



An Investment Case for Eliminating Malaria in Bangladesh



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The **Malaria Elimination Initiative (MEI)** at the University of California San Francisco (UCSF) Global Health Group believes a malaria-free world is possible within a generation. As a forward-thinking partner to malaria-eliminating countries and regions, the MEI generates evidence, develops new tools and approaches, documents and disseminates elimination experiences, and builds consensus to shrink the malaria map. With support from the MEI's highly-skilled team, countries around the world are actively working to eliminate malaria – a goal that nearly 30 countries will achieve by 2020.

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Key Terms and Acronyms

ACT	Artemisinin-based combination therapy	MoH&FW	Ministry of Health and Family Welfare
ADB	Asian Development Bank	MPEAT	Malaria Program Efficiency Analysis Tool
API	Annual parasite index	NGO	Non-governmental organization
APLMA	Asia Pacific Leaders Malaria Alliance	NMEP	National Malaria Elimination Program
BRAC	Building Resources Across Communities	NMET	National Malaria Elimination Taskforce
CDC	Communicable Disease Control Division	NSP	National strategic plan
CHT	Chittagong Hill Tracts	OOP	Out-of-pocket
D	Diagnosis	OP	Outpatient
DSF	Demand-side financing	PAR	Population at risk
FY	Fiscal year	PM	Program management
GoB	Government of Bangladesh	POR	Prevention of reintroduction
GDP	Gross domestic product	PPP	Public-private partnerships
Global Fund	Global Fund to Fight AIDS, Tuberculosis and Malaria	PVC	Prevention and vector control
G6PD	Glucose-6-phosphate dehydrogenase	RDT	Rapid diagnostic test
icddr,b	International Centre for Diarrhoeal Diseases Research, Bangladesh	ROI	Return on investment
IEC	Information, education, and communication	SDGs	Sustainable Development Goals
IP	Inpatient	SEM	Surveillance and epidemic management
IRS	Indoor residual spraying	THE	Total health expenditure
LLIN	Long-lasting insecticidal net	TP	Treatment and prophylaxis
MDA	Mass drug administration	UCSF	University of California, San Francisco
ME	Monitoring and evaluation	USD	United States dollar
MEI	Malaria Elimination Initiative	VLY	Value life year
		WHO	World Health Organization

Executive Summary

Bangladesh—having committed to a malaria-free Asia Pacific by 2030—has declared a national elimination goal of 2027. The country has made impressive progress towards this goal, reducing cases by 50% and deaths by 54% in just six years. The malaria program has renamed itself as the National Malaria Elimination Program (NMEP) due to its recent successes and transition from control to elimination activities.

Nevertheless, the NMEP faces key challenges ahead. Malaria is endemic in 13 out of 64 districts in Bangladesh with roughly 17.5 million people living at risk. These endemic districts are typically located in hard-to-reach areas, resulting in inadequate surveillance and limited access to healthcare services. In addition, external financing for malaria from the Global Fund to Fight AIDS, Tuberculosis and Malaria is declining, particularly for low transmission settings. The malaria program will need to ensure continued financial and political commitment from the Government of Bangladesh. Donor assistance for malaria has declined by almost 60% in Bangladesh between 2013-2015, and current domestic financing contributions are not sufficient to meet the need, threatening Bangladesh's momentum towards elimination.

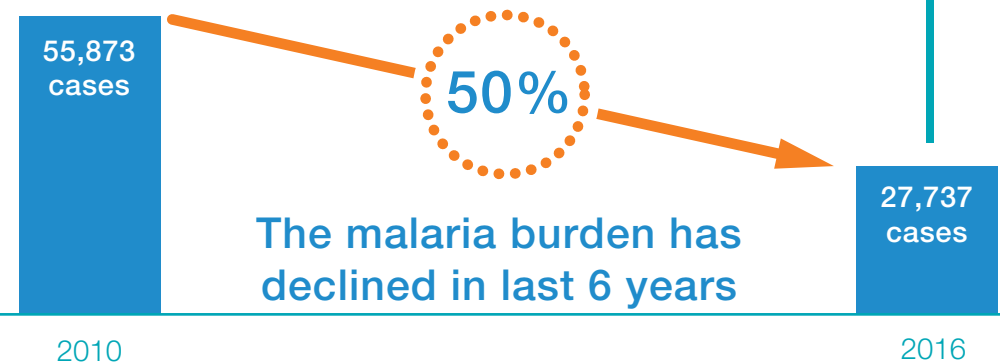
To provide evidence of the economic rationale for malaria elimination in Bangladesh, the UCSF Global Health Group's Malaria Elimination Initiative, Mahidol-Oxford Tropical Medicine Research Unit (MORU), the International

Centre for Diarrhoeal Diseases Research, Bangladesh, and the NMEP, with support from the Asian Development Bank and the Bill & Melinda Gates Foundation, developed an investment case for malaria elimination. Leveraging several approaches, the investment case estimates the costs of malaria elimination through 2030, estimates the economic and financial returns of malaria elimination, and explores feasible and sustainable financing options for Bangladesh.

Using data from five sample districts of varying endemicity levels, we estimated the median cost of the malaria program from fiscal year 2015-16 to be USD 20.4 million or USD 1.54 per person at risk. The costs and benefits of elimination were generated using outputs of a transmission model that projected rates of decline to elimination by at least 2030. The economic benefits of elimination were calculated using estimates of the mortality and morbidity averted and the return on investment.

The model predicts that it will cost approximately USD 76.9 million (range USD 68.8 million to USD 92.2 million) to achieve elimination in 2025 and USD 14.64 million (range USD 10.5 million to USD 19.9 million) for prevention of reintroduction until 2030; a total of USD 91.5 million. Elimination was predicted to prevent 829,605 clinical cases, save over 1,577 lives (range: 697 to 17,277), and generate economic benefits of USD 343.5 million (range: USD 153.4 million to USD 3.6 billion) through reductions in deaths, cases, household and healthcare system spending, and increases in productivity over a fifteen year time period. By investing in malaria elimination, Bangladesh can expect to see a return of nearly 7 to 1 on every additional dollar spent on elimination.

ECONOMIC BURDEN



Despite progress, the National Malaria Elimination Program faces key challenges

17.5 million people at risk

13 endemic in out of 64 districts

The endemic districts are typically located in hard-to-reach areas

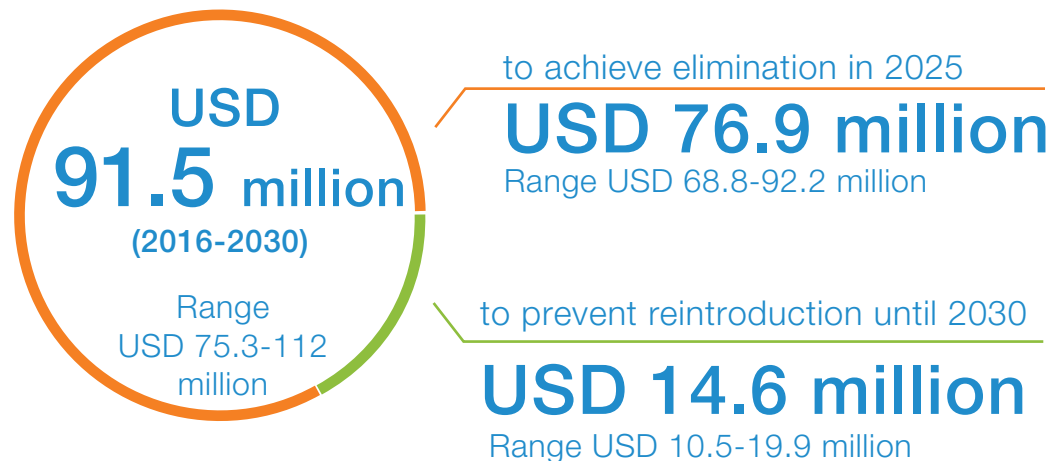
inadequate surveillance

limited access to healthcare services

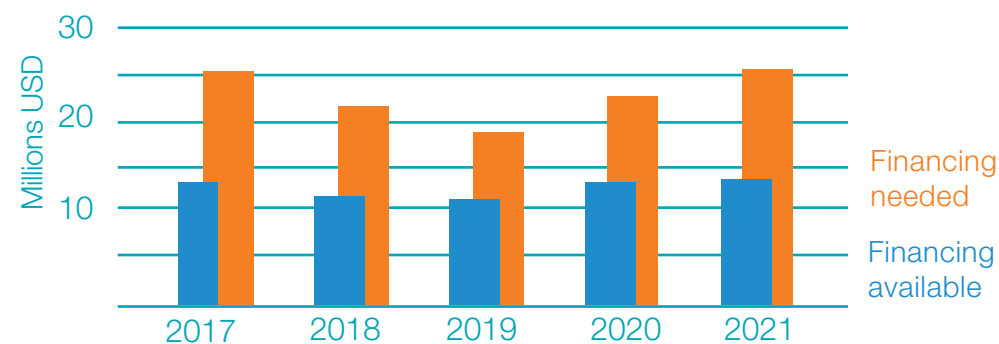
THE ACTUAL COST OF THE MALARIA PROGRAM (2015-16)

USD 20.4 million **USD 1.54** per population at risk

COST OF ELIMINATION



FUNDING GAP FOR THE NEXT 5 YEARS



OPPORTUNITIES FOR RESOURCE MOBILIZATION

NEW REVENUE

- International or regional funds
- Public-Private Partnerships
- Taxes
- Demand-side financing

EFFICIENCY IMPROVEMENTS

- Technical
- Allocative
- Financial

BENEFITS & RETURN ON INVESTMENT (ROI)

2027 Estimated costs and benefits in line with Bangladesh's elimination goal of 2027

Malaria cases averted: 829,605
Malaria deaths averted: 1,577

Saving in healthcare costs, lost wages and productivity due to illness: **USD 343.5 million**

Incremental cost: **USD 44.1 million**

ROI
7 : 1

Malaria elimination is a "best buy" comparable to other high value investments such as immunization.

Introduction

Bangladesh has made great strides in reducing the burden of malaria in the last decade and a half, allowing the country to meet its targets for the malaria Millennium Development Goals. In 2016, reported malaria cases were down to 27,737 from 55,873 in 2010, signifying a reduction of 50% (Figure 1).¹ Furthermore, between January and March of 2017, there has been a 17% reduction in cases compared to 2016 levels.²

Figure 1. Malaria cases and deaths in Bangladesh, 2007-2016³



Many of the gains that have been made can be attributed to political and financial commitment by the Government of Bangladesh (GoB) and donors, predominantly the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) since 2007.⁴ Having endorsed the Asia Pacific Leaders Malaria Alliance (APLMA) roadmap for a malaria-free Asia Pacific by 2030, Bangladesh and other countries must sustain and scale up their malaria control and elimination activities, which will require securing sufficient funding.

In order to achieve elimination by 2027, Bangladesh has implemented a phased district-by-district approach. To eliminate malaria in the eight low endemic districts, accelerate control in the five moderate and high endemic districts to the pre-elimination phase, and to prevent re-introduction of indigenous malaria in all other districts by 2020, Bangladesh will need to develop a comprehensive resource mobilization strategy to ensure adequate financing for all activities. The National Malaria Elimination Program (NMEP) of Bangladesh has projected a substantial financial gap in the coming years, which has historically imposed a threat to the program's ability to reach elimination targets.

The development of this investment case for malaria elimination in Bangladesh was led by the UCSF Global Health Group's Malaria Elimination Initiative (MEI), in collaboration with Mahidol-Oxford Tropical Medicine Research Unit (MORU), the International Centre for Diarrhoeal Diseases Research, Bangladesh (icddr, b) and the NMEP. This report provides financial and economic evidence to inform malaria program budgeting and strategic planning, domestic and international resource mobilization, and advocacy to accelerate towards elimination.

This work is part of a larger project funded by the Asian Development Bank (ADB) and the Bill & Melinda Gates Foundation, to gather and generate evidence for sustainable financing in support of achieving malaria elimination in Asia Pacific by 2030.

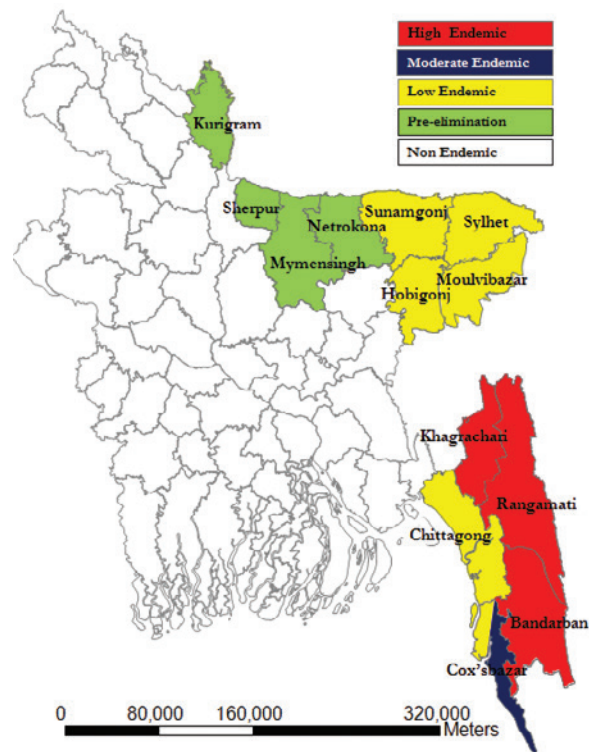
Background and context

Malaria transmission continues in 13 out of 64 districts in the northeast and southeast areas of the country (Figure 2), putting 17.5 million people at risk. Over 90% of all malaria cases arise from five districts, namely Rangamati, Khagrachari, Bandarban, Chittagong, and Cox's Bazar.⁵ The NMEP has stratified the 13 malaria-endemic districts according to endemicity level to achieve and implement interventions according to phased elimination targets. Each district is categorized as high endemic, moderate endemic, low endemic, or pre-elimination. Currently, there are three high endemic districts, one moderate district, and nine low endemic districts. The three districts of the Chittagong Hill Tracts (CHT) and Cox's Bazar, where malaria incidence and transmission are highest, are characterized by inaccessibility, hilly geography, and limited infrastructure.⁶

Previous studies show that farming/cultivation is the primary occupation of 46% of household heads, including plain land and Jhum cultivation. Jhum, or shifting cultivation, is adopted by 18% of households, covering an approximate area of 99,000 acres in CHT.⁷ icddr,b studies revealed Jhum cohabitants have 2.5 fold higher risk of malaria compared to non-Jhum cultivators.⁸ This may explain the higher burden of disease in CHT, as well as the added need for strengthened malaria activities in this area.

The main malaria parasite in Bangladesh is *Plasmodium falciparum* (*P. falciparum*), which accounts for as much as 93% of all microscopy- or rapid diagnostic test (RDT)-confirmed cases.⁹ The remaining 7% are *Plasmodium vivax* (*P. vivax*), although isolated cases of indigenous

Figure 2. 13 malaria-endemic districts stratified according to level of endemicity, 2014⁵



Plasmodium ovale and *Plasmodium malariae* have also been reported.¹⁰⁻¹² Over eleven *Anopheles* mosquito species^a that are positive for malaria parasites have been found in Bangladesh.^{13,14}

National Malaria Elimination Program in Bangladesh

The NMEP, an agency within the Communicable Disease Control Division (CDC) of the Ministry of Health and Family Welfare (MoH&FW), oversees the malaria control and elimination efforts in Bangladesh. The NMEP has benefited largely from the consortium of 21 non-governmental organizations (NGOs) run by BRAC (Building Resources Across Communities). This partnership has led to successful scale-up of diagnosis and treatment services, long-lasting insecticidal net (LLIN) distribution, and the implementation of behavior change communication programs.¹⁵

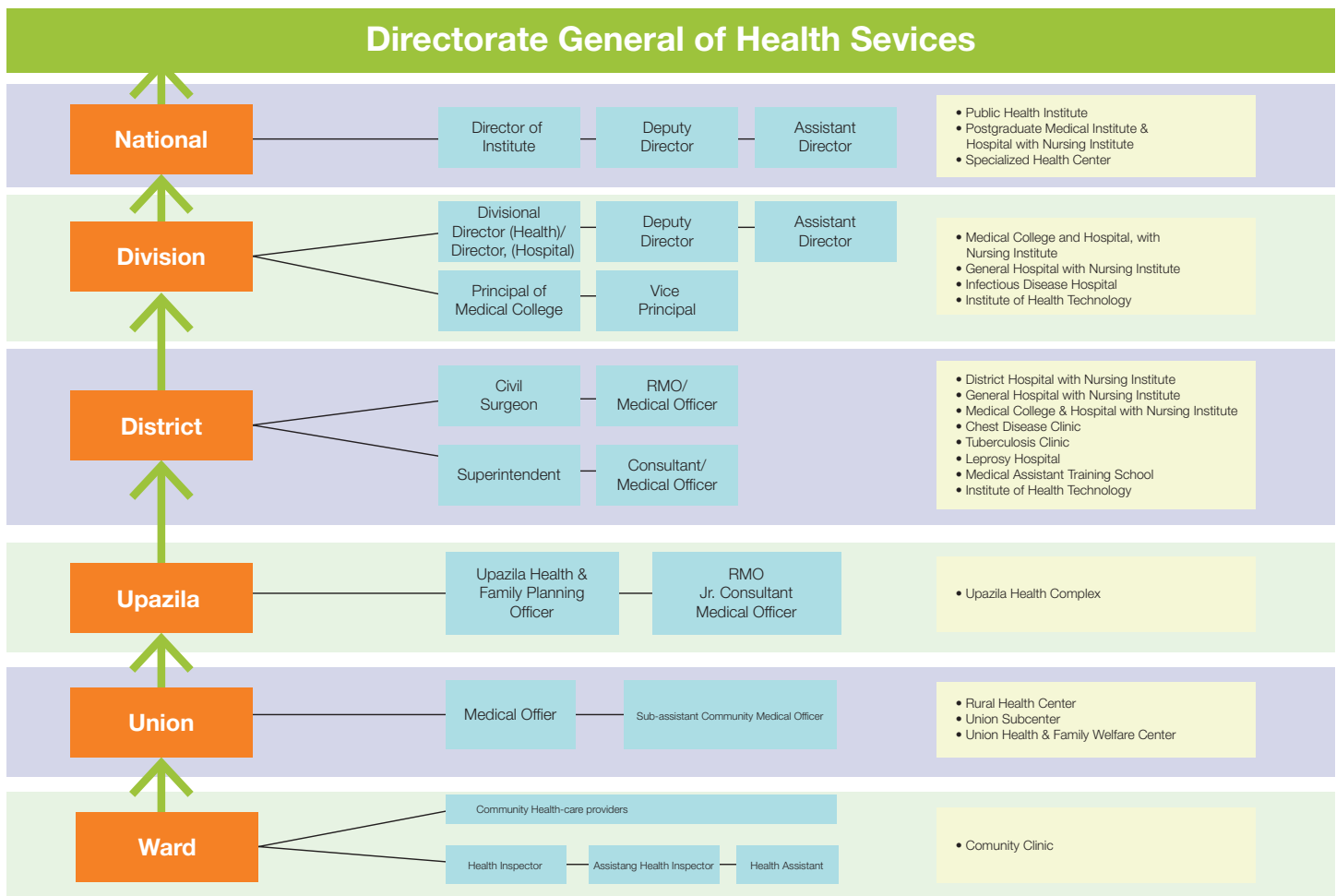
The significant progress that Bangladesh has already seen has been made through the high coverage of and increased use of LLINs, RDTs, and anti-malarial treatment with artemisinin-combination therapies (ACTs), coupled with strengthened disease and vector surveillance and monitoring and evaluation towards elimination, and improving advocacy, communications, and social mobilization.^{5,15}

a *An. maculatus*, *An. umbrosus*, *An. barbirostris*, *An. nigerrimus*, *An. nivipes*, *An. jeyporiensis*, *An. kochi*, *An. vagus*, *An. karwari*, *An. subpictus*, and *An. philippinensis*

In 2017, the malaria program shifted from the National Malaria Control Program to the NMEP, signifying their commitment and progress towards elimination. With this shift, they have also issued a revised National Strategic Plan (NSP) for the years 2017-2021 that reflect modified targets, including eliminating malaria in less endemic areas, while accelerating control efforts in high endemic areas. After 2021, the NMEP expects that all areas will be targeted for elimination or prevention of reintroduction (POR). This strategy is aligned with the *Strategy for Malaria Elimination in South East Asia Region (2017-2030)* and the *Global Technical Strategy for Malaria 2016-2030*.¹⁶

Governance of the malaria program

Bangladesh has a highly centralized health system, therefore strategic planning, implementation, and monitoring and evaluation activities are completed at the central level in Dhaka under the stewardship of the CDC of the Directorate General of Health Services and local levels have little authority.¹⁷ Malaria activities are implemented at the district, upazila (sub-district), and community levels. The managerial hierarchy of health services is depicted in Figure 3.

Figure 3. Healthcare facility levels with managerial hierarchy¹⁷

Financing for malaria in Bangladesh

The two major sources of malaria financing in Bangladesh are the GoB and the Global Fund. Domestic financing streams from the GoB are centrally located and disbursed into the 13 endemic districts. In addition to the central domestic financing flows, the Global Fund, the World Health Organization (WHO), and the World Bank have provided funding for the malaria program. Funds from the Global Fund are predominantly used for human resources recruitment and capacity building, drug procurement, diagnostics, LLINs and logistics, and implementation of surveillance and monitoring and evaluation systems. The WHO mainly finances technical assistance in Bangladesh.

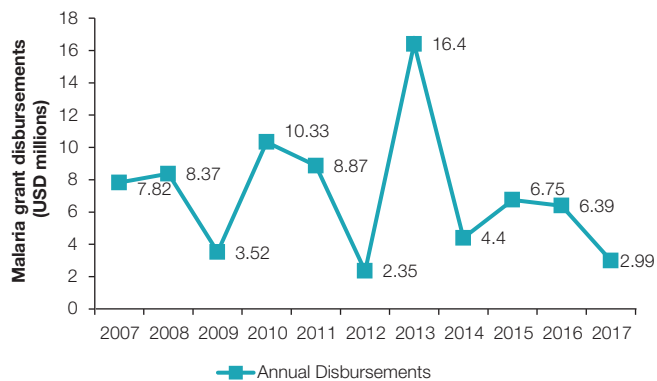
Since 2005, development assistance for malaria to Bangladesh has been variable (Figure 4). Bangladesh received its first grant from the Global Fund in 2007, which supported increased access to diagnostics and treatment; LLIN provision to 100% of households in three malaria-endemic districts and 80% coverage in the other ten endemic districts; strengthening the surveillance system and partnerships in malaria control; and provision of periodic treatment of non-LLIN with insecticides. Despite these

gains, domestic financing for malaria declined between 2014 and 2015, and cases of malaria simultaneously increased.

Support from the Global Fund began in 2007 in Bangladesh with USD 7.82 million, and the country has experienced significant variability for annual disbursements since then. Importantly, Global Fund financing has steadily declined since 2013, with a 61% decline of annual disbursements between 2013 and 2016 (Figure 5). If Global Fund financing continues its downward trend at this rate, it will jeopardize progress already made and put an overwhelming amount of stress on the GoB to fill the gap.

Malaria program challenges

Inadequate human resources have been described as a major challenge to the health system in Bangladesh. Staff shortages and rapid turnover have previously posed a threat to program implementation. The country has 4.9 physicians and 2.9 nurses per 10,000 persons.¹⁸ Sixty-two percent of medical doctors are working in the private sector, and formal healthcare service provision is concentrated in urban areas, leaving the remote, hard-to-reach

Figure 4. Sources of malaria financing in Bangladesh¹**Figure 5. Annual Global Fund malaria grant disbursements in Bangladesh, 2007-2017**

areas extremely vulnerable. As 13 of the 64 districts in Bangladesh are endemic for malaria and described as border districts (facing the eastern states of India and a small portion of Myanmar), cross-border migration and imported cases are a major issue.¹⁹ Drug resistance to ACTs has been reported at the Thai-Cambodia border and more recently, the Thai-Myanmar border.²⁰ These malaria-specific challenges create formidable obstacles in surveillance, case reporting, and access to care. The other notable challenges that Bangladesh faces in achieving elimination are reported insecticide resistance, asymptomatic malaria, competition with non-communicable diseases, and lack of a political platform.⁶

Significance of the study

This investment case for malaria elimination provides evidence of the economic returns from investments in malaria elimination in Bangladesh. The findings from this investment case can be used by the NMEP and GoB in its advocacy efforts to ensure sufficient financial resources and political commitment are maintained to reach elimination, malaria program budgeting and strategic planning, and the identification of gaps in malaria financing.

Specific objectives

The investment case aims to:

- Estimate the actual costs of malaria control and elimination programs activities in Bangladesh in fiscal year (FY) 2015-16;
- Project the costs of elimination and POR until 2030;
- Assess the benefits of elimination and estimate the return on investment (ROI) for elimination and POR through 2030;
- Estimate gaps in funding for malaria; and
- Explore opportunities for financing and resource mobilization for malaria elimination.

Methodology

To estimate the cost of malaria from the public health program perspective, we employed a micro-costing approach to calculate the cost of the malaria program in Bangladesh from FY 2015-16 in five sample districts. These estimates were extrapolated to compute the total cost of the NMEP for the whole country. To measure the broader economic costs of malaria, we used a dynamic transmission model that estimated the morbidity and mortality averted from malaria. The economic burden averted is categorized based on three broad dimensions: 1) cost to the health system, 2) cost to the individual households, and 3) cost to the society, estimated using averted deaths and cases through elimination.

The investment case employed multiple methodologies and data sources, which are described in more detail in Annex 1.

Economic burden of malaria

To estimate the economic burden of malaria to society, we evaluated: (1) direct cost to the health system; (2) direct cost to the household; and (3) indirect costs (Table 1).

Table 1. Estimating the economic burden of malaria

Direct cost to the health system	Direct cost to individual households	Indirect cost to society
1. Cost due to increased health service utilization for malaria	1. Out-of-pocket (OOP) expenditure incurred due to malaria	1. Cost due to loss of life to malaria mortality
2. Cost of increased vector control		2. Cost due to loss of productivity due to malaria morbidity
3. Cost of increased diagnosis		
4. Cost of human resource training and community education		

Direct health system costs

Malaria activities were valued along three dimensions: (1) cost by source; (2) cost by input; and (3) cost by activity (Table 2).

To obtain national costs, we collected malaria expenditure data from the NMEP and BRAC. If expenditure data was unavailable, budgetary items and grey literature were used. Input costs were assigned by activity

Table 2. Categories for direct health system costs

Cost by source	Cost by input	Cost by activity
Domestic	Capital	Prevention and vector control
External	Consumables	Diagnosis
	Personnel	Treatment and prophylaxis
	Services	Surveillance and epidemic management
		Monitoring and evaluation
		Information, education, and communication
		Program management

using self-reported hours collected during key informant interviews.

Budget and expenditure data was collated from the central NMEP office, as the health system in Bangladesh is highly centralized. Self-reported hours were collected from malaria staff in five sample districts (Bandarban, Sherpur, Moulvibazar, Cox's Bazar, and Chittagong) to calculate the malaria spend and distribution of cost at the subnational level. These sample districts were purposely selected with expert knowledge of the NMEP and icddr,b based on their annual parasite index, population at risk (PAR) and accessibility.

Direct household costs

It is widely accepted that malaria constitutes a significant economic burden on households.²¹ Many malaria patients pay OOP for treatment, including transport costs, diagnostic costs, and antimalarials. To estimate the direct cost to households, we multiplied the number of outpatient (OP) and inpatient (IP) malaria cases in 2015 by the average OOP expenditure for a malaria episode.

Indirect costs

The burden of malaria can be experienced through the indirect costs of reduced household productivity and premature death through losses in lifetime productivity.²² Reduced productivity due to illness is represented by the

loss of potential earnings, both for the malaria patient and the patient's caregiver. Reduced productivity from premature death is represented by reductions in lifetime productivity and in the value that individuals place on longer, healthier lives.

To measure the economic impact of malaria-related morbidity, we assumed that all malaria cases and their caregiver incur productivity and income losses. We employed the 2014 gross domestic product (GDP) per capita per day as a substitute for daily income and multiplied it by illness duration.²³ The duration of illness was obtained for both OP and IP cases.

To calculate the economic impact of premature death, we used the full income approach, which assesses the value of additional life years (VLYs).²⁴ VLYs account for people's willingness to trade off income, pleasure, or convenience for an increase in life expectancy. One VLY is the value in a country of a one year increase in life expectancy. Total life years lost per malaria death was calculated using life expectancy tables and multiplied with the VLY.²⁵

Malaria Elimination Transmission and Costing in the Asia Pacific (METCAP)

The costs and benefits of elimination were generated using the Malaria Elimination Transmission in the Asia Pacific (METCAP), developed by MORU in collaboration with MEI. Empirical cost data were incorporated into the epidemiological model to estimate the cost of elimination and the economic impact of interventions against transmission of *P. falciparum* and *P. vivax*; this permitted the examination of numerous control and elimination scenarios to determine cost and economic and epidemiological efficiencies. The full description of the transmission model and list of the scenarios can be found in Annex 2 and elsewhere.⁴⁹

Several scenarios were simulated and outputs from three scenarios were used in this investment case. The business as usual and reverse scenario represents the counterfactual to malaria elimination.

- **Business as usual:** This scenario projects the malaria burden in 2016-2030 based on continuing the mix and scale of malaria interventions implemented in 2014.
- **Reverse scenario:** This scenario projects the malaria burden in 2016-2030 assuming that LLIN distribution ceases, indoor residual spraying (IRS) is halted, and treatment rates decline by 50%.
- **Elimination scenario:** This is the scenario that allows attainment of the elimination threshold using a minimum package of interventions. This scenario projects the malaria burden in 2016-2030 based on the col-

lective impact of the following interventions: (1) test and treat coverage increased from 2017 onwards in a linear fashion over eight years to 80% by 2025; (2) increased effectiveness of LLINs; (3) increased surveillance using community health workers.

Scenarios were modeled separately using three different baselines:

1. A constant 5% probability of treatment failure to ACTs across all countries and separately for a baseline in which the probability of treatment failure to ACTs increased to 30% by 2025 across all countries.
2. No mass drug administration (MDA) and separately using five annual rounds of MDA at 50% coverage (of PAR), from 2018, starting four months before the peak of the season.
3. Maintaining LLIN coverage at 2015 levels and separately scaling up LLINs to 80% effective coverage deployed in a 3-year cycle (50%, 25%, and 25%).

The PAR values used to estimate costs in the model were adjusted to incorporate the decrease in incidence predicted due to elimination-focused interventions. Historical incidence and PAR data were analyzed 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 modelled scenarios. This method has limitations, including a non-standardized definition of PAR.

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% year-to-year among the PAR for all three scenarios, with and without the resistance assumption.

Cost projections

We estimated the costs of the elimination scenario by multiplying the outputs of the transmission model by unit costs from our costing exercise and relevant inputs from published literature. Inputs and assumptions for these calculations can be found in Table A1-1 in Annex 1. To calculate the incremental or additional costs of elimination (which is used to calculate the ROI), we subtracted the estimated costs of the business as usual and reverse scenarios from the elimination scenario. Costs were discounted at 3%.

Benefits estimation

We calculated the benefits of malaria elimination by first subtracting the estimated cases and deaths of the elimination scenario from the corresponding outputs of the business as usual and reverse scenarios. The resulting figure—referred to as the morbidity and mortality averted by malaria elimination—were valued using the same methods described previously in estimating the economic burden of malaria (Table 1). In addition, we also estimated the

^b The Commission on Investing in Health estimates the VLY average for Bangladesh to be 2.8 times the 2014 GDP per capita.

benefits of continuing current interventions by comparing the business as usual and reverse scenarios. Benefits were discounted at 3%.

Return on investment

To calculate the ROI of malaria elimination in 2016-2030, we subtracted the benefits of elimination by the incremental cost of elimination and divided the resulting figure by the incremental cost of elimination. The ROI can be understood as incremental returns of additional investment in malaria over 15 years with the eventual interruption of local transmission by 2030.

Financial gap

We consulted various sources to estimate past, present, and future financing for malaria. We calculated the financial gap by subtracting the projected costs of the malaria program from 2017 to 2021 from the expected available financing from domestic and donor sources. Cost projections were informed from the revised NSP for the years 2017-2021. Available financing was sourced through the NSP, the Global Fund concept note, and through conversations with the NMEP.

Sensitivity analysis

We performed stochastic sensitivity analyses on the epidemiological and cost outputs of the 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, 10, 25, 50, 75, 90 and 95 percentile uncertainty ranges, which are presented in Annex 2.

Limitations

It should be noted that this transmission model was not designed for accurately modeling individual countries as it uses only one patch for each country. Thus it is unable to take account of subnational heterogeneities in transmission and delivery of interventions. Treating the whole country as a single unit in this way is likely to lead to over-estimates in costs of elimination. The project team are planning to develop the METCAP model to incorporate multiple patches for each country to model scenarios for individual countries in detail.

Results

Direct health system costs

The median cost of the malaria program from FY 2015-16 was estimated at USD 20.40 million or USD 1.54 per PAR. Bangladesh’s health system is highly centralized and accordingly, the majority of the total cost flows from the central level into the endemic districts. According to our data, 76% of total cost was found at the central level (NMEP and BRAC) and disbursed to district and sub-district levels, 17% of the total cost was found at district level, and 7% at the sub-district level. Trends in our data show that the largest investment (39% of total cost) was funneled into Sherpur, a district in pre-elimination stage, followed by Moulvibazar and Chittagong (low endemicity), Cox’s Bazar (moderate endemicity) and lastly, Bandarban (high endemicity). This trend indicates that more money is funding districts closest to achieving malaria-free status.

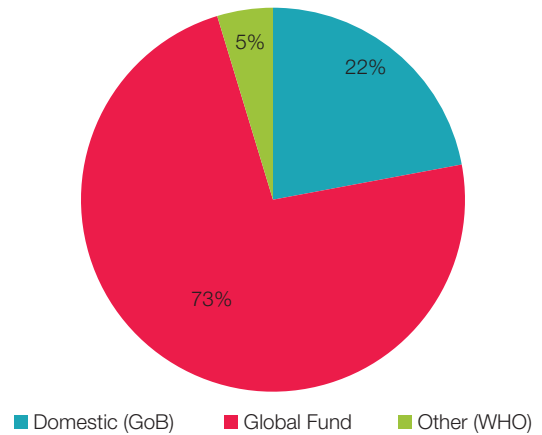
Economic burden of malaria

The total economic burden of malaria in Bangladesh in FY 2015-16 was estimated to be USD 35.3 million or 0.02% of the GDP. Direct health system costs had the largest share (89% or USD 31.56 million), followed by indirect costs from productivity losses due to malaria morbidity and mortality (9% or USD 3.15 million) (Figure 6).

Cost by source

The majority of funding for malaria activities in Bangladesh is provided for by the Global Fund, contributing 73% of the total cost, followed by the GoB at 22%, and lastly by the WHO at 5% (Figure 7).

Figure 7. Distribution of total cost by source



Cost by input

Cost was organized along four inputs of production: capital, consumables, personnel, and services. Capital costs included vehicles, buildings and office space, furniture, computers, and other durable supplies. Personnel costs included salaries, allowances, and any other compensation to staff involved in malaria. Consumable costs included office and laboratory supplies, medicines, insecticides, and other expendable products. Service costs included utilities, transport (domestic and international), trainings, maintenance, and security.

Cost was further classified as fixed (i.e. capital) and recurrent (i.e. consumables, personnel, and services). Consumables were the biggest cost driver at 35%, followed by personnel and services (Figure 8).

Figure 6. Economic burden of malaria in Bangladesh, FY 2015-16

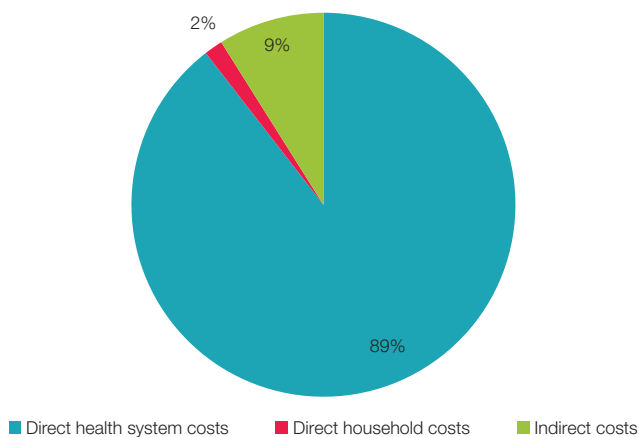
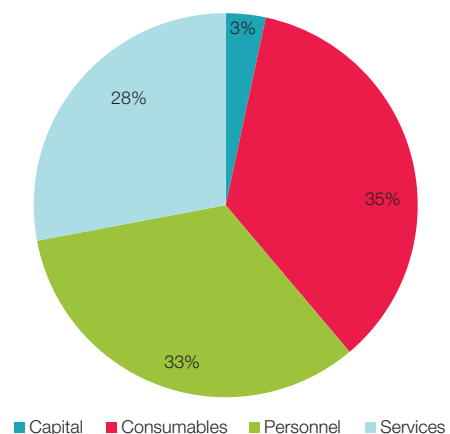


Figure 8. Distribution of cost by input



At the sub-district level, personnel constituted the highest costs at an average of 58%, followed by services and capital (Figure 9).

Cost by activity

Cost was analyzed across seven malaria-related activities: prevention and vector control (PVC), diagnosis (D), treatment and prophylaxis (TP), surveillance and epidemic management (SEM), monitoring and evaluation (ME), information, education, communication (IEC), and program management (PM). The major cost driver was PVC at

38%, followed by PM at 28%, and ME at 10% (Figure 10). PVC activities are measures that prevent human contact to mosquitoes or limit the ability of mosquitoes to transmit the disease through interventions like IRS, LLIN distribution, and larvaciding. PM is defined as the oversight of malaria activities including operations, human resource management, financing, training, and performance improvement for both individual components and the overall program. And lastly, ME is the routine and episodic efforts to determine the relevance, effectiveness, and impact of malaria activities.

Figure 9. Distribution of cost by input at the district and sub-district level

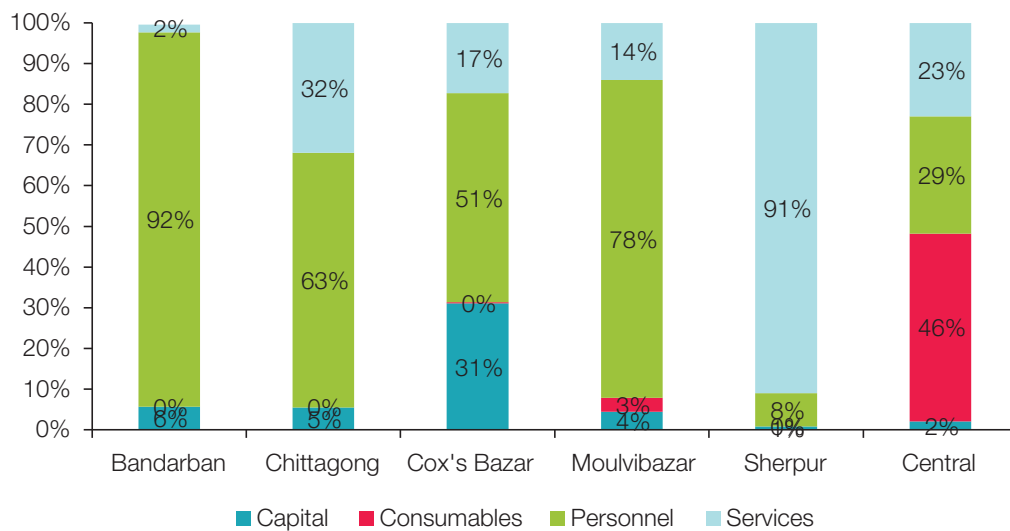
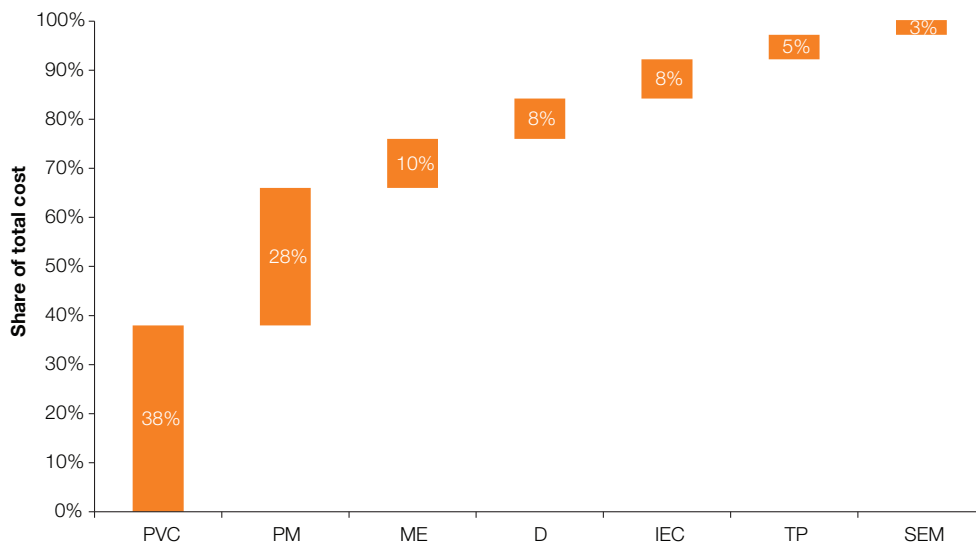


Figure 10. Distribution of total cost share across activities



PVC – prevention and vector control; PM – program management; ME – monitoring and evaluation; D – diagnosis; IEC – information, education, and communication; TP – treatment and prophylaxis; SEM – surveillance and epidemic management.

Transmission model predictions

Epidemiological projections

Based on the epidemiological outputs of the transmission model, we employed three scenarios to compare the rates of decline of malaria incidence from 2016 to 2030.

Figure 11A models the median number of reported cases in 2016-2030 in Bangladesh among these scenarios. The scenario that predicted reductions of malaria incidence required to achieve elimination is titled “effective usage” and is defined by the collective impact of:

- Test and treat coverage increased from 2017 onwards in a linear fashion over eight years to 80% by 2025;
- Increasing the effectiveness of LLINs; and
- Increase in surveillance.

Figures 11A and 11B show the reported and clinical malaria cases^c projected by the malaria transmission model for the business as usual, reverse, and elimination scenarios with the resistance assumption. To account for potential underestimation of reported cases, clinical cases were used to calculate modeled costs and benefits, but both are shown here.

Not surprisingly, halting vector control interventions and cutting treatment rates by 50% will increase the number of clinical

c A clinical malaria case is an individual who tests positive for malaria while displaying malaria-related symptoms such as fever, headache, and vomiting. A reported malaria case refers to a malaria case reported by medical units and medical practitioners to either the health department or the malaria control program, as prescribed by national laws or regulations.

malaria cases, with a peak of over 1.56 million in 2030. Under the business as usual scenario, malaria cases steadily decline in both reported and clinical projections.

The spread of artemisinin resistance can intensify the burden of disease, particularly in Bangladesh, where there is increasing drug resistance in neighboring countries and a growing trend of reported insecticide resistance. Despite this threat, the model predicts elimination can be achieved by 2025.

Cost projections

The transmission model predicts Bangladesh will reach elimination in 2025. If scaled up, the model predicts it will cost approximately USD 76.9 million (range USD 68.8 million to USD 92.2 million) to achieve elimination in 2025 and USD 14.64 million (range USD 10.5 million to USD 19.9 million) for POR until 2030, costing a total of USD 91.54 million (range USD 75.3 million to USD 112 million).^d This equates to an annual average USD 6.1 million per year (range USD 5 million to USD 7.5 million) from 2016-2030. The cost of implementing the elimination scenario^e is depicted in Figure 12. As other countries in the Asia Pacific region continue to reduce their burden, thereby reducing the risk and vulnerability to malaria, Bangladesh will dually benefit.

d As malaria will not be eradicated in 2030, POR activities will need to continue in Bangladesh until eradication. The transmission model does not account for the cost of the additional POR activities beyond 2030, but it is critical to note the importance of this.

e This scenario projects the malaria burden in 2016-2030 based on the collective impact of (1) increased protective effectiveness of LLINs; and (2) increased surveillance using community health workers.

Figure 11A. Projected median reported malaria cases, 2016-2030

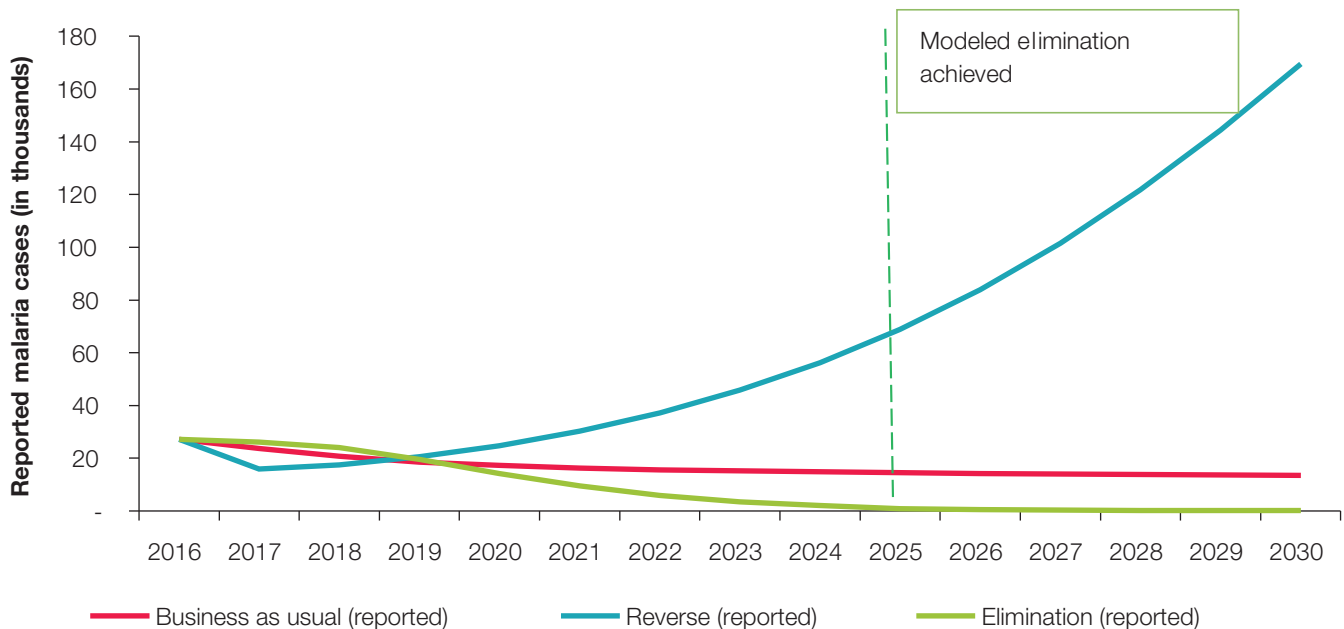


Figure 11B. Projected clinical malaria cases, 2016-2030

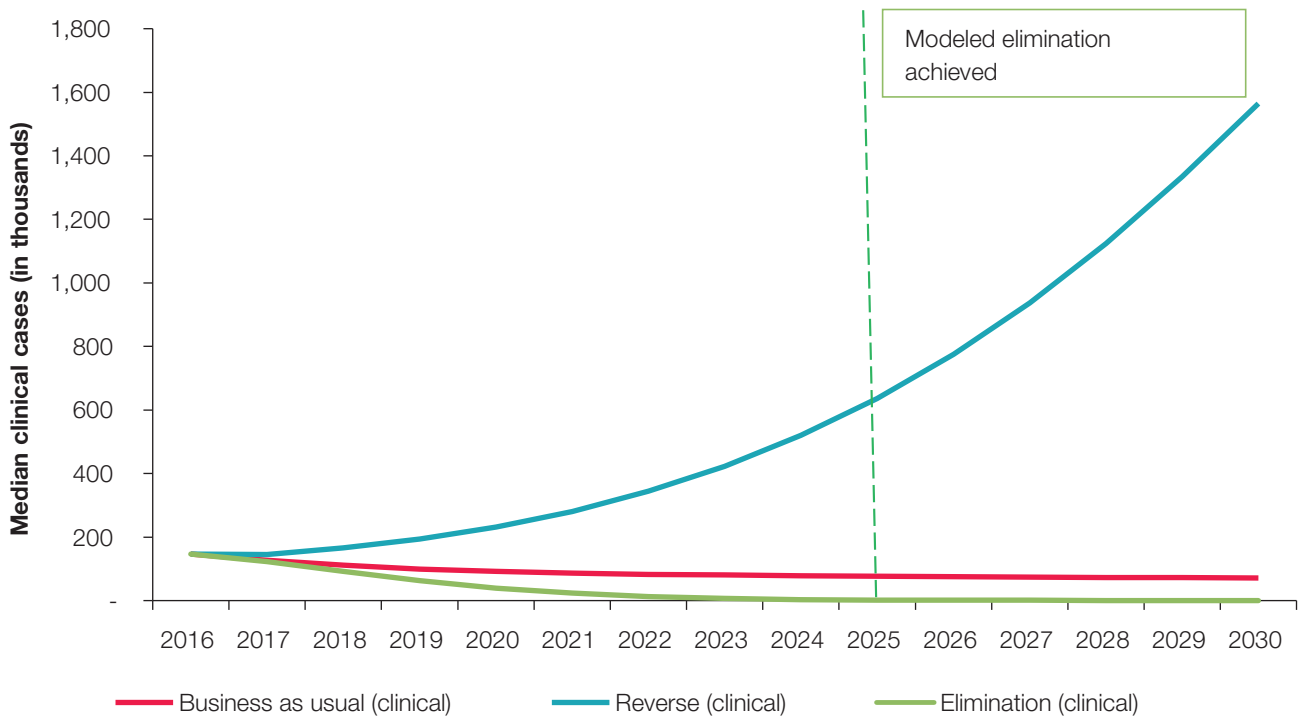
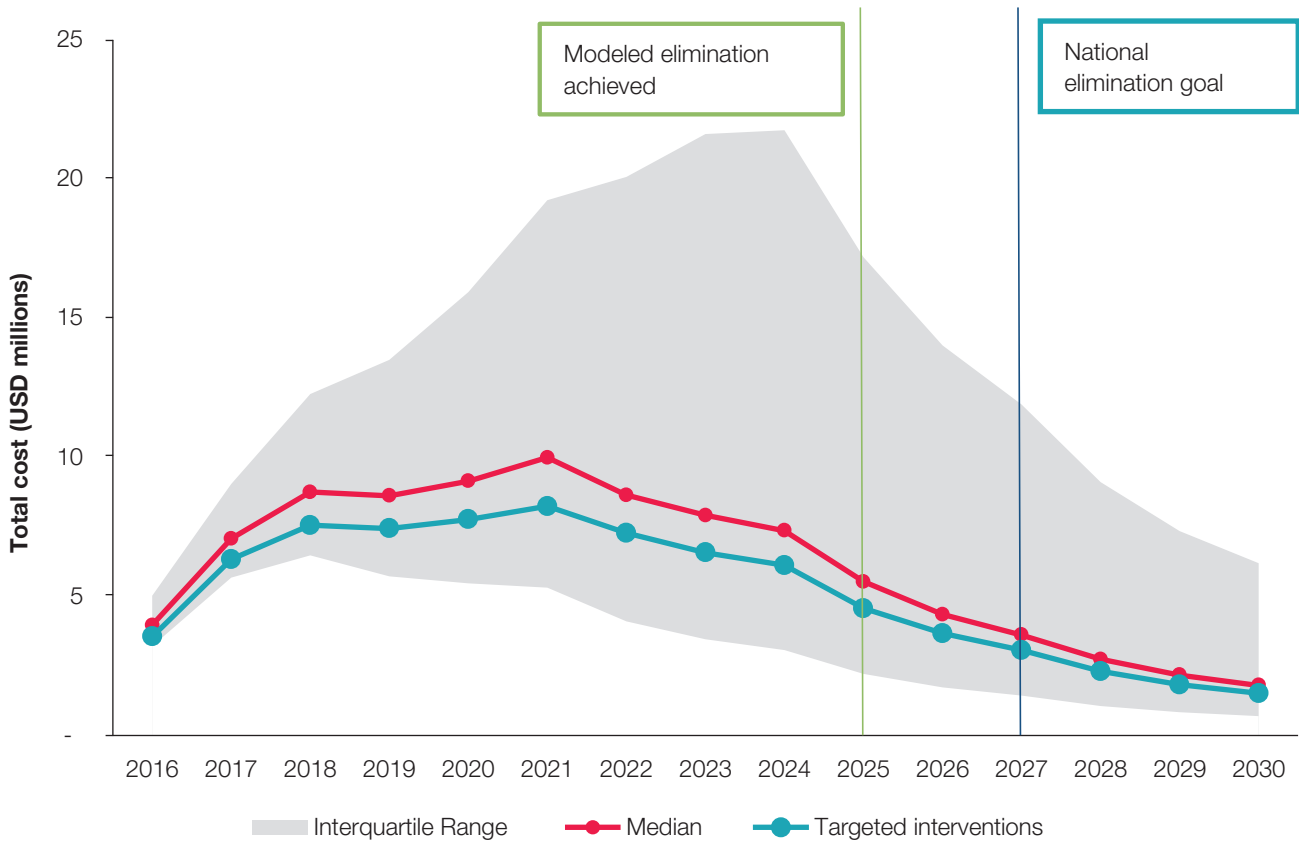


Figure 12. Cost projections for elimination scenario 2016-2030



Targeted interventions, whereby interventions are applied focally to a subset of the PAR (specifically a 30% reduction in intervention coverage among the PAR) are also depicted in [Figure 12](#). Median elimination costs in 2016-2030 would be reduced by an average of 15% over this 15-year time period under this reduced PAR assumption.

Benefits estimation

To estimate the benefits of elimination, we calculated the averted costs, cases, deaths, and ROI for the scenario comparisons listed in [Table 3](#). As shown in [Table 3](#), the elimination scenario with anticipated drug resistance will avert 829,605 clinical cases (range 364,333 to 9.1 million) and 1,577 deaths (range 697 to 17,277) during this 15-year period. This scenario generates economic benefits of USD 343.5 million (range USD 153 million to USD 43.65 billion) through reductions in deaths, cases, and household and healthcare system spending as well as increases in productivity over a fifteen year time period. A summary of the results of various scenarios is found in [Table 3](#).

Return on investment

The ROI was calculated by subtracting the benefits of elimination by the incremental cost of elimination and dividing the resulting figure by the incremental cost of elimination ([Table 3](#)). Without increased risk for artemisinin resistance, the ROI of malaria elimination for 2016-2030 is roughly 4 to 1 when compared to business as usual.

The ROI nearly doubles when the resistance assumption (the probability of treatment failure to ACTs is constant at 5% across all countries until 2018, where it increases to 30% by 2025) to 7 to 1. This translates to every additional dollar spent on malaria elimination generating USD 7 in economic and financial returns over a 15-year period.

Under targeted interventions, whereby interventions are applied focally to a subset of the PAR, the ROI is higher at 9 to 1 between 2016 and 2030. This reduced PAR assumption would be the most efficient use of resources, as it has zero additional cases, coupled with reduced cost and a higher ROI. Targeted interventions in Bangladesh provide cost-efficiencies and should be discussed with the program as they move towards their elimination goal (see section on program efficiencies below).

Gaps in malaria financing

We have compared the expected influx of financing (both domestic and donor) with the projected cost of the malaria program from 2017 to 2021. Cost projections are based off assumptions and forecasting posited by the NMEP in their revised NSP for the years 2017–2021 and through deliberation with the program ([Table 4](#)).

The current cost of the program at USD 20.4 million does not include measures to improve efficiencies. In addition, the program costs were calculated before Bangladesh reconfigured its malaria control program to a malaria elimination program within which activities and

Table 3. Median costs and benefits of malaria elimination compared to counterfactuals, 2016-2030

Scenario comparisons (Baseline – Intervention)	Clinical cases averted	Deaths averted	Net economic benefits (USD)	Incremental cost (USD)	ROI
Business as usual vs. elimination (baseline)	501,403	954	215,866,919	43,888,460	4
Business as usual vs. elimination (with resistance assumption)	829,605	1,577	343,487,841	44,123,949	7
Reverse vs. elimination under resistance assumption	8,305,224	17,279	4,768,895,801	2,389,392	
Interventions reduced to 30% for PAR only					
Business as usual vs. elimination under resistance assumption	829,605	1,577	343,487,841	34,501,976	9

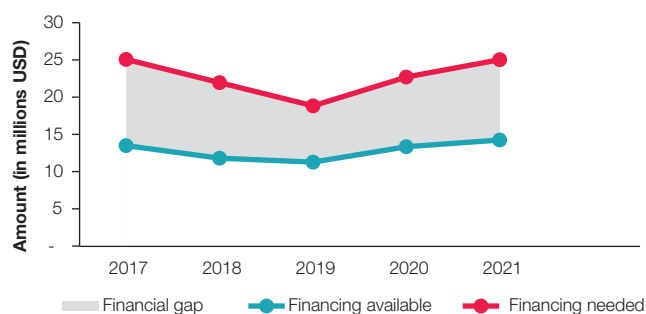
interventions will need to be aligned with those consistent of an elimination program. Targeted interventions such as vector control to high risk areas and populations will likely provide considerable cost-efficiencies.

The modeled cost of elimination in Bangladesh is estimated at USD 91.54 million until 2030. This equates to a minimum of about USD 9 million annually for the first five years, assuming that the aggressive interventions predicted by the model are implemented in the most efficient way. Bangladesh is currently highly dependent on financing from the Global Fund. Current levels of domestic financing are about USD 3 million per year. As cases decline in Bangladesh, it is unlikely that the Global Fund will maintain its current levels of funding and the resulting financial gap will need to be met by increased domestic financing if the country is to stay on track toward elimination.

Given the global trend of declining donor assistance for malaria eliminating countries and Bangladesh's goal to reach middle-income country status by 2021 (which requires higher levels of co-financing to Global Fund grants), there is heightened pressure to increase domestic financing levels. A funding request to the Global Fund for malaria has been developed for the period of 2018-2020, listing the GoB^f and BRAC as the principle recipients. The request is for USD 26.8 million and will be focused on vector control measures, increasing microscopy capacity, improved case management, augmented cross-border collaboration with India and Myanmar, and the strengthening of outbreak and foci preparedness. Despite this expected level of financing, a major annual gap remains (Table 4).

The average annual gap between 2017-2021 is USD 9.8 million (Figure 13). It is important to note that these figures do not account for the increased levels of co-financing levels required by the Global Fund if and when Bangladesh reaches lower-middle income country status. The NMEP would expect a lessened amount of external funds, coupled with higher domestic financing to fill that gap.

Figure 13. Average financial gap, 2017-2021, in Bangladesh



Opportunities for resource mobilization

To continue acceleration towards elimination, Bangladesh must safeguard political and financial commitment for malaria both domestically and externally. Malaria financing must be prioritized in a state of competing disease priorities, lack of exposure to the disease at the central level, and declining trends in donor support. There are positive synergies between investing in malaria and achieving progress towards many of the Sustainable Development Goals (SDGs). Sustained investment in malaria can be a catalyst in unlocking human capital to generate growth more broadly. As Bangladesh achieves its SDG targets, the country can use the robust benefits of malaria investments as advocacy for continued growth development. The below section discusses the potential opportunities for Bangladesh to generate new revenue to optimize the impact of the existing funds for malaria.

Potential new revenue

The economic landscape of Bangladesh is important when discussing malaria elimination for a number of reasons related to realizing opportunities for resource mobilization. Goldman Sachs has identified Bangladesh as one of the “Next Eleven”, a group of eleven economies selected as having the capacity to emerge as a major economy

Table 4. Estimated financial gap, 2017-2021 (in USD)

Financing sources	2017	2018	2019	2020	2021	Average
Domestic	3,000,385	3,019,628	3,129,955	3,072,226	2,734,189	2,991,277
Global Fund	10,385,101	8,631,171	8,039,655	10,129,174	11,543,267	9,745,674
Other (WHO)	110,000	165,000	137,500	151,250	-	140,938
Program cost	25,065,358	21,943,490	18,833,867	22,723,401	25,018,594	22,716,942
Gap	11,569,872	10,127,691	7,526,757	9,370,751	10,741,138	9,867,242

^f Economic Relations Division of the Ministry of Finance, GoB, which provides financial support to the NMEP via the MoH&FW.

in the 21st century. Experiencing stable economic growth since its economic reform in the 1990s, Bangladesh is expected to continue to grow at a rapid pace with 4.5% GDP growth until 2050.²⁶ Total health expenditure (THE) in Bangladesh as a percent share of GDP was 2.81% in 2014, with government expenditure accounting for 27.9% of THE. This translates to spending roughly USD 8.60 per capita on health.^{23,26} In the same year, we estimated that the GoB allocated only 0.12% of its total domestic health spending on malaria (GoB allocated USD 5.59 million to malaria in 2014).¹ This small allocation towards malaria is significant for a number of reasons. In the current state of the country's expanding economy, an inadequately or poorly funded malaria program has the potential to jeopardize economic growth more broadly. What's more is that the GoB appears to have the capacity to allocate more resources. With an average annual financial gap of USD 9.8 million between 2017-2021, Bangladesh needs to generate new revenue, as well as maximize the allocations already existing in the malaria envelope. This investment case illustrates the robust benefits of eliminating malaria with an ROI of nearly 7 to 1, representative of a sound investment for the country.

The private sector is a major driver of the economy in Bangladesh, accounting for 93% of its GDP in 2010, and has the capacity to be a major player in malaria elimination efforts.²⁷ Surveillance, procurement and supply chain management, and the distribution of resources are activities that can potentially benefit from innovative approaches to revenue generation. Much of this private sector development can be attributed to the agriculture sector, which employs 47% of the labor force and contributes roughly 15.5% to GDP, and the ready-made garments sector, which accounts for 83% of the country's total exports and was valued at USD 25.5 billion from 2014 to 2015.²⁶

ADB has been a key partner in advancing economic development in Bangladesh since 1973. As of December 2016, ADB has loaned^g Bangladesh USD 18.3 billion over 265 loans and USD 249.5 billion over 419 technical assistance projects.²⁸ Though most of its funding has historically prioritized energy, transportation, agriculture, natural resources, urban development, and education, ADB is committed to simultaneously boosting the economy and improving health outcomes.

Despite recent economic growth, Bangladesh faces major challenges ahead. With the projection of becoming a middle-income country by 2021, the country will need to address its infrastructure deficit, diversify the economic base, and engage the private sector to further link health with sustainable growth. The transmission model predicts that elimination in Bangladesh can generate economic benefits of approximately USD 343.5 million from 2016-2030 by increasing productivity and reducing malaria

deaths, cases, and household and healthcare spending. Elimination is an attractive investment both in Bangladesh and more broadly.

The benefits of achieving malaria elimination are extensive. The more obvious ones are lives saved, cases averted, and costs averted. From 2016 to 2030, elimination in Bangladesh can save over 1,500 lives, avert nearly 830,000 cases, and pay for itself via future reductions in spending. The less obvious ones, like enhanced health security, a fortified health system, increased tourism, and improved cognitive function are challenging to quantify but have the potential to positively impact society. These benefits are not included in this investment case, and thus the ROI is likely an underestimate. It will be challenging to realize these positive externalities of elimination unless the GoB can increase its spending.

Innovative financing, defined as instruments that can generate additional revenue and mechanisms of allocating funds more efficiently to optimize impact, can help Bangladesh's malaria program to cover their financial gap. These instruments have gained significant traction in recent years:

- **International or regional funds**

Pooled funds from various development agencies, institutions, governments, foundations, and individuals are used to support specific causes. In Bangladesh, this is happening with climate change. There are numerous regional initiatives specifically for malaria elimination. APLMA is a key player in supporting the elimination agenda at the regional level (albeit it does not provide financing). ADB set up the Regional Malaria and Other Communicable Disease Threats Trust Fund in December of 2013 to develop cross-border and multi-sector responses to urgent challenges related to malaria and other communicable diseases.²⁹ This fund has been used to develop responses to disease threats in ADB developing member countries, including Bangladesh.

A working example of pooling resources from various sources can be seen in the climate change efforts in Bangladesh. Bangladesh is considered one of the most vulnerable countries to climate change and has subsequently joined the conversation around climate finance. Climate finance can be drawn from public, private, or alternative sources to help national planning for climate adaptation and mitigation, and the malaria program can use lessons learned from these sources to establish similar funds. The Bangladesh Climate Change Trust Fund was set up in 2009 and receives funds from the GoB. A parallel fund, called the Bangladesh Climate Change Resilience Fund, consists of funds from various development partners. These two funds are mainstreaming climate change in national planning and 10% of each fund is allocated to civil society and NGOs through the Palli Karma

^g These are loans at concessional rates.

Sahayak Foundation, which focuses on carrying out community-based activities in vulnerable parts of the country.

If the NMEP can provide a compelling case for the links between climate change and malaria burden, the program may be able to leverage this 10% allocation, or a portion of it, as an alternative source of funding.

- **Public-Private Partnerships**

Public-private partnerships (PPPs) are a mechanism for governments to draw private financing support for public initiatives.²⁶ The GoB and BRAC is a prime example of a successful PPP in Bangladesh, whereby the government sets out national policy and retains budgetary control, and the NGO facilitates activities within the policy. A PPP office was established to support private investors entering the public market. Incentives and financial benefits for PPPs have been created to ensure sustainability, which include: fiscal incentives^h, special (non-fiscal) incentivesⁱ, viability gap financing^j, technical assistance fund^k, and the Bangladesh Infrastructure Finance Fund Limited^l.³⁰ In 2012, the PPP office became operational under the Prime Minister's Office and with the support of ADB's technical assistance and the World Bank's Investment Promotion and Financing Facility project. Bangladesh is the global leader in the number of solar home systems installed (over three million in 2015) through the public-private partnership of the Infrastructure Development Company and its franchise.³¹

The list of approved projects under the PPP Office focuses on transportation, energy, and health. The PPP Technical Assistance Fund is something that the NMEP may be able to engage with to obtain early stage project development funding support to sanctioned PPP projects. The Viability Gap Fund provides supplementary government financing to projects that the PPP Unit believes is economically vital to public interest. The Finance Division through its PPP Unit will manage and disburse these funds upon request made by the Line Ministry. The Bangladesh Infrastructure Finance Fund Limited was incorporated by the Ministry of Finance in 2011 to provide long-term financing to infrastructure projects. This fund seeks to attract investments from foreign institutions and retail investors.³²

h Provisions permitting investors to benefit from fiscal incentives to reduce the cost of implementation.

i To enhance efficiency of a project, exemptions from insurance, banking, or foreign exchange regulations.

j Creation of a budgetary fund to provide a financial subsidy.

k A public-private partnership technical assistance fund with an endowment of USD 12 million to provide early stage project development.

l Incorporated by the Ministry of Finance in 2011 to allow for long-term financing of infrastructure projects.

- **Taxes**

Taxation as a means of generating revenue that governments can utilize for health programs can have considerable potential. The Health Development Surcharge (HDS) in Bangladesh is a type of tax that is applied to importing and producing products that are harmful for public health (i.e., tobacco and alcohol). This type of tax, also known as a "sin tax" concurrently reduces usage of harmful products while collecting additional revenue for health programs. Currently, Bangladesh has imposed a 1% HDS on tobacco products on the national budget of FY 2014-15.³³ Another prime example of a sin tax is found in the Philippines, which increased the Department of Health's budget by 63% in 2015 compared to 2013.

Despite stable economic growth and opportunities for innovative financing, increasing domestic resources remains a key issue for Bangladesh, both because it has one of the lowest revenue-to-GDP ratios globally, and, as it transitions to a lower-middle-income country, it has less access to international development assistance.³⁴ The Tax Modernization Plan 2011-2016, which envisioned policy reform coupled with a program for automating National Board of Revenue (NBR) operations to enhance services, decrease administrative costs, and improve compliance for taxpayers, was not as successful as planned.

To ensure increased domestic resources for health, Bangladesh needs to expand the tax base, while simultaneously registering informal individuals and companies to bring them into the NBR, generating higher levels of revenue growth.

- **Demand-side financing**

Demand-side financing (DSF) was initiated as a tool for some developing countries to improve access to and utilization of health services by putting purchasing power in the hands of the patient. The premise of DSF is that patients face financial barriers that prevent them from seeking care, so providing them with a voucher or accreditation will not only incentivize the patient, but ensure quality health care delivery. Bangladesh launched a DSF scheme that provided vouchers to pregnant women, authorizing free antenatal, delivery, emergency referral and postpartum care services, along with cash reimbursements for transport. This scheme increased institutional deliveries and reproductive health in the 33 upazilas in which it was launched.³⁵ DSF can be effective in certain settings, but challenges around sustainability are important to consider. The malaria program can leverage its experience with DSF in reproductive health services and apply it to malaria-specific healthcare provision.

Successful resource mobilization will be a result of a number of influences: political capital, sustained donor and private sector commitments, and the political acceptance

of policy reforms. The private sector in Bangladesh, specifically the ready-made garment sector, is a key driving force for the economy. The private sector accounts for roughly 93% of its GDP, 81% of total investments, 94% of consumption expenditure, and 80% of domestic credit.³⁶ Economic growth coupled with low government investment has cultivated an infrastructure deficit with the rising demand for energy, transportation, and telecommunications. This infrastructure deficit can be seen as one of the major impediments to private sector development. Agriculture and agribusinesses (i.e., plantations) are also a large part of the economy of Bangladesh, accounting for 147% of the labor force and contributing 15.5% to GDP.³⁶ Historically, the agribusiness is a large employer of seasonal workers and mobile migrant populations. The majority of these workers are female (80%) and, due to the very nature of their work, are at elevated risks of malaria (late treatment due to lack of access to services and inefficient surveillance). In Bangladesh, where many of the endemic districts are found in hilly, forested regions, plantation workers are at higher risk. In Bangladesh, plantation workers tend to be illiterate and lack general knowledge about malaria.³⁶ To mitigate this, some plantation companies have their own medical centers and awareness programs.

To increase resource mobilization efforts, malaria must be politically positioned strategically. Bangladesh has frequently been described as a political “paradox”, as it scores low on many governance indicators, ranks extremely high for corruption, and yet has maintained steady economic growth and improved health indicators across many health priorities. Despite progress in driving down malaria, malaria often competes with other disease areas to garner political interest at the center.

To promote malaria elimination and secure a place on the health agenda, the NMEP is already underway to increase political support. The NMEP plans to establish a Malaria Elimination Oversight Committee (MEOC), which will be backed by the Prime Minister. The NMEP’s Malaria Technical Committee will be transformed into a high-level multi-sectoral National Malaria Elimination Taskforce (NMET), chaired by the health minister. The NMET will include representatives from NMEP, MoH, NGOs and technical partners including the WHO. The NMET will establish working and executive groups in line with specific requirements. The NMEP has plans to host a meeting to explore prospective domestic investors and financing. They envision inviting stakeholders from other countries and plan to have this before September 2017.

Addressing efficiencies in malaria programs

The current and projected costs of malaria elimination are inclusive of the inefficiencies present within the malaria program. To maximize impact of the existing program’s interventions, different kinds of efficiencies can be improved. Efficiency gains have been cited by the

World Bank as the most practical vehicle for resource mobilization.

Health systems and public health programs are under increasing pressure to ensure that available resources are used efficiently to deliver services and provide value for money. The Malaria Program Efficiency Analysis Tool (MPEAT) was developed by the UCSF Global Health Group’s Malaria Elimination Initiative to help malaria program managers assess key performance measures of programmatic efficiency in the malaria program. We define efficiency here as the ratio of actual output to effective capacity, where effective capacity is the target or benchmark. When a health program faces insecure or inadequate funding, the pressure to safeguard existing funding and/or resources is heightened, subsequently calling the maximizing of value, reduction of waste, and ultimately the protection of resources.

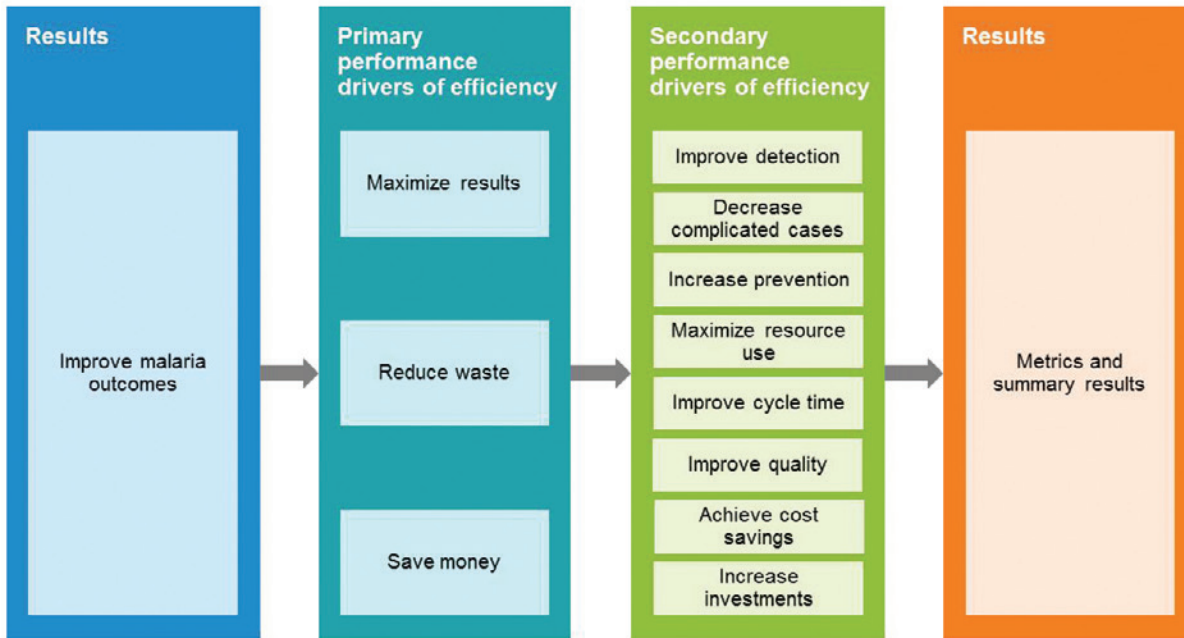
Optimizing a program’s efficiency can help a country leverage scarce resources for maximum impact. In other words, it is the practice of figuring out how to best manage the growing demand for services within a limited amount of funding. There are three major concepts of efficiency: technical, productive, and allocative. Technical efficiency is concerned with the physical relation between resources (capital and labor) and a specific health outcome. Productive efficiency refers to the optimization of a health outcome for a given cost.³⁷ Allocative efficiency is when resources are put to their best possible use for society so that no further changes are needed. Together, these three economic efficiencies will measure whether resources are being used to achieve the highest value for money^m.³⁸ The outputs of the MPEAT can be used to:

- Identify inefficient areas that require further examination;
- Improve operations;
- Defend annual budget requests; and
- Advocate for more financing for the program.

The tool identifies the relevant drivers for achieving intended results and critical inputs required. It is based on the premise that efficiency of health service delivery as measured by its output is directly related to resource inputs. [Figure 14](#) illustrates the framework of the tool. While there is no one-size-fits-all mix of interventions to reduce the burden of malaria, we hope that this tool can highlight areas that are potentially inefficient in Bangladesh. More information on the tool, its structure, and uses are available in the MPEAT manual.

^m Value for money has many definitions but can best be defined as finding the optimal balance between economy, efficiency, and effectiveness.

Figure 14. Framework used to design MPEAT



Discussion and Conclusion

This investment case estimates the economic costs, benefits, and financial landscape of malaria elimination in Bangladesh. The total cost of Bangladesh's malaria program from FY 2015-16 was estimated at USD 20.4 million or USD 1.54 per PAR.⁴⁰ The current investments being made, both from the GoB and external financing, predominantly the Global Fund, have been targeted at PVC activities, which require substantial consumables, and PM, which requires significant personnel financing. To achieve elimination, it is estimated that USD 91.54 million is needed over the next 15 years, according to the transmission model. By investing in malaria elimination, Bangladesh can expect to see an ROI of nearly 7 to 1 on every additional dollar spent on elimination, whereas the ROI of continuing with the business as usual scenario drops by half. The ROIs are likely undervalued, as we did not include the distal benefits of malaria control and elimination (e.g., improvements in educational performance and cognitive development).

The transmission model predicted that the collective impact of increasing test and treat to 80% between 2017 and 2025, coupled with increased effectiveness of LLINs and increased surveillance, can interrupt local malaria transmission in Bangladesh in 2025 – just two years before the country's national elimination target and five years before the 2030 goal of APLMA. Bangladesh is undoubtedly an important country for the region reaching this goal of elimination by 2030.

The country faces challenges with geographical inaccessibility, increasing drug and insecticide resistance in neighboring countries, and cross-border malaria, particularly as it shares porous borders with both India and Myanmar. Insecticide resistance reduces the efficacy of pyrethroids, increasing the mosquito survival rate, and drug resistance threatens the efficacy of antimalarials; together they create large obstacles to elimination. A recent study conducted by the Mahidol Oxford Research Unit projected the health and economic costs of widespread malaria resistance to ACTs. This study found that widespread antimalarial resistance will result in an increase of 116,000 deaths, an excess of USD 32 million in healthcare costs, and USD 385 million in productivity losses every year.³⁹

The Global Fund contributed the majority of malaria financing (73% of total cost) in the past, and they may decrease their support as malaria incidence declines, thus stressing the importance for the GoB to increase its financing share in the future. Global Fund financing for malaria has leveled off since 2011 under its New Funding

Model, which makes it particularly more challenging to receive funding if a country is not defined as high-burden and low-income.⁴⁰ Funding gaps have, in many cases, caused resurgences because of weakened malaria prevention and response programs. In Bangladesh, where malaria competes with non-communicable diseases, which have been cited as accounting for 80% of the total health budget, financial and political commitment to malaria elimination is needed more than ever.

Bangladesh will need to explore innovative sources of financing to meet the malaria program's needs in the short- and medium-terms. Bangladesh should also maximize value, reduce its waste, and obtain best value for money in its current interventions for peak efficiency.

Limitations

The transmission model was designed with a single homogeneous patch for the whole of each country. Thus spatial heterogeneity within each country was not modeled including malaria transmission and interventions. Targeting of interventions within a country may reduce the costs of elimination thus the estimated costs are likely to be an over-estimate. There is much uncertainty in the estimated malaria burden in each country with a resulting impact on the predicted costs of elimination. Population movement was not included in the model and this is likely to have reduced the predicted costs. During the data collection process, we calculated the percent of time spent on malaria activities by all personnel via self-reporting, which inherently has its limitations. 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. Furthermore, the cost of new interventions such as more effective LLINs and a radical cure for *P. vivax* such as tafenoquine are based on historical estimates of the cost of new tools when they were first adopted. For the financial gap analysis, we used projected program costs from the NSP, rather than using the projected costs from the transmission model.

The evidence generated by this study can be used by the NMEP, the GoB, and partners to advocate for continued resource mobilization to overcome the economic and financial barriers to achieving elimination in Bangladesh. The findings in this investment case can also inform an advocacy strategy for achieving elimination by the nationally set goal of 2027.

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Annex 1. Methods and Data Sources

Data collection

Financial, economic, and epidemiologic data were collected through visits to Bangladesh and communication with members of the NMEP, icddr,b, and BRAC. A comprehensive literature review was conducted to obtain an in-depth understanding of the current malaria situation in Bangladesh, as well as the financial landscape for malaria. Key stakeholder interviews were conducted with health staff involved in malaria activities at the central, district, and sub-district level. These interviews followed a semi-structured format to learn more about malaria programming and financing across the country. Self-reported time per malaria activity and sub-activity were obtained through the interviews to account for time spent by personnel. Malaria expenditure data was collected at the central level for FY 2015-16.

Data was organized and analyzed in Microsoft Excel® 2011. Files were stored in encrypted, password-protected computers. All monetary figures are expressed in 2015 USD, using a mid-year exchange rate of 77.95 Bangladeshi Taka per USD.⁴¹

Economic burden of malaria

To estimate the economic burden of malaria, we evaluated: (1) direct cost to the health system; (2) direct cost to the household; and (3) indirect costs (Table A1).

Table A1. Estimating the economic burden of malaria

Direct cost to the health system	Direct cost to individual households	Indirect cost to society
1. Cost due to increased health service utilization for malaria	1. Out-of-pocket (OOP) expenditure incurred due to malaria	1. Cost due to loss of life to malaria mortality
2. Cost of increased vector control		2. Cost due to loss of productivity due to malaria morbidity
3. Cost of increased diagnosis		
4. Cost of human resource training and community education		

A summary of inputs and assumptions used in our data analysis are found in Table A1-1.

Table A1-1. Inputs and assumptions used in various analyses

Indicator	Value	Source
Mortality		
Life expectancy at age 40	36.79	25
Epidemiology and length of disease		
Prop of IP cases	0.11	Transmission model output
Prop of OP cases	0.89	Transmission model output
Length of OP malaria case (days)	4	42
Length of IP malaria case (days)	7.5	42
Economics		
GDP per capita (USD)	1,211.70	23
Exchange rate (mid-year)	77.95	23
Coefficient	2.80	43
Cost (USD)		
Cost per person protected by IRS	2.31	4
OOP per IP case	48.77	42
OOP per OP case	2.085	42
Cost per person treated as IP	59.91	44
Cost per person treated as OP	14.98	44
Average cost of G6PDd test	7.00	
Average cost of drug (per unit) for treating inpatient malaria case	25.89	44
Average cost of treatment for inpatient malaria case	22.88	44
Unit cost per RDT	1.20	15
Unit cost per slide	0.86	15
Proportion of cases diagnosed with RDT	0.37	15
Average cost of surveillance/capita	0.03	15
Average cost of training/capita	0.0024	15
Average cost of IEC/capita	0.06	15
Out-of-pocket expenditure incurred to the household due to malaria (per episode)	15.04	45
Injectable artesunate treatment (drug only)	11.57	15
No of CHWs working on program	0.00	15
Slope of increase in CHWs working	0.00	15
Cost increase factor for hang up campaign	1.28	15
Cost of increased surveillance factor	2.00	15
New radical cure (i.e., tafenoquine)	0.50	15
Cost per person covered by new LLINs	3.10	46
New <i>P. falciparum</i> drug	2.50	46
Cost per person receiving MDA	13.00	46
Cost per CHW worker	1,726.00	46

Direct health system costs

We employed a micro-costing, activity-based approach to capture direct health system costs. Cost data was collected from five sample districts including, Bandarban, Sherpur, Moulvibazar, Cox's Bazar, and Chittagong. These districts were purposely sampled through the help of expert opinion from the NMEP and icddr,b. The five sample districts are seen as representative to the remaining unsampled eight districts based on endemicity band, API, and PAR.

Cost by source

Costs were disaggregated by funding source, either domestic funding (i.e. direct allocations from GoB) or external funding, primarily through the Global Fund. GoB financing is disbursed from the central level at the NMEP in Dhaka, out to the 13 endemic districts. Global Fund money is sent through the NMEP and/or BRAC at the central level, which is then distributed into the endemic districts.

Cost by input

Cost was organized along four inputs of production: capital, consumables, personnel, and services. Capital costs included vehicles, buildings and office space, furniture, computers, and other durable supplies. Personnel costs included salaries, allowances, and any other compensation to staff involved in malaria. Consumable costs included office and laboratory supplies, medicines, insecticides, and other expendable products. Service costs included utilities, transport (domestic and international), trainings, maintenance, and security.

Cost was further classified as fixed (i.e. capital) and recurrent (i.e. consumables, personnel, and services). Capital goods were annualized and discounted using common useful life and standard annuity factors based on a 3% discount rate (Table A1-2).

Table A1-2. Values used in discounting capital expenditure

Capital Goods	Useful Life Years*	Annuity Factor†
Motorcycles and computers	5	4.58
Vehicles and microscopes	10	8.53
Buildings	20	14.88

* The useful life years used are based on the recommendations in the Bill & Melinda Gates Foundation's *Guidance for Estimating Cost for Malaria Elimination Projects*.

† Taken from Drummond, Michael F., et al. *Methods for the Economic Evaluation of Health Care Programmes*. 4th ed. Oxford, UK: Oxford University Press, 2015.

Cost by activity

Cost was analyzed across seven malaria-related activities: PVC, D, TP, SEM, ME, IEC, and PM. A detailed list of interventions included under each category is provided in Table A1-3. Resources were apportioned across activities based on self-reported time spent by interviewees.

Direct cost to individual households

OOP expenditures incurred due to malaria include both direct and indirect costs incurred by households for preventing or seeking care for malaria. These include expenses for patients and their caretakers (i.e., transportation costs, expenditures on products for preventing malaria like bed nets, mosquito coils, and repellants). To calculate the household costs of malaria, we multiplied the number of reported cases of malaria in 2015 by the average expenditure per treatment for any illnesses, as reported by the Bangladesh Bureau of Statistics 2013 and converted to 2015 USD. We calculated direct household spending for OP and IP cases separately.

Indirect cost to society

There are many costs of malaria that extend beyond the health system. Malaria has been shown to negatively impact school performance, educational attainment among children, tourism, worker's productivity, and economic growth.^{47,48} For this study, the indirect costs we estimated were productivity losses among patients and caregivers and the economic impact of premature morbidity.

Cost due to loss of productivity due to malaria morbidity

The lost earnings from an episode of illness due to malaria can have a significant impact on society. For patients' productivity losses, we multiplied the number of malaria cases by the average number of days malaria patients are ill and the 2015 GDP per capita per day. We assumed that the productivity losses of caregivers were equal to those of patients.

Cost due to loss of life to malaria mortality

To estimate the potential social value of life lost due to malaria, we employed the full income approach endorsed by the *Lancet Commission on Investing in Health*.⁴³ The full income approach combines growth in national income with the value individuals place on increased life expectancy. This approach accounts for people's willingness to trade off income, pleasure, or convenience for an increase in life expectancy. One VLY is the value in a particular country or region of a 1-year increase in life expectancy. The average life expectancy at 40 years was used as the life years lost due to premature death.

Table A1-3. Cost categories and activities

Activity category	Definition	Activities
Prevention and vector control (PVC)	Measures that prevent human contact to mosquitoes or limit the ability of mosquitoes to transmit the disease	LLIN distribution Environmental management IRS Chemical larviciding Training
Diagnosis (D)	Detection and identification of malaria infection due to Plasmodium species	Microscopy Rapid diagnostic test Training
Treatment and prophylaxis (TP)	Use of antimalarial drugs to treat or prevent malaria infections	Treatment Case management Provider training
Surveillance and epidemic management (SEM)	Identification, investigation, and elimination of continuing transmission, the prevention and cure of infections	Passive case detection Malaria Information System (MIS) Entomological surveillance Case investigation and response Epidemic response Surveillance training Active case detection Reactive case detection
Monitoring and evaluation (ME)	Routine and episodic efforts to determine the relevance, effectiveness, and impact of malaria activities	Routine monitoring of program activities National Health Insurance Scheme Performance sharing meeting Supervisory visits Monitoring visits Training for M&E personnel
Information, education, and communication (IEC)	Combination of communication strategies, approaches, and methods that provide knowledge to enable individuals, families, groups, organizations, and communities to play active roles in achieving, protecting, and sustaining their own health	Provider training Partnership development Behavior change communication programs (BCC) Policy advocacy School-based education Multi-stakeholder meeting
Program management (PM)	Oversight of malaria activities including operations, human resource management, financing, training, and performance improvement for both individual components and the overall program	Operational research Training Capacity building Staff placement and recruitment Coordination meetings Supervision and monitoring General administration Supply chain management Strategy planning

Annex 2. METCAP scenarios and detail

The investment case for malaria elimination was generated using the outputs of a mathematical model (METCAP) to project rates of decline to elimination by at least 2030 and determine the associated costs. The dynamic epidemiological models estimated the impact of a variety of interventions against the transmission of *P. falciparum* and *P. vivax* using four infection classes: severe, clinical, asymptomatic and detectable by microscopy, asymptomatic and undetectable by microscopy. *P. vivax* infections were characterized by relapses of malaria arising from persistent liver stages of the parasite (hypnozoites). The relationship between glucose-6-phosphate dehydrogenase deficiency (G6PDd) and *P. vivax* malaria was captured using existing estimated G6PDd proportions in the population (those with G6PDd have a reduced probability of clinical infection compared to the non-G6PDd proportion of the population)ⁿ. The model was designed to be spatially explicit with interconnected patches representing whole countries.

Data on historical malaria incidence (2000-2014) and intervention coverage used to calibrate and validate the models were sourced from:

1. World Malaria Reports, 2008-2015;
2. Country data collected from the NMEP;
3. Mahidol Oxford Tropical Medicine Research Unit; and
4. Peer reviewed literature.

ⁿ Unpublished estimates from the Malaria Atlas Project

The models were validated against the estimated burden of disease separately for *P. falciparum* and *P. vivax* malaria and accumulated case fatalities. While reported coverage of interventions (particularly LLINs and IRS distribution) were included in the models to inform changes in incidence, there was little available data on health system advances between 2000 and 2015, such as the introduction of community health workers (CHWs); these were therefore imputed based on observed changes in reported incidence. The fatalities predicted by the models were validated against reported case fatalities. As mentioned above, the METCAP transmission model was only able to provide rough estimates of predicted costings. It was not designed to study individual countries in detail as it uses only one patch per country. Future work will adapt METCAP to incorporate multiple subnational units to model individual countries in detail. A full description of the mathematical models and the parameters driving the models is available elsewhere.⁴⁹

The models predicted reductions of malaria incidence required to reach malaria elimination on or before 2030 (based on a set of intervention coverage scenarios described in [Table A2-1](#)). Elimination was defined as the first year in which less than one reported clinical case is achieved. Note that the models do not distinguish between indigenous and imported cases. Hence the definition of elimination is strict compared to zero indigenous cases. The scenario that allowed attainment of the elimination threshold using a minimum package of interventions was considered as the “elimination” scenario. The elimination threshold for each country was determined using a regression model of local and imported clinical cases. The outputs of averted mortality and morbidity under the elimination scenarios were used to estimate the cost, benefits, and ROIs.

Table A2-1. Modeled scenarios

Scenario	Description
1	Business as usual
2	Reverse scenario 1
3	Reverse scenario 2
4	Reverse scenario 3
5	Universal coverage
6	IRS
7	Effective usage
8	New <i>P. vivax</i> treatment
9	New LLINs
10	New <i>P. falciparum</i> treatment
Assumption	Description
A	Artemisinin resistance
B	MDA
C	LLIN deployment

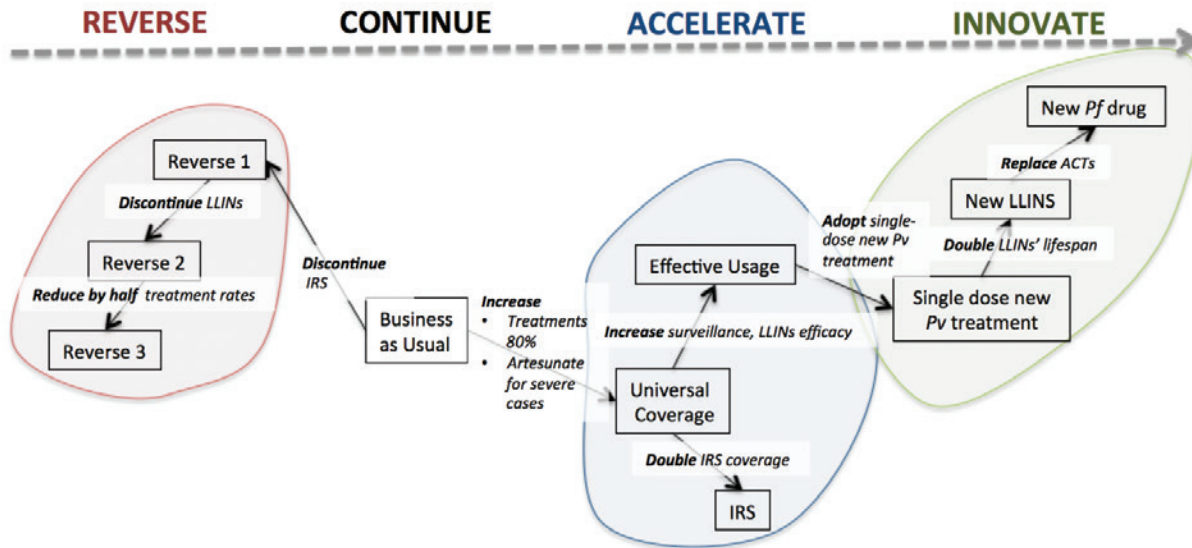
The 10 scenarios were modeled separately using three baselines:

1. Baseline 1: a constant 5% probability of treatment failure to ACTs across all countries and separately for a baseline in which the probability of treatment failure to ACTs increased to 30% by 2025 across all countries
2. Baseline 2: no MDA and separately using five annual rounds of MDA at 50% coverage (of PAR), from 2018, starting four months before the peak of the season

3. Baseline 3: maintaining LLIN coverage at 2015 levels and separately scaling up LLINs to 80% effective coverage deployed in a 3-year cycle (50%, 25% and 25%).

These additional baseline scenarios produced a total of 80 scenarios (with and without resistance, with and without MDA, and with and without LLIN scale up). 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 PAR for all three scenarios, with and without resistance.

Figure A2-1. Visual representation of modeled scenarios



Cost estimation

We built a companion cost estimation model aligned with the outputs of the METCAP to estimate the costs associated with implementing each of the scenarios above. Program costs were modeled to include costs of testing and treatment of uncomplicated and severe malaria, LLINs, IRS, supply chains, service delivery (outpatient and inpatient), surveillance, CHWs, IEC, training, MDA, new treatments and a new radical cure for *P. vivax* (tafenoquine), and new LLINs. Costs for each of these inputs were obtained using a combination of empirical data collected in the country by the MEI, literature reviews and proxies when neither of the previous options was available. The cost inputs for the model are provided in Table A1-1 in Annex 1. The minimum elimination packages were costed under two scenarios:

- Interventions are applied to the entire PAR (low and high risk).
- Interventions are applied focally to a subset of the PAR.

The total cost of the elimination scenario(s) of interest was used to construct the investment case.

Economic benefits estimation

We used outputs from the transmission models that estimated the mortality and morbidity averted and compared the elimination scenario to the counterfactual baseline scenarios: a “business as usual” scenario in which interventions continued at the same coverage levels in 2015 and a “reverse” scenario (scenario 4) in which LLINs and IRS were stopped, and treatment coverage rates were reduced to 50%. The economic benefits estimation was

developed using the full income approach as recommended by the *Lancet Commission on Investing in Health*.⁴³

The economic burden averted in the elimination scenario was categorized based on three broad dimensions: 1) cost to the health system, 2) cost to individual households, and 3) cost to society and estimated using the averted deaths and cases through elimination:

1. Cost averted to the health system: These were the costs averted for diagnosis and treatment costs as inpatients and outpatients;
2. Cost averted to individual households: OOP expenditures for seeking care; and
3. Cost averted to society: Patients lost productivity due to premature death and morbidity and caretaker’s reduced economic output as a result of taking care of patients.

The same inputs used in the cost estimates were used for the economic benefits estimation. Unit costs of case management include outpatient visits, diagnostic tests and drug treatments for uncomplicated malaria cases, hospital hotel costs, and drug treatments for severe malaria cases. OOP expenditures were estimated by applying the country-specific OOP expenditure per capita for each outpatient and inpatient. We calculated productivity loss among patients and caretakers by multiplying an estimate of daily productivity by the number of days lost due to illness or care seeking. The total income approach was used to determine the economic impact of lost productivity due to illness and death. This approach quantifies the value that people place on living longer and healthier lives. The value-of-statistical-life method was used to evaluate

population-level reductions in mortality risk. Specifically, we assumed that the global value of a one-year increase in life expectancy was 2.8 times the GDP per capita for Bangladesh, as recommended by the *Lancet Commission on Investing in Health*. This was applied to the numbers of life years saved through elimination.

Economic benefits were calculated by adding together the cost averted to the health system to the cost averted to individual households and cost averted to society.

Return on investment

To calculate ROI of malaria elimination in 2016-2030, we subtracted the benefits of elimination by the incremental cost of elimination and divided the resulting figure by the incremental cost of elimination. The ROI is interpreted as the economic return from every additional dollar spent on malaria above the counterfactual scenario.

All costs and economic benefits are presented in 2015 USD, and future costs are discounted at 3% to the present.

Uncertainty analysis

We performed stochastic sensitivity analysis on the epidemiological and cost outputs of the 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. A similar sensitivity analysis was conducted over a range of baseline estimated incidence values.

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, 10, 25, 50, 75, 90 and 95

Figure A2-2. Cost sensitivity analysis

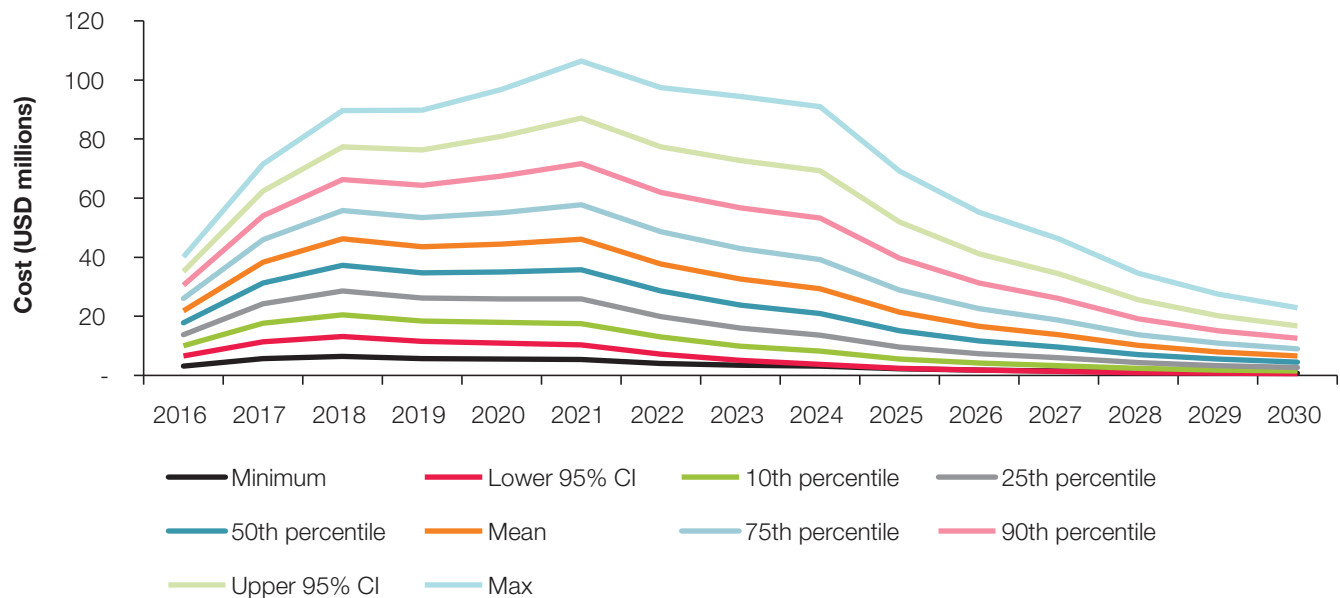
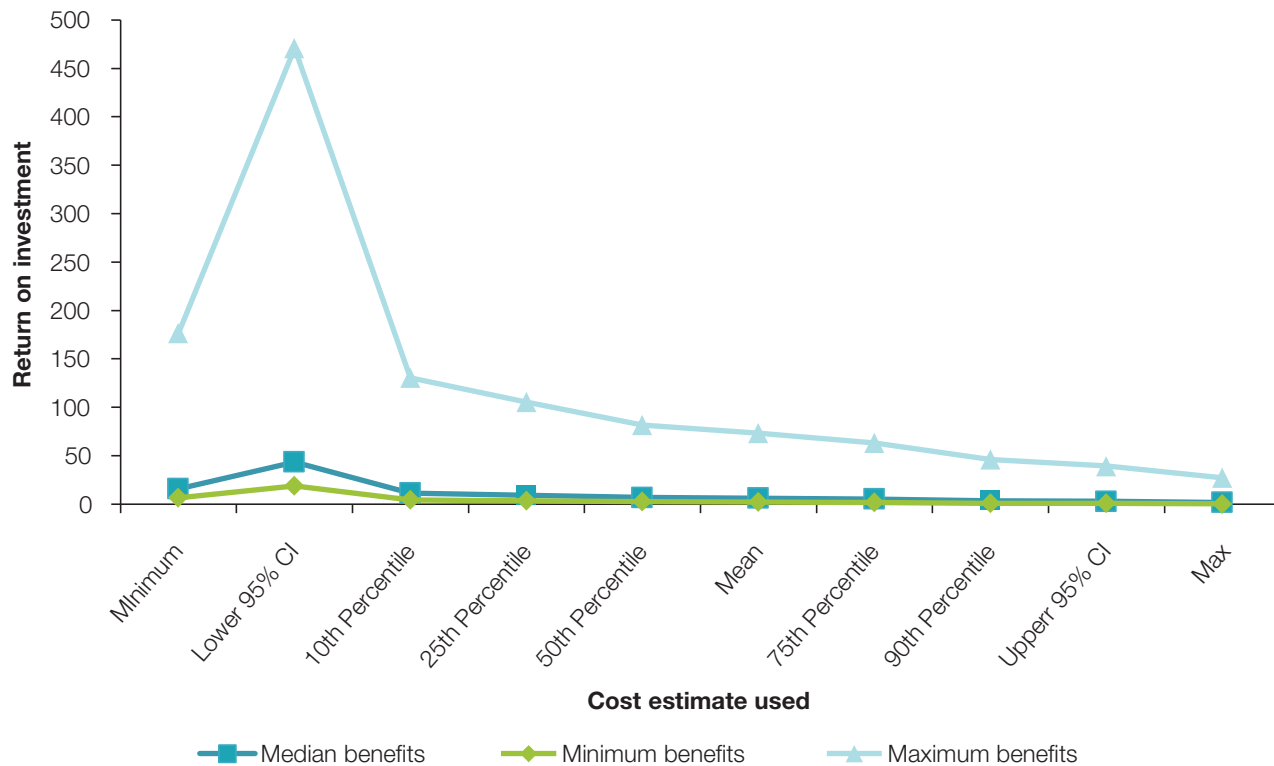


Figure A2-3. Median ROI sensitivity analysis

percentile uncertainty ranges for the minimum, median, and maximum ROI (Figure A2-3).

Limitations

There is considerable uncertainty associated with the estimates. A range of possible incidence estimates was used as input to the model. The model itself was not designed to model individual countries in detail. 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. Furthermore, the cost of new interventions such as new LLINs and a radical cure for *P. vivax* such as tafenoquine are based on historical estimates of the cost of new tools when they were first adopted. For the financial gap analysis, we used projected program costs from the NSP, rather than using the projected costs from the transmission model.



