



Shrinking the Malaria Map

A Guide on
Malaria Elimination
for Policy Makers

Richard G.A. Feachem and
The Malaria Elimination Group

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**By RICHARD G.A. FEACHEM and
THE MALARIA ELIMINATION GROUP**

The Global Health Group
UCSF Global Health Sciences

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PREFACE AND ACKNOWLEDGMENTS

This Guide on Malaria Elimination for Policy Makers is a companion to the *Prospectus on Malaria Elimination*, written by the members of the Malaria Elimination Group (MEG) and published by the Global Health Group at the University of California, San Francisco. Its content owes much to the work of MEG and, particularly, to the authors of the individual chapters of the *Prospectus*. These are Scott Barrett, Suprotik Basu, Colin Boyle, Justin Cohen, Grant Dorsey, William Dyckman, Ali Enayati, Brian Greenwood, Simon Hay, Janet Hemingway, Michelle Hsiang, Dean Jamison, Jim Kahn, Jo Lines, Rajendra Maharaj, George Malefoasi, Patrick Moonasar, Bruno Moonen, Claire Panosian, Allison Phillips, John Reeder, Oliver Sabot, Dennis Shanks, Cara Smith-Gueye, David Smith, Tom Smith, Lori Spivey, George Taleo, Marcel Tanner, Geoffrey Targett, Jim Tulloch, Andrew Vallely, Walther Wernsdorfer, and Shunmay Yeung. All members of MEG have contributed in various ways, and a complete list of MEG membership is found in Annex 1.

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The full *Prospectus* can be found at www.malariaeliminationgroup.org. It will be periodically updated as new information and analyses become available. I wish to thank our collaborators in the elimination countries for their generosity in sharing insights and experiences. The Global Health Group and MEG are conscious of the failure to adequately document the experiences in some of the recent and current eliminators. Elimination case studies are therefore underway, will be posted on the Web site mentioned above, and will lead to additional revisions and improvements to the *Guide* and the *Prospectus*. I encourage all those working on malaria elimination to comment on and contribute to this evolving work.

In conclusion, I thank the Bill and Melinda Gates Foundation, and especially Drs. Regina Rabinovich and David Brandling-Bennett, for so strongly supporting this work on malaria elimination. I am also most grateful to ExxonMobil, and especially Dr. Steven Phillips, for outstanding support for MEG and elimination in southern Africa.

Professor Sir Richard Feachem
Director, The Global Health Group,
UCSF Global Health Sciences and
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San Francisco
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EXECUTIVE SUMMARY

The purpose of this Guide on Malaria Elimination for Policy Makers is to provide guidance and high-level technical insight to leaders in governments that are considering or have embarked upon a national or regional strategy of malaria elimination and to the donors, agencies, and others who support them. This document is a policy digest of the *Prospectus on Malaria Elimination*, published by the Global Health Group at UCSF Global Health Sciences on behalf of the Malaria Elimination Group (MEG) and available at www.malariaeliminationgroup.org.

Today, 108 countries in the world are malaria free. One hundred countries have continuing malaria transmission, and of these, 39 are embarked upon malaria elimination, either nationally or subnationally. It is primarily for these countries, and those who support them, that this document is written. It will also be useful to those of the 61 countries currently engaged in the sustained control of malaria that are considering a switch to a policy of elimination.

This *Guide* first considers the challenging question of whether and when to embark upon malaria elimination. This decision rests on both consideration of costs and benefits and a detailed review of technical, operational, and financial feasibility. For countries that have made an affirmative decision on elimination, the *Guide* then reviews a two-stage process of “getting to zero” and “holding the line.” The first task for countries, which can take a decade or more, is to reduce the local transmission of malaria to zero. Having achieved this, countries must then maintain it; how this can be done and the perils inherent in a failure to maintain adequate financing and programmatic strength are described.

The relationships between malaria elimination and health systems strengthening are spelled out, and the value of engagement with nongovernmental health care providers, and of outsourcing malaria elimination functions, are

described. The essential role of full participation and engagement by communities is stressed. The *Guide* goes on to discuss the importance of regional, multi-country, and cross-border collaborations, without which malaria elimination is scarcely possible for many continental countries. Last, the need to sustain political will and commitment for a long period is emphasized and discussed.

Those readers wishing to have greater detail in any of these areas are encouraged to refer to the full-length *Prospectus*.

THE “E” WORDS

Malaria **Elimination** is:

The interruption of local mosquito-borne malaria transmission in a defined geographical area, creating a zero incidence of locally contracted cases. Imported cases will continue to occur and continued intervention measures are required.

Malaria **Eradication** is:

The permanent reduction to zero of the worldwide incidence of malaria infection.

DEFINITIONS BY THE WORLD HEALTH ORGANIZATION

MALARIA

Malaria is one of the oldest diseases of humankind and has been a leading cause of illness and death over the tens of millennia of human history. It is caused by a single-cell parasite of the genus *Plasmodium* and is transmitted by mosquitoes of the genus *Anopheles*. The parasite has a complex life cycle, in both its human and mosquito hosts.

The Parasite

Humans are mainly infected by four species of *Plasmodium*: *P. falciparum*, *P. vivax*, *P. ovale*, and *P. malariae*. The majority of all human malaria is caused by the first two of these.

P. falciparum is the major cause of malaria in Africa; it also occurs in many other parts of the world, and it is the form of malaria most likely to lead to rapid death, especially in children. *P. vivax* can also cause severe malaria and causes a large number of malaria episodes. It is not found in much of Africa because of a genetic resistance to it among Africans, but it is widespread elsewhere. *P. vivax* causes relapsing malaria. This is due to its ability to remain dormant in the liver for months to years, during which it may cause no illness and be difficult to detect and treat.

The Mosquito

All malaria is transmitted by females of the genus *Anopheles*. These mosquitoes occur throughout the world, with the exception of the Polynesian and Micronesian islands of the Pacific Ocean. Roughly 70 species of *Anopheles* transmit human malaria but, in any given area, only a few are responsible for the majority of malaria transmission.

SETTING THE SCENE

At the end of World War II in 1945, malaria transmission was occurring on every continent (except Antarctica) and in every country, with the only exceptions being Iceland, Lesotho, Mongolia, Norway, Sweden, Switzerland, Uruguay, and the island nations of Micronesia and Polynesia. Malaria transmission occurred as far north as parts of Canada, Finland, and the Soviet Union and as far south as Chile and Australia. Since 1945, exceptional progress has been made in eliminating malaria, country by country, and shrinking the malaria map. By *elimination* we mean stopping transmission in a country or other defined geographical area. The word *eradication* is now used to mean the global end of malaria from all countries, as was achieved with smallpox in 1979.

From 1945 to the present day, countries in the northern hemisphere have progressively pushed the border of malaria southward, and to a more limited extent, countries in the southern hemisphere have pushed the malaria border northward.

Today, 108 countries in the world are malaria free. One hundred countries have continuing malaria transmission, and of these, 39 are embarked on or contemplating malaria elimination, while 61 are focusing on the sustained control of malaria. These countries are shown as green, blue, and red, respectively, in Figure 1 (following page 33).

While there has been very substantial progress in shrinking the malaria map over the last 60 years, the countries that have eliminated transmission from within their borders (the green countries in Figure 1) represent, to some degree, the winning of the easy battles. Eliminating malaria from Australia, Chile, Italy, or the United States, for example, was an easier task than today's challenge of elimination in the countries shown in blue in Figure 1, and a

much easier task than the eventual struggle to eliminate in the malaria heartland, represented in red in Figure 1. Despite these challenges, further progress in malaria elimination and in shrinking the malaria map is being made and must continue to be made. The 39 eliminating countries, shown in blue in Figure 1, have set, or are considering, the objective of freeing themselves of malaria within the next decade or two. They are all countries in which this is a plausible, although in some cases an ambitious, goal.

The Three-Part Strategy

On October 17, 2007, Bill and Melinda Gates, at a major malaria meeting in Seattle, announced the goal of eventual eradication of human malaria from the planet. This is an ambitious and long-term goal, but an achievable one. No one can say for sure when the task will be completed, but many experts believe that 2050 or 2060 is a reasonable time frame. New drugs, diagnostics, vaccines, and other tools, together with widespread political stability, will be essential for eradication to be finally achieved.

Much work has gone into elaborating the strategy for rapid progress on malaria control and elimination in the short term and the eventual achievement of global malaria eradication. This strategy was articulated in the recent Roll Back Malaria Global Malaria Action Plan, which was launched in September 2008. From this Action Plan, and the work of the Malaria Elimination Group (MEG), there has emerged a three-part strategy to progressively reduce the burden of malaria, leading eventually to global eradication. This strategy is summarized below:

- 1. aggressive control in the malaria heartland, to achieve low transmission and mortality in those tropical countries currently experiencing the highest burden of disease and death**
- 2. progressive elimination from the endemic margins, to shrink the malaria map**
- 3. research, to bring forward a vaccine and better drugs, diagnostics, insecticides, and other tools**

The three parts of this strategy must proceed simultaneously. Part 1 of the strategy focuses on the need for greatly strengthened and expanded malaria control programs in the malaria heartland countries, where the majority of deaths and disease from malaria occur and where the burden on the population and the economy is greatest. Investment in this expanded effort has increased

greatly since the creation of the Global Fund to Fight AIDS, Tuberculosis and Malaria, in 2002, and other multilateral, bilateral, and private initiatives to combat malaria. It is the part of the overall strategy receiving the most investment and attention, and rightly so. It is from this strengthened counterattack against malaria in its heartland, especially in Africa, that the biggest benefits in reduced death and suffering will be achieved.

Part 2 of the strategy is an essential complement to Part 1. It continues the historic process of progressively shrinking the malaria map. It reduces the number of countries that have to invest in fully developed malaria control programs. It decreases global incidence and brings hope and opportunity to the countries in the malaria heartland, ensuring that they also will eventually eliminate malaria from within their borders.

Part 3 of the strategy, strongly supported by the Bill and Melinda Gates Foundation and by many other government and private research funders, is bringing forward new and improved tools to fight malaria. Malaria is a disease against which we can make much progress with today's tools, but we also need to continually develop improved tools and techniques and to use them wisely and widely. For example, resistance by the malaria parasite to today's drugs will eventually develop, and new generations of drugs will be required. The same is true for mosquitoes and the insecticides that we use against them. Vaccines against malaria are under development, and over the next decades, we will see the mobilization of several generations of vaccines of different kinds. There are many other examples of priority research and development topics that are being pursued to strengthen the armory of weapons that we can utilize in the fight against malaria.

In the journey to malaria elimination, the green countries (Figure 1) used yesterday's tools yesterday, the blue countries are using today's tools today, and the red countries will use tomorrow's tools tomorrow.

The three parts of the strategy are intimately interlinked. Success in Part 1 is necessary to reduce importation of malaria into eliminating countries and thus facilitate Part 2. Success in Part 2 brings the border of malaria transmission to an increasing number of Part 1 countries and allows them to aspire to elimination. Success in Part 3 provides the essential new technologies and approaches that will assist Parts 1 and 2 and makes the eventual goal of eradication attainable. Although MEG fully supports all three parts of the strategy, this *Guide* and the *Prospectus* focus particularly on the relatively neglected Part 2.

The Guide for Policy Makers

This *Guide* is a companion to a longer document entitled *Shrinking the Malaria Map: A Prospectus on Malaria Elimination*, available in print and online at www.malariaeliminationgroup.org. It is intended for leaders and policy makers in the public and private sectors and, particularly, for those who are contemplating investment in malaria elimination and are struggling with the questions of if, when, and how a particular country should embark on this ambitious goal. This *Guide* is not intended to provide much technical detail nor references to relevant literature (although Annex 2 lists selected readings and sources). Supporting information of these kinds can be found in the *Prospectus*.

A country that waits too long before embarking on elimination may miss an important opportunity to bring greater benefits to its population and its economy and to reduce the overall levels of investment in malaria control. A country that embarks on malaria elimination prematurely, especially one surrounded by highly endemic countries from which malaria will be constantly imported, risks wasting time and money on an unachievable goal or a goal that, even if achieved, might be quickly lost.

The history of malaria elimination is replete with examples, not only of countries that were successful (the green countries in Figure 1), but also of countries that came close but then suffered huge malaria resurgence. Ethiopia, India, Madagascar, and Sri Lanka are archetypal examples of this type of setback. Getting the decision on elimination right is a key task for policy makers and their technical advisers and is a subject on which this document provides substantial guidance.

Understanding Elimination

Malaria elimination means reducing malaria transmission to zero in a defined geographical area. Typically, the defined geographical area is a country, although regional, multi-country strategies will sometimes offer a greater chance of success.

The geographical unit used in this *Guide* to describe the current state of malaria elimination in the world is the country (Figure 1). It is countries that typically embark on malaria elimination goals, and it is countries that are eventually certified by the World Health Organization as malaria free. However, there are important subnational and supranational components to malaria elimination.

Countries can choose to pursue malaria elimination in certain areas while

preparing a nationwide effort to eliminate. For example, the island nation of Vanuatu has embarked on elimination on the three malarious islands in the province of Tafea before expanding its elimination efforts to other islands and provinces. Large countries, such as China, India, and Indonesia, have chosen to focus initially on malaria elimination in certain states and provinces before launching a nationwide elimination effort. Similarly, countries such as Madagascar have chosen to demarcate a certain ecological zone, such as an arid area or an area of higher altitude, for initial malaria elimination efforts before tackling the lower and more humid areas of the country, where elimination will undoubtedly prove more difficult.

Supranational and regional malaria elimination efforts are also important.

Continental countries will find malaria elimination impossible without strong and effective collaboration with their neighbors, especially in the border areas.

Well-coordinated multi-country approaches, with strong cross-border collaboration, are therefore essential. An outstanding example of this is the collaborative efforts of Botswana, Namibia, South Africa, and Swaziland, under the leadership of the Southern African Development Community (SADC), to eliminate malaria together from their subregion by 2015. These four southern African countries will find the task easier together than they would individually. Having eliminated malaria, they then can focus on the challenges of malaria importation across their northern borders, since their western, eastern, and southern borders will be protected by malaria-free neighbors or the sea. Similarly, both Koreas must work together if malaria is to be re-eliminated from their border areas.

Eradication refers to the eventual ending of human malaria infection on the planet. When this is achieved, malaria control programs can be ended and continuing investments and efforts by individual countries will not be necessary. By contrast, once a single country has eliminated malaria, it must continue to be vigilant and active in order to accomplish the following:

- **reduce the number of malaria-infected individuals that cross its borders**
- **identify and treat them as quickly as possible**
- **promptly control any outbreaks that the imported cases may cause**

This continued vigilance is essential to preserve elimination and is practiced on a daily basis in Australia, Italy, Singapore, the United States, and other green countries shown in Figure 1.

Malaria elimination is achieved by eliminating the malaria parasite from the human population, not eliminating the mosquito vector. This is a common misunderstanding.

To achieve elimination, strenuous vector control interventions must be implemented in order to greatly reduce the level of transmission. However, the endgame is the elimination of the parasite from the human population. Malaria-free countries still have active populations of the vector *Anopheles* mosquitoes, which still bite people, especially in the warm time of the year. This causes minor irritation but no malaria, because there is no malaria parasite in the human population for the mosquito to transmit.

All post-elimination countries face a steady trickle of imported malaria cases, which they must identify and treat. Occasionally, these imported cases give rise to local outbreaks, precisely because the vector mosquito is still present. These outbreaks occur occasionally in the United States and commonly across many other malaria-free countries shown in Figure 1, especially those that border blue or red countries. Countries must therefore maintain the ability to rapidly identify and control these outbreaks to ensure that endemic malaria is not reestablished and that large numbers of cases and deaths do not occur. Outbreak risk, or receptivity, is a key determinant of whether a country is ready for elimination and how easy it will be to maintain elimination if achieved.

The Elimination Countries

The 39 elimination countries, shown in blue in Figure 1 and listed in Table 1, are from a combination of three categories:

1. countries that have formally declared a national elimination goal and have embarked upon malaria elimination from within their borders
2. countries that are seriously considering a national elimination goal and that have already made significant progress in eliminating malaria in some areas and in greatly reducing malaria nationwide
3. countries that, although they have not yet announced or seriously contemplated national elimination, are nonetheless making steady progress in spatially progressive elimination, for example, by eliminating from certain islands, provinces, or geographic areas

These three categories are combined into the “elimination countries” because, in practical terms, the differences between them are not significant.

For example, China is yet to formally declare a national malaria elimination goal, but it has announced an elimination plan for Hainan Island and successfully eliminated malaria in hundreds of mainland counties. From these successes and goals, it is clear that China is heading toward nationwide malaria elimination.

The elimination countries, so defined, share three important characteristics. First, all of them lie at the margins of the malaria-endemic zone. For example, Algeria, China, and Mexico lie at the northern margin for Africa, Asia, and the Americas, respectively. Similarly, Argentina, South Africa, and Vanuatu lie at the most southerly margins of endemic malaria transmission today. Second, the elimination countries already have significant areas within their borders that are malaria free. These malaria-free areas are a combination of areas that never had malaria, typically because they are too high or too dry, and areas where malaria has already been eliminated. Third, malaria transmission in the elimination countries has typically already been greatly reduced, and the incidence of cases and deaths is low. These three properties, for obvious reasons, make the task of malaria elimination considerably easier.

By contrast, the red countries in Figure 1 are typically surrounded by other malaria-endemic countries, have malaria widely distributed within their borders, have yet to create any significant malaria-free zones, and have remaining areas of high-level transmission. Some of these countries are talking about elimination but have not been included among the 39 elimination countries (Table 1) because elimination for them is almost certainly premature. However, at the margin, these are matters of judgment, and these judgments will change through time. Today's control countries (red) will become tomorrow's elimination countries (blue).

The 39 malaria elimination countries range in size from small island nations with populations of only a few hundred thousand people to large countries with populations of up to 1.3 billion (Table 1). It is generally true that small countries will find malaria elimination easier than large countries, although this will not be the case where the small countries are also poor. Concerning poverty, the data on gross national income (GNI) per capita show that 28 of the 39 elimination countries are middle-income or high-income countries (GNIs above \$936 per capita per year). However, there are 11 low-income countries in the list of elimination countries, and for obvious reasons, they will find the task of elimination much more challenging than more-wealthy countries on the list. It is probably the case that none of today's malaria-free countries (the green countries in Figure 1) were low-income at the time they eliminated. However, with today's technology and adequate external financial assistance,

TABLE 1 | Demographic, economic, health, and aid characteristics of the 39 elimination countries¹

Country	Population (millions)	Life expectancy at birth (years)	GNI per capita (U.S. \$) ²	Health expenditure per capita (U.S. \$) ²	Private health expenditure (% of total health expenditure)	GFATM ³ R9 malaria eligibility (Y/N)	PMI ⁴ selected (Y/N)	World Bank IDA ⁵ eligible (Y/N)
LOW-INCOME ECONOMIES								
Comoros	0.6	65	650	14	47	Y	N	Y
Haiti	9.6	61	420	28	69	Y	N	Y
Korea (North)	23.7	66	—	14	14	Y	N	N
Kyrgyz Republic	5.2	66	450	29	60	Y	N	Y
Madagascar	19.7	59	290	9	38	Y	Y	Y
Sao Tome and Principe	0.2	61	800	49	15	Y	Y ⁶	Y
Solomon Islands	0.5	67	630	28	8	Y	N	Y
Tajikistan	6.7	64	330	18	77	Y	N	Y
Uzbekistan	26.9	68	530	26	52	Y	N	Y
Yemen	22.4	61	650	39	58	Y	N	Y
Zanzibar ⁷	1.0	43	340	17 ⁸	43 ⁸	Y	Y	Y
LOWER-MIDDLE-INCOME ECONOMIES								
Algeria	33.9	71	2,720	108	25	Y	N	N
Armenia	3.0	69	1,470	88	67	Y	N	Y
Azerbaijan	8.6	64	1,260	62	75	Y	N	Y
Bhutan	0.7	64	1,270	52	29	Y	N	Y
Cape Verde	0.5	70	1,980	114	18	Y	N	Y
China	1,320.0	73	1,740	81	61	Y	N	N
Dominican Republic	9.8	70	2,310	197	67	Y	N	N
Egypt	75.5	68	1,270	78	62	Y	N	N
El Salvador	6.9	71	2,530	177	53	Y	N	N
Georgia	4.4	70	1,300	123	80	Y	N	Y
Iran	71.0	71	2,580	212	44	Y	N	N
Iraq	28.5	56	—	—	26	Y	N	N
Namibia	2.1	61	2,950	165	35	Y	N	N
Paraguay	6.1	75	1,230	92	64	Y	N	N
Philippines	87.9	68	1,270	37	63	Y	N	N

TABLE 1 | (continued)

Country	Population (millions)	Life expectancy at birth (years)	GNI per capita (U.S. \$) ²	Health expenditure per capita (U.S. \$) ²	Private health expenditure (% of total health expenditure)	GFATM ³ R9 malaria eligibility (Y/N)	PMI ⁴ selected (Y/N)	World Bank IDA ⁵ eligible (Y/N)
Sri Lanka	19.9	72	1,170	51	54	Y	N	Y
Swaziland	1.1	42	2,210	146	36	Y	N	N
Turkmenistan	5.0	63	1,234	156	33	Y	N	N
Vanuatu	0.2	69	1,580	67	35	Y	N	Y
UPPER-MIDDLE-INCOME ECONOMIES								
Argentina	39.5	75	4,460	484	56	N	N	N
Botswana	1.9	52	5,320	362	36	N	N	N
Costa Rica	4.5	78	4,660	327	24	N	N	N
Malaysia	26.5	72	5,070	222	55	N	N	N
Mexico	105.3	74	7,300	474	54	N	N	N
South Africa	47.6	51	4,810	437	58	N	N	N
Turkey	73.9	73	4,750	383	29	N	N	N
HIGH-INCOME ECONOMIES								
Korea (South)	48.0	79	15,880	973	47	N	N	N
Saudi Arabia	24.2	70	12,540	448	24	N	N	N
Total countries	39							
Total population	2,173,020,000							

1. All data are from standard Web sources provided by the World Bank; World Health Organization; British Broadcasting Corporation; Central Intelligence Agency; the Global Fund to Fight AIDS, Tuberculosis and Malaria; and the Government of Tanzania. Data are from the most recent year available, mostly 2005-2008.
2. Atlas method (U.S. dollars): The Atlas Conversion Factor is used by the World Bank in order to facilitate cross-country comparisons of national income and health expenditure. The method uses the 3-year average of the local currency exchange rate to U.S. dollars, adjusting for inflation.
3. GFATM is the Global Fund to Fight AIDS, Tuberculosis and Malaria. R9 refers to applicant eligibility for Round 9 in 2009.
4. PMI is the President's Malaria Initiative of the U.S. Government.
5. World Bank IDA is the International Development Association.
6. Sao Tome and Principe is not among the PMI 15 focus countries but is receiving support from from the governments of Brazil and the USA for its elimination program.
7. Throughout this document we treat Zanzibar as if it were a country, because its malaria situation and intentions are different from those of mainland Tanzania.
8. These data include both Tanzania and Zanzibar.

the 11 low-income countries have a real opportunity to achieve their elimination goals, with consequent benefits to their people and economies.

In terms of the overall health of the populations of the elimination countries, life expectancy at birth, shown in Table 1, provides a good single indicator. Life expectancy among elimination countries spans a huge range, from 42 to 79 years. The countries with the lowest life expectancies are those with high child mortality, weak health infrastructure, and/or high rates of HIV/AIDS. This reality reveals the tough decisions that countries must make concerning priorities and resource allocation.

An important financial issue for a country embarking on elimination is whether it is eligible for grants from the Global Fund to Fight AIDS, Tuberculosis, and Malaria; the President's Malaria Initiative (PMI) of the United States; or the International Development Association (IDA) window of the World Bank. Global Fund eligibility is dependent on GNI per capita. Table 1 shows that 30 of the elimination countries are Global Fund eligible and 9 are not. The ones that are not are upper-middle-income countries or high-income countries and therefore should not have too much difficulty in financing malaria elimination from their domestic resources. Only Madagascar, Sao Tome and Principe, and Zanzibar are receiving support from the PMI, a program that focuses on malaria control in the heartland and covers 15 of the red countries in Africa (see Table 1). IDA eligibility is, with some exceptions for very small countries, based on GNI per capita. Table 1 shows that 17 of 39 elimination countries are IDA eligible and therefore are receiving, or can receive, highly concessionary loans for malaria elimination.

Another key variable in relation to financing elimination efforts is the current total health expenditure per capita per year. If this is small, malaria elimination can consume a significant (and possibly unjustifiable) proportion of all funds available to health. If the number is large, malaria elimination may be financed without significant distortion of other health priorities or of the health sector as a whole. We see from Table 1 that total health expenditures per capita per year vary from \$9 to \$973. Typically, the low-income countries are spending less and will be substantially dependent on Global Fund and other external support to fully finance elimination and to maintain elimination, having achieved it.

Private health care expenditures are typically outside the control of government. Where these expenditures are a significant proportion of the total, governments may struggle to ensure that the activities of privately financed and provided health care are fully aligned with national goals and policies. The proportion of all health care expenditure that is private (typically paid for

out of pocket) in elimination countries ranges from a low of 8% to a high of 80%. Typically, the poor—who also suffer most from malaria—are heavy users of private health care and commonly pay from their own meager resources. Of the 39 elimination countries, 19 have private health care expenditures that are more than 50% of the total. In these countries, especially, a very active engagement with the private health care sector will be essential.

The total population of the elimination countries is 2.2 billion (or 0.9 billion excluding China); they are found in every region and continent, and collectively, they comprise over one-third of all the current malaria-endemic countries and over half of all people at risk from malaria globally. Achieving elimination in these countries, and turning the color blue to green in Figure 1, will be a very significant and historic stride toward eventual eradication of malaria from planet Earth.

The Continuum from Control to Elimination

Malaria elimination is the endpoint of a journey. This journey starts with Scaling Up for Impact (SUFU). This is the process in which many of the red countries in Figure 1 are currently engaged. Under SUFI, the scale and intensity of the key malaria control interventions is taken from low and patchy to high and countrywide. As a result of this, malaria illness and death fall rapidly, and the burden of malaria on health services is greatly reduced. SUFI is followed by sustained control, in which interventions are further refined and strengthened, the malaria death rate may be reduced to an extremely low level, and the incidence of malaria cases continues to fall and becomes increasingly localized. It is from this platform that countries will choose to launch malaria elimination in order to reduce local transmission to zero.

Some countries are finding that the transition from SUFI to sustained control is challenging, partly because success with SUFI creates an environment where malaria is no longer a major public health problem and the incentive to maintain political commitment and financial allocation is diminished. In these countries, it may be that the eventual pathway to elimination becomes the motivating force for adequate effort and investment in sustained control. Sustained control can then be seen, not as an endless and somewhat unrewarding task, but rather as a stepping-stone to malaria freedom with its obvious advantages. Clearly, such an approach needs to be balanced by frank recognition that, following elimination, continuing investments will be required to prevent reintroduction until malaria is eventually eradicated from the planet.

EMBRACING ELIMINATION

A country that decides to embark on malaria elimination is making a big and bold policy decision with implications that will stretch for decades. The challenge of malaria elimination for many countries is that it requires them to continue to take very seriously a disease that is no longer very serious.

Elimination countries are, almost by definition, ones in which malaria is no longer one of the foremost health challenges. It does not exist in certain areas of the country. It has already been eliminated from certain other areas, and typically, in areas where endemic transmission still occurs, it is not a leading cause of morbidity and mortality. Of the 39 elimination countries shown in Table 1, the only major exceptions to these generalizations are Madagascar, Sao Tome and Principe, the Solomon Islands, Vanuatu, and Zanzibar.

In considering elimination, it is important to be clear about the alternative. The alternative, which economists call the counterfactual, is not doing nothing about malaria but, rather, continuing to mobilize and deliver the national malaria control program, possibly for a very, very long time. The analysis and policy decision on whether to eliminate rests on contrasts and comparisons between the attractiveness of elimination and the attractiveness of sustained control.

Formally, the decision to eliminate derives from the answers to two questions:

- Do the benefits to the people and economy of our country exceed the costs?
- If so, is elimination feasible, given our epidemiologic, socioeconomic, and geographic circumstances?

MEG recommends that a rigorous elimination feasibility assessment be conducted before a country embarks on elimination. The great majority of the green and blue countries in Figure 1 never conducted an assessment of this kind. Rather, and reasonably, they embarked on elimination based on a judgment that it was possible and a political sense that it was worth doing. This is how most big decisions in life and the history of human affairs are made, and there is nothing fundamentally strange or wrong about this approach. However, as the frontier of elimination now moves to countries and areas where malaria elimination will prove more difficult, the value of pausing to conduct a formal and rigorous feasibility assessment has increased.

Zanzibar leads the way in this new approach. A formal study, assessing the technical, operational, and financial feasibility of elimination, was completed in April 2009, with assistance from MEG. We will be publicizing and disseminating this feasibility assessment as a model that can be modified and used by other countries that are contemplating subnational, national, or regional elimination goals.

Do the Benefits Outweigh the Costs?

The benefits of malaria elimination are a national public good, a regional public good, and a global public good. In other words, the benefits of elimination in a particular country accrue not only to the people and economy of that country but also to neighboring peoples and countries and, more broadly, to the world at large.

In considering costs and benefits, most countries will choose to focus inward on the costs and benefits to them. However, some consideration of regional benefits, which should be regionally financed, and global benefits, which should be financed by international donors, is appropriate.

The key potential national benefits from elimination are likely to be these:

- the reduction in malaria morbidity and mortality to zero, except for imported cases
- the associated savings to the health sector
- the associated increases in school attendance, educational attainment, and productivity
- a better climate for foreign direct investment
- increased tourism

- national satisfaction, and morale raising in the health sector, resulting from a historic achievement and the elimination of a major infectious disease
- long-term cost reductions as the malaria elimination program changes to the maintenance of malaria freedom rather than the ongoing control of malaria

Costs and benefits of elimination must be considered in comparison with the counterfactual, namely sustained control. Thus, in considering the benefits, one cannot include all those benefits that would result from taking a tropical country from high-level endemic malaria to no malaria. The benefits considered should be only those that arise from moving from low-level malaria, resulting from a sustained control program, to no malaria. Similarly, the costs to be considered are the incremental costs of achieving and maintaining elimination, as compared with sustained control.

Generalizations about these topics have limited value. Each country has very particular and different circumstances, which need to be analyzed and considered in detail. For example, tourism is an important benefit for some countries. Botswana has a great deal of tourism, and the tourists want to visit the parts of the country where malaria transmission is currently the highest. Vanuatu is developing its tourist industry and is in competition with malaria-free Fiji and Polynesian destinations. Some elimination countries have little potential for tourism, and so this benefit is not significant for them.

The simplest form of analysis looks at cost over the long term. As a country achieves elimination and then moves to a set of post-elimination interventions to prevent reintroduction, will there be an overall cost saving in the long term, compared with the alternative of maintaining sustained control? This is a question that is easily answered, although it seldom has been. Elimination will typically increase costs in the short run (5 to 10 years, say) but may be cost-reducing compared with sustained control over 20 to 25 years. If so, there is clearly a strong case for embarking upon elimination as an investment now to realize costs savings later. Locally specific circumstances determine just how attractive such an investment may be, but several analyses undertaken for MEG suggest the possibility of rates of return up to 10%. In such cases, expanding the analysis to include other benefits is not strictly necessary, although it will provide a stronger case to make the argument for elimination in political circles and through the media.

If, on the other hand, elimination costs are similar to, or greater than, those of sustained control over the next few decades, it is worth first pausing to factor

in regional and global benefits from elimination. This will be especially relevant if regional and/or global sources of financing are available to help meet the costs of the elimination effort. In practice, however, these broader arguments may fail to convince national politicians and decision makers, and it will be essential to identify and quantify the full range of incremental benefits to the country from elimination, and to compare these with the incremental costs.

I Malaria elimination will be a strong equity-enhancing policy.

A further dimension of the benefits from elimination as distinct from sustained control is the boost that elimination will give to equity. Most health programs, including most malaria control programs, reach the less poor before they reach the very poor, remote, and marginalized population groups. By definition, an elimination program must reach everybody equally. Indeed, in the last stages of elimination, the program will be focused on the very poor, remote, and marginalized people because it is they who will suffer from the residual malaria transmission and lack access to medical services. This will always be true for the elimination or eradication of poverty-related diseases, as it was for smallpox.

Feasibility

Even if elimination is good to do because the benefits exceed the costs, is it possible? There are three major dimensions of feasibility: technical, operational, and financial. All of these need detailed consideration.

TECHNICAL FEASIBILITY

We define technical feasibility as the probability that malaria transmission can be reduced to zero within a decade in a given area using currently available tools and that zero transmission can be maintained in that area once elimination has been achieved.

Technical feasibility considers the epidemiological circumstances, and especially the intensity of current transmission, together with the frequency of imported infections and the risk of outbreaks resulting from them. These matters are assessed in relation to current tools and current circumstances in neighboring countries. In places where malaria elimination is not feasible today, it may become feasible in the future when new tools are developed and socioeconomic and regional circumstances are improved.

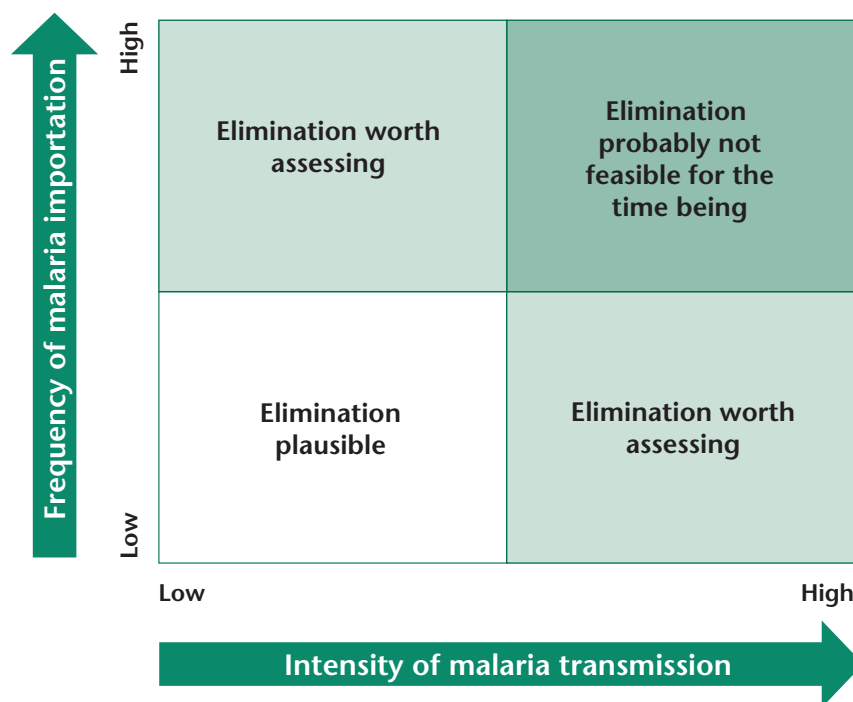


FIGURE 2 | Some factors determining technical feasibility

Mathematical modeling is becoming an increasingly useful tool in judging technical feasibility. Previously it has been recommended that elimination only becomes technically feasible when specific epidemiological milestones are met—for example, a slide positivity rate (SPR) of less than 5%. Modeling allows a more sophisticated and multivariate approach to technical feasibility. In the case of Zanzibar, for example, modeling shows that elimination may be possible within 6 to 10 years, even though the current SPR exceeds 5%.

Figure 2 shows a simple matrix for considering the technical feasibility of elimination. If the current intensity of transmission is low and the risk of importation is also low, as in Sri Lanka, elimination is clearly more feasible. When both are high, as in Ghana or Nigeria today, elimination is better deferred to a later time when malaria has been further reduced and when significant progress with elimination has been achieved by neighboring countries. If transmission is high but importation is low, as in the Solomon Islands, elimination may be a feasible goal, and a big effort to eliminate could be sustained. If the opposite is the case, low transmission but high rates of importation, as in Bhutan, then elimination will require ongoing aggressive transmission control, as in the areas of Bhutan bordering India, and a surveillance system able to detect and treat imported cases.

Generally speaking, the elimination of *P. vivax* malaria will prove more technically challenging than the elimination of *P. falciparum* malaria, as discussed below in the section Killing the Parasite. However, it is encouraging that all the green countries in Figure 1 were primarily or exclusively experiencing *P. vivax* malaria at the time they eliminated.

The next few years will see much greater sophistication in the analysis and measurement of technical feasibility, to the benefit of countries that are debating the transition from control to elimination. The feasibility of malaria elimination rests on its technical feasibility. If the assessment concludes that, technically, it is unlikely that malaria can be eliminated, further evaluations of operational or financial feasibility become unnecessary.

OPERATIONAL FEASIBILITY

We define operational feasibility as the existence of, or ability to create, the capacity to effectively implement all the activities needed to achieve and maintain elimination. Two questions must be posed:

- **What activities are essential, and for how long, to achieve and maintain elimination?**
- **Can these activities be effectively implemented in the local context?**

Operational feasibility is extremely context dependent, but the following operational requirements can be considered universal components for any malaria elimination program:

- a health system that is capable of the timely diagnosis and treatment of nearly all malaria cases
- the ability to ensure an ongoing high level of coverage with bed nets, indoor residual spraying, and other locally appropriate vector control interventions
- the capacity to implement an excellent surveillance and response system, to design and run an effective communications program, and to establish a monitoring and evaluation (M&E) system to reliably measure malaria elimination targets
- an enabling environment with political stability, strong political buy-in and support from the highest level, a legal framework adapted to the operational needs of elimination, good collaboration between different sectors of government, strong community participation, and excellent cross-border collaboration with stable neighboring states

There are no black-and-white answers to these questions. Judgment is required. In addition, it is not necessary that all the capacity to support operational feasibility be in place on the first day of the elimination program. Elimination can take a decade or more, and the strengthening of the capacities to ensure that it is successfully completed and maintained can be a goal of the elimination program itself and, more broadly, of the health system.

A benefit of an unambiguous and unrelenting commitment to elimination is that it will cause aspects of the health system, such as surveillance, M&E, and reference laboratory facilities, to be greatly strengthened, to the benefit of the health system as a whole.

Two enemies of operational feasibility are natural disasters and conflicts. Given a strong response by national and international agencies, the disruption to malaria elimination caused by natural disasters should be short-lived. Conflicts, however, have the potential to radically disrupt the progress toward malaria elimination and seriously threaten the maintenance of elimination once achieved. A number of the elimination countries (e.g., Iraq, the Philippines, and Sri Lanka) are experiencing local or widespread conflict, which is slowing their progress toward elimination. Other countries (such as some former Soviet republics and the Solomon Islands) have recently emerged from conflicts that have set back their malaria control and elimination programs. Conflicts in neighboring countries, resulting in a breakdown of cross-border collaboration and an influx of refugees, will also undermine elimination efforts. The negative effect of instability in Zimbabwe on malaria elimination in Botswana and South Africa is a current example.

In the final analysis, the operational feasibility of malaria elimination rests on strong management, effective community participation, and excellent cross-border collaboration.

FINANCIAL FEASIBILITY

A long-term financing base for achieving elimination and sustaining it is absolutely critical. If elimination programs crumble because their financial support is no longer available, malaria will resurge and the investments and efforts of the past will be quickly lost.

Financial feasibility in a particular country rests on the answers to three questions:

- How much will it cost to achieve elimination (getting to zero) and to sustain it (holding the line)?
- Can these funds be found on a long-term and reliable basis from domestic and international sources?
- If the funds are available, is it reasonable to use them for this purpose, given other demands on health sector expenditure?

How much does malaria elimination cost? Historical estimates from the Global Malaria Eradication Program in the 1950s and 1960s suggest costs ranging between \$0.50 and \$2.00 per person per year, or \$3 to \$13 per person per year in today's dollars. More reliable and up-to-date are the estimated costs for elimination in countries or regions that are currently embarked on elimination and have made detailed Global Fund proposals to support their costs. Six such estimates are available:

- For **Hainan Island, China**, the annual costs of elimination are estimated to be \$0.25 per person for the whole population of Hainan, and \$2 per person at risk.
- For **Sao Tome and Principe**, the annual costs of elimination are estimated to be \$11 per person.
- For the **Solomon Islands** and for **Vanuatu**, the annual costs of elimination are estimated to be \$18 and \$25 per person, respectively.
- For **Sri Lanka**, the annual costs of elimination are estimated to be \$1 per person for all Sri Lankans, and \$5 per Sri Lankan at risk.
- For **Swaziland**, the annual costs of elimination are estimated to be \$3 per person for all Swazis, and \$7 per person at risk.

An important caveat about these cost data is that they relate to the costs of achieving elimination, rather than the costs of maintaining it once achieved. We know very little about the latter topic, and the collection of better cost data, both pre-elimination and post-elimination, is a high priority for operational research.

Caution is needed in interpreting elimination cost differences among countries, because the different costing exercises do not all include the same activities. For example, the costs for the Solomon Islands and Vanuatu include both significant support for the malaria component of the routine health services, and for external management and technical assistance provided by the Pacific

Malaria Initiative Support Centre in Brisbane. The costs for Swaziland, by contrast, include neither routine health service contributions to malaria elimination nor technical support from partner organizations.

Costs also vary widely depending on local circumstances. The high costs in the Solomon Islands and Vanuatu are linked to the logistic challenges of providing sustained services to small populations on remote islands. Cost structures, particularly in the labor markets, in the different economies will also have a large effect on elimination costs.

These elimination costs also vary greatly as a proportion of total health sector expenditure, from a high of 20% in Vanuatu to a low of 0.1% in Hainan. Finally, the reliance on international rather than domestic sources to fund elimination will also vary greatly in relation to the costs and to the overall GNI of the country concerned. External financing from Australia and the Global Fund is paying for about 90% of the elimination programs in the Solomon Islands and Vanuatu. In Swaziland, the elimination program is financed by the Swaziland Government (14%) and the Global Fund (86%). In Sri Lanka and Hainan, external financing from the Global Fund will cover 45% and 22% of elimination costs, respectively.

For the nine upper-middle-income and high-income elimination countries (Table 1), achieving and sustaining elimination should be possible entirely from domestic resources, and there should be no need for international investment. The costs of malaria elimination are small relative to many other tasks that the health sectors in those countries have successfully taken on. It is not a question of the availability of money; it is a question of investment choices and political will. If these governments wish to finance malaria elimination, they are able to do so.

For the lower-middle-income countries, and especially for the low-income countries, international financing will be required and will need to be maintained and sustained over decades. This is a challenge.

Donor financing for the health sector and for other development priorities is notoriously unpredictable and volatile. Even the Global Fund, with its large resources, focused commitment to malaria, a steady and rising flow of investment, and no overall volatility, may decline to support a particular application. A country close to elimination that applies to the Global Fund to finance the final stages risks losing everything if its application is rejected. A country that has achieved elimination and looks to the Global Fund for financial support to maintain malaria-free status is in uncharted waters.

Although Azerbaijan, Georgia, Kyrgyzstan, the Solomon Islands, Sri Lanka,

Swaziland, Tajikistan, Uzbekistan, and Vanuatu already successfully applied to the Global Fund to finance malaria elimination, only Kazakhstan applied to sustain it and was rejected. Maintenance of elimination in this country will, of course, be essential to the elimination goals of its southern neighbors. The Global Fund has no stated policies on this subject, and the same is true, to our knowledge, for other multilateral and bilateral sources of financial support for malaria control and elimination. This is a matter requiring urgent attention. The Global Fund, the World Bank, and the major bilaterals should consider whether they are willing to finance the maintenance of malaria elimination.

In the context of the 30 eliminating countries that are Global Fund eligible, the Global Fund's willingness to finance the maintenance of freedom from malaria is a critical issue.

A number of broader considerations should be factored into discussions concerning bilateral and multilateral financial support for achieving and sustaining elimination:

- The consequences of achieving elimination or a high degree of control and then losing it are particularly grave with regard to mortality. A population growing up or living in a malaria-free zone lacks or will lose immunity. Such a population can suffer high mortality rates if major malaria epidemics spring up many years after malaria was eliminated.
- Malaria elimination is an essential part of the overall global strategy to achieve eventual malaria eradication. Unless countries are assisted by international financing to achieve and sustain elimination, the final goal of eradication becomes far less probable. Elimination investments in a particular country should be seen also as investments in elimination in its neighbors, its region, and the planet.
- Perhaps the biggest global threat in the field of malaria is the emergence and spread of resistance by the parasites to commonly used drugs. The development of resistance will always occur, eventually. The international task is to minimize and delay both the emergence and the spread of resistance. Elimination is a helpful tool here. As a country approaches elimination and every case is being assiduously followed and treated, the spread of drug resistance becomes less likely. Once a country has eliminated and is treating only a small number of imported cases, the selective pressure being placed on parasites within that country is greatly reduced, and any

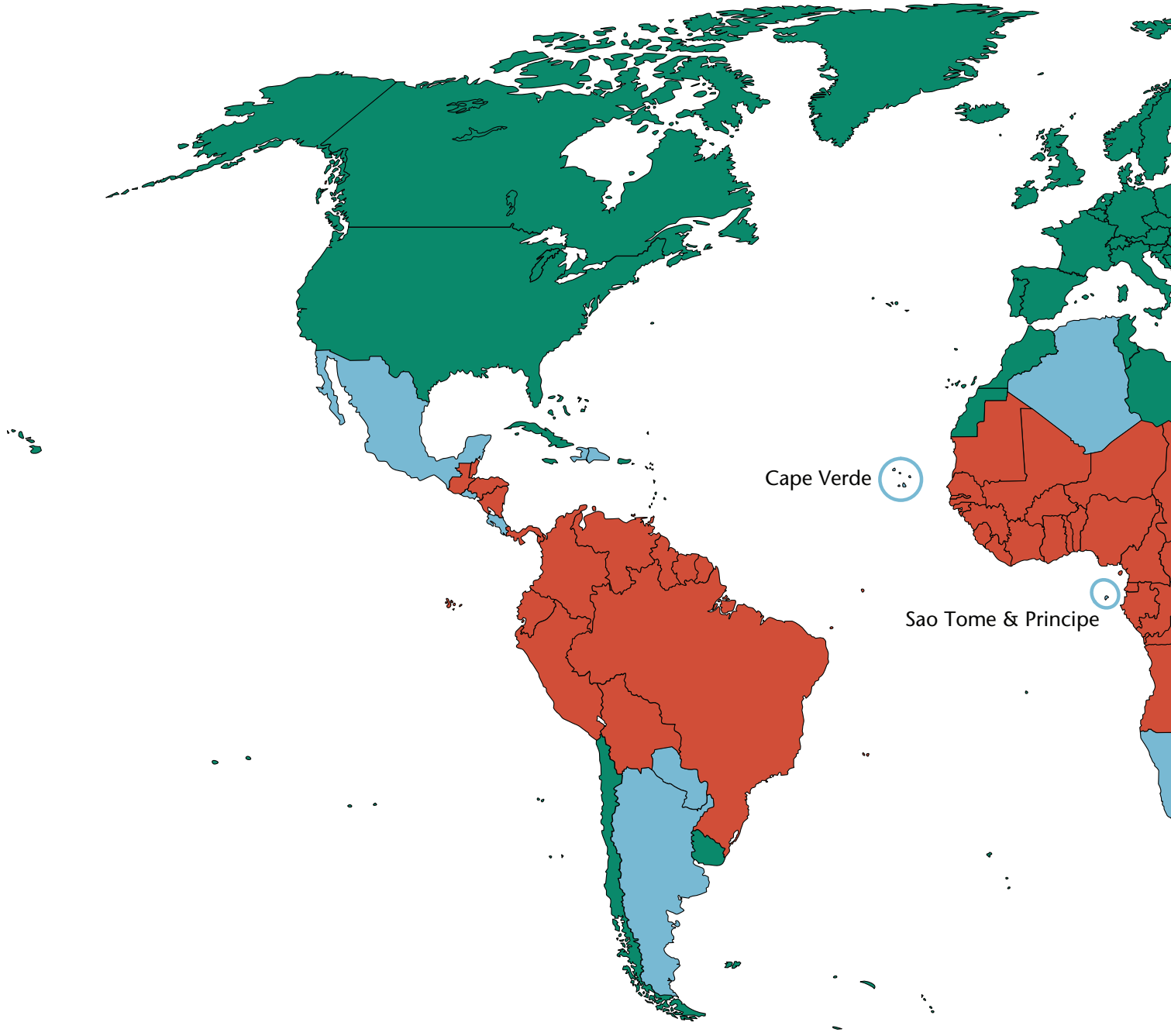
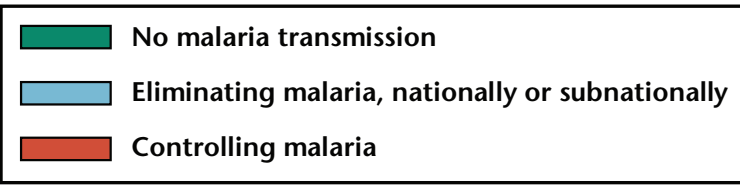
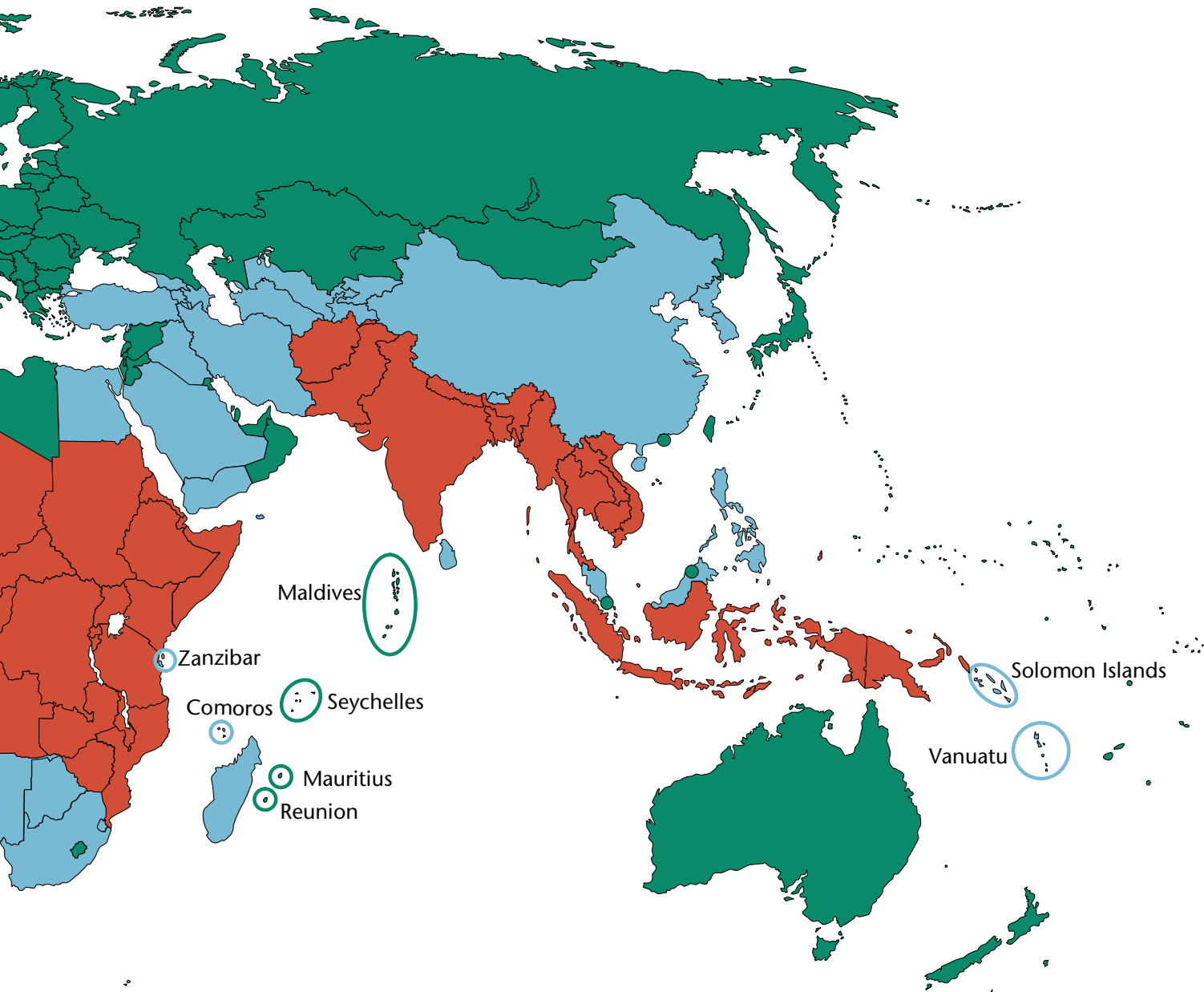


FIGURE 1 | Malaria freedom, elimination, and control, by country, 2009



resistance that may emerge cannot spread, as long as elimination is maintained. This is of substantial global benefit. It is for this reason that malaria elimination in parts of Cambodia, where resistance to the drugs of the artemisinin class is beginning to manifest itself, is being seriously considered.

- Following malaria elimination, the costs and structures previously in place for malaria are likely to shift toward more-integrated vector control and disease surveillance systems, bringing broad benefits for the health sector. In many post-elimination countries, such as Australia, we see an integration of malaria efforts within programs against dengue and a variety of other vector-borne diseases. This is a significant benefit to the health system as a whole, in which both countries and donors have a long-standing interest.
- Finally, donor countries have a major interest in not losing the value of their prior investments. For example, donors invested in malaria elimination in Zanzibar in the 1960s, and malaria was then allowed to resurge. They invested again in the 1980s, and once again, a slackening of efforts caused resurgence. Donors are now reinvesting heavily in malaria control in Zanzibar, and the program may move to an elimination focus. It would be both a human tragedy and an extraordinary waste of resources to once again permit resurgence to occur.

Financing cross-border collaboration is critical for malaria elimination in continental countries. There are two approaches. First, countries can receive donor funding individually and then collaborate effectively across their borders. Second, countries can form a regional consortium and apply together to the Global Fund or other sources of international financing. This is particularly attractive in regions where some countries are eligible for Global Fund financing and some are not. For example, the four eliminating countries in southern Africa comprise two (Namibia and Swaziland) that are Global Fund eligible and two (Botswana and South Africa) that are not. By joining forces and linking also with their northern neighbors, they can make an application that is Global Fund eligible and strengthen not only their national malaria elimination work but also effective coordination and implementation on their borders.

The Global Fund and the World Bank should actively encourage multi-country malaria elimination programs and develop ways to lower the bureaucratic hurdles and raise the chances of obtaining the necessary financing to implement regional programs successfully.

Clearly, responsibility lies not only with donors but also with countries that must find new ways to work harmoniously and coordinate policy and action, particularly in border areas.

The Decision

Having analyzed and weighed the many factors and issues discussed above, each country and region must reach its own decision on elimination. Some will decide correctly to postpone elimination and pursue a vigorous program of strengthening malaria control nationally and in their region. This program of strengthened control will, in practice, involve putting in place many of the same elements that are necessary for elimination. As stated earlier in this document, control and elimination are a continuum. Some countries, however, will decide, on the basis of the analyses described above, to embark on elimination. In so doing, they will either confirm their position as eliminating countries in Table 1 or be new additions to this list.

The decision to eliminate malaria is complex and should not be made lightly. The consequences for an ill-informed and premature move to elimination are serious. Equally, much benefit may be lost to a country, and to its region and the world, by a failure to grasp the possibility of elimination when it presents itself.

We anticipate that the tools for making these decisions will improve greatly over the next few years and that countries will learn from each other through sharing the results of modeling, analyses, and elimination feasibility studies. In particular, the Zanzibar elimination feasibility study, and those that follow, will provide an increasingly rational and rigorous methodology for synthesizing the varied and sometimes contradictory evidence.

Countries should be bold but not reckless. They should consult fully with their neighbors and, wherever possible, embark on elimination together. They should also enter into early discussions with bilateral and multilateral donors to ascertain their willingness to support both elimination and post-elimination costs over the long term.

GETTING TO ZERO

The move from control to elimination, as emphasized above, should be based on a range of political, economic, and epidemiological factors. Programs must then be reoriented to focus on the goal of elimination. This reorientation does not entail a wholesale change of strategies and interventions but, rather, the modification and intensifying of certain strategies that are already in use for the purpose of control. This situation is illustrated in Table 2, emphasizing those interventions and program components that must undergo the most significant change as a country moves from control to elimination.

Focusing on Foci

One of the greatest distinctions between control and elimination efforts is the importance of geographical focus for key interventions. In malaria control programs, activities tend to be applied uniformly across wide areas of the country.

As malaria cases decline, they become increasingly localized, and the heterogeneity of malaria transmission becomes increasingly apparent.

For elimination, interventions must be increasingly targeted and intensified in the residual foci of malaria transmission. For example, in some countries in Southeast Asia where residual malaria foci tend to occur at the forest fringe, interventions must be targeted at the individuals who work in these environments and their families.

TABLE 2 | Major intervention transitions by program phase

Activity	Control	Elimination	Prevention of reintroduction
Intervention target	Entire or broad areas of country	Residual and potential transmission foci	Potential transmission foci and individual imported cases
Diagnosis	High reliance on clinical diagnosis; limited quality assurance	All cases confirmed with microscopy and/or RDTs; robust quality assurance	All cases confirmed with microscopy and/or RDTs; robust quality assurance
Private sector	Diagnosis and treatment provided in private sector (with support from public sector in some settings)	No diagnosis or treatment in informal private sector; formal private facilities fully integrated into surveillance system	No diagnosis or treatment in informal private sector; formal private facilities fully integrated into surveillance system
Program management and legislation	Often limited central capacity, including M&E; limited or no cross-sectoral collaboration and enabling legislation	Strong central capacity with extensive analytical and technical capacity; substantial cross-sectoral collaboration and relevant legislation	Reduced or reoriented, targeted central capacity; potential additional legislation (e.g., border screening)
Surveillance	Limited reporting and analysis of cases through passive system	All new cases rapidly reported and analyzed through both passive and active systems	Sustained, comprehensive, and rapid detection of new cases through passive system
Border measures	Limited or no cross-border initiatives	Initiatives pursued to dramatically reduce transmission in key neighboring areas; prophylaxis for travelers to endemic areas	Cross-border initiatives and provision of prophylaxis maintained; potential border screening of travelers from endemic areas; potential screening and treatment of migrant workers and refugees

Building Strong Surveillance

Surveillance is perhaps the most important component of an elimination program.

To achieve and sustain zero transmission, a program must be able to rapidly detect, investigate, and respond to every individual case of malaria. A surveillance system to achieve this is composed of three core activities:

- collection of case data through active and passive detection methods
- analysis and interpretation of data, including case investigation
- appropriate response, including treatment, screening, and targeting of foci with enhanced vector control interventions

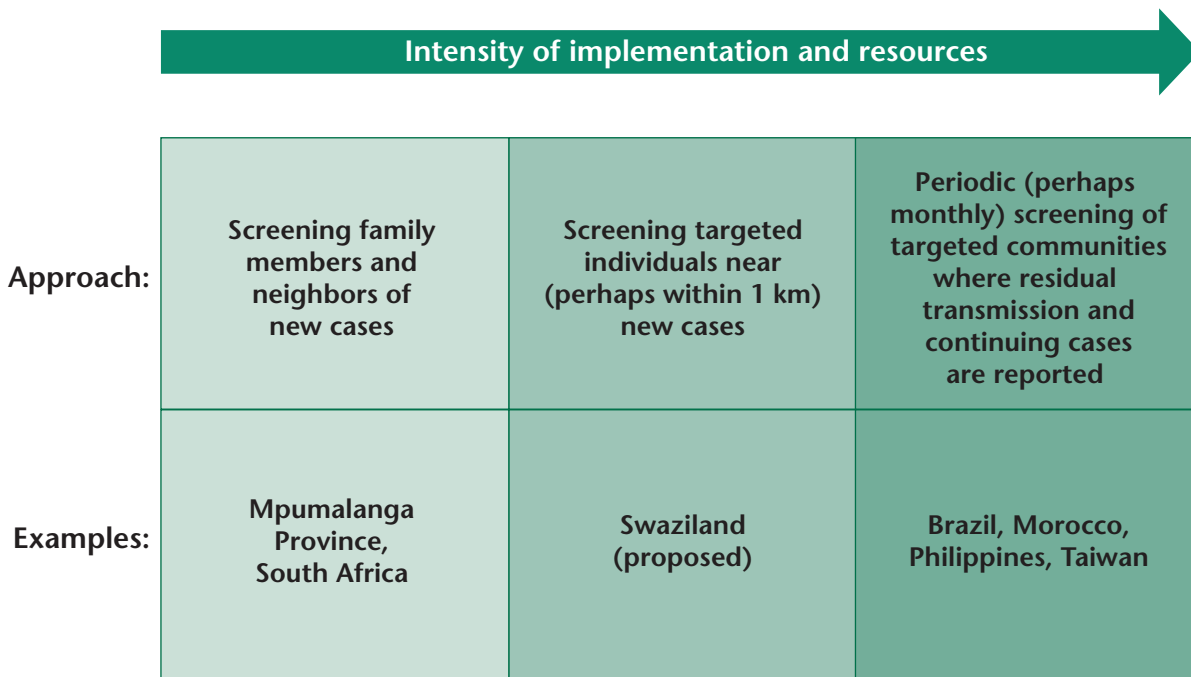


FIGURE 3 | Approaches to active case detection

A robust passive case detection system (reporting of cases captured through normal patient visits to health facilities) is the cornerstone of surveillance.

For elimination to be achieved, new malaria cases identified at government and private health facilities must be promptly reported and followed up. This will require significant and sustained investment in equipment, personnel, training, and communication systems. In some countries, it may be necessary to create a malaria-specific reporting system that is distinct from the core health management information system. However, parallel reporting systems are not desirable and should only be used if elimination will not be achieved otherwise. If this is the case, systems should be incorporated into the core system as soon as possible. Community health workers will need to be trained to be the frontline “eyes and ears” of the system and to alert others to the possibility of malaria cases identified with rapid diagnostic tests (RDTs) or symptomologically.

For elimination, countries will also need to employ some form of active case detection (proactive screening of certain segments of the population for malaria parasites) in order to identify new cases and infections and interrupt transmission.

Active detection also provides the distinct benefit of enabling treatment of asymptomatic parasite carriers, who may be a major source of continued transmission. Many different approaches to active detection have been used. Figure 3 shows a spectrum of active case detection methods that have been employed.

| The surveillance system is only as useful as the response it elicits.

Developing Diagnosis

In control countries, the great majority of malaria cases are never formally diagnosed but are treated on the basis of the symptoms of the patient. This gives rise to the treatment of a lot of “malaria” that is not in fact malaria at all. For elimination, this approach does not suffice. Malaria cases, and preferably also malaria infections in asymptomatic persons, must be accurately diagnosed and effectively treated. Achieving this requires a comprehensive and modern case detection and management system that promotes prompt and sensitive diagnosis and treatment, as well as providing all malaria services free of charge at both public and private facilities. Diagnosis will continue to use the time-honored technique of examining blood slides under a microscope (microscopy), but it will also increasingly employ the new RDTs, whose sensitivity and specificity for both *P. falciparum* and *P. vivax* malaria are improving rapidly.

Of particular note in the elimination context is the need for one or more referral laboratories (a large country would need many) where the latest gene-based tests can be used. The purpose of these sophisticated tests is to better detect and characterize low levels of infection and to help to distinguish locally transmitted from imported cases. Laboratories with these capabilities will also be able to provide quality assurance for the work done in smaller and peripheral laboratories by microscopy and RDTs.

| The widespread use of new and improved RDTs in the field and of sophisticated, modern, and automated techniques in central laboratories will prove extremely useful in elimination programs.

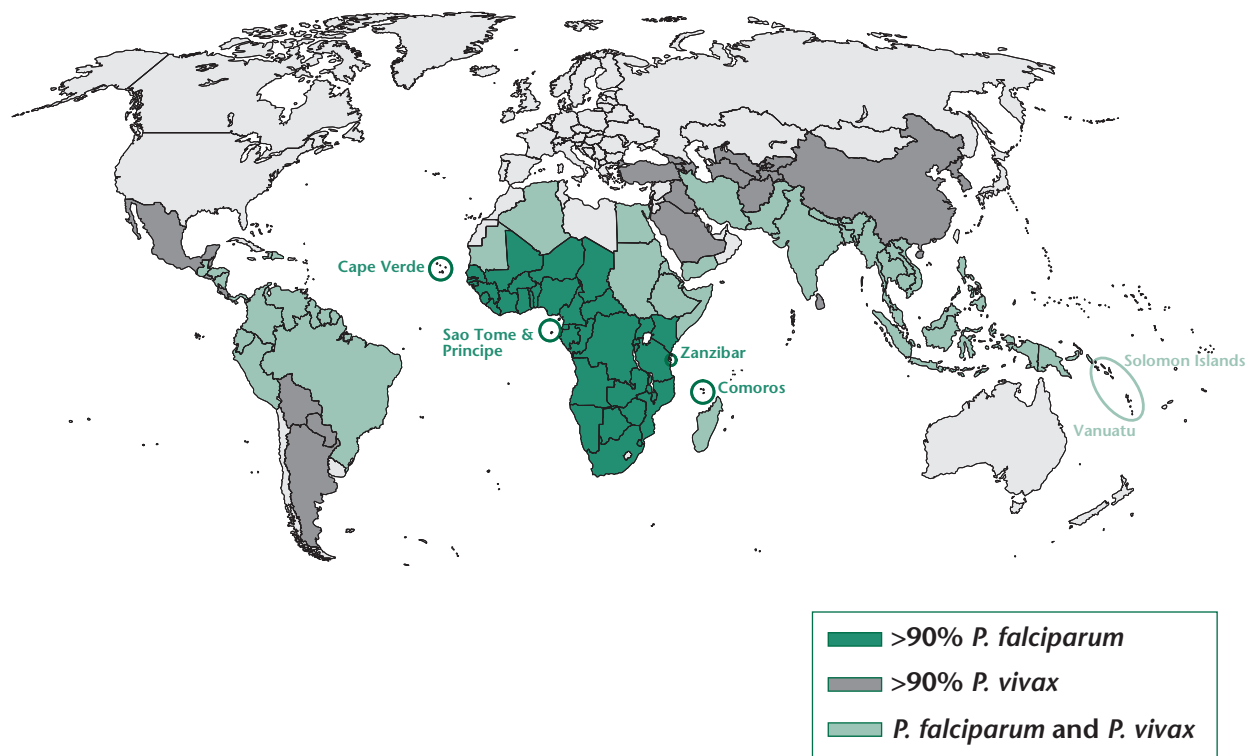


FIGURE 4 | Distribution of *P. falciparum* and *P. vivax* by country

Killing the Parasite

Elimination means no local transmission, and this requires that there be no remaining reservoir of parasites in the human population.

The distribution of the two leading malaria parasites of humans around the globe is shown in Figure 4. It is noteworthy that *P. falciparum* predominance today is a feature exclusively of sub-Saharan Africa, where many people have genetically conferred resistance to *P. vivax*, although *P. falciparum* predominance was previously commonplace in areas of high transmission.

In malaria research and control hitherto, *P. falciparum* has received the majority of attention because it is responsible for the most deaths and is the only significant species in large parts of Africa. The importance of *P. vivax* has been under-recognized until recently. The proportion of the roughly 3.6 billion people in the world who live at risk from malaria is higher for *P. vivax* than for *P. falciparum*, and *P. vivax* may account for as many as 250 million infections every year.

In the context of elimination, *P. vivax* requires increased attention for several additional reasons:

- Outside Africa, *P. vivax* is often the dominant malaria species.
- *P. vivax* has a dormant liver stage, which can allow an individual to remain infected but healthy for long periods, and these dormant infections are hard to diagnose and treat.
- As work on elimination proceeds, the proportion of all malaria infection caused by *P. vivax* grows, so the final stages of the elimination struggle are likely to be against *P. vivax* only, except in parts of Africa.
- Due to biological differences, prompt diagnosis and treatment will block *P. falciparum* transmission more effectively than *P. vivax* transmission.

To eliminate the malaria parasite from the human population, individuals who are sick with, or infected by, the malaria parasite must be effectively treated. In most situations, this is best done with artemisinin-based combination therapy (ACT), now the most widely used firstline treatment for malaria across all countries. In special situations, additional drugs will be required, and this is discussed in more detail in the *Prospectus on Malaria Elimination*.

P. vivax provides a particular challenge for treatment. Although the illness may be cured by chloroquine, or by ACT where there is *P. vivax* resistance to chloroquine (for example in Turkey and Vietnam), the parasite may hide in the patient's liver for long periods. These dormant *P. vivax* infections will, from time to time, cause new illness and new transmission. Primaquine is the drug used today to cure these persistent *P. vivax* infections, but it has dangers and limitations for widespread use. Research is underway to bring forward new drugs against *P. vivax* that can be used more widely and more safely.

In an elimination program, the purpose of treating those who are sick or infected by malaria is not only to make them well but also to stop transmission from those individuals to mosquitoes and subsequently to other individuals. This approach is sometimes referred to as "prevention through treatment." Thus, it is important that the drugs used are effective against the gametocyte of the parasite, which circulates in the blood and is the stage that is taken up by and infects a biting mosquito. Of particular concern are asymptomatic adults who carry gametocytes and are hence potentially infectious. These people need to be identified and treated. They are hard to detect, partly because they are not ill and partly because standard tests may not detect low levels of infection.

In certain settings, mass drug administration (MDA) to the entire population, or mass screening and treatment (MST) of those infected (even though not sick), will be employed. To prevent promotion of drug resistance, a full curative dose of drugs must be taken by everyone treated. Wherever possible, mass drug administration regimens should include a gametocytocidal drug, as well as a drug that is effective against the dormant liver stage of *P. vivax*.

While MDA and/or MST have played a role in previous elimination successes and are used today in China, North Korea, and elsewhere and are under consideration in other elimination countries, they remain controversial. To be effective, the drug regimen has to include primaquine, which may cause severe side effects in a small minority of people. MDA and MST should always be done in the context of strenuous vector control to minimize transmission and the risk of resurgence. MDA and MST may have the greatest applications in smaller populations that constitute stubborn residual foci of malaria. Some experts fear that more-widespread MDA could allow rare parasites, resistant to all drugs being used, to flourish. MDA and MST remain important areas for research, and further evidence must be gathered as these approaches are tried with different designs in different settings.

Suppressing the Mosquito

All malaria is transmitted by female mosquitoes of the genus *Anopheles*. Most human malaria is transmitted by roughly 30 species of *Anopheles*. Typically, a few species are responsible for most malaria transmission in a particular ecological or geographical zone. *Anopheles* species vary widely in terms of the following:

- their preference for feeding on humans rather than other animals
- the time and place when they prefer to bite
- their preferred breeding sites, which can range from transient puddles such as flooded hoofprints and tire tracks, through brackish lagoons and river mouths, to larger bodies of freshwater such as lakes, marshes, or rice paddies
- their efficiency as vectors of malaria, which is the product of their longevity and their biting behavior

Knowing the local *Anopheles* species and adapting the control program to their particular characteristics is essential in all malaria control and elimination activities.

Interventions against the mosquito vector will need to be continued, intensified, and concentrated during the elimination phase. The purpose is to drive down transmission to very, very low levels to assist with the process of completely removing the parasite reservoir from the human population.

In most cases, this will entail strengthening the existing antimosquito interventions:

- the widespread use of insecticide-treated bed nets (ITNs or LLINs)
- indoor residual spraying (IRS)
- other measures, including larval control and environmental management, as appropriate given the local vector species

The modern approach is integrated vector control, using a variety of methods tailor-made to the local ecology.

Two general issues with vector control may particularly affect the success of an intense elimination effort. First, the variation in mosquito biting behavior and the possibility that this will change in the face of antimosquito measures presents a challenge. In much of Africa, most vector species bite indoors and between dusk and dawn. This makes both IRS and ITNs ideally effective. By contrast, in some areas of Asia, the vector mosquitoes bite primarily outdoors and maybe earlier in the evening. In such settings, IRS and ITNs may have limited impact.

Second, just as the parasites develop resistance to the drugs used against them, the mosquitoes will develop resistance to insecticides. Resistance is not the most frequently encountered obstacle to effective vector control, but it is one of the most difficult to overcome. Resistance management can be practiced using combination and rotation of insecticides, which requires a good understanding of the underlying resistance mechanisms and the cross-resistance they produce.

An additional important principle in vector control as elimination approaches is to not make matters worse. All sections of the economy must be conscious of the need to not create new mosquito breeding sites. This particularly applies to the construction and agriculture industries, both of which have the potential to significantly increase mosquito breeding by creating new breeding sites. In the case of the construction industry, by definition in close proximity to human settlement, some elimination countries have targeted specifically these risks and even shifted responsibility onto the shoulders of the perpetrators. For example, during elimination in Singapore, the construction industry was made responsible for ensuring that there was no *Anopheles* breeding taking place on

construction sites. Those who failed to do this were fined. Approaches of these kinds should be more commonly used.

Enlisting the Private Sector

The private sector (meaning all agencies and entities that are not part of government) plays a prominent role in malaria control and must in elimination as well. There are two dimensions to this: malaria diagnosis treatment and other malaria elimination activities.

In most countries in the world, a large proportion of all malaria patients seek treatment outside the public sector.

These private treatment outlets range from drug peddlers on bicycles and village stores, via more-or-less trained private nurses and doctors, through to private clinics and hospitals. Misdiagnosis and inappropriate use of malaria drugs on a large scale in the private sector will undoubtedly impede elimination efforts and make the targeting of effective elimination interventions more difficult.

In an elimination program, only high-quality private facilities, such as formally accredited private and NGO hospitals and clinics, should continue to provide malaria diagnosis and treatment. This will take substantial intervention by government. Some countries, where much malaria is treated outside government facilities, will find it difficult to fully regulate informal and private providers. These countries will need to implement a comprehensive and innovative approach, including incentives, training, and patient behavior change, together with increased regulation.

Concerning other interventions, such as bed net distribution, IRS, community education, and many more, a variety of private sector organizations must continue to play a strong role. The mix will be different in different countries. However, typically, faith-based organizations, NGOs, community-based organizations, and some sections of the for-profit private sector may be mobilized to increase the strength and reach of government programs.

Strengthening Capacity

Most national malaria programs will need to strengthen their capacities in order to successfully take on elimination.

Management is of the essence, and effective program management at all levels is essential for elimination to be achieved. A culture of performance, and accountability for meeting targets, will need to be strengthened or established.

In addition, technical staff of various kinds, especially in the areas that are being expanded and intensified, will need to be recruited and trained. This may be especially the case for entomology services and for surveillance and data management, which are weak features of most control programs, and for the significant strengthening of the diagnostic and laboratory facilities described above. Community health workers, nurses, and doctors will all require special training and ongoing supervision to ensure that they play their full role in the elimination effort.

Another important element is the capacity to collaborate with other branches of government and with the private sector. For example, the ministry of defense must ensure that interventions are appropriately implemented for all military locations and personnel, while the ministry of immigration is important for measures to limit the introduction of new cases. Partnering with private sector collaborators, including formal partnering through subcontracting, will be an important element of elimination in many countries and may well require strengthened capacity and new skills within the ministry of health.

HOLDING THE LINE

Malaria elimination is hard to win and easy to lose. The task of staying at zero is as challenging as the task of getting to zero. Planning for the maintenance of elimination, and being sure to have in place all the necessary programmatic elements to achieve it, is as important as elimination itself.

As mentioned earlier, there are striking examples of countries that, having achieved or almost achieved elimination, have then experienced a massive resurgence of malaria, in some cases taking them back to the pre-elimination era. Two concepts drive our thinking on holding the line of malaria elimination: importation risk, sometimes called vulnerability, and outbreak risk, sometimes called receptivity.

Importation Risk (Vulnerability)

Although the *Anopheles* mosquito is called the “vector” of malaria, the animal most responsible for moving malaria from place to place is *Homo sapiens*. Mosquitoes typically fly short distances. They can occasionally get blown much further and can also be transported in vehicles, airplanes, and ships. Therefore, importation of malaria by mosquito is not unknown. However, far more importation of malaria is by humans. Humans travel more frequently and much farther than mosquitoes and tend not to die quickly upon arrival.

Importation risk can be thought of as the product of the rate of cross-border movement of people and the level of malaria endemicity in the place they have come from.

Important considerations include the following:

- the rate of cross-border movement of people
- the likelihood that travelers carry malaria
- the parasite species likely carried (*P. vivax* may be more difficult to detect and treat)
- where the travelers visit, work, or settle, and for how long

The frequency of cross-border movement varies enormously by economic and geographic circumstance. Remote islands have relatively little human movement in and out, whereas continental countries dependent on migrant labor, or countries receiving refugees from neighboring areas, may experience large cross-border volumes. South Africa, for example, currently faces both of these circumstances, making elimination more difficult.

The chances that arriving persons will be carrying malaria are dependent not only on where they came from but also on their socioeconomic status. A poor migrant worker, for example, is more likely to be positive than a wealthy tourist, even if they are both coming from the same place.

In assessing importation risk, it is not enough to know how many people are crossing the border and where they come from. It is also necessary to know where they go to.

This is in part dependent on their means of transport. Many of the people entering the country on foot or by bus will do so to trade, to find work locally, or to visit friends and relatives locally. These imported infections and cases are likely, therefore, to occur mostly in the border areas. Those arriving by boat will potentially bring malaria into ports and their hinterlands. Those arriving by plane will bring malaria primarily into the capital city and other major airports. Different destinations will have differing outbreak risks, which will suggest differential responses from the elimination maintenance program.

Finally, in some countries a significant proportion of persons entering the country who carry malaria will be returning nationals rather than foreigners. Importation risk by returning nationals, especially those who have only been abroad for a few days or weeks, can be reduced by the use of malaria prophylaxis by all travelers to endemic countries.

Outbreak Risk (Receptivity)

Outbreak risk refers to the potential for malaria transmission in the elimination area and the likelihood that an imported case will give rise to other cases,

which in turn could give rise to still more cases and so on, causing a local outbreak.

Each country, or ecological area within a country, will have a natural or baseline level of outbreak risk dependent on the local details of the vector, the human populations, the climate, and the environment. Roughly speaking, in areas where malaria was previously highly endemic, this natural level of outbreak risk is high. The comprehensive application of IRS, ITNs, and other vector control measures will have greatly reduced outbreak risk by the time elimination is achieved, but continuing effort is required to maintain this low risk. By contrast, in arid or upland areas where malaria was less frequent and possibly highly seasonal, the outbreak risk will be far lower.

Post-elimination, the challenge is to minimize outbreak risks, particularly in areas where imported malaria is most likely to be introduced. For example, a lowland agricultural area with previously highly endemic malaria that is presently receiving migrant labor from a neighboring endemic country will be a major target area for ongoing vector control and case-finding activities to keep outbreak risk at a low level. Conversely, an urban area at 1,500 meters with little malaria prior to elimination will not be of great concern in relation to outbreak risk in the post-elimination environment.

Management and Implementation

Holding the line entails an ongoing commitment to and investment in certain elements of the national malaria control program that were strengthened in order to achieve elimination, in addition to some new measures required to screen and trace those entering the country and reduce the chance that they are infected (see Table 2).

Figure 5 illustrates, in a simplified way, the possible strategies for holding the line depending on the levels of importation risk and outbreak risk. As importation risk rises, the emphasis shifts more to screening and tracing those entering the country, and working with the source countries to reduce the risk of infection in the first place. As outbreak risk increases, the emphasis shifts toward the maintenance of comprehensive transmission-lowering interventions, of exactly the kind that were used to achieve elimination in the first place.

To maintain elimination, a country will certainly need an ongoing national malaria or vector-borne disease program. Closing down such programs and allowing the expertise and the staff to dissipate over time has proved disastrous. Ongoing vigilance and activity over many years are essential.

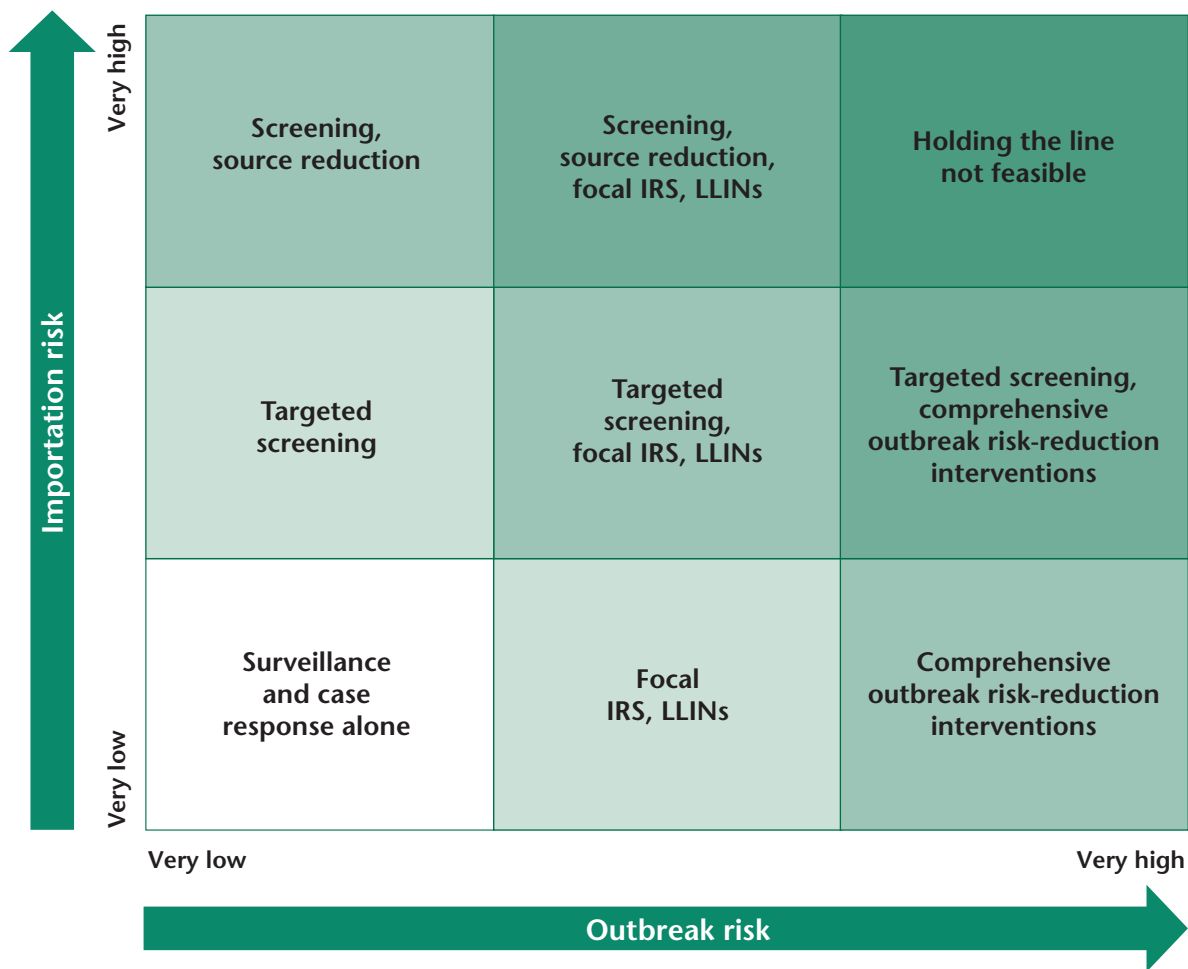


FIGURE 5 | Measures necessary to maintain elimination at differing levels of importation and outbreak risk

The task of holding the line is likely to go on for several decades. However, it will become easier through time as the source countries of imported cases achieve better control and, eventually, elimination. Countries that have eliminated have a substantial interest in assisting their neighbors and other sources of imported infections to also eliminate. Oman, for example, has a major interest in successful elimination in Zanzibar, because it is from Zanzibar that a large number of its imported cases come. Holding the line will also become less challenging through time as living standards and housing improve and health systems strengthen.

Identifying the individuals who are infected and treating them promptly is the essence of holding the line. For some situations this may be best done at points of entry. The screening must be applied not only to foreign visitors but also to returning nationals of the country. Such screening will become progres-

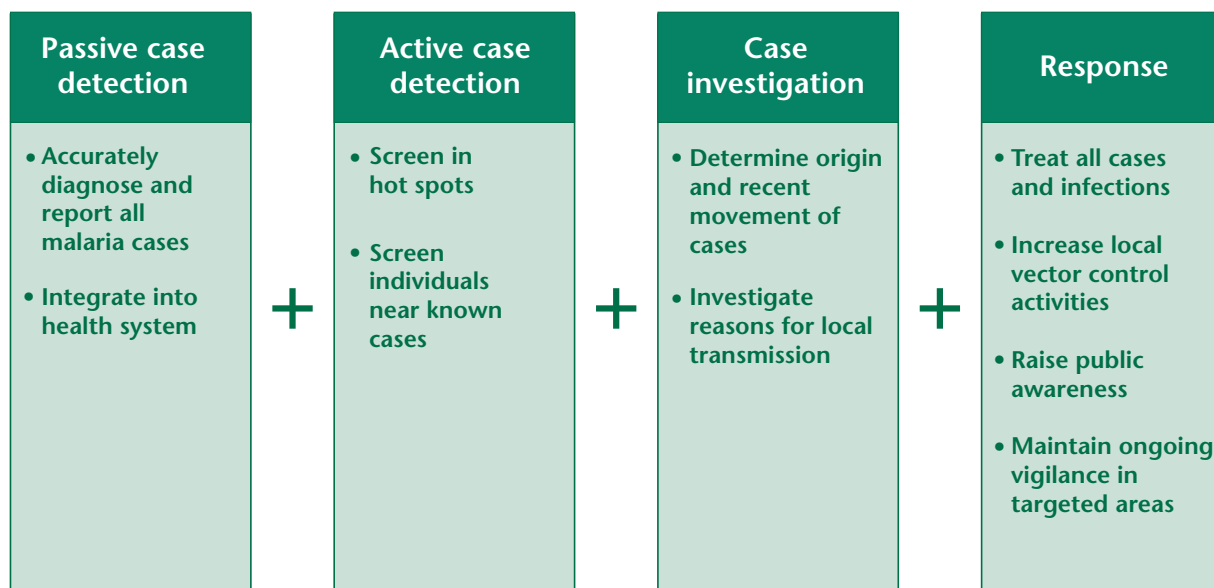


FIGURE 6 | Components of a surveillance and response safety net

sively easier with further advances in RDTs, which give quick and increasingly reliable results.

When cross-border volumes are high and screening all arrivals becomes impractical, efforts should focus on high-risk groups, such as migrant laborers coming from endemic countries. Large influxes of laborers for agriculture, mining, or construction are well-known sources of imported malaria. Countries can choose to focus screening efforts at the sites of employment, rather than at the points of entry. Laws can be passed to make it mandatory for the employers of these migrant workers either to do the screening and treat appropriately or, at the very least, to fully collaborate with and facilitate the government program of screening and treatment. Mass treatment of migrant workers may have a role in some circumstances.

When a country is moving progressively toward elimination, county by county or island by island, the issues of holding the line may become considerably more complex. For an island, a focus on points of entry is still possible, and for this purpose, an island is similar to a country. However, for a county or area, there will typically be large numbers of unrecorded human movements in and out, and the prospects for screening and treating will be low. In these situations, it is necessary to ensure that the surveillance system can detect cases, treat them, and look for and respond to local outbreaks that may occur. Components of a surveillance and response safety net are shown in Figure 6.

Financing

The financial feasibility of elimination is discussed above. Many of the same points apply in the financing of the maintenance of elimination in the long term. However, financing this ongoing effort to ensure that malaria is not reintroduced poses some special challenges, especially to low-income countries that may be reliant on external financial support.

Maintaining the activities necessary to hold the line requires ongoing financing. In the absence of malaria and the presence of other pressing health priorities, this may prove difficult.

While in the long term it will generally be the case that post-elimination program costs will fall and that elimination will be cost-saving, these reductions in costs may not happen quickly. In the years immediately following elimination, the program of surveillance, response, and outbreak control that needs to be in place may not cost much less than the previous program that achieved elimination. Countries will need to be cautious and not reduce expenditure too rapidly.

For the maintenance of elimination, low-income countries especially may need to put in place innovative schemes to ensure the long-term sustainability of financing. Some examples are given below:

- **Trust funds** Some countries have created trust funds to which both they and donors contribute over the long term. These funds are reserved for particular purposes. Trust funds dedicated to the maintenance of malaria elimination could be created.
- **Earmarked taxes** Hypothecated taxes—for example, on tobacco and airline tickets—are already used to fund health programs. Similar earmarked taxes, possibly on the tourist industry, among others, could provide funds for continuing malaria activities. Zanzibar currently taxes tourists the amount of U.S. \$5 per visit, and yet many of these tourists pay more than U.S. \$70 for malaria prophylaxis. A quadrupling of the tourist tax to maintain malaria elimination will represent good value for money for the tourists and raise significant revenue for Zanzibar.
- **Donor funding guarantees** Donors, especially some European bilateral donors, are increasingly making multiyear pledges for certain development priorities. Similar long-term commitments could support malaria activities, even after transmission no longer occurs.

All these innovative possibilities, and others that may be proposed, should be actively investigated well before elimination is completed.

Sustaining the financing to hold the line is essential if hard-won gains are not to be lost.

ROUNDING OUT THE STRATEGY

Engaging with the Health System

The strength of the national health system is integral to elimination, and most countries will have to strengthen their systems to achieve and sustain zero malaria transmission. However, it is not the case that a health system must be perfect for elimination to be achieved. Rather, action to strengthen the health system should be taken as a result of detailed analysis and planning around the following questions:

- Which aspects of the malaria elimination program should be delivered through the public part of the health system, and what elements of this public health care system need to be strengthened to make this possible?
- Which elements of the malaria elimination program could, alternatively, be delivered through the nongovernmental and private parts of the health system, and how do these parts need to be strengthened and engaged with to ensure that they effectively play this role?
- Which aspects of the malaria control program are best delivered, not through the health system at all, but through other channels and by outsourcing?

These questions open up a range of opportunities that are seldom, in practice, considered. Typically, the national malaria control program of the ministry of health takes on the task of malaria elimination as if it alone has to

employ all staff, procure all commodities, and deliver all services and interventions. This approach to malaria elimination is unnecessary and may lead to failure. Collaborations and partnerships with other government agencies and nongovernment actors can greatly enhance capacity and quality.

The government need not assume the burden of malaria elimination alone, and productive engagement with numerous partners will greatly assist in getting to zero and holding the line.

The possible roles of the nongovernmental part of the health system include both diagnosis and treatment and other aspects of malaria elimination, as discussed earlier in this document. Full engagement and close coordination with nongovernment actors will be essential for success.

More broadly, there are many aspects of malaria elimination that do not lend themselves to being delivered through primary clinics or secondary hospitals, and they are probably best contracted out to appropriate NGOs, faith-based groups, or private sector organizations. Detailed surveys may be conducted by the local university or research institute. Responsibility for IRS and the distribution and appropriate use of bed nets could be passed to NGOs, faith-based organizations, or private contractors. Contracting out may be attractive in the establishment of laboratory capacity and the training of a new generation of laboratory staff familiar with the latest tests and technologies. Last, public relations and advocacy campaigns are seldom well done by governments and may be better contracted out to the public relations and advertising industry.

Notwithstanding the above, the government-owned and controlled health system will be the backbone for the malaria elimination efforts. There is great potential to use malaria elimination to strengthen this health system and to institutionalize new capacities that can be invaluable in the fight against other diseases and the achievement of other public health goals.

Leadership and coordination for malaria elimination must lie with the government and, within government, with the ministry of health.

It is the government that must set the elimination goal, elaborate the elimination strategy, and develop and constantly revise the detailed elimination action plans. It is the government that must reach out to others for collaborative partnerships or outsourcing. It is the government that must operate and control the surveillance system and be constantly aware of the evolving epidemiologic situation. There can be no substitutes for this leadership role for government.

Partnering with Communities

Malaria elimination is not possible without the full participation and engagement of the affected communities. The way that this is achieved, and the exact role that communities will play, will vary greatly from country to country.

At a minimum, communities have to be knowledgeable and willing participants in the various interventions that will achieve and maintain malaria elimination. Individual families must accept, use, and maintain ITNs. Community leaders and organizations can play a significant role in ensuring a high level of bed net coverage. In communities in which IRS is being conducted, cooperation from individual families is required. In some communities, acceptance of IRS has been maintained over long periods and is welcomed for its general impact on household pests. In other places, the disruption that it causes and fears concerning its safety have led to a lack of cooperation or even hostility.

Concerning treatment, it is essential that individuals and communities are well informed about the symptoms of malaria and the appropriate measures to take. If a diagnosis of malaria has been made, it is extremely helpful if the patient, or the mother of the patient, is knowledgeable about the appropriate form of treatment so that she can insist on getting the right product at the right price, especially if she is purchasing malaria medicines from a private outlet.

Beyond these dimensions of community collaboration, active and engaged participation by communities and their representatives can accelerate the journey toward elimination and can help to sustain it. Communities that are knowledgeable about malaria, fully subscribe to the malaria elimination goals, and see elimination as an important benefit for their community can contribute much. On the island of Aneityum in southern Vanuatu, for example, the community has been the key to elimination and the maintenance of a malaria-free island. This is motivated both by the obvious benefits to the health of the islanders and by the fact that cruise ships call at the island and would stop doing so if malaria returned.

Active community participation, especially around keeping villages tidy and well drained, can reduce mosquito breeding and contribute directly to the lowering of malaria transmission. On the island of Santa Isabel, in the Solomon Islands, it is believed that the very successful clean villages program, to which the local government, the chiefs, and the churches all subscribe, has had an important effect in reducing malaria transmission to low levels and will further contribute to the journey to elimination. In El Salvador and Honduras, active community participation in reducing mosquito breeding has not only lowered malaria incidence but reduced insecticide use.

Closely linked to the participation of the communities is the participation

of community organizations and structures. These will almost always include local government and faith-based organizations. In some settings, they will also include chiefly structures or other forms of traditional leadership and authority.

There is no single blueprint for community participation. What we know is that malaria elimination cannot be done *TO* the people; it must be done *BY* and *WITH* the people.

Collaborating with Neighbors

Countries that pursue elimination face the challenge of continued malaria transmission in neighboring countries. This is particularly the case for countries that share lengthy land borders, but it also applies to island countries with multiple entry points. Borders between the countries are typically porous, with high levels of human traffic, including migrant laborers. Unless eliminating countries can ensure a significant and sustained reduction in transmission in the border areas of neighboring countries, it is unlikely that they will be able to achieve or sustain zero local transmission.

A number of different approaches to cross-border initiatives have been pursued in the past:

- An eliminating country, which typically benefits from more capacity and resources, directly implements or provides detailed support for interventions in the neighboring country. This approach has been followed in the Lubombo Spatial Development Initiative (LSDI), a highly successful collaboration between Mozambique, South Africa, and Swaziland that has reduced malaria prevalence in targeted areas by more than 90%.
- The eliminating country provides more-limited or remote technical and financial assistance to the targeted areas. An example of this is an intermittent collaboration between Saudi Arabia and Yemen, where the principal activities have included training of Yemeni staff in Saudi facilities.
- Participating countries engage only in targeted coordination of policies, and increased communication and data sharing, between their programs. This is the de facto approach used by most regional initiatives. An example is the Tashkent Declaration, a group of nine countries in the WHO European Region who have committed to working together to eliminate malaria by 2015.

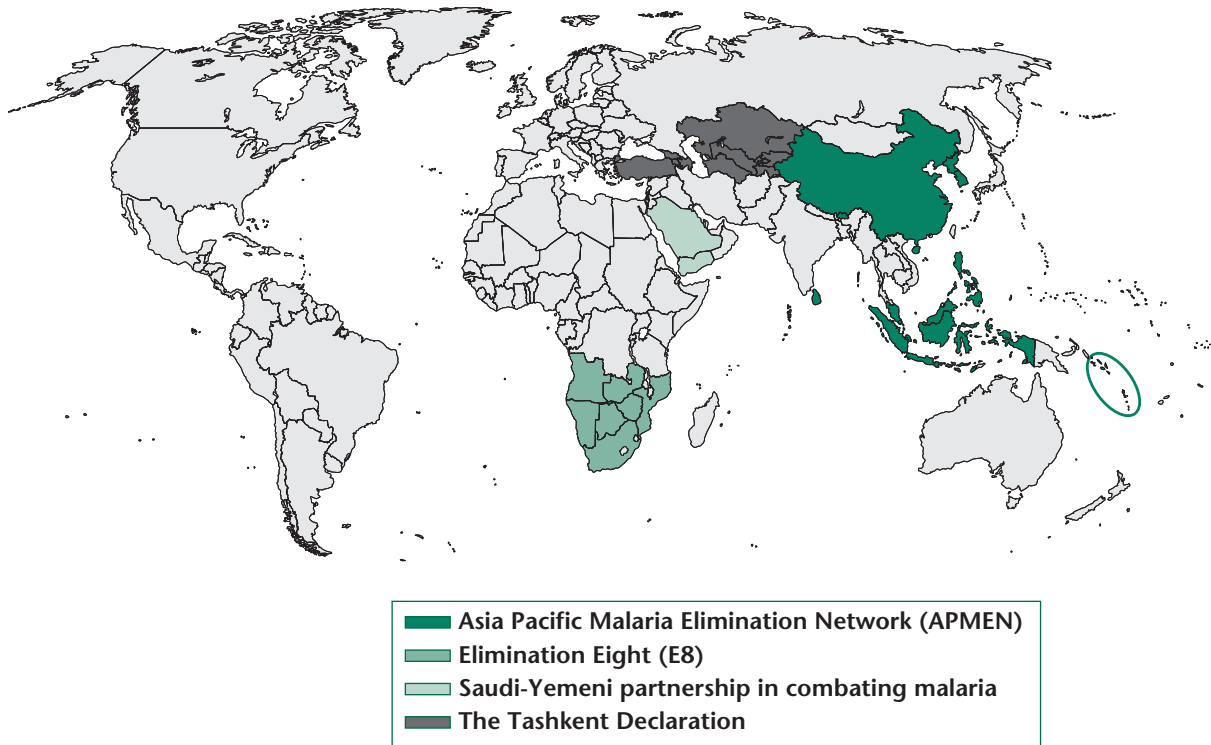


FIGURE 7 | Regional elimination initiatives

There are substantial challenges to developing and executing successful cross-border initiatives. Many initiatives have been conceived and planned, but few have had notable impact. Drawing on lessons learned from the LSDI, success factors for cross-border efforts include the following:

- political and administrative support
- technical leadership
- significant and independent funding
- strong centralized management

Figure 7 shows four multi-country collaborations for elimination. One is the E8 (the Elimination Eight) in southern Africa. The E8 comprises the four front-line malaria elimination countries (Botswana, Namibia, South Africa, and Swaziland), who have together set the goal of malaria elimination by 2015, together with their northern neighbors, the second-line elimination countries

(Angola, Mozambique, Zambia, and Zimbabwe). The inaugural meeting of E8 ministers of health took place in Windhoek in March 2009. The E8 have pledged to work together to achieve malaria elimination in the frontline four and, subsequently, in the second-line four. Without close collaboration among all of the eight, these goals will be unachievable.

A second example is APMEN, the Asia Pacific Malaria Elimination Network. This comprises ten countries from the Asia-Pacific region that are aiming for elimination on a national or significant subnational scale. They are Bhutan, China, Indonesia, Malaysia, North Korea, Philippines, Solomon Islands, South Korea, Sri Lanka, and Vanuatu. Representatives of these countries met for the first time in Brisbane in February 2009 to discuss common goals and objectives and to agree on a process of information sharing and collaborative operational research from which all members of APMEN may benefit. Although some members of APMEN are contiguous and have cross-border agendas (e.g., Indonesia, Malaysia, and the Philippines), generally speaking, this is a collaboration about evidence and policies, rather than about working together in border areas.

Other multi-country elimination partnerships, in the Middle East and Central Asia, are also shown in Figure 7. It is likely that other examples of regional malaria elimination collaborations will form, and early examples might include the countries of Mesoamerica and the Andean countries.

Sustaining Political Will

Although recent experience has reconfirmed that dramatic reductions in malaria incidence can be achieved in a short time, fully eliminating local transmission is a war of attrition in most settings. Finding and clearing the last cases and foci, particularly of *P. vivax*, often require five or more years of effort, even in relatively conducive settings such as in the Middle East. As history has consistently shown, attention, resources, and diligence cannot waver during this time or malaria will resurge, and the gains of the preceding years will be lost.

Fatigue among key actors, from local communities and implementers to national politicians and donors, is one of the greatest threats to a malaria elimination program.

TABLE 3 | Framework for an elimination advocacy campaign by stakeholder group¹

Stakeholder	Outcome	Message	Information needs
National leaders (e.g., heads of state)	Commitment to long-term support for elimination	Elimination will bring great benefits to your country and your neighbors.	Health and economic impact estimates; elimination commitments by neighbors
Ministry of finance	Significant and long-term financial support	Malaria elimination is good for economic development and is cost-effective.	Economic impact and cost-effectiveness estimates
Ministry of health	Leadership of elimination program; appropriate investment in and management of the health system	Eliminating malaria will reduce the burden on the health system. Maintaining elimination requires constant vigilance.	Detailed analysis of health system needs to achieve and sustain elimination
Local government leaders	Effective sustained management of activities; commitment of local resources and leadership	Elimination is a national priority that will greatly benefit communities in your area. Activities need to be sustained, or dangerous epidemics will occur.	Commitments by national and regional leaders; local budget and management needs for effective implementation
Business leaders	In-kind and financial contribution to elimination activities	Malaria elimination is good for business (e.g., greater productivity and more tourism and investment).	Economic impact estimates; mapping of opportunities for business contribution
Donors	Substantial and sustained funding for elimination program	Elimination will contribute to health and economic development goals. Elimination funding must be long-term and predictable.	Inclusion of elimination in national development strategies; analysis of long-term financing needs and mechanisms for predictability
NGOs	Active participation in malaria elimination activities	Elimination will save many lives and benefit communities. NGOs have an important role to play.	Mapping of opportunities and needs for NGO engagement
Public	Sustained engagement in elimination activities and appropriate health behavior	Malaria remains a deadly threat even once it has been eliminated.	Simple examples of malaria resurgence from other countries

1. Courtesy of Professor Matthew Lynch, Johns Hopkins University

Key components of the strategy to maintain local and national support and enthusiasm for elimination will include the following:

- securing and sustaining high-level political support
- demonstrating wider benefits to the health system from investments in malaria elimination
- building and maintaining community engagement and public awareness
- targeting vulnerable populations
- setting expectations and promoting vigilance
- developing robust financial arrangements

Well-targeted and sustained advocacy and communications campaigns will be essential tools. An example of a comprehensive elimination advocacy campaign is outlined in Table 3. Government departments will often not be competent or well suited to deliver aspects of this campaign. Strategic partnerships and outsourcing with NGOs and commercial enterprises will be necessary to ensure high-quality and professional campaigns and to measure their impact.

LOOKING FORWARD

In charting the course for malaria control and elimination over the coming decades, the three-part strategy must be kept constantly in mind (see The Three-Part Strategy section above). Part 1, the aggressive reduction of morbidity and mortality in the high-transmission and high-burden countries, is the absolute priority and must receive the lion's share of the funding. Part 3, the research and development that will bring forward new tools, is essential, for without new tools, we will be overtaken by resistance and the endgame of eradication will not be won.

While Parts 1 and 3 are pushing ahead, Part 2 will engage the intellectual commitment and energy of roughly 39 countries (the blue countries in Figure 1) and those who advise and support them. Part 2 of the strategy is not optional; it should not be understood as something nice to have only if there is a surplus of money and energy after having fully dealt with Parts 1 and 3. Part 2 is critical to a global advance toward final eradication, as it has been over the past century.

Some people fear that resources may be transferred away from investment in malaria control in the high-burden countries and devoted to elimination in low-burden countries. This should not be allowed to occur. Of the \$7 billion total of Global Fund resources committed to malaria, only \$0.7 billion, or 10%, has been devoted to the 39 elimination countries shown in Figure 1. For the President's Malaria Initiative, the focus is almost entirely on scaling up control in the high-burden countries, and only Madagascar, Sao Tome and Principe, and Zanzibar receive any support for elimination (Table 1). In addition, only 11 of the 39 elimination countries are low-income countries that will be heavily reliant on international financing.

While the share of international investment in malaria that goes to elimination will rise, indicating good progress toward eradication, the great majority of funds will continue to be directed toward the heartland for the foreseeable future.

As we look at Figure 1, we have to wonder how many of the blue countries will be green in 2020. There is little doubt that it could be all of them, but it is probable that this will not be the case. If the majority succeed and we learn the maximum from their experience, the unsuccessful minority will be reequipped and invigorated. Equally, even if only half of the blue countries eliminate malaria by 2020, the front line will have shifted considerably, and a new generation of red countries will take up the baton of elimination and become blue. While all this is happening, new drugs, insecticides, diagnostics, and vaccines will have been brought forward for use in appropriate settings. The field of malaria elimination is dynamic and ever changing.

In conclusion, let us not underestimate the enormously encouraging and uplifting effect of declaring a country free from a disease that has killed its people for millennia. This produces a surge of pride and morale for the country concerned, for those who were assisting, and for the health community worldwide. Such demonstrations of success have an intrinsic value and will move us forward to greater challenges and greater victories.

ANNEX 1: MEMBERSHIP OF THE MALARIA ELIMINATION GROUP (MEG)

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Dr. Carlos C. (Kent) Campbell	Director Malaria Control Program PATH	USA
Mr. Ray Chambers	Secretary General’s Special Envoy for Malaria United Nations	USA
Dr. John Paul Clark	Senior Technical Specialist Booster Program for Malaria Control in Africa The World Bank	USA
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Mr. Oliver Sabot	Director Malaria Control Team Clinton Foundation	USA
Dr. Dennis Shanks	Director Australian Army Malaria Institute	Australia
Dr. Laurence Slutsker	Chief Malaria Branch Centers for Disease Control and Prevention	USA
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Dr. Linhua Tang	Director National Institute of Parasitic Diseases Chinese Center for Disease Control and Prevention	China
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ANNEX 2: SELECTED READINGS AND SOURCES

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