the greatest potential for high impact with additional funds" [10]. Incentive funding can increase the national allocation up to 15 % and is only available to eligible countries in bands 1-3.

Apart from the national allocations, the GFATM approved regional grants under the NFM to three regions that applied for malaria funding within an amount set aside for regional investments. As of January 2016, three regional grants have been signed: the Elimination 8 (E8) [11] in southern Africa, the Elimination of Malaria in Mesoamerica and the Island of Hispaniola (EMMIE) [12] and the Regional Artemisinin-resistance Initiative (RAI) [13] in the Mekong Region. While national grants tend to focus on in-country commodities and activities, regional grants can play a complementary role, supporting activities that may not be funded through country programmes, such as cross-border surveillance programmes.

The malaria disease burden is calculated using the number of deaths + the number of cases + 0.5 × incidence + 0.5 × mortality rate, based on 2000 malaria incidence data (taken from the World Health Organization), and country income level defined by GNI per capita [9].

Since the GFATM has been such a significant supporter of malaria-eliminating countries, which are by definition, low burden and typically middle-income, and the financial impact of the NFM's funding methodology is not clear, the authors initiated an analysis to understand the projected increase or decrease national and regional funding from the GFATM to the 34 eliminating countries.

Table 8.2. Band assignments for malaria-eliminating countries eligible for GFATM national malaria funding

Band 1	**Band 2**
Lower income, High burden	**Higher income, High burden**
Vietnam	Korea, Dem. Rep.
	Kyrgyzstan
	Nicaragua
	Sao Tome and Principe
	Solomon Islands
	Tajikistan
	Uzbekistan
Band 3	**Band 4**
Lower income, Low burden	**Higher income, Low burden**
Botswana	Bhutan
Namibia	Cape Verde
Philippines	El Salvador
Swaziland	Paraguay
Thailand	Sri Lanka
	Vanuatu

Source: The Global Fund to Fight AIDS, Tuberculosis and Malaria. *Overview of the Allocation Methodology (2014-2016): The Global Fund's new funding model.*2014 http://www.theglobalfund.org/documents/fundingmodel/FundingModel_OverviewAllocation_Methodology_en/. (12 January 2016, date last accessed)

8.3 Methods

8.3.1 Countries included in this analysis

As of 2010, 34 countries have been identified as malaria eliminating [1]. Of these, 26 countries were included in the analysis; all met at least one of the following criteria: recently eligible for a GFATM malaria grant under the old funding model; has an active malaria grant from the GFATM; is eligible for a malaria grant under the NFM; and/or is expected to receive funds from the GFATM under a regional malaria grant. The list of countries with their stated national elimination goal is given in Table 8.1. Eliminating countries that have never been eligible for malaria funding from GFATM or that hold membership to the Group of 20 major economies were excluded from the analysis (Algeria, Argentina, China, Malaysia, Mexico, Republic of Korea, Saudi Arabia, and Turkey).

Eligibility status of the 34 eliminating countries generated by the GFATM is shown in Table 8.1. Nineteen of the 34 eliminating countries are eligible for NFM national malaria funding with allocation amounts ranging from USD 500,000 to USD 27 million. Although 19 countries are eligible

for national malaria grants and were given allocations in the NFM, four did not receive an allocation with any additional funding apart from the existing, unspent funds from previous grants: Kyrgyzstan, Tajikistan, Thailand, and Vanuatu. Five countries are not eligible for national malaria grants, but are expected to receive funds through a regional malaria grant: Belize, Costa Rica, Dominican Republic, Panama, and South Africa.

8.3.2 Analysis on national level funding changes

Using publicly available GFATM grant data [14] collated in Microsoft Excel 2010, average annual funding from the old funding model was calculated using the total disbursed amounts from each country's most recent active malaria grant(s) averaged over the respective grant start date through December 31, 2013, the GFATM specified cut-off date for the round based system. Disbursed amounts rather than the signed amounts in grant agreements from the old funding model were used in order to avoid "double counting" of money not yet disbursed that will later be incorporated into the new NFM national allocation. Using the average disbursements from the entire previous grant(s), rather than the last 3 years under the old funding model, ensures that this analysis compares previous full grants to potential full grants, while capturing any programme scale-up or frontloading.

Estimated NFM average annual allocation amounts were calculated by averaging the GFATM specified national allocation [7] over the 4-year period of 2014– 2017. This time period was used since the next GFATM replenishment will take place in the last quarter of 2016. Thus, countries will likely not receive new funding until mid-2017. No regional grant amounts were included in this portion of the analysis.

Average annual grant amounts disbursed under the old funding model were compared to average annual national allocated amounts under the NFM to determine the % change between old and new average annual funding. A cumulative % change between the old funding model and NFM was calculated between the sum total of the old disbursed and new allocated amounts. The cumulative percent change in funding accounts for countries that had an unquantifiable percent change (e.g. those that received no money under the old funding model, and then assigned an allocation under the NFM).

8.3.3 GFATM NFM regional grants

Funding channeled to malaria-eliminating countries through the E8, EMMIE, and RAI GFATM regional malaria grants was included. While the RAI grant has a predetermined country-level breakdown of funding, in this analysis country shares for EMMIE and E8 were assumed to be divided equally among the countries involved and are described in Table 8.5.

For eliminating countries included in a regional grant, the country share of regional grant funding was added to the national allocations and a new percent change of funding from the previous funding model compared to the NFM was calculated.

8.3.4 NFM malaria funding ranges

Since the national malaria allocation is the calculated amount a country is eligible for and not necessarily a final grant amount, the funding range (minimum and maximum) each country could receive was estimated, taking into account potential adjustments and/or additional funding (e.g. regional grant funding under E8, EMMIE, and RAI grants) (Table 8.3). Because regional grants have already been signed, regional funding amounts remain constant in this portion of the analysis.

Table 8.3. Potential adjustments and additional funding to national allocations

Potential Dimension for Adjustments	Definition	Adjustment	Timing of Adjustment
Willingness to Pay	Amount the country is willing to put forth beyond the required counterpart financing. The amount is negotiated between each country and the GFATM.	-15% of national allocation if criteria is not met	During Country Dialogue
Disease Split between HIV, TB, Malaria	Amount of funding allocated to each disease, decided upon by the Country Coordinating Mechanism.	Up to +/- 10% of the national allocation amount for each disease	During Country Dialogue
Incentive Funding	Aimed to reward high impact, well preforming projects.	+15% for eligible countries (Bands 1-3)	During grant-making with the Grant Approvals Committee
Additional Funding			
Regional Grant Funding	Any funding granted to a country from a regional grant (E8, EMMIE, and RAI) – this amount would be additive to any national grants.	Country share breakdown per regional grant amounts	Independent of national grant process

Source: Global Fund to Fight AIDS, Tuberculosis and Malaria Resource Book for Applicants: The Global Fund's New Funding Model (2014)

In order to access the full national allocation, each country must meet a conditional counterpart financing requirement, or a minimum level of government contribution to the national disease

programme as a share of total government financing plus GFATM financing for that disease [9]. The counterpart financing requirement is based on a sliding scale of income level: low-income countries must reach a minimum threshold contribution of 5 %, lower LMICs must reach a minimum threshold contribution of 20 %, upper LMICs must reach a minimum threshold contribution of 40 %, and upper–middle-income countries must reach a minimum threshold contribution of 60%.

Countries must then meet their willingness to pay criteria, which is an additional amount beyond the counterpart-financing requirement. If a country does not meet their willingness to pay criteria, 15 % of the national allocation for each disease component can be withheld. Furthermore, during the country dialogue process, the country-level stakeholder partnership that manages the proposals and grants, also known as the Country coordinating mechanism, can adjust the GFATM's suggested national disease split, potentially transferring up to 10 % of malaria funding to supplement HIV or TB or vice versa. Table 8.3 summarizes potential adjustments and additional funding used to determine the range of a country's allocation from the GFATM.

Percentage adjustments were calculated from the suggested national allocation amounts announced by the GFATM in March 2014 [15]. To calculate the minimum funding for a country's malaria programme, the national allocations were decreased by 15 % to simulate unmet willingness to pay criteria and by an additional 10 % to account for a possible Country coordinating mechanism decision to move malaria funding to another disease. Independent of national allocation adjustments, any country's share of regional grants is consistent in the minimum funding amounts.

The maximum potential funding was then calculated based on meeting the willingness to pay criteria, a 10 % disease split increase, a 15 % increase for incentive funding (for those in bands 1–3 that are eligible), and additional regional grant amounts.

8.3.5 NFM minimum and maximum funding amounts compared to the old funding model

Both the minimum and maximum funding amounts (national allocations plus regional grants) were averaged over the 4-year period of 2014–2017 and compared to the average annual disbursements under the old funding model to determine the range of % change in funding for eligible eliminating countries.

8.4 Results

8.4.1 Funding changes to the GFATM's malaria portfolio

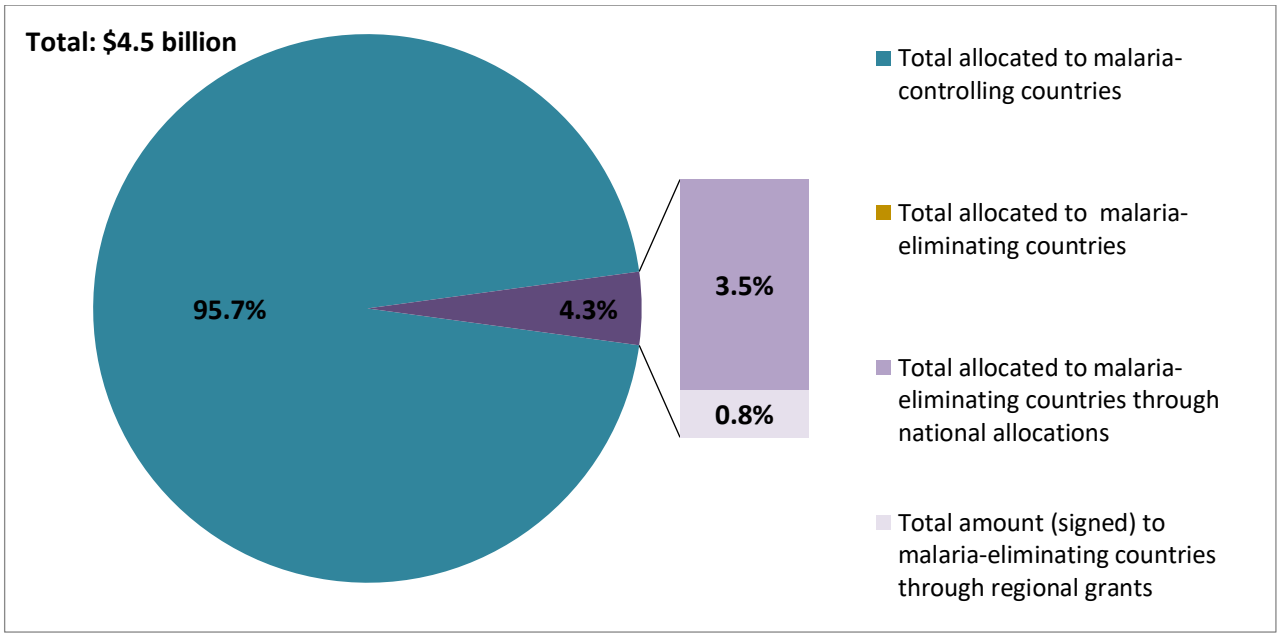
Under the NFM, 4.3 % of the GFATM's malaria portfolio of USD 4.5 billion (including national allocations and regional malaria grant funding) is allocated to the focus countries in this paper (Figure 8.1). Of the 4.3, 0.8 % of the malaria portfolio supports eliminating countries through three regional grants for malaria: E8, EMMIE, and RAI. Under the NFM, the total portion of the malaria

portfolio going to malaria-eliminating countries is lower (4.3 %) than under the old funding model (7 %).

8.4.2 Analysis on national level funding changes

Changes in annual national funding between the most recent grant(s) under the old funding model and the average annual allocation under the NFM are shown in Table 8.4. Overall, there is a projected 31 % decrease in average annual funding during the 2014–2017 timeframe for malaria-eliminating countries. Twelve countries (Azerbaijan, Cape Verde, Dominican Republic, Iran, Kyrgyzstan, Philippines, Solomon Islands, Sri Lanka, Tajikistan, Thailand, Uzbekistan and Vanuatu) are expected to see an extreme decrease (30–100 %) in funding, with three (Democratic People's Republic of Korea, Swaziland and Vietnam) expected to have a less severe decrease in funding (1–29 %). Four countries (Bhutan, Namibia, Nicaragua, and São Tomé and Príncipe) will see increases in funding, ranging between 1 and 54%.

Figure 8.1. The GFATM malaria portfolio under the New Funding Model including national allocations and signed regional malaria grants



The percent change for three countries (Botswana, El Salvador, and Paraguay) could not be quantified, as they have not received any prior funding from the GFATM, but allocations and potential grants to these countries would be an increase. The remaining four countries (Belize, Costa Rica, Panama, and South Africa) have no change in national funding

When percent changes for the national allocations were aggregated regionally (also shown in Table 8.4), it is clear that the Eastern Mediterranean and Europe and the South-East Asia and Western Pacific regions are the hardest hit with declines of 93 and 32%, respectively. The majority of the

eliminating countries in these regions are projected to experience mild to steep declines in funding. Malaria-eliminating countries in the Americas are expected to see an overall increase of 30%, while malaria-eliminating countries in sub-Saharan Africa will likely have an overall 37% increase in allocations under the NFM.

Table 8.4. Average annual disbursements under the old funding model versus average annual NFM national allocations 2014–2017

Countries	Average annual disbursements before the NFM as of Dec 31st, 2013b	Average annual allocation under NFM: 2014–2017	Percent change[a]
Eastern Mediterranean and Europe			
Azerbaijan	D 1,049,387	D 0	−100 %
Iran	D 5,461,418	D 0	−100 %
Kyrgyzstan	D 884,028	D 113,074	−87 %
Tajikistan	D 2,721,312	D 335,802	−88 %
Uzbekistan	D 578,319	D 350,280	−39 %
Regional subtotal	*D 10,694,464*	*D 799,156*	*−93 %*
The Americas			
Belize	D 0	D 0	0 %
Costa Rica	D 0	D 0	0 %
Dominican Republic	D 1,592,747	D 0	−100 %
El Salvador	D 0	D 963,783	+
Nicaragua	D 2,431,682	D 2,921,343	20 %
Panama	D 0	D 0	0 %
Paraguay	D 0	D 1,338,783	+
Regional subtotal	*D 4,024,429*	*D 5,223,908*	*30 %*
South-East Asia and Western Pacific			
Bhutan	D 595,598	D 641,075	8 %
Korea, Dem. Rep.	D 4,878,128	D 3,966,350	−19 %
Philippines	D 8,594,847	D 5,543,637	−36 %
Solomon Islands[c]	D 2,329,166	D 1,617,630	−31 %
Sri Lanka	D 5,310,434	D 3,194,798	−40 %
Thailand	D 13,611,345	D 8,914,463	−35 %
Vanuatu[c]	D 1,552,777	D 813,042	−48 %
Vietnam	D 4,895,794	D 3,778,554	−23 %
Regional subtotal	*D 41,768,089*	*D 28,469,547*	*−32 %*
Sub-Saharan Africa			
Botswana	D 0	D 1,282,149	+
Cape Verde	D 633,015	D 320,537	−49 %

Countries	Average annual disbursements before the NFM as of Dec 31st, 2013b	Average annual allocation under NFM: 2014–2017	Percent change[a]
Namibia	D 2,431,682	D 3,018,565	24 %
Sao Tome and Principe	D 1,807,650	D 2,733,377	51 %
South Africa	D 0	D 0	0 %
Swaziland	D 1,420,225	D 1,290,603	−9 %
Regional subtotal	*D 6,292,571*	*D 8,645,232*	*37 %*
Total	*D 62,779,553*	*D 43,137,843*	*−31 %*

a + indicates a percent change was unquantifiable (e.g. a country who had received no previous GFATM funding is allocated funding under the NFM.)
b This is calculated by taking the total grant disbursement through 2013 and dividing it by each grant's start date through 31-December-2013
c These countries compose the multi-country Western Pacific, whose previous grant was split 60/40 (Solomon Islands: Vanuatu)

8.4.3 GFATM NFM regional grants

Regional grants provide USD 39.6 million over 3 years in extra support for 12 malaria-eliminating countries located in southern Africa, Central America, and the Mekong region (as shown in Table 8.5) and boost overall funding for malaria elimination from −31% to an increase of 32%. Adding regional grant country shares to national funding have a clear positive affect to funding. With the addition of regional funding, malaria-eliminating countries in the Americas are expected to see a cumulative 171 % increase in funding compared to the old funding model.

Similarly, malaria-eliminating countries in South-East Asia and Western Pacific are expected to see an overall 28 % increase in funding, and malaria eliminating countries in sub-Saharan Africa are expected to see an overall 179 % increase in funding. No regional grant funding for malaria has been provided to malaria eliminating countries in the Eastern Mediterranean and European regions.

8.4.4 NFM malaria funding ranges

As an example, Fig. 8.2 illustrates the breakdown of the estimated funding range available for Vietnam for the period of 2014–2017. The range is determined by the adjustments made during the country dialogue process and the addition of regional grant funding. The area at the bottom of the funding range represents Vietnam's portion (USD 15 million) of the RAI regional grant. The solid fill area represents the full national allocation, which totals USD 15 million, with the various shaded areas showing the portion of the national allocation Vietnam would receive based on unmet willingness to pay criteria and/or a reduction of the disease split amount. Possible upward adjustments include an increase in disease split funding (an additional USD 1.51 million) and successful award of incentive funding (USD 2.27 million) and are represented at the top of the funding range. Accordingly, Vietnam's minimum possible funding of about USD 26 million would include the RAI regional grant share plus the minimum national allocation (unmet willingness to pay

and a Country Coordinating Mechanism decision to move 10 % of malaria funding to HIV or TB). Vietnam's maximum funding amount of nearly USD 34 million includes the RAI regional grant share plus the full national allocation and all upward adjustments (a Country Coordinating Mechanism decision to increase malaria by 10 % and successful award of incentive funding).

Table 8.5. Regional grants for malaria under the NFM

GFATM regional grant for malaria	Total grant amount	Total estimated to malaria-eliminating countries included in grant scope	Malaria-eliminating countries included in regional grant scope
Elimination 8 (E8)	USD 17,800,000	USD 8,900,000	Botswana, Namibia, Swaziland, South Africa
Elimination of Malaria in Mesoamerica and the Island of Hispaniola (EMMIE)	USD 10,000,000	USD 5,666,668	Belize, Costa Rica, Dominican Republic, El Salvador, Nicaragua, and Panama
Regional Artemisinin-resistance Initiative (RAI)	USD 100,000,000	USD 25,000,000	Thailand and Vietnam

Notes: The E8 is not structured such that it has country specific breakdowns of funding. For this analysis, it was assumed that the USD 17.8 million is divided equally among the eight countries (Angola, Botswana, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe).
The USD10 million EMMIE regional grant covers 10 countries, 5 of which are eligible for startup funding (Costa Rica, Belize, El Salvador, Mexico, Panama), and 9 of which are eligible for payouts (all but Mexico). EMMIE is a cash-on-delivery model and of the USD 10 million, USD 3 million will go to Population Services International as the Principal Recipient. Because it will not be known which countries will be successful in meeting targets until the end of Years 2 and 3, this analysis assumed that the remaining amount (USD 7 million) was evenly split over the 9 eligible countries and added to startup funding, if applicable.
15 % of the USD100 million RAI regional grant goes to Vietnam and 10% goes to Thailand.

Applying the same structure, Figures 8.3, 8.4, 8.5, and 8.6 show the possible funding ranges for eligible eliminating countries for the period of 2014–2017, by region. The possible adjustments and additional regional grant funding have the potential to change the allocations by either 25 % more or less than the amount originally communicated to the countries in March 2014. In the Americas, Belize, Costa Rica, Dominican Republic and Panama are not eligible for national grants and thus do not have national allocations, however they can receive funding through the regional EMMIE award. Similarly, South Africa is not eligible for a national allocation, however is assumed to receive one-eighth of the E8 regional grant.

Figure 8.2. Estimated Global Fund NFM malaria funding range for Vietnam as an example, for the period of 2014-2017 using adjustments and additional funding

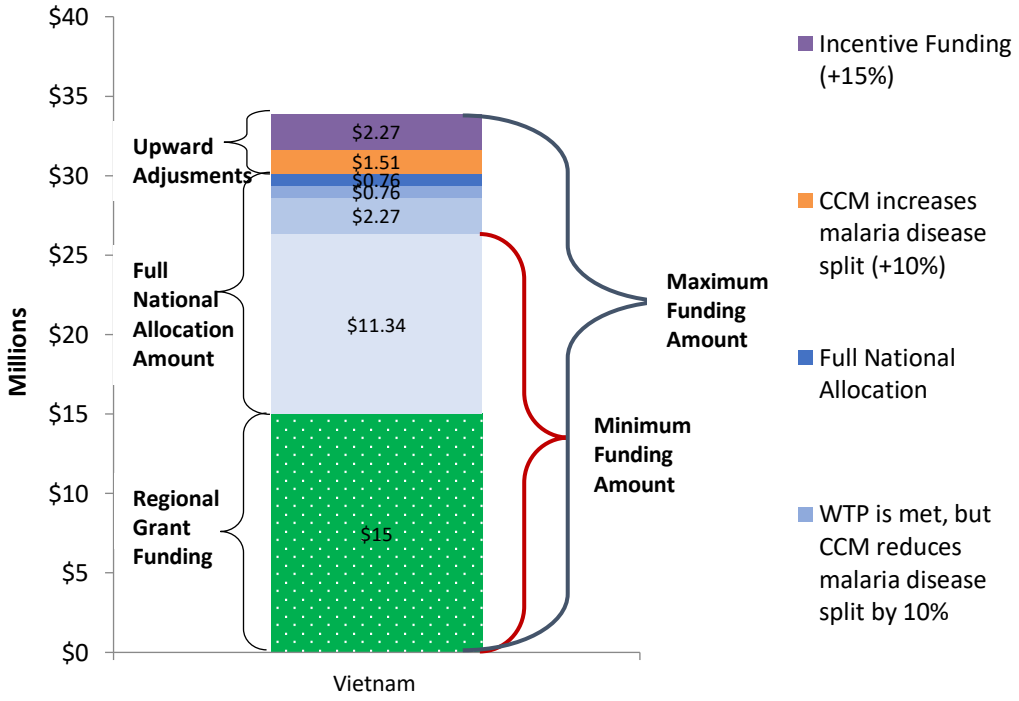


Figure 8.3. Estimated Global Fund NFM malaria funding ranges for malaria-eliminating countries in the Eastern Mediterranean and Europe regions, for the period of 2014-2017 using adjustments and additional funding

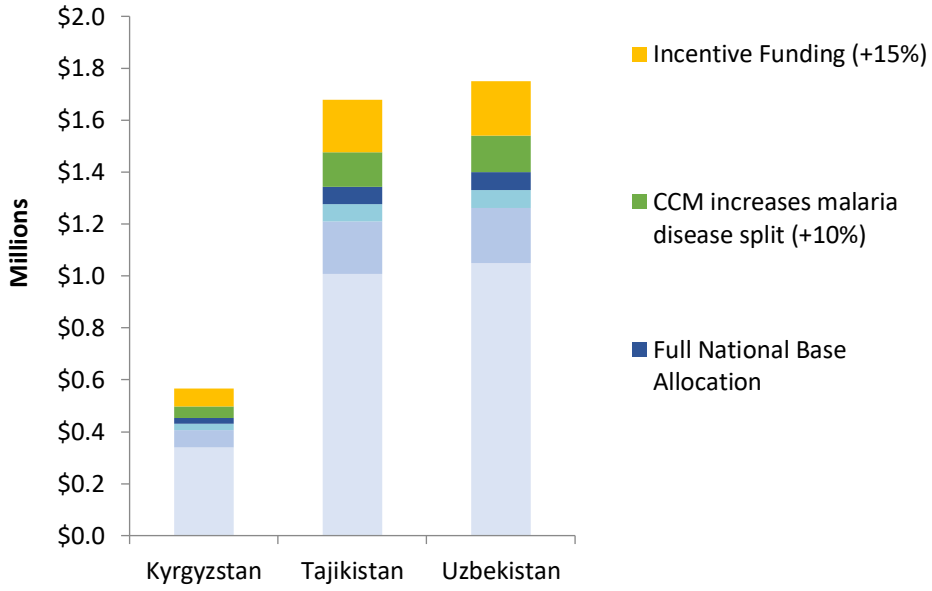


Figure 8.4. Estimated Global Fund NFM malaria funding ranges for malaria-eliminating countries in the Americas, for the period of 2014-2017 using adjustments and additional funding

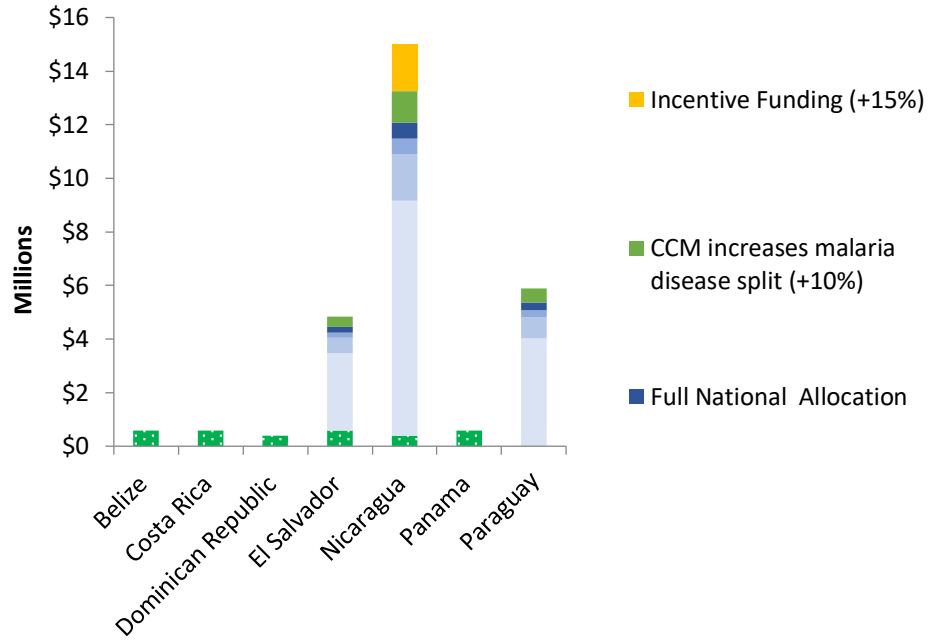


Figure 8.5. Estimated Global Fund NFM malaria funding ranges for malaria-eliminating countries in the South-East Asia and Western Pacific, for the period of 2014-2017 using adjustments and additional funding

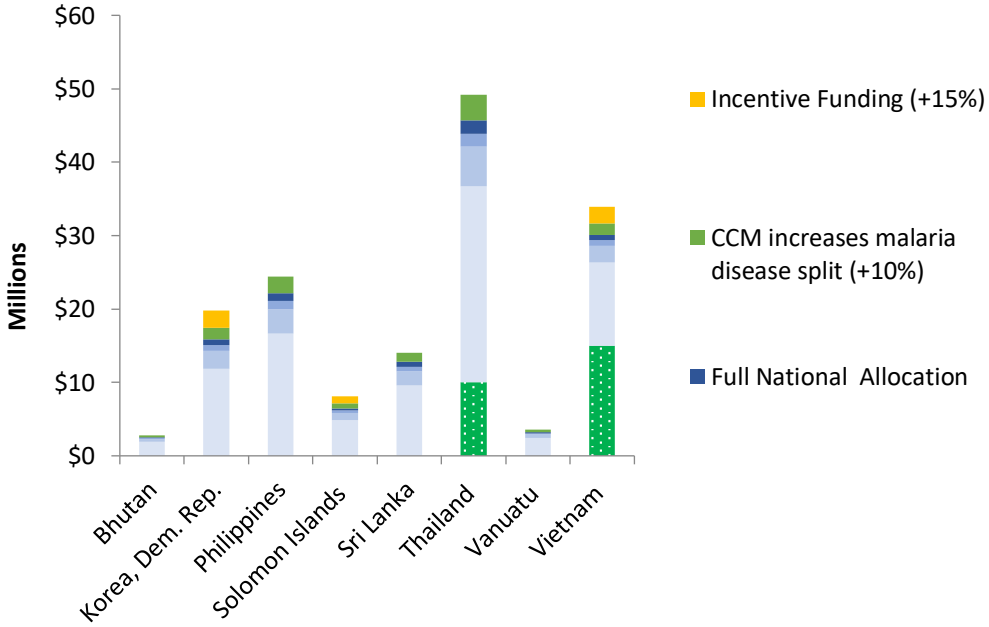
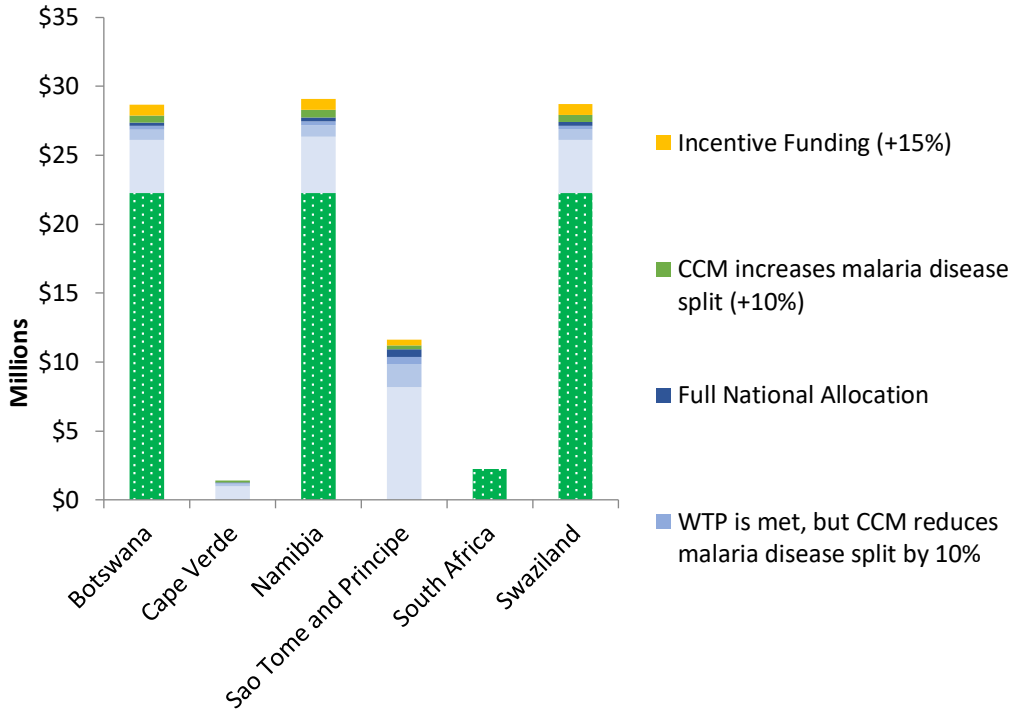


Figure 8.6. Estimated Global Fund NFM malaria funding ranges for malaria-eliminating countries in Sub-Saharan Africa for the period of 2014-2017, using adjustments and additional funding



8.4.5 NFM minimum and maximum funding amounts compared to the old funding model

The range of percent differences between the estimated minimum and maximum average annual allocations for 2014–2017 determined in Figs. 8.3, 8.4, 8.5, 8.6 are compared to average annual disbursements under the old funding model and are shown in Fig. 8.7. Percentages on the left side of a country's range indicate the percent change between a country's minimum funding amount compared to their funding under the old funding model. Similarly, percentages to the right side of the range indicate the change between a country's maximum funding amounts compared to funding under the old funding model. In the best-case scenario (receiving maximum funding from the GFATM for malaria), 46 % of the countries included in this analysis will still see decreases in funding (Cape Verde, Philippines, Solomon Islands, Sri Lanka, Tajikistan, Thailand, Uzbekistan, and Vanuatu). For countries like Bhutan, Namibia, Nicaragua, Sao Tome and Principe, Swaziland and Vietnam, the extra adjustments, if made, could mean a considerable increase in support for their elimination efforts. Azerbaijan, Dominican Republic, Iran, and Kyrgyzstan are no longer eligible for funding due to either their low malaria burden or income level.

Figure 8.7. Percent changes between the average annual disbursements under old funding model to average annual NFM minimum and maximum funding amounts

Min and max funding (2014-2017) range percent changes compared to OFM	-100 to -91	-90 to -81	-80 to -71	-70 to -61	-60 to -51	-50 to -41	-40 to -31	-30 to -21	-20 to -11	-10 to -1	0%	1 to 10	11 to 20	21 to 30	31 to 40	41 to 50	51 to 60	61 to 70	71 to 80	81 to 90	91 to 100	No previous funding
Eastern Mediterranean and Europe																						
Azerbaijan	-100%																					
Iran*	-100%																					
Kyrgyzstan		-87%																				
Tajikistan	-91%	-85%																				
Uzbekistan					-55%			-24%														
The Americas																						
Belize																						+
Costa Rica																						+
Dominican Republic	-94%																					
El Salvador																						+
Nicaragua										-6%							54%					
Panama																						+
Paraguay																						+
South-East Asia and Western Pacific																						
Bhutan									-19%				18%									
Korea, Dem. Rep.							-39%					2%										
Philippines					-52%			-29%														
Solomon Islands						-48%			-13%													
Sri Lanka					-55%		-34%															
Thailand							-33%			-10%												
Vanuatu				-61%		-42%																
Vietnam															34%				73%			
Sub-saharan Africa																						
Botswana																						+
Cape Verde				-62%		-44%																
Namibia									-12%							47%						
Sao Tome and Principe													13%					61%				
South Africa																						+
Swaziland							-32%						14%									

*Although Iran is marked as -100%, they still have funding from grants under the OFM that were not rolled in to grants under the NFM since they are no longer eligibile.

8.5 Discussion

Under the NFM, a total of USD 4.5 billion has been allocated to 75 countries deemed eligible for GFATM malaria support through national allocations and countries included in three regional grants to E8, EMMIE, and RAI [7]. The proportion of the overall GFATM malaria portfolio to eligible malaria-eliminating countries has decreased—from 7 % under the old funding model to 4.3% under the NFM, less than a quarter of which is from funding through the three regional grants. Despite this small and shrinking portion of GFATM funding, this money has been and will continue to be catalytic in accelerating toward malaria elimination in these countries. In contrast, roughly 20 % (USD 0.9 billion) of the GFATM malaria portfolio goes to just two countries (Democratic Republic of Congo and Nigeria) [7]. 30 % (USD 1.3 billion) goes to ten countries (Burkina Faso, Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Mozambique, Tanzania, Sudan and Uganda) [7].

Currently, there is a projected overall decrease of 31 % in allocated national funding to eliminating countries from the GFATM. The change in total allocations to the eligible eliminating countries compared to previous disbursements under the old funding model varies widely by country: some countries are allocated up to 100 % more than previous disbursements and other countries are allocated significantly less. However, this allocation formula provides a preliminary guideline for the signed grant amounts, which are shaped by the Country coordinating mechanisms who have the opportunity to negotiate for additional resources based on the country's needs and timelines. This flexibility in the NFM allows for countries to take full ownership of the grants once implemented on the ground.

Still, uncertainties remain for countries around the grant making process and the adjustments that could be applied, including the domestic counterpart financing requirement and willingness to pay criteria. All allocations are conditional on countries reaching their minimum counterpart-financing requirement, based on income level. While 78 % of financing for malaria elimination is generated at the domestic level, many of the low-income and LMICs depend heavily upon GFATM financing (such as Bhutan, Nicaragua, Philippines, the Solomon Islands, Sri Lanka, and Vietnam) [16] and any reduction in donor financing could hinder their efforts to eliminate malaria and prevent re-introduction. Past estimates calculated from World Malaria Report 2012 data for years 2005 through 2010 indicate that roughly 20 % of eliminating countries have not historically met what would be a 5–60 % domestic counterpart-financing requirement [4].

Along with the counterpart-financing requirement, the willingness to pay adjustment is an effort to increase domestic financing and promote sustainability of GFATM investments. While intended to support sustainability, the domestic funding contribution criteria require

additional facilitation from the GFATM, especially for countries transitioning to higher income levels. The GFATM can help countries advocate for increased domestic financing through a variety of channels, using tools such as the WHO's Global Technical Strategy for Malaria 2016–2030 [17] and Roll Back Malaria's Action and Investment to Defeat Malaria 2016–2030 [18] to demonstrate the strategies and economic investment cases for funding, and by leveraging regional organizations such as the African Leaders Malaria Alliance [19], the Asia Pacific Leaders Malaria Alliance [20], and the Asia Pacific Malaria Elimination Network [21] to help garner the high-level political support and to implement tools needed to increase domestic financing.

Analysis of the funding ranges suggests that projected funding amounts are quite variable. Countries could receive roughly 25 % more or 25 % less than their allocated amounts, as exemplified by the variance in Vietnam's funding range for the period of 2014–2017. If Vietnam does not meet the willingness to pay requirement and their Country Coordinating Mechanism prioritizes HIV or TB over malaria, their GFATM's national malaria allocation can decrease from about USD 15 million to just over USD 11 million (about 25 % less than the full national allocation amount). In this case, the minimum funding amount would equal a USD 11 million national allocation plus USD 15 million in regional grant funding. Furthermore, if Vietnam's minimum funding amount is compared to their average funding under the old funding model, they are expected to see a 34 % increase in funding. If the Country Coordinating Mechanism prioritizes malaria funding, and the GFATM determines the country should receive their full incentive allocation in addition to their national allocation and regional grant funding, it is possible that Vietnam could receive almost USD 34 million (about 73 %) more funding than under the old funding model. However, this is not the case for about half of the malaria-eliminating countries. Even if they receive their maximum funding amount, 46 % of eliminating countries are projected to see a decrease in funding from the GFATM under the NFM when compared to the old funding model. It is unlikely that many countries would receive the estimated maximum funding calculated by the post-allocation adjustments.

These findings suggest an unpredictable environment for malaria programmes to operate in. Due to competing disease priorities, some eliminating countries may not be able to continue to adequately fund national malaria programmes, putting them at higher risk of resurgence. Historical evidence suggests that if malaria funds are interrupted, programmes are weakened, or interventions are disrupted before malaria has been eliminated, there is a danger of malaria resurgence [22]. Furthermore, this reduction in funding is not limited to malaria-eliminating countries; many control countries such as Ethiopia, Haiti, Côte d'Ivoire and Uganda are also projected to see a decline in funding [7], straining resources in these settings as well. To mitigate the risk of resurgence, account for progress in burden reduction, and address the malariogenic potential of endemic countries, the GFATM has

used malaria epidemiology data from the World Health Organization from 2000 to 2010 in the allocation methodology.

With the addition of regional grants, a 31 % decrease in national funding is augmented to a cumulative 32 % increase in funding for malaria-eliminating countries. Regional trend analysis suggest the malaria-eliminating countries in the Eastern Mediterranean and Europe region are expected to see a 93 % decrease in GFATM national financing, mainly due to steep declines in malaria cases. Malaria-eliminating countries in Southeast Asia and Western Pacific are expected to experience an overall 32 % decline in aggregated national funding, as countries such as the Philippines, the Solomon Islands, Sri Lanka, and Vanuatu all are expected to experience decreases in funding ranging from 30 to 50%.

However, with the addition of the RAI regional grant, the eliminating countries in the region are expected to see a 28 % increase in funding, mainly through RAI support to Thailand and Vietnam. The RAI grant is a particularly strategic investment and is expected to have a positive impact for elimination in the region, providing additional support to higher burden Mekong countries. This is especially critical given the serious threat of anti-malarial drug resistant malaria. Despite the Dominican Republic's recent ineligibility for malaria funding, eliminating countries in the Americas are expected to see an overall 171 % increase with the additional funding through EMMIE, particularly to countries that would otherwise be ineligible for national malaria funding. The malaria-eliminating countries in sub-Saharan Africa are expected to see an overall 179 % increase in funding due to the addition of the E8 grant funds and because Botswana, although previously eligible, did not receive funding under the old funding model but did receive a malaria allocation of roughly USD 1.3 million under the NFM. The E8 regional grant, which will support eight countries in the southern Africa region, also includes South Africa, who is otherwise ineligible for national malaria funding.

Despite providing much needed additional funding for elimination, funds granted through regional channels will likely not fill all the gaps from reduced national level allocations as they usually will not cover country specific activities or necessary commodity procurement. Regional grants can, however, leverage country-level efforts by providing complementary investments to sup- port cross-border initiatives and collaboration that would not otherwise be included in country grants. Another benefit is that the regional approach is two-pronged; it supports both high- and low- transmission countries by creating a platform for data and information sharing and provides an opportunity for enhanced collaboration between countries.

Because the eliminating countries are a critical part of a global movement toward eradication and maintaining essential national level funding is crucial, a mix of regional and country investments by the GFATM can leverage the gains already made toward eradicating malaria. Country grants support core malaria interventions, while regional grants support collaborative surveillance platforms and demonstrate strong value for money by driving economies of scale among low burden countries. The regional grants can also hold regions accountable for reaching goals for elimination and eventual global eradication by jointly monitoring national and regional activities that are mutually reinforcing. Funding from the GFATM has been essential to many of the eliminating countries, and maintaining this level of funding, through a mix of national and regional funding streams, will be needed in order protect investments and sustain progress toward a malaria-free world.

8.6 Limitations

The adjustments made to the national allocation introduce important limitations in this analysis, which affect the quantification of the funding ranges for each country. These ranges were quantified based on the information provided by the GFATM; however, other factors are evaluated on a case-by-case basis and how decisions affect funding is ultimately determined by the GFATM and the Country coordinating mechanism. Thus, these funding ranges should be taken as estimations to provide guidance on potential funding ranges from the GFATM.

Another major limitation is the analysis is that due to a significant time lag between programme implementation and impact on malaria epidemiology, the analysis cannot fully assess the financial impact on in-country malaria burden.

There are likely other benefits of the NFM on malaria eliminating countries that are outside the scope of this analysis. GFATM funding for health system strengthening, separate from the three disease streams, would likely improve overall outcomes across the board.

8.7 Conclusion

Funding from the GFATM has been critical for many countries to accelerate progress toward malaria elimination. As the GFATM prioritizes higher burden, lower income countries, national funding streams to many eliminating countries are projected to be at risk. A decrease in national funding could reverse all the hard earned gains and returns on the GFATM's investment to-date. For some of these eliminating countries, regional grants for malaria have augmented funding for elimination activities and helped encouraged regional collaboration but they are unable to fill all the gaps in funding created through reductions in

national funding. Without strong national malaria programmes, regional grants may be less effective in achieving regional goals. By creating a more nuanced allocation formula or a mix of other mechanisms to invest in malaria eliminating countries, the GFATM has an opportunity to ensure their previous investments in malaria are not lost. As the global community sets its sights on a malaria-free world, the GFATM's continued investments in both high and low burden countries will signal alignment with countries and regions that are paving the way toward malaria elimination and eventual eradication.

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8.9 References

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CHAPTER 9

Transitioning from Global Fund Financing: Challenges and Implications for Malaria Elimination: A Commentary

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9.1 Abstract

Despite global commitments to "leave no one behind" [1], many donors, including the Global Fund to Fight AIDS, Tuberculosis and Malaria are now focusing their limited resources on countries with the highest disease burden and the least ability to pay. As donors reduce their financial support to geographies that do not meet these criteria, the implicit expectation is that domestic resources finance critical activities previously supported by foreign aid. This managed "transition" from donor aid to domestic-supported health programmes is novel and fraught with challenges. In this policy piece, we outline key challenges faced by countries undergoing this transition, explore gaps that exist in current evidence, and highlight policy recommendations for donors and national malaria programmes to facilitate a more successful transition process.

9.2 Background

Since its inception in 2002, the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) has been the world's largest financier of malaria programmes, providing in excess of USD 9.1 billion to more than 100 countries between 2002 and 2016. This investment contributed to declines in global malaria incidence and deaths of 20 and 26%, respectively, between 2010 and 2016 [2]. However, since 2010, donor aid for malaria globally has plateaued and declined by more than 60% for the 35 countries actively pursuing malaria elimination [3, 4]. This trend is projected to continue due to changes in donor investment strategies, which increasingly prioritize support to the highest-burden countries with the least ability to pay. Historically, the Global Fund has dispersed approximately 7% of its total portfolio to eligible malaria-eliminating countries. However, under a formula-based allocation model adopted by the Global Fund Board in 2012, malaria resources for this sub-set of eliminating countries declined to less than 5% and are projected to decline further under the revised 2017-2022 strategy [5, 6].

These policy changes have major implications for the delivery of health services, particularly in countries that are nearing malaria elimination, many of which relied on considerable financial support from the Global Fund to reduce their disease burden in the past decade. Malaria-eliminating countries typically have a lower disease burden, are often categorized as middle-income, and under the new allocation model are no longer eligible for Global Fund financing. At the same time, the Sustainable Development Goals include a target of ending malaria, and the World Health Organization (WHO*) Global Technical Strategy for Malaria 2016–2030* [7] calls for malaria to be eliminated from at least 35 countries by 2030. The newly ineligible countries must therefore find new ways to continue financing their malaria elimination plans in order to meet these global expectations. Eliminating countries are already funding the majority of malaria activities domestically, relying on donor financing primarily for the delivery of high-impact interventions to high-risk populations living in border areas and the management of health programmes and systems [8]. As these countries no longer meet donor eligibility requirements, these critical aspects of their national malaria programmes may be at risk, unless the transition is carefully managed so that domestic funding can be secured to fill the emerging gap [9].

This issue is pervasive. Many malaria-eliminating countries are approaching one or more donor eligibility thresholds. Since 2011, seven countries (Brazil, China, Colombia, Dominican Republic, Ecuador, Equatorial Guinea and Iran) have graduated from Global Fund malaria financing and now implement their national malaria programmes independent of this support. Seven additional malaria-eliminating countries are in their final round of Global Fund Support or will reach the Global Fund's eligibility thresholds in the next five years:

Bolivia, Botswana, El Salvador, Guatemala, Sri Lanka, Paraguay, and the Philippines [10]. In spite of these anticipated transitions, and the emphasis in the 2017-2022 Global Fund strategy on the critical importance of sustainability, there is currently no planning process in place for transition or consensus on the best model for an effective strategy to withdraw aid for malaria.

Without adequate time and careful advance planning to replace donor aid with domestic resources, gains in malaria elimination made with decades of investment from the Global Fund and others are in jeopardy. Abrupt withdrawal of donor funding may lead to disruptions in a country's delivery of critical malaria interventions, confer negative cross-border externalities to neighboring nations, and increase the risk of deadly and costly malaria resurgences [11, 12]. The resulting potential excesses in mortality and morbidity may undermine progress towards national elimination goals, compromising regional elimination targets, and ultimately preventing global eradication. Such risks may be compounded if countries face multiple funding cliffs from donors that are phasing out simultaneously from various disease-specific programmes.

In this commentary, we outline the key challenges faced by countries undergoing transitions from donor funding to fully domestically financed programmes, and offer policy recommendations to support eliminating countries' continued progress towards a malaria-free future.

9.3 Challenges

Countries need sufficient and advance notice from donors to ensure that the transfer of responsibilities for programmes to deliver critical health care services happens in a planned and sustainable fashion. Experiences with HIV programme transitions demonstrate that a process lasting at least five years is necessary. For example, the Avahan HIV/AIDS programme, which was transitioned from the Bill and Melinda Gates Foundation to the Government of India over a period of nearly eight years, is hailed as a successful transition [14, 15]. Both GAVI and the Global Fund have been credited with providing public information about the transition timeframe and procedures. The Global Fund's Eligibility Policy [16] allows for up to one allocation of three years of transition funding following a change in eligibility. However, as described in the following challenges, transitions often can have a deep impact on the health system, programme management, and the delivery of health care, that go far beyond financing.

9.3.1 Challenges in management capacity

Donor transitions are not just about money. The most salient and yet often neglected issue for many national malaria programmes is management. Many programmes rely heavily on donors not only for funding of health delivery, but also for support of the technical and programmatic leadership. Key staff positions are often supported by the Global Fund especially in countries where restrictive human resource processes can prevent malaria programmes from hiring technical experts or deploying field staff during an outbreak. In addition, salaries for staff implementing a donor programme may differ substantially from a fully government-funded employee, which may cause problems retaining talent. Without greater attention to developing transition strategies for the donor-supported management and stewardship functions, including retaining essential human capital, programmes risk losing essential technical and management capacity for implementation.

9.3.2 Lack of financial planning data

Many malaria programmes operate without financial data needed to effectively budget, mobilize, and allocate resources because they have been supported by external funds for so long. Few programmes have strong financial management systems in place to track the sources of funds and expenditures, and many lack the capacity to establish accurate estimates of short- and long-term financing needs. Without an understanding of the actual cost of the programme or financing available, it is challenging for programmes to anticipate, quantify, and mitigate financial gaps that will occur during a transition.

9.3.3 Diminishing political will

Even though donor financing for malaria represents only a small share of a country's total health expenditure – less than 2 % in countries outside of Africa, such as Indonesia, Philippines and Sri Lanka in 2014 [17] – these grants lead to valuable political support and visibility for malaria programmes. For example, Sri Lanka's robust national malaria programme, bolstered by additional financing from the Global Fund, cultivated high-level political support during the malaria elimination and malaria-free certification phase. The programme, a heralded success in the region, is now undergoing a transition from Global Fund support as it no longer meets eligibility requirements. However, it is critical that the programme continue to prevent reintroduction of malaria even as national political priorities shift towards other threats, such as Dengue fever. Maintaining the high-level ministerial support to maintain successful programmes without the political pressure exerted by providers of foreign aid will require significant advocacy efforts by national malaria programmes and others.

9.3.4 Concurrent epidemiological changes and changing priorities after elimination

Many malaria-endemic countries are undergoing an epidemiological transition at the same time as they experience a donor financing transition, adding complexity to their strategic planning and prioritization of efforts. There is little available technical guidance on the minimum level of interventions needed to prevent reintroduction once elimination is on the horizon or has been achieved. National malaria programmes must juggle a delicate balance of scaling back interventions without risking the reversal of previous progress. This shift from control to elimination requires countries to adopt increasingly sophisticated and targeted strategies; using analysis of high quality sub-national data to deploy focused interventions to the remaining clusters of malaria transmission. However, sub-national data and surveillance systems are often poor, and the mechanisms needed to identify and treat every case are often human resource intensive and costly. Given the historical reliance on donor funds for system strengthening efforts, transitions may limit resources available for these pending infrastructure needs. This becomes even more difficult in the context of a financial transition that constrains available budgets and intensifies pressure to find efficiencies.

9.3.5 Parallel donor and government systems

In many countries, donors and national programmes operate parallel systems for information, supply chain, and service delivery and in some cases malaria programmes rely on the donor-operated systems alone. As funding transitions, so too must the integration and ownership of these systems and the historical data they possess to avoid gaps in essential services when donors are no longer playing a key role in malaria programmes. The practical matter of ensuring that these systems, including the data, hardware, software, and trained operators can be maintained by the government, is a critical aspect of the transition process. This effort will take time and financial resources to do effectively, which may not be top of mind in transition planning that is focused primarily on funding.

9.3.6 Integration of vertical programmes

As countries move towards elimination there is often a need to integrate the malaria programmes into other public health and vector control programmes. In addition to being led and delivered by different individuals, in many countries, vertically managed disease programmes operate separate surveillance, information, and vector control systems. While integration may offer opportunities for greater efficiency, the loss of specialized knowledge and experience and the challenges of integrating disparate information systems can be costly. Staff integration may mean that the malaria elimination programme is left to rely on health care workers without specialized training to deliver complicated interventions. Data system integration often takes significant time and resources and may mean that some data is lost or granularity of information sacrificed. Integration of human resources and data

systems needs to be approached carefully due to the potential risk of further reduced attention on malaria and the corresponding risk of outbreaks.

9.3.7 Procurement pricing and quality commodities

When no longer eligible for Global Fund support, countries lose access to the Fund's volume-based commodity pricing benefits. The use of wambo.org, an online platform for countries to procure health products through a pooled procurement mechanism, is currently only available to Global Fund recipients. The Global Fund's policies require countries to procure quality-assured products, but when medicines and commodities are no longer procured using donor systems and domestic resources are limited, there is an incentive to procure less expensive and potentially lower quality products. In addition, without access to a pooled procurement mechanism, countries that require smaller quantities of key commodities often must spend much more on the same volume of products. The overall cost for their programme will increase and they may face challenges in maintaining adequate stocks or prepositioning commodities for future outbreak responses.

9.3.8 Strategic programme delivery and management

In many contexts, health programmes financed by donors are delivered through contracts with non-governmental organizations (NGOs). This arrangement is often made to reach marginalized populations that do not have access to government-run public facilities or because donors are unwilling to directly finance government health systems. When they lose eligibility for donor support, countries may face legal impediments to contracting with the same NGOs, find that managing delivery partners' activities is too difficult, or learn that private service providers are too expensive. These potential changes in the structure of the system may cause interruptions in the delivery of health services to high-risk populations without access to public facilities.

9.4 Policy recommendations

Despite challenges inherent in the withdrawal of donor support, transitions create an opportunity for countries to assess the strength of their governance, financing, and service delivery systems. By providing adequate time and resources to ensure a successful and sustainable transition, donors can protect their investments in the health systems and safeguard the gains made in morbidity and mortality. Countries must conduct a review of their programmes and develop a robust transition plan that allows for sustainability of core functions that they share and coordinate with donors. Through the transition planning process, national malaria programmes enumerate the need for and request additional financing to be used to strengthen and integrate affected systems. It is the goal of these

policy recommendations to offer suggestions to maintain the progress made toward the elimination and prevention of the reintroduction of malaria.

9.4.1 Country-level actions

The transition plan starts with a readiness assessment to identify areas of strength and weakness of the malaria programme. These findings are used to build a transition plan that addresses priority financing, management, and programme delivery gaps [18]. Countries need to determine their "true need" by developing or strengthening surveillance and financial tracking systems, as well as strategic planning capacity within the government. They must understand the changing epidemiological patterns, the impact of changes to the delivery system, and the effect of increased pricing levels in order to enumerate the resource needs. To address the financing gaps left by the withdrawal of foreign aid, national malaria programmes can then effectively implement efficiency measures, or advocate for an increased budget from domestic sources.

To strengthen management capacity, national malaria programmes can seek and leverage transitional financing grants to build staff expertise and skills, strengthen and integrate surveillance, reporting, human resources and information systems that are essential to inform decision-making, and assess the overall reach and strength of the delivery system. Country preparations for transition should include plans and resources to mitigate turnover of staff in key technical and leadership positions, particularly in cases where the grant is being managed outside of the national government. It may be important to develop or review the facilities in which malaria related health care is delivered by NGOs or private providers to identify where direct relationships with the government may need to be built. And finally, a review of short- and long-term health workforce needs can also strengthen planning and advocacy, especially in countries where recruitment and staffing policies are restrictive.

Furthermore, the malaria programme's strategy may need to evolve during transition to address new epidemiological challenges. To improve efficiencies and integrate essential donor-supported staff and systems, health ministries may need to consider opportunities to integrate and align the malaria programme's surveillance, reporting, and information systems with those from other disease programmes. The malaria programme may consider sharing personnel with other disease efforts, but with an eye toward a limit of compromising staff technical capacity, overburdening the health worker, or losing the focus on finding every malaria case. Regional malaria elimination initiatives, if available, could also offer national malaria programmes pooled procurement options to guarantee competitive pricing of quality commodities.

9.4.2 Donor-level actions

Donors can provide guidance and support to national malaria programmes to conduct transition assessments and institute country-led transition plans, particularly by helping to engage to key stakeholder groups. Inclusion of relevant national (e.g., ministry of finance) and sub-national (e.g., regional malaria programme staff) partners in the process is important to facilitate broad support for and effective implementation of the transition plan. In addition, the donors and the country need to work closely with technical partners, (e.g., WHO) to ensure there is technical support for planned interventions during the expected epidemiological changes as malaria cases decline.

Most importantly, donors should be responsive to the needs described in the transition plans developed by countries. To support countries in preparing for transition, donors will likely need to increase their investments and shift existing investments from supporting commodity procurement and service delivery to long-term investments in capacity building, system development (e.g. surveillance, information management, financial management), and human resources. Donors may also consider sustaining investments to NGOs or private sector partners already engaged in delivering health services, or working with governments to develop direct relationships with these organizations to ensure that high-risk populations are consistently able to access malaria services. Finally, additional donor investments may be required for regional and cross-border initiatives that target high-risk vulnerable populations (e.g., migrants) or malaria transmission hotspots that would otherwise not be prioritized by national governments.

As the risks of transition can be compounded with multiple donors (or diseases) phasing out simultaneously, coordination amongst donors and country programmes is vital to avoid unforeseen, concurrent funding cliffs. Donors can play an important role in convening stakeholders to develop shared action plans at the regional and global levels and advocating to create pressure to maintain political support and allocate domestic resources to programmes that are facing transition.

9.5 Conclusion

As donors, including the Global Fund, increasingly focus their investments on high-burden countries with the least ability to pay, low-burden and middle-income countries face steep challenges as they navigate the transition from donor to domestic financing. This is a particularly acute problem for efforts to eliminate malaria, as many of the countries that have become ineligible or are rapidly approaching ineligibility are those that are actively pursuing malaria elimination. An abrupt or mismanaged donor transition affects more than

just funding. Countries may face programmatic challenges related to gaps in management or technical capacity, misaligned information systems, uncompetitive procurement, and inflexible human resource systems. In the face of these challenges, countries must develop clear transition plans based on evidence of the needs and potential gaps their programmes will face as donor aid is reduced or terminated.

While it is important to prioritize the use of limited resources as the disease burden decreases and financial means grow in middle-income countries, the Global Fund and other donors must be cautious and careful during transitions. There are significant risks with an untimely withdrawal, most critically losing hard fought progress toward the elimination of malaria. Transition planning should catalyze national malaria programmes to assess gaps and opportunities for strengthened governance, financing, and service delivery and build a clear transition plan based on this information on which they work closely with donors and other stakeholders. While the success of a donor transition largely depends on the capacity of a country to assume autonomous responsibility for its programmes, donors do bear responsibility to ensure that countries are well prepared and equipped to manage the process. Anything less will undermine decades of investment and unprecedented gains towards achieving a global public good - a world free of malaria.

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CHAPTER 10

Discussion and Conclusions

10.1 General discussion

Despite international consensus that malaria elimination leading to global eradication is a worthwhile goal [1], sustaining domestic and international funding as the malaria burden declines is a serious concern for many countries. The World Health Organization's (WHO) Global Technical Strategy (GTS) estimated that an annual investment of USD 6.4 billion would be needed to achieve the 2020 target of a 40 % reduction in malaria-related mortality and morbidity by 2020. Total funding for malaria control and elimination was estimated at USD 2.9 billion in 2015 [2], leaving a significant gap of about 54 %.

Lessons learned from the Global Malaria Eradication Programme (GMEP) affirm that while well-funded interventions can have a major impact on the disease, such gains are fragile and can easily be reversed. This is affirmed by a review of malaria resurgence which demonstrated that almost all historical resurgence events could be attributed, at least in part, to the weakening of malaria control programmes resulting from resource constraints [3]. At the same time the detection and spread of drug and insecticide resistance [4-7], particularly in Asia, has the potential to undermine past gains and compromise future effectiveness. There is general consensus that the only way to curb the spread of drug resistant malaria is to eliminate the parasite altogether [8]. However, accelerating and sustaining malaria elimination goals will require focused implementation of effective and high-impact strategies supported by unrelenting financial and political commitment at the global and domestic levels. Thus in turn will need to be backed by robust evidence on the health, social and economic benefits of malaria elimination.

Although the economic impact of malaria has been studied for well over a century, recent evidence on the financing and economics of malaria elimination remains disparate. There is little published information about the how much malaria elimination will cost in the short, medium and long-term; whether the cost savings of elimination will offset the initial

investment that elimination requires; what the economic returns of elimination are, versus maintaining the status quo; the sources of financing and how these funds are spent; and the impact of changing donor policies on elimination efforts.

This body of work provides strong evidence on the costs and benefits of malaria elimination. It demonstrates that while malaria elimination will cost more in the short term, these costs taper off as more countries eliminate and move to more efficient Prevention of Reintroduction (POR) strategies. In addition, it analyzes the trends in financing and the future availability of funding for malaria elimination and the potential implications of changing donor policies on malaria elimination programs. The findings are highly relevant and topical to inform policies and strategies to support the continued investment in malaria elimination.

One of the strongest arguments against eliminating or eradicating any disease involves the costs associated with finding and treating the decreasing numbers of cases [9], which will likely require an outlay of resources that appear to be disproportional to the marginal return. Maintaining a high level of financial support when transmission has been reduced to low levels therefore remains a challenge. Articulating the country-specific costs of elimination and the relative benefits of investment in elimination versus maintaining the status quo will help the advocacy argument to influence these decisions.

Although past analyses can provide some guidance on the costs of malaria control and elimination, most have used varying methodologies, cost inputs, intervention mixes and discount rates. Earlier studies did not incorporate post-elimination costs of surveillance and other interventions to prevent re-introduction of the disease and most used a public sector perspective for economic analysis, which only represents part of the equation [10]. Costs also differ by the region and smaller countries may have higher costs due to diseconomies of scale. Historical costs should therefore be used with caution to inform contemporary decisions.

Nevertheless, past studies provide some evidence that the immediate costs for elimination will initially be equal to, or higher than those of a control programme, due to initial investments in programme re-orientation to strengthen surveillance systems. Costs however, tend to decrease as the focus progresses to the POR phase [11-13] due to streamlining of surveillance activities, reductions in commodity expenditures and in some cases, integration of supporting health system activities [14]. This study estimated the total economic cost of the malaria program in Sri Lanka to be USD 0.57 per capita per year with a financial cost of USD 0.37 per capita. In the early 1980s, the cost of the control programme was estimated at USD 1.7 per capita, supporting the assumption that costs for POR are likely to decline in the medium term.

Using the outputs of a transmission model, our findings demonstrate that the cost of elimination of both *Plasmodium falciparum* and *Plasmodium vivax* malaria in all 22 countries in the Asia Pacific region would be about USD 1.5 billion, peaking to USD 4.29 billion annually in 2020. The costs drastically decrease to less than USD 1 billion in 2027 and less than USD 450 million in 2030 when elimination is expected to be achieved in all 22 countries. While these immediate costs may appear to be high, the benefits, many immeasurable, vastly outweigh the epidemiological and economic costs of inaction. This study estimated that in the Asia Pacific, malaria elimination will avert over 123 million cases and approximately 3.5 million deaths in the region over 14 years, saving almost USD 90 billion in economic benefits as measured by savings in health facility costs and human productivity. In a "reverse" scenario, where malaria elimination interventions are halted and reduced there will be an excess of 3.5 million additional deaths and 1 billion additional cases equating to an excess economic cost of about USD 7 billion between 2017-2030. The return on investment (ROI) for each additional dollar invested in malaria elimination in the Asia Pacific region was calculated to be 6:1.

Similarly in Sri Lanka, the financial cost required to maintain the current level of malaria activities in Sri Lanka in 2015 was estimated to be on average about USD 7,673,961 million annually. Domestic financing covered approximately 53% at USD 4,054,878. However, keeping the country free of malaria of malaria produced economic benefits of 169 million or an investment return of 13 times the cost of maintaining existing activities or 21 times based on financial costs alone. This by far exceeds the threshold on returns that are considered to be high- impact investments such as those from immunization programs and cardio-vascular disease research [15].

Nevertheless there is likely to be significant funding gap in Sri Lanka unless the government markedly increases the levels of funding available for malaria or alternative sources of financing are identified. The financial cost required to maintain the current level of malaria activities in Sri Lanka in 2015 was estimated to be an average of about USD 7,673,961 million annually. Government financing covered approximately 53% at USD 4,054,878.

Most studies monetize the value of the expected benefits from malaria elimination by quantifying the increased labour productivity due to reductions in premature mortality, morbidity and absenteeism as well as the direct savings accrued to the health system through reductions in malaria related outpatient and inpatient expenditures. However, many of the economic benefits associated with malaria interventions extend to other areas within and beyond health to include larger macroeconomic and demographic effects not included in our analysis. For example, past studies have been shown the benefits to include reduced private out-of-pocket expenditures on prevention and treatment [16,17], increased

agricultural output via reclaimed land [18-20]. Lower child mortality may reduce fertility [21], increase literacy and human capital [22] and eventually increase labour productivity. Domestic and foreign investment may be channeled to formerly malarious areas, also contributing to fiscal growth.

Elimination can also improve health equity because the last remaining foci of infection are often concentrated within poor or marginalized populations [22]. POR also protects against resurgences. Furthermore, eliminating malaria within a single country may confer substantial regional externalities and global public good, fostering collaboration. Elimination may also confer threshold benefits by permanently reducing the receptivity of an area to the reestablishment of local transmission [7, 14, 23], but methods to measure the value of the diminished resurgence risk have yet to be established. Lastly, the benefits of achieving and maintaining elimination include a strong public good component—an incremental contribution to global malaria eradication. As benefits become less tangible, they are more difficult to measure. However gaining an understanding of this larger set of economic benefits will require better macroeconomic models that quantify the links between elimination and other outcomes to give more realistic benefit estimations [19]. Moreover, the underlying assumptions in a cost-benefit analysis (CBA) comparing the net benefits of elimination with those of control are that both programmes are operating at their maximum potential. Ideally CBAs and the associated investment cases should begin with cost-minimization analysis to establish the optimum package of interventions with which to achieve control and elimination. Nevertheless, the overall favourable Benefit Cost Ratio (BCR) in both studies discussed here supports the case for continued investment in malaria elimination within individual countries and globally.

Despite these demonstrated returns from malaria elimination, countries who have successfully lowered their malaria burden are faced with the risk of losing or severely reducing their recurrent expenditure for elimination and preventing the re-introduction of malaria at a critical period in the malaria elimination efforts. Donor funding is on the decline in favour of programmes with seemingly greater potential impact on mortality and morbidly [24-26]. Although middle-income countries will eventually be able to fund their programmes, domestically; they are faced with competing priorities for the current limited government resources from other pressing disease priorities. At the same time, malaria-eliminating countries are also faced with the risk of resurgence due to the persistent importation of new cases placing an additional health and economic burden on the health system.

In the 35 malaria-eliminating countries, total financing for malaria grew from USD 179.5 million to USD 301.7 million between 2000 and 2013 of which DAH accounted for 19% in 2013. Development Assistance for Health (DAH) began to decline in 2011, coinciding with

the Global Fund's decision to halt its 11th grant cycle [27]. During this period, DAH declined by 65% in these countries and is projected to further decline. While government health expenditure has almost doubled in the eliminating countries between 2000 and 2010, this increase has not been proportional to the rate of diminishing external financing leading to a potential gap in service delivery needed to attain elimination, particularly in middle-income countries.

The Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) is the largest external financier for malaria providing 96% of the total external funding for malaria in 2013. The new allocation methodology adopted by the Global Fund in 2012, uses a combination of disease burden and Gross National Income (GNI) per capita to determine the financing that countries will receive for the three diseases [25]. In 2014, a total of USD 4.5 billion was allocated to 75 countries deemed eligible for GFATM malaria support through national allocations and to the countries included in three regional grants to Elimination Eight (E8) in Southern Africa, the Malaria Elimination Program in Mesoamerica and the Island of Hispaniola (EMMIE) and the Regional Artemisinin Initiative (RAI) [28,29]. The proportion of the overall Global Fund malaria portfolio to eligible malaria-eliminating countries has decreased—from 7 % under the old funding model to 4.3 % under the New Funding Model (NFM), less than a quarter of which is from funding through the three regional grants [30]. Malaria-eliminating countries in South- East Asia and Western Pacific are expected to experience an overall 32 % decline in aggregated national funding, as countries such as the Philippines, the Solomon Islands, Sri Lanka, and Vanuatu all are experienced decreases in funding ranging from 30 to 50 % [31]. Overall, the findings showed a cumulative 31 % decrease in financing for malaria elimination from the Global Fund as a result of the allocation model. Further declines in allocations have been noted under a subsequently revised strategy adopted in November 2016, potentially leaving critical gaps in essential program activities.

Although 78 % of financing for malaria elimination is generated at the domestic level, Global Fund financing is catalytic in delivering of high-impact interventions to high-risk populations living in border areas and the management of health programmes and systems [31]. Reductions in financing could hinder their efforts to eliminate malaria and prevent reintroduction. These risks could be compounded if countries face funding cliffs with multiple donors phasing out simultaneously.

Notwithstanding, existing financing has not been used in the most cost-effective or efficient manner and spending is often not uniform or consistent with epidemiological profiles or regional policies. Mechanisms to increase efficiency and value for money are urgently needed as well as further analysis on the extent to which expenditures are in line with the interventions recommended by the WHO. Thirty-one of 35 eliminating countries spent less

than 10% of their malaria DAH funding on surveillance, a key malaria elimination intervention between 2010 and 2013. Morel and colleagues noted, "it is important to ask whether current interventions are used appropriately and what is the most cost-effective way to scale up activities to the levels needed" [32]. With declining DAH, available resource will need to be used more efficiently. This would include focusing the needs of the malaria programme on the most effective interventions coupled with better targeting of intervention delivery to strategic populations to maximize value-for-money and prevent drug and insecticide resistance and from available resources.

Since 2011, seven countries (Brazil, China, Colombia, Dominican Republic, Ecuador, Equatorial Guinea and Iran) have graduated from Global Fund malaria financing and now implement their national malaria programs independent of this support. Seven additional malaria-eliminating countries are in their final round of Global Fund Support or will reach the Global Fund's eligibility thresholds in the next five years: Bolivia, Botswana, El Salvador, Guatemala, Sri Lanka, Paraguay, and the Philippines [33]. As these countries no longer meet donor eligibility requirements, critical aspects of their national malaria programmes may be at risk, unless the transition is carefully managed so that domestic funding can be secured to fill the emerging gap. Furthermore, there is currently no planning process in place for transition or consensus on the best model for an effective strategy to withdraw aid for malaria. Countries are faced with challenges in management capacity; lack of financial planning data; diminishing political will; concurrent epidemiological changes and changing priorities after elimination; parallel donor and government systems; integration of vertical programs; procurement pricing and quality commodities and; strategic program delivery and management. Donors and national malaria programs will need to engage in a process and plan for adequate time and resources with a robust transition plan that allows for sustainability of core functions that they share and coordinate with donors. At the same time, there is a need to move donor funding for malaria control away from an input model that mostly focuses on the procurement and distribution of key inputs (most notably mosquito nets) towards more support for operational improvements, capacity building in programme management, improved disease and intervention surveillance as well as knowledge generation and sharing to strengthen the impact of elimination interventions.

This discussion around the financing of malaria elimination is no different to that of other elimination and eradications programmes. Since the start of the Global Polio Eradication Initiative (GPEI), the burden has been reduced by over 99%. Finishing the job of eradicating polio will cost an additional USD 1.5 billion to enhance vaccination and surveillance efforts in hard- to-reach places and eliminate the remaining 37 cases worldwide in 2016 [34]. This translates into a cost of about USD 0.5 billion a year or USD 14 million per case averted. However, eradicating polio will have saved at least USD 40–50 billion between 1988 and 2035. In the USA alone, eradicating polio is estimated to have saved about USD 220 billion

since 1955. In 2003, certain states in Nigeria briefly stopped delivering vaccines in 2003 and as a result, GPEI spent USD 220 million dealing with the resultant outbreak [35]. Withdrawing support will have devastating health, social and economic effects. In the same vein, high-level advocacy to policy makers and donors is needed to ensure sustained financing for malaria. This study provides compelling evidence on the economic benefits of continued prioritization of funding for malaria, which can be used to strengthen the advocacy argument for increased domestic and external funding.

10.2 Limitations of the methodologies used

The detailed limitations of each of the analyses conducted is presented in each chapter, however, an overarching summary is provided below.

The costs of medicines and other interventions have been estimated based on available data and proxies were used when data were unavailable. Obtaining accurate data on the cost of program operations, particularly in an integrated health system, is challenging. Several malaria program resources are shared across other public health programs and peripheral level staff are often designated to perform other public health functions leading to difficulties in attributing specific resources to malaria alone.

Furthermore, activities for malaria were paid for through a combination of government and external resources. Costs were estimated using self-reported hours by country-level partners during the interview process and apportioned to the respective malaria activities or intervention to arrive at disaggregated costs. While this is a common methodology used in other studies, the authors acknowledge the potential reporting bias in the estimates.

For the regional investment case, the projected costs are highly dependent on the output of the transmission model, which was developed using national-level data on incidence and intervention coverage. These estimates are subject to error, particularly in countries with heterogeneous transmission patterns. Furthermore, elimination often requires targeted interventions to risk areas or populations, rather than ubiquitous coverage to an entire country. Without subnational estimates of incidence and coverage, targeted interventions are difficult to estimate and cost. Assumptions were also made on the effect of drug and insecticide resistance on cost however, it is impossible to predict accurately the future extent of these phenomena. In addition, the impact and cost of known tools in the innovation pipeline have been modeled, however, the impact of new tools and approaches not yet developed is unknown and will be likely to decrease costs.

This investment cases utilize reported cases from the World Malaria Reports as well as estimated clinical cases for the countries in the Asia Pacific region derived by the Mahidol-

Oxford Tropical Medicine Research Unit in collaboration with a number of partners including the WHO [36]. This was calculated by combining and triangulating data from a variety of data sources and used to populate the models used in the analysis. Nevertheless, the wide variation in estimates of burden makes it harder to be sure of the resources required to eliminate the disease.

Beyond the direct benefits of achieving malaria elimination on health system savings and worker productivity, other benefits are likely, but are harder to quantify. As a by-product of national elimination, other positive externalities such as increased tourism, a strengthened health system, and improved regional health security could result. In addition, elimination may bring significant benefits to other regional public goods including opportunities to create stronger cross-border disease coordination. The investment case therefore quantifies the minimum benefits of continued prioritization of funding for malaria.

The total income approach [37] was used to compute income losses from malaria mortality. Although this methodology provides more generous estimates of losses than other methods, given the small number of deaths in the resurgence scenario, the use of this method is not likely to have resulted in a significantly higher than expected Return on Investment (ROI).

The findings of the investment case in Sri Lanka and the resulting ROI are based on a hypothetical resurgence scenario, which may or may not be realistic. While uncertainty analyses have been conducted, the findings should be interpreted as such.

For the financial tracking, many of the DAH expenditures could not be allocated to specific interventions, therefore introducing a potential bias. In addition, the spending by governments could not be further disaggregated by intervention area and it is possible that DAH was spent on particular interventions due to co-financing of others through domestic sources. Estimates of domestic expenditures on malaria were obtained from sources, which relied on self-reporting by countries with little triangulation of data.

For the Global Fund analysis, adjustments were made to the country allocations based information provided by the GFATM; however, other factors are evaluated on a case-by-case basis and the final allocation levels are ultimately determined by the Global Fund and the Country Coordinating Mechanism (CCM).

10.3 General recommendations

While achievements made in the past 15 years give reason for optimism, a concerted effort at ensuring that adequate resources are available for countries to continue with the

necessary interventions is crucial. There are several complementary ways for countries to fill the gap between needs and resources until government allocations catch up with the financing transition.

The Addis Ababa Action Agenda calls on a number of resource mobilization efforts encompassing external financing, government resources and support from the private sector [38]. Many national governments are considering raising health budgets by improving the capacity to raise tax revenue. In the Asia Pacific countries, tax revenue, in 2016 as a percent of GDP varied between 10.5 % in Bangladesh to 34.6 % in the Solomon Islands [39]. In Sri Lanka, tax revenues constituted about 13.1 % of Sri Lanka's total GDP in 2013, although the government of Sri Lanka has recently announced new adjusted tax proposals [40-42]. Raising tax revenues to 20 % of GDP as recommended by the by the Addis Ababa Accord for the Sustainable Development Goals would generate an additional revenue of USD4.35 million per year—a potential funding source for malaria POR.

The diversification and socioeconomic changes in Asia Pacific countries, presents a unique opportunity to engage the private sector in malaria elimination. It is likely that as the contribution of the private sector to the economy increases, they will also become increasingly involved in social development efforts across Asia. In Sri Lanka, a total of 40 companies collectively spend about USD 30.5 million annually on Corporate Social Responsibility (CSR) covering a wide range of development issues [43]. The CSR consortia has recently partnered with Sri Lanka's Public Health Department for dengue eradication. Tapping into the resources from CSR programs of large multinational firms operating in countries to fight malaria may also be a potential resource.

The implementation of Pigovian or sin taxes is another mechanism for increasing resources. In the Philippines, the Sin Tax Reform Bill, passed in 2012, increased taxes on tobacco and alcohol, generating USD 2.3 billion within 2 years increasing the Department of Health budget by 63 % in 2015 [44]. This revenue has freed up resources, which would have otherwise been used for social protection of the poor and has trickled down for use for malaria and other diseases targeted for elimination. Similarly, Sri Lanka has recently adopted a policy for discouraging alcohol consumption and smoking by raising taxes on both products in recent years to providing additional government revenue.

Innovative approaches, such as social impact bonds, airline and financial transactions taxes also have the potential to increase domestic financing [45-47]. Air travel has doubled between 2010 and 2015 in Asia, increasing connectivity and facilitating trade and tourism, which has almost quadrupled since 2000. An airline levy such as the UNITAID model could raise more than USD 300 million per year just in the Asia Pacific [48].

Blended approaches which refer to the use of funds to leverage or de-risk private investment in development are increasingly being explored. Although there are no current estimates on their scale, these financing instruments have been used with success in other sectors within and outside of health and have the potential to catalyze additional private sector support. The Inter American Development Bank (IDB) and the Bill & Melinda Gates Foundation (BMGF) recently announced a partnership which would allow countries in Central America to benefit from combining concessional loans with "buy-downs" based on performance of certain health indicators [49]. A similar mechanism is being planned by the Asian Development Bank and the Global Fund [50]. Multilateral and Regional Development Banks can also provide new financing opportunities, including cross-sectoral financing for health programs incentivizing companies to invest in health interventions. MDBs can be encouraged to incorporate health impact assessments, which include malaria indicators as a pre-requisite for infrastructure or other loans.

In addition to increasing available health revenue and allocating additional resources, improved efficiencies can generate cost-savings, freeing up resources to cover financing gaps. Assessing and identifying current inefficacies and drivers of inefficiency can increase utilization of current funds. Greater efficiency can be achieved by targeting and implementing an optimal mix of malaria interventions that will create the most impact; or by maximizing the impact of current inputs to the malaria programme.

As with any disease elimination programme, the final few cases is likely to require an outlay of resources that may be considered disproportionate to the marginal return [51]. These higher costs must be built into programme budgets with appropriate actions to ensure that financing is maintained well after elimination is achieved.

Many countries will soon improve their income status and therefore graduate from donor financing. Malaria elimination programs, given the low disease burden, may lose eligibility before then. In addition to pursuing additional domestic financing and meeting current co-financing requirements of existing grants, countries should appropriately plan the transition from donor to domestic funding sources 3-5-years in advance of the actual transition.

Given the context of declining malaria case numbers across the region, malaria advocacy will need to be tied to a wider narrative that includes other communicable diseases such as dengue, which has seen a dramatic resurgence in recent years as part of a regional health security response. In addition, malaria elimination can be viewed as an entry point to strengthen health systems and can be used to highlight how elimination can lead to increased equity. In low transmission settings, where cases cluster among high-risk populations, programs must tackle areas and communities that do not have access to critical health services. These systems will also be able to better deliver universal health

coverage, and the funds no longer needed for malaria, can be redirected to tackle other pressing health challenges. Many malaria-endemic countries have political assets that can be leveraged to increase political influence. Deploying support to mobilize these political assets towards a country resource mobilization objective will ensure strategies are aligned with the malaria programme and will increase the sustainability of future advocacy and accountability efforts. Leaders, political figures and celebrities can serve as ambassadors for malaria. Drawing on country-level political assets can also ensure continuity in political engagement.

10.4 Areas for future research

There are several gaps in the current toolbox of economic evidence and priorities for research remain:

1. The benefits of achieving and maintaining elimination include a strong public good component—an incremental contribution to global malaria eradication. Gaining an understanding of this larger set of economic benefits will require better macroeconomic models that quantify the links between elimination and other outcomes to give more realistic benefit estimations.
2. Methods to measure the value of the diminished resurgence risk need to developed as does a mechanism for quantifying malariogenic potential of countries or territories.
3. There is an urgent need to develop a standard methodology or guidance for computing the cost of malaria control and elimination. Past studies have employed a wide range of inputs to compute the cost of malaria control and elimination to arrive at the costs, making meaningful comparisons difficult. For elimination, this standardization needs to include the cost likely to be incurred in a post-elimination scenario to allow appropriate budgeting and planning.
4. While comprehensive WHO guidance exists on interventions for the control of malaria, there is a need for better direction on the epidemiological and economic efficiencies of various mixes of interventions utilized for malaria elimination.
5. The start-up costs of malaria elimination, particularly the cost of strengthening surveillance systems for enhanced case identification, the true cost of the human resources and programmatic management and health system are also largely unknown and need to be estimated.
6. Enhanced methods to comprehensively quantify the non-health benefits to the economy will greatly enable stakeholders to strengthen the elimination argument.
7. Due to changing strategies and costs, it is important that economic estimates are constantly reviewed in the light of new information.
8. Further analysis is required to adapt the existing transmission model to individual

country settings and develop country-level estimates based on the national context.

9. There is a need to continue to track changing donor policies and financing trends to ensure that upcoming gaps in financing and be identified early and alterative sources of funding be mobilized.
10. Innovative financing solutions need to be pilot tested and lessons learned documented and disseminated widely.

These areas for research should be considered for inclusion into the Malaria Eradication Research Agenda (malERA) Refresh process to accelerate malaria elimination [52].

10.5 Conclusion

Global progress against malaria has been dramatic over the past decade. These gains, however, have been driven by substantial political and financial commitments that must be sustained to avoid a resurgence of malaria. There are several critical reasons why malaria elimination should receive a special focus for financing. Malaria is a major ongoing cost driver burdening national health systems and eliminating the disease will confer public health benefits as well as major cost savings to national health systems. If successful, countries would no longer need to implement prevention measures, thereby reaping an "eradication dividend" and accruing substantial economic benefits for all countries. As with any disease elimination programme, the cost of 'finishing the job' is likely to be higher than merely controlling the disease. Although the short-term investment needed may seem substantial, these are time-limited as costs taper off significantly as more countries eliminate the disease. These costs must be built into programme budgets with appropriate advocacy actions to ensure that financing is maintained well after elimination is achieved. Secondly, there is a strong correlation between the decline in malaria burden and sustained financing. Declining financing for malaria is an imminent threat to malaria elimination, the spread of drug resistance, and regional and global health security. At the same time, it is tacit that the total benefits of elimination, many immeasurable, vastly outweigh its cost. The investment cases provide compelling evidence for the benefits of continued prioritization of funding for malaria, and can be used to develop an advocacy strategy for increased domestic and external funding for elimination. While increasing numbers of countries are moving toward financing their own programs, external assistance to the last affected countries will be essential—possibly through a dedicated "last-mile fund"—to ensure that the resources required to complete eradication are available in the final phase. Failure to sustain financing until the end game will undermine decades of investment and unprecedented gains towards achieving a global public good - a world free of malaria.

10.6 References

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CURRICULUM VITAE

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EDUCATION

SWISS TROPICAL AND PUBLIC HEALTH INSTITUTE | Basel, Switzerland
PhD Candidate Epidemiology **|** 2018
Economics and financing for malaria elimination
Magna cum Laude

LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE | London, United Kingdom
MSc Public Health in Developing Countries **|** 1999
Distinction: *Emphasis on health policy analysis*

UNIVERSITY OF BRIGHTON | Brighton, United Kingdom
BSc Pharmacy **|** 1990

PROFESSIONAL WORK EXPERIENCE

ASIA PACIFIC LEADERS MALARIA ALLIANCE **Singapore**
Director – Malaria Financing **2016-present**

- Advocacy and relationship development amongst key opinion leaders
- Development of economic and epidemiological evidence for policy change in support of communicable disease elimination and health security
- Tracking of Development Assistance for Health, government financing and policies
- Development and implementation of resource mobilization strategies and innovative financing mechanisms for communicable disease in Asia

THE GLOBAL HEALTH GROUP, UNIVERSITY OF CALIFORNIA, SAN FRANCISCO **San Francisco, CA, USA**
Associate Director, Economics and Financing, Global Health Group **2014-present**

- Principal investigator on grant from Global Fund to develop and implement tool for transition readiness assessments

- Principal investigator on grant from the Asian Development Bank on developing the economic evidence base for malaria elimination in the Asia Pacific region
- Strategy development and execution of the work of the Malaria Elimination Initiative related to health systems, economics, policy and innovative finance
- Tracking of Development Assistance for Health, government financing and policies
- Research design, implementation and analysis of costs and investment cases
- Development of mechanisms and policy solutions for countries and donors to strengthen country health systems
- Management of strategic partnerships and relationships at the global, regional and county levels
- Recruitment and management team, workplan and budgets
- Management of over USD 20 million in research grants

MANAGEMENT SCIENCES FOR HEALTH (MSH) **Arlington, VA, USA**
Principal Technical Advisor **2001-2014**

- Technical assistance to and evaluation of health projects
- Principal investigator on grants from TDR, Resources for the Future, Center for Disease Dynamics Economics and Policy (CDDEP), Institute of Medicine, Global Fund and USAID
- Management and technical assistance to countries in Africa and Asia on pharmaceutical management for malaria, child health and other infectious diseases to improve access to quality medicines
- Development of tools and trainings including manuals, standard operating procedures and guides for transitioning to new technologies
- Management over USD 5 million in annual budgets including workplan development and recruitment

WORLD HEALTH ORGANIZATION (WHO) **Geneva, Switzerland**
Technical Officer **2000 - 2001**

- Development of evidence based guidelines for treatment and policy change
- Development of processes and frameworks for medicine policies
- Organization technical expert groups and development of WHO guidelines
- Engagement of private sector for increasing access to treatments

WELLOME TRUST RESEARCH LABORATORIES/
KENYA MEDICAL RESEARCH INSTITUTE COLLABORATIVE PROGRAM **Nairobi, Kenya**
Research Fellow **1998 - 2000**

- Research on pharmaceutical policies and process for policy change in Kenya
- Modeling of policy and decision making processes at different levels of the patient-provider-policy maker strata
- Compilation of database on drug resistance in East Africa.
- Situation analysis and mapping of malaria transmission patterns

CYANAMID TRANSNATIONAL CORPORATION AND PARAMED HEALTHCARE LTD. **Nairobi, Kenya**
Technical Consultant **1997 - 1998**

- Analysis of the market size for insecticide treated nets in Kenya, Uganda and Tanzania
- Business cases and marketing strategies

PEER REVIEWED PUBLICATIONS

1. Shretta R, Zelman B, Birger M, Haakenstad A, Singh L, Liu Y, Dieleman J. 2018. Tracking Development Assistance and Government Health Expenditures in the Asia Pacific, Southern Africa and the Latin American Region: 1990-2017. *Submitted.*
2. Shretta R, Silal SP, Celhay OJ, Mercado CG, Kyaw SS, Avanceña A.L.V, Zelman B, Fox K, Baral R, White L, Maude R. 2018. An investment case for malaria elimination in the Asia Pacific Region. *Submitted.*
3. Silal SP, Shretta R, Celhay OJ, Maude R, Mercado CG, and White LJ. 2018. A mathematical model for malaria elimination in the Asia Pacific. *Submitted*.
4. Shretta R, Fewer S, Beyeler N, Phillips A, Rossi S, Larson E, Alberga J, Lockwood A, Gosling R. 2018. Transitioning from Global Fund financing: challenges and implications for malaria elimination. *Submitted.*
5. Hanson K, Anderson S, Lishi H, McPake B, Palafox B, Russo G & Shretta R. 2018. *Pharmaceuticals* in **Global Health Diseases, Programs, Systems, and Policies**. Fourth edition. Merson MH, Black RE & Mills AJ. MA, USA. *In press.*
6. Shretta R, Zelman B, Birger M, Haakenstad A, Singh L, Liu Y, Dieleman J. 2017. Tracking Development Assistance and Government Health Expenditures for 35 malaria- eliminating Countries: 1990-2017. *Malaria Journal* 16:251.
7. Lover AA, Harvard KE, Lindawson AE, Smith Gueye C, Shretta R, Gosling R, Feachem RGA. 2017. Regional initiatives for malaria elimination: Building and maintaining partnerships. *Plos Medicine* 10:1371.
8. Shretta R, Liu J, Cotter C, Cohen C, Dolenz C, Makomva K, Phillips A, Gosling R, Feachem RGA. 2017. Chapter 15: *Malaria Elimination and Eradication* in **Disease Control Priorities**, Third Edition (Volume 4): AIDS, STI, TB, and Malaria. World Bank Publications.
9. Shretta R, Baral, R, Avancena, AL, Fox K, Dannoruwa, AP, Jayanetti, R, Hasantha, R., Peris L, Premaratne R. 2017. An investment case for preventing the re-introduction of malaria in Sri Lanka. *American Journal of Tropical Medicine & Hygiene* 96(3):602–615.
10. Shretta R, Avanceña ALV, Hatefi A. 2016. The Economics of Malaria Control and Elimination: A Systematic Review. *Malaria Journal* 15:593.
11. Hemingway J, Shretta R, Wells TNC, Bell D, Djimdé AA, Achee N, Qi G. 2016. Tools and Strategies for Malaria Elimination. What do we need to achieve a grand convergence in malaria? *PloS Biology* 14(3):e1002380.
12. Newby G, Bennett A, Larson E, Cotter C, Shretta R, Phillips A, Feachem RGA. 2016. The path to eradication: A progress report on the malaria-eliminating countries. *Lancet* 387. April 23.
13. Zelman B., Melgar M, Larson E, Phillips A, Shretta R. 2016. Global fund financing to the 34 malaria-eliminating countries under the new funding model 2014–2017: an analysis of national allocations and regional grants. *Malaria Journal* 15:118.
14. Shretta R, Johnson B, Smith L, Doumbia S, de Savigny D, Anupindi R & Yadav P. 2015. Costing the procurement and distribution of ACTs and RDTs in the public sector in Kenya and Benin. *Malaria Journal* 14:57.
15. Yamey G & Shretta R. 2014. The 2030 sustainable development goal for health. Must balance bold

aspiration with technical feasibility. *BMJ* 349:g5295.

16. Shretta R & Yadav P. 2012. Stabilizing the supply of artemisinin and ACTs in an era of widespread ACT scale-up. *Malaria Journal* 11:399.

17. Hanson K, Palafox B, Anderson S, Guzman J, Moran M, Shretta R & Wuliji T. 2011. *Pharmaceuticals* in **Global Health Diseases, Programs, Systems, and Policies**. Third edition. Merson MH, Black RE & Mills AJ. MA, USA.

18. Hensen B, Paintain LS, Shretta R, Bruce J, Jones C & Webster J. 2011. Taking stock: provider prescribing practices in the presence and absence of ACT stock. *Malaria Journal* 10:218.

19. Abuya T, Amin A, Memusi D, Juma E, Akhwale W, Ntwiga J, Nyandigisi A, Tetteh G, Shretta R & Chuma J. 2009. Reviewing the literature on access to prompt and effective malaria treatment in Kenya: implications for meeting the Abuja targets. *Malaria Journal* 8:243.

20. Williams HA, Durrheim D & Shretta R. 2004. The process of changing national treatment policy: lessons from country-level studies. *Health Policy and Planning* 19(6):356-370.

21. Shretta R, Walt G, Brugha R & Snow RW. 2001. A political analysis of corporate drug donations: the example of Malarone® in Kenya. *Health Policy and Planning* 16(2):161-170.

22. Shretta R, Brugha R, Robb A & Snow RW. 2000. Sustainability, affordability and equity of corporate drug donations: the case of Malarone®. *Lancet* 355:1718-1720.

23. Shretta R, Omumbo J, Rapuoda R & Snow RW. 2000. Using evidence to change anti-malarial drug policy in Kenya. *Tropical Medicine & International Health* 5(11):755-764.

24. Brooker S, Guyatt H, Omumbo J, Shretta R, Drake L & Ouma J. 2000. Situational analysis of malaria in school-aged children in Kenya-What can be done? *Parasitology Today* 16(5).

TEACHING EXPERIENCE

- Guest lectures on Economic applications of mathematical models for Infectious diseases short course, University of Cape Town. May 2017.
- Science of Eradication: Malaria: Leadership course. Co-organized by Harvard University, Swiss Tropical and Public Health Institute and IS Global: Barcelona Institute for Global Health. June 2014.
- Global Health Spring Lecture Series: Medical University of South Carolina

LANGUAGES

English, French, Hindi, Gujarati, Kiswahili, Spanish (Beginner)