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Maintaining zero: An update to the Sri Lanka malaria elimination case study

UCSF Global Health Sciences
Global Health Group

TEDHA

The guard stone of the Polonnaruwa "Vatadage" (meaning circular relic house), an ancient and venerated Buddhist structure dating back to the 12th Century, represents protection and prosperity. This image embodies the rich cultural heritage of Sri Lanka, and the use of it on the cover of this report symbolizes the country's need to guard its citizens from external threats, namely importation, in order to ensure a malaria-free future.

Contents

Acknowledgments

This report was authored by Professor Rajitha Wickremasinghe of the University of Kelaniya and technical advisor to the Sri Lanka Anti-Malaria Campaign (AMC), and Gretchen Newby of the Global Health Group at University of California, San Francisco (UCSF), in collaboration with Lanka Jathika Sarvodaya Shramadana Sangamaya (Sarvodaya), Tropical and Environmental Disease and Health Associates (TEDHA) Pvt. Ltd, and the Sri Lanka Ministry of Health.

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Executive summary

Following decades of remarkable progress towards elimination, Sri Lanka has successfully interrupted local malaria transmission. After embarking upon a pre-elimination plan in 2009 that emphasized intensive parasitological and entomological surveillance, closely observed radical cure including administration of gametocytocidal drugs for *P. falciparum* infections, and rigorous community engagement, the Anti-Malaria Campaign brought indigenous cases down to zero in November 2012. This success has been maintained over the past two years and Sri Lanka is now launching a prevention of re-introduction strategy with a near-term goal of malaria-free certification. This report details the strategies and activities carried out by the Anti-Malaria Campaign and its implementing partners during the period 2009–2014 in order to document Sri Lanka's success and provide lessons for other countries aiming for malaria elimination.

Introduction

Sri Lanka's progress toward malaria elimination was documented in 2012 in the third of a series of elimination case studies conducted by the Global Malaria Programme of the World Health Organization (WHO) and the Global Health Group at the University of California, San Francisco (UCSF), in partnership with the Sri Lanka Anti-Malaria Campaign (AMC). The Sri Lanka case study described the malaria control efforts carried out by the AMC from the first days of the program in 1911 through to 1999, with a detailed look at the activities implemented from 2000 to 2009 as malaria transmission approached zero [1]. Since 2009, however, substantial changes have occurred in program strategy and focus, funding, and the country's political environment. Within this context of shifting priorities and circumstances, the last indigenous case was recorded in October 2012, and the program has since maintained zero local transmission.

In light of this significant achievement, the Sri Lanka AMC and the UCSF Global Health Group have partnered to produce an update to the 2012 case study, documenting the strategies and activities carried out since 2009 that led to malaria elimination and maintenance of malaria-free status. The challenges faced by the program as it pursues a WHO certification of elimination and reorients toward the prevention of reintroduction (PoR) phase are described. The objective of this case study update is to comprehensively describe the factors that led to malaria elimination in Sri Lanka, in order that other countries may benefit from best practices and lessons learned. The case study update was presented and discussed at the 9th Malaria Elimination Group meeting,[1] held in Sri Lanka in October 2014.

District- and national-level data were collected from the AMC, Tropical and Environmental Diseases and Health Associates (TEDHA) Pvt. Ltd, and Lanka Jathika Sarvodaya Shramadana Sangamaya (Sarvodaya)[2] over a three-month period in 2014, and included epidemiological trends, vector control intervention coverage, entomological and parasitological surveillance activities, community engagement activities, importation trends, and funding for the program during the period 2009–2013. Current and planned activities were captured through consultations with AMC staff as well as reviews of the new National Malaria Strategic Plan for Elimination and Prevention of Re-introduction 2014–2018 and the 2014 Concept Note prepared for the Global Fund.

Background

Sri Lanka has a long history of malaria control (Figure 1). The first iteration of the Anti-Malaria Campaign was formed in 1911, followed ten years later by the appointment of the country's first malariologist. The AMC saw Sri Lanka through a massive epidemic in the mid-1930s, largely controlled through the use of mineral oils as larvicides and distribution of antimalarial drugs. DDT was introduced in 1945, and its early success in reducing case burden compelled the country to embark on a malaria eradication strategy in 1957. During this period, coinciding with WHO's Global Malaria Eradication Programme, Sri Lanka experienced a dramatic decline in cases and nearly achieved elimination after reporting just six indigenous cases out of 17 total in 1963. However, in response to such incredible success, political and financial support was cut back dramatically and the program grew complacent. A few years later, malaria resurged and the AMC reoriented back to a control phase which continued until 2009, with modifications over time based on recommendations by WHO [2].

A number of significant events took place in 2008 and 2009 that influenced the malaria program strategies and activities in Sri Lanka, much of which centered on the conclusion of a nearly 30-year long separatist war between the Liberation Tigers of the Tamil Eelam (LTTE) and the government of Sri Lanka.

Pre-elimination phase

Although Sri Lanka had already reached the WHO-defined elimination phase (<1 case per 1000 population at risk) [3] by 2004 based on a population at risk of approximately 5 million, the AMC opted to launch an official pre-elimination strategic plan, the implementation of which commenced in September 2009 with support from a Global Fund Round 8 grant [4]. The AMC took a more conservative approach toward elimination in light of the instability and disruption of government services in the North and East of the country caused by the separatist war.

New implementing partners

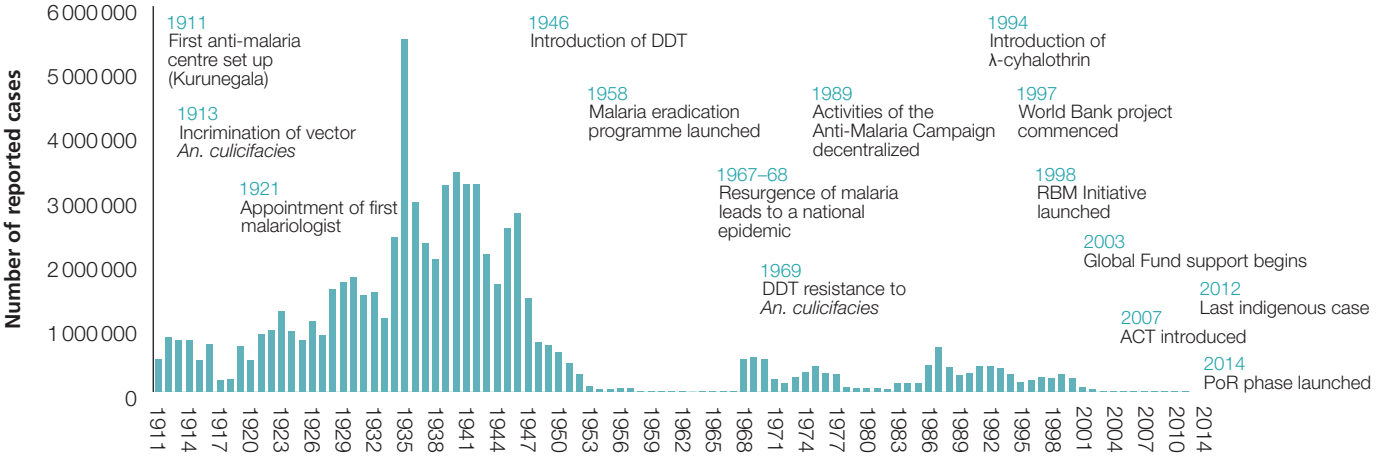
At the launch of the pre-elimination program in 2009, the AMC was unable to provide services to the entire country, as some districts in the conflict areas had limited infrastructure and poor accessibility. The separatist war had displaced hundreds of thousands of civilians and undermined civil administration, including health care delivery, in eight districts that were highly endemic for malaria (Figure 2).

Because the AMC had limited reach in these affected districts, two additional Principal Recipients (PRs) were identified for implementation of the Global Fund grant: Sarvodaya, the largest

1 The Malaria Elimination Group (MEG) is a global advisory body on malaria elimination convened by the UCSF Global Health Group.

2 TEDHA and Sarvodaya are implementing partners of the AMC, and Principal Recipients under the Global Fund Round 8 grant

Figure 1. Historical timeline of malaria control in Sri Lanka, 1911-2014



ACT, artemisinin-based combined therapies; PoR, prevention of re-introduction

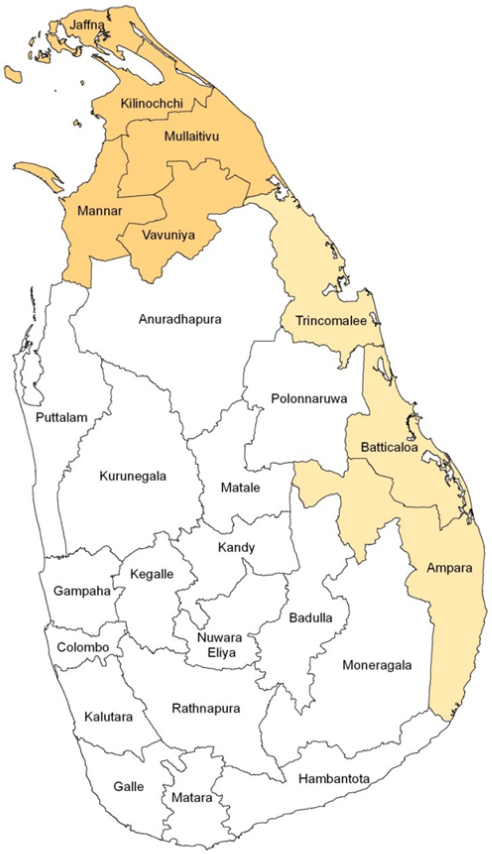
non-governmental organization in Sri Lanka known for its grass-roots-level infrastructure throughout the country; and TEDHA, a private sector company founded in the wake of the 2004 tsunami with a focus on preventive health and sustainability [5].

Sarvodaya had served as PR under the previous two grants, conducting larval control activities, distributing LLINs and educating communities in conflict districts on malaria prevention through their extensive network of community health volunteers. These activities, as well as grassroots-level advocacy and awareness-raising for malaria pre-elimination, were scaled up under the Round 8 grant. TEDHA was a new partner with expertise in program management and malaria epidemiology, parasitology, and entomology, tasked with intensifying surveillance in the conflict areas through the recruitment and training of staff and the establishment of parasitological and entomological surveillance sites [5].

End of separatist war

The separatist war eventually came to an end in May 2009, shortly before the onset of Round 8 funding, and the affected districts entered a post-war transition phase. Despite the conclusion of the fighting, the AMC's capacity in the former conflict districts, or 'transition districts' as they were then called, was still extremely limited. The infrastructure and processes for delivery of health care in these areas were in total disarray after decades of fighting. Health facilities were dilapidated, equipment was not in working order, utilities such as electricity and water lines were not in place, and there was a lack of government personnel to fill vacant district malaria posts. During this period, the AMC carried out routine pre-elimination operations in most parts of the country, and monitored the work carried out by TEDHA and Sarvodaya in the transition districts. Later, in 2011, the Global Fund awarded the Sri Lanka Ministry of Health a grant of USD 15.5 million for strengthening the community-based Primary Health Care workforce in post-conflict areas [6], allowing for increased capacity-building and improved public health infrastructure in the districts where the AMC had been unable to fully function.

Figure 2. Map of conflict districts in Sri Lanka



Findings for the period 2009–2014

Epidemiological trends

Indigenous cases steadily declined since 2008, other than a slight increase in 2010 which was likely a result of intensified surveillance after the onset of Round 8 funding (Figure 3). Most of the cases reported in 2009 and 2010 were *Plasmodium vivax* infections among armed forces personnel who had served in the conflict areas during the war; once these cases were aggressively treated, a significant drop in indigenous cases was observed between 2010 and 2011. Figure 4 shows the distribution of the last indigenous cases in 2012. By 2013, cases were reported only sporadically throughout the year, no longer following the seasonal patterns observed in the past when the case burden was much higher, and all were identified as imported. During this period, the proportion of imported cases increased from 3% in 2008 (the first year when cases were classified as indigenous or imported) to 75% in 2012, and finally 100% in 2013. In 2014, 49 imported cases were reported. No indigenous malaria deaths have been reported since 2007.

As the incidence of indigenous malaria declined, there was a decrease in the proportion of *P. falciparum* cases (Figure 5). The last indigenous case of *P. falciparum* was reported in September 2012 and the last indigenous case of *P. vivax* was reported in October 2012. It is likely that some of the last few *P. vivax* infections reported in 2012 were in fact relapses and not new infections acquired locally. Some had a previous history of malaria, but because there was some doubt as to whether they were relapses, the AMC reported them as new indigenous cases.

Figure 4. Geographic distribution of indigenous malaria cases, 2012

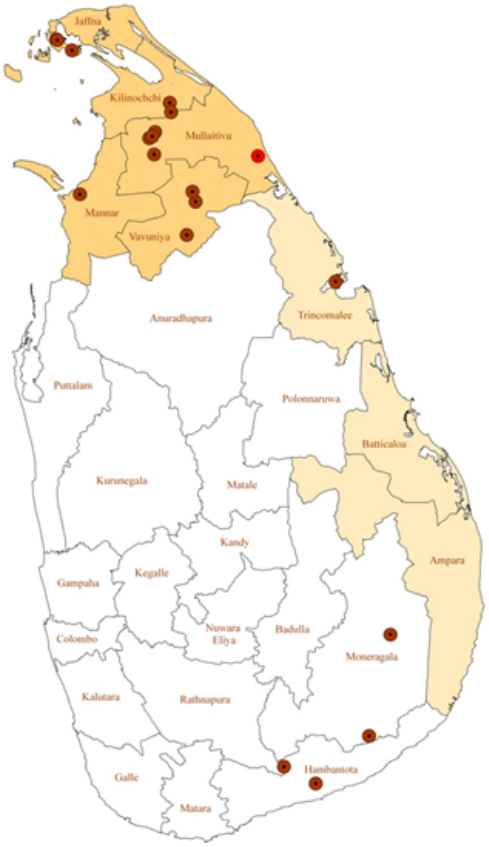


Figure 3. Reported malaria cases in Sri Lanka, 2008–2013

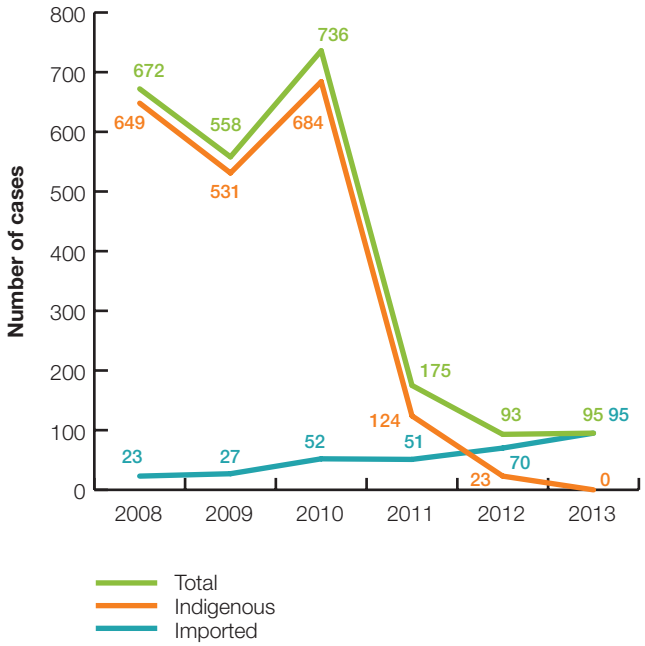
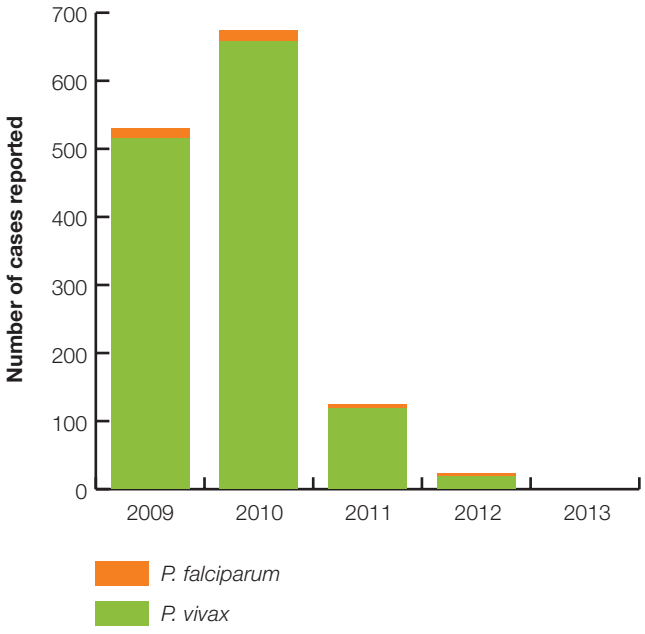


Figure 5. Indigenous cases by infection type, 2009-2013

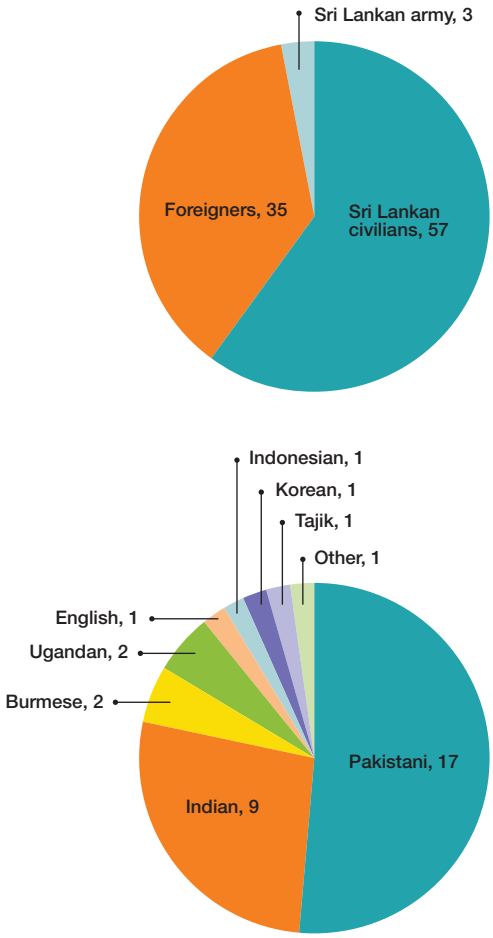


Importation

The percentage of malaria cases in Sri Lanka that are imported has rapidly increased from just 3% in 2008, when the AMC began distinguishing imported vs indigenous cases, to 100% in 2013. Of the 95 imported cases reported in 2013, 60% occurred among Sri Lankans returning from overseas travels (Figure 6), and most of these were diagnosed and reported by health institutions in the Western Province, an area that was not endemic for malaria in the past (see Table 1 for breakdown of indigenous and imported cases by province, and the appendix for district-wise breakdown). The non-Sri Lankans recently diagnosed with malaria were primarily tourists, as well as some political asylum-seekers coming from malaria endemic countries. Tourist arrivals have increased almost threefold in the last several years, from 447,820 in 2009 to 1,274,593 in 2013 [7]. Most arrivals are currently from Europe, although the number of tourists coming from neighboring malaria endemic countries such as India continues to increase. The threat of importation is likely to intensify because these trends are projected to continue.

While malaria is not endemic in the Western Province, the local population, particularly those living in close proximity to the capital city of Colombo, is of a higher socioeconomic status and more likely to travel overseas, including to highly malaria endemic countries such as India. This explains the concentration of imported cases in the Western Province, although the risk of local malaria outbreaks in this area is minimal given its historically low receptivity. However, Western Province residents with recent international travel history are also more likely to visit popular tourist destinations in traditionally malarious areas within Sri Lanka, increasing the risk of focal outbreaks and resurgence of malaria transmission in regions of the country with much higher receptivity. The observed increase in population movement and imported case incidence in the Western Province, and the dangers of re-introduction of malaria in receptive areas, prompted the AMC to invest additional resources to improve surveillance in 2012, including individual case follow-up by dedicated malaria control officers.

Figure 6. Distribution of imported cases by country of origin, 2013



Note: Investigation revealed that the English case was acquired in Mali
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Table 1. Incidence of malaria cases by province, 2009–2013

	Indigenous					Imported				
Province	**2009**	**2010**	**2011**	**2012**	**2013**	**2009**	**2010**	**2011**	**2012**	**2013**
Western	1	4	0	0	0	9	36	36	25	58
Central	4	2	0	0	0	7	1	5	4	6
Southern	88	89	13	2	0	1	1	1	2	4
Northern	297	442	104	18	0	4	3	2	25	9
Eastern	20	17	2	1	0	3	7	2	10	5
North Western	9	6	0	0	0	1	2	1	2	4
North Central	10	28	2	0	0	1	1	1	1	3
Uva	99	96	3	2	0	0	0	0	1	2
Sabaragamuwa	3	0	0	0	0	1	1	3	0	4
Total	531	684	124	23	0	27	52	51	70	95

The majority of imported malarial infections reported in 2013 (77 out of 95) were detected in public sector hospitals. 18 (19%) imported malaria cases reported in 2013 were detected in private sector hospitals, primarily large facilities in and around Colombo. This underlines the importance of engaging the private sector in surveillance, particularly in urban areas where private facilities are more abundant.

Case management

With the introduction of Artemether/Lumefantrine as the first line drug for uncomplicated *P. falciparum* infections in 2007, all *P. falciparum* cases since adoption of the policy were hospitalized for 3 days to ensure compliance to treatment and to monitor cases for potential adverse events. In 2010, in partnership with the armed forces, the AMC adopted a new case management approach for military personnel focusing on radical cure, ensuring that all military *P. vivax* patients were hospitalized for three days in military medical facilities throughout the country. After their stay, military patients were kept within their barracks for two weeks to ensure compliance with a 14-day primaquine regimen, 0.25 mg/kg body weight, in addition to chloroquine for 3 days. This strategy is likely to have led to the sharp case decline observed between 2010 and 2011, and prevented focal outbreaks when the soldiers responsible for the majority of indigenous cases in 2009 and 2010 were re-deployed in malaria endemic areas of the country after the war.

The treatment guidelines for malaria introduced in 2007 were revised in 2013 with the inclusion of a stat dose of 0.75 mg/kg body weight of primaquine, a gametocytocidal agent, for all *P. falciparum* cases prior to hospital discharge. In addition, the AMC recommends that all members of large population groups from endemic countries who have come to reside in Sri Lanka be treated with 0.25mg/kg body weight of primaquine for 14 days as radical cure, upon detection of imported *P. vivax* infections within the groups. Screening for G6PD deficiency is not currently done prior to administration of primaquine radical cure, but it will be introduced upon implementation of the National Malaria Strategic Plan for Elimination and PoR 2014–2018.

Since 2012, blood samples of all malaria cases reported in the country have been genotyped and archived in order to identify sources of outbreaks that may occur in the future.

Parasitological surveillance

The AMC has regularly carried out parasitological surveillance over the years, including passive case detection (PCD), activated passive case detection[3] (APCD) and active case detection (ACD). TEDHA commenced parasitological surveillance activities in February 2010 after training 45 Parasitological Surveillance Assistants (PSAs) who performed microscopy in 4 districts. An additional four PSAs were trained by TEDHA in 2012 to cover the Kilinochchi district. During the period of review, PCD and APCD surveillance was provided at 372 hospital sites (323 located throughout the country managed by the AMC and 49 located in 5 districts in the Eastern and Northern provinces managed by TEDHA) with facilities for microscopy. ACD was conducted in selected areas through mobile malaria clinics on a voluntary basis; the criteria for selection of ACD locations included past incidence of malaria, difficult to reach areas, areas with high malaria receptivity, and the presence of high risk populations such as armed forces personnel and displaced persons (Figures 7–9).

The majority of screenings between 2010 and 2013 were APCD and PCD conducted in hospital settings (Figure 10). Patients with symptomatic malaria are most likely to present at hospital settings given the low immunity to malaria in the population with a decreasing case load, while asymptomatic cases are targeted through mobile malaria clinics. TEDHA has reported that 8 of the 9 cases they detected between 2010 and 2012 were detected by ACD [8].

Since the commencement of the pre-elimination phase in September 2009, the AMC and TEDHA have maintained a combined annual blood examination rate (ABER) of nearly 6% (Table 2). The ABER of almost 6% is based on the entire population of Sri Lanka. If only the population resident in traditional malaria endemic areas in the dry zone of Sri Lanka is considered, comprising approximately half of the country's total population, then the ABER is over 12%. A major problem encountered as the country moves to the PoR phase is how to define the population at risk. The AMC plans to maintain an ABER of at least 5% based on the total population in the next few years to provide sufficient evidence for malaria-free certification.

Table 2. Annual blood examination rate based on persons screened, all detection methods, 2010–2013

Year	Number screened	Estimated total population*	ABER**
2010	1,098,741	20,513,990	5.36
2011	1,242,692	20,283,910	6.13
2012	1,185,883	20,328,000	5.83
2013	1,236,248	20,493,000	6.03

* Sri Lanka total population estimates obtained from the Department of Census and Statistics

** Annual Blood Examination Rate calculated as (number screened/total population)*100

3 Activated passive case detection involves screening of all fever cases for malaria in health care facilities, regardless of whether malaria is suspected or patients have been referred by a clinician. In contrast, passive case detection involves screening of suspected malaria cases only after clinician referral.

Figure 7. Distribution of AMC mobile malaria clinics, 2011-2013

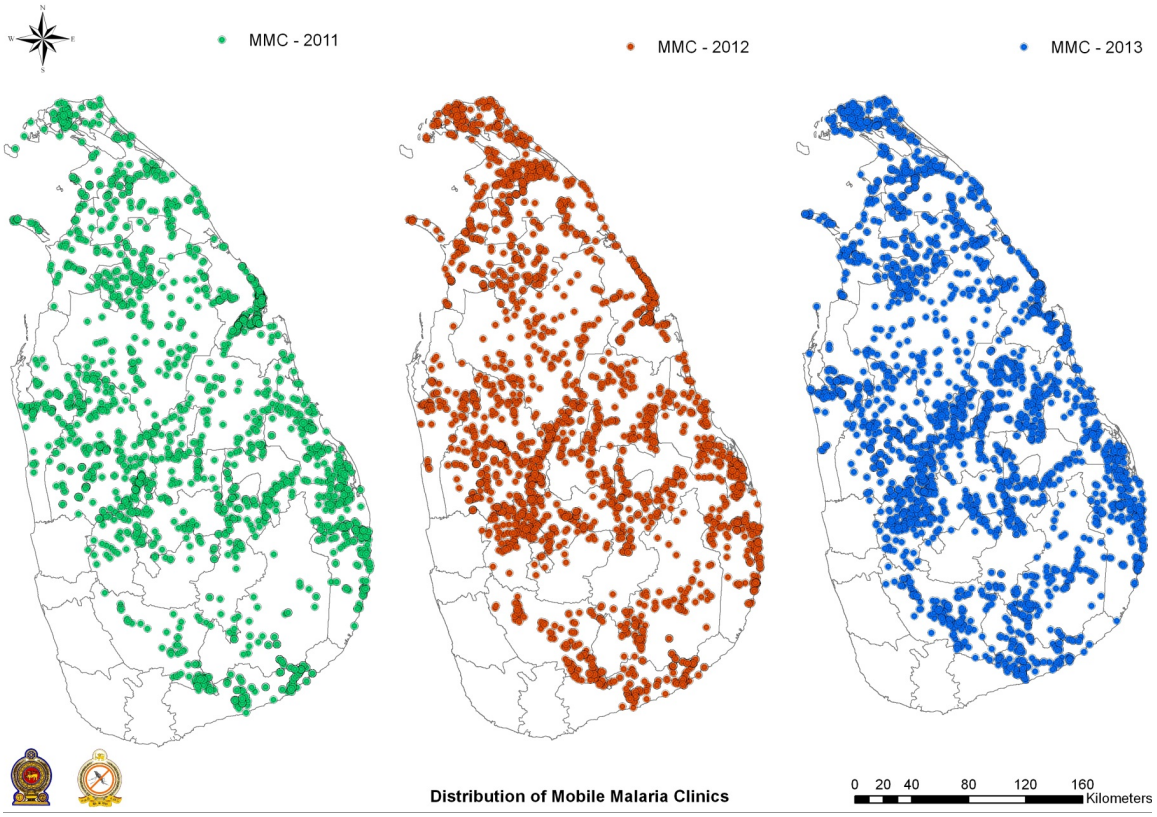


Figure 8. Distribution of TEDHA mobile malaria clinics, 2013

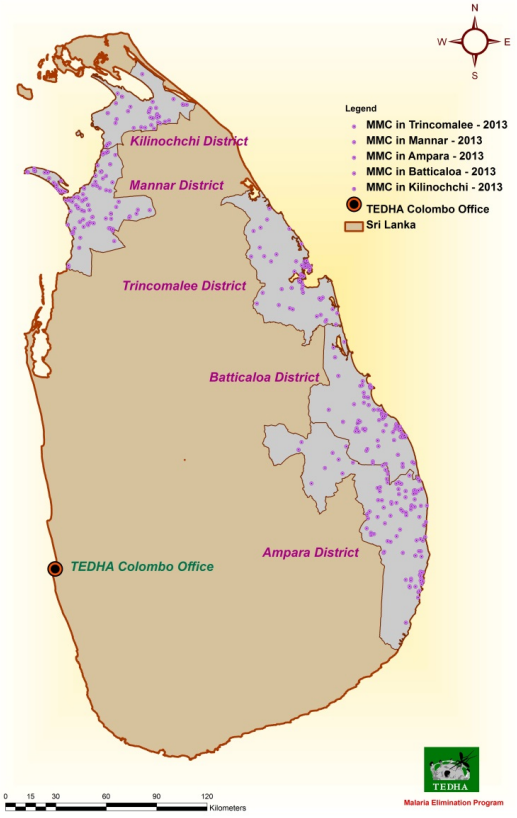
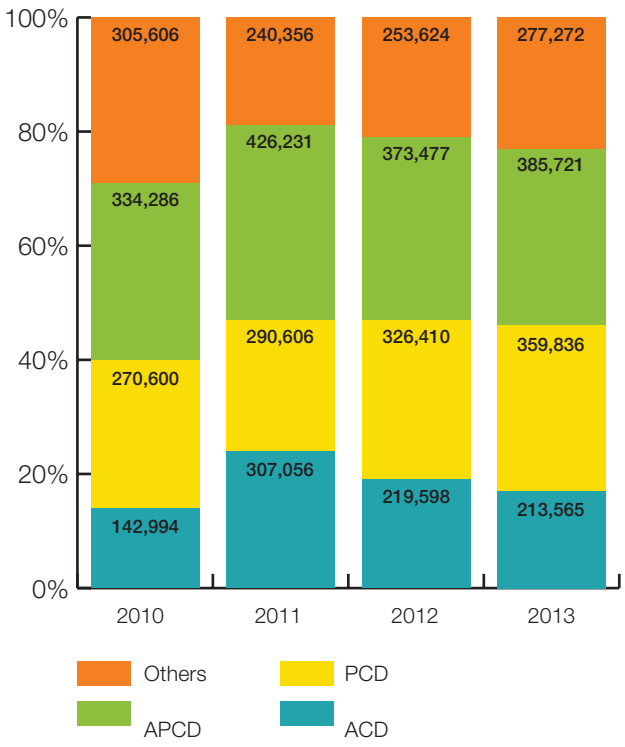


Figure 9. Active case detection at a TEDHA-operated mobile malaria clinic in Eastern Province

Figure 10. Screenings performed by AMC and TEDHA, 2010–2013



Note: 'Others' category includes routine screening of blood donor samples, pregnant women and selected populations

Figure 11. AMC staff collecting mosquitoes in a cattle-baited hut in the early morning

Figure 12. Cattle-baited net trap

Entomological surveillance

Entomological surveillance was routinely carried out during the period of review to monitor vector control activity and insecticide effectiveness. The AMC deployed 33 teams throughout the country, while 17 TEDHA teams worked in five districts in the northern and eastern provinces. Entomological surveillance techniques for adult mosquitoes included cattle baited net and hut traps, exit trap collections, insecticide spray sheet collections, and hand collections (Figures 11 and 12). Other activities done at regular intervals include: larval surveys to estimate larval densities; insecticide bioassays for IRS and LLINs; and insecticide susceptibility tests using wild caught mosquitoes.

Entomological surveillance was monitored in terms of entomological days, defined as conducting at least one entomological surveillance activity per day. Entomological surveillance activities conducted by the AMC in 2012 and 2013 are shown in Table 3. While most activities conducted during this period were funded by the Round 8 Global Fund grant, Provincial Councils funded additional days of entomological surveillance in some districts.

TEDHA has conducted entomological surveillance in a staggered manner in the districts of Ampara, Batticaloa, Mannar and Trincomalee through 15 teams since June 2010, and extended surveillance through an additional two teams in the Kilinochchi district from July 2012 to August 2014. TEDHA's entomological surveillance days for 2010–2013 are shown in Table 3.

Entomological surveillance data were channeled to the national AMC to guide program decisions on vector and larval control activities. While entomological surveillance continues, there is a paucity of information regarding optimal entomological surveillance in PoR phases in malaria control programs in tropical conditions. Sri Lanka has been using the entire gamut of traditional techniques described in the literature, which is costly; however, under the National Malaria Strategic Plan for Elimination and PoR 2014–2018, the AMC will develop a core set of optimal approaches for entomological surveillance and monitoring.

Table 3. Entomological surveillance days conducted by the AMC and TEDHA, 2010–2013

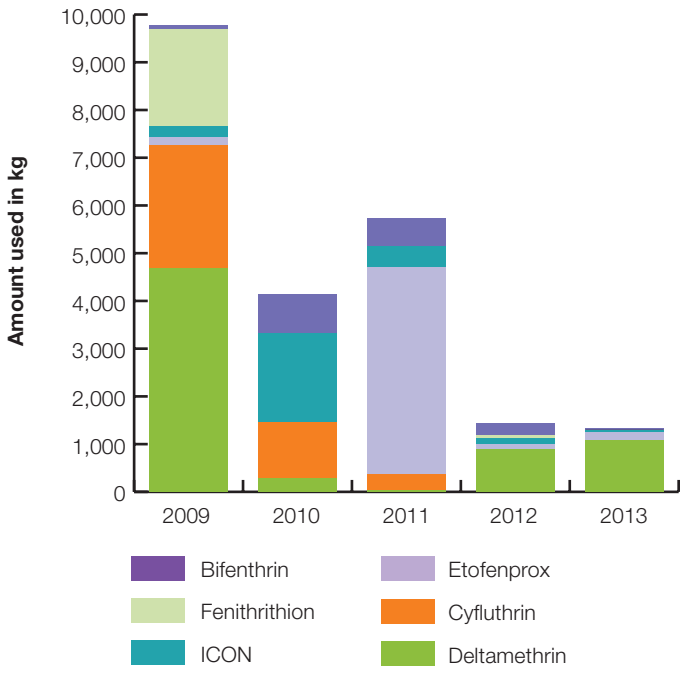
Year	AMC Ento Days*	TEDHA Ento Days	Total
2010		1,898	1,898
2011		3,404	3,404
2012	3,387	3,665	7,052
2013	4,082	4,047	8,129

*AMC data unavailable for 2010 and 2011

Vector control

Sri Lanka traditionally relied heavily on IRS as a vector control measure since the eradication era, but with the adoption of the WHO's Global Malaria Control Strategy of 1992, reliance on IRS gradually waned in favor of insecticide treated nets. The AMC implemented a spatial insecticide rotation approach to IRS in 1998, rotating through organophosphate and pyrethroid insecticides by geographic location in order to minimize the potential for resistance [9]. This rotation is still in place, although the use of insecticides for malaria control has dropped since 2009 (Figure 13). The relative rise in 2011 was a reaction to the increase in incidence in 2010 and the need to utilize the procured insecticides prior to their expiration.

Figure 13. Insecticide usage, 2009-2013



The AMC collaborated with Sarvodaya in the distribution of LLINs in targeted high risk areas and among vulnerable populations. During Phase 1 of the Global Fund Round 8 project, from October 2009 through September 2011, Sarvodaya distributed 97,241 LLINs in malaria endemic areas, including the North and East parts of the country. During Phase 2, from October 2011 to September 2014, 472,293 LLINs were distributed in malaria endemic areas throughout the country based on malaria receptivity and vulnerability. The areas and populations covered included high risk areas with high vector densities, difficult to reach areas, malaria foci in the last 5 years, and displaced populations.

Based on the current epidemiological situation, there is limited evidence and justification for use of IRS or LLINs when most of the cases are being reported in traditionally non-malarious areas. In addition, there is scant literature and international guidelines justifying the use of LLINs in the prevention of re-introduction phase of a malaria control program in a tropical setting. Under the new strategic plan, LLINs and IRS will be deployed focally in receptive areas and among vulnerable populations through an integrated vector management approach, informed by intensive entomological surveillance data. In addition, buffer stocks of LLINs and insecticides will be maintained for use in the event of an outbreak.

Larval control and environmental management

During the period under review, larval control was implemented in all malaria endemic areas using chemical and biological larviciding, informed by entomological surveillance data. Temephos has been applied in a variety of settings where use of larvivorous fish was not feasible. The use of larvivorous fish, primarily guppies (*Poecilia reticulata*), has been promoted in all malaria endemic districts. During Phase 1 of the Global Fund Round 8 grant, Sarvodaya constructed 22 tanks for larvivorous fish breeding in non-conflict and transitional areas. Fish breeding tanks were maintained in Regional Malaria Offices and in other centers with support from Sarvodaya. The AMC and volunteer organizations such as school health clubs directly applied larvivorous fish to sites where larval densities were high and conditions were conducive for fish survival. Targeted biological larval control will continue under the new strategic plan as part of the integrated vector management approach.

Sarvodaya has also been involved in filling abandoned gem pits, a major site of vector breeding. 2,505 gem pits in the Matale and Moneragala districts were filled during Phase 1, and 4,325 pits in the Hambantota, Matale, Moneragala and Ratnapura districts were filled during Phase 2.

Community engagement

The AMC was actively involved in raising community awareness and in community engagement during the period of review, together with Sarvodaya and TEDHA. Through its headquarters and regional offices, the AMC and the Medical Officers of Health regularly conducted awareness-raising programs to a wide range of audiences, including personnel from other government sectors, school children, and travel agents. In addition, the AMC raised awareness of malaria among the general public through print and electronic media.

Sarvodaya was instrumental in training volunteers and conducting village-level seminars on malaria prevention. The organization was responsible for erecting 60 hoardings and 50 bus shelters carrying malaria messages throughout the Global Fund Round 8 grant (Figure 14). Sarvodaya also printed a large number of posters, leaflets and other promotional material on malaria prevention, reaching hundreds of thousands of health workers and community members with malaria-related messages. In addition, TEDHA conducted some awareness-raising through their ACD surveillance activities. The AMC, Sarvodaya and TEDHA jointly organized regular, high-impact events in malaria endemic districts, including Malaria Day walks and special gatherings with the participation of local politicians, other stakeholders, and the general public.

Funding and technical assistance

In the past, Sri Lanka's malaria control program has benefitted immensely from funding partners including the Global Fund, USAID, WHO, and UNICEF. During the period of review, the Global Fund Round 8 malaria grant contributed significantly to the elimination drive. Likewise, government spending on malaria control has increased over the same time period (Table 4). The projected and actual funds spent by the government have remained constant in the years under consideration. The challenge for the AMC is to maintain funding until certification and beyond while competing with more visible public health threats such as dengue.

During the period of review, WHO provided technical assistance for the preparation of strategic plans for pre-elimination and elimination, funding proposals to the Global Fund, treatment policy changes, and specifications for the procurement of supplies and training of staff on elimination. WHO also provided expert insight on quality assurance. The total cost of this technical assistance is not available for documentation, however.

Figure 14. Bus shelter displaying Sarvodaya messaging for prevention and control of malaria

Next steps for preventing re-introduction

As Sri Lanka transitions to the PoR phase, the program faces several challenges that must be met in order to obtain malaria-free certification from WHO and maintain zero malaria transmission into the future [10]. The new National Malaria Strategic Plan for Elimination and Prevention of Re-introduction 2014–2018, recently finalized, takes these challenges into account and outlines strategies and activities to address them.

Screening for imported malaria

Because large areas of Sri Lanka remain both receptive and vulnerable to malaria transmission, importation is a major threat. Ports of entry (sea and air) as well as labor-intensive activities and areas that rely on overseas migrant workers, e.g. construction sites, free-trade zones, new sea ports and industrial parks, will be the focus of enhanced surveillance for malaria under the new strategic plan. The recently-adopted National Migration Health Policy of Sri Lanka [11] will be used to guide the policy and strategy adjustments needed to deal with the influx of foreign labor and migration from highly malarious neighboring countries, such as compulsory screening of migrant labor upon arrival.

Diagnostic services for all travelers are available at ports of entry on a voluntary basis, and mandatory malaria screening among refugees and service personnel returning from UN peace-keeping missions is a routine activity. Screening of migrant labour, refugees and returning UN peace-keeping forces has resulted in the detection of a number of imported cases when the AMC is informed in advance through official channels. Chemoprophylaxis is also available at the two international airports, free of charge for travelers visiting malaria endemic countries. However, the uptake has been poor with only 1,784 travelers availing of this service in 2013. The new strategic plan outlines approaches to improve uptake, including awareness-raising programs among the public, key government sectors, and the travel industry.

Table 4. Actual and projected expenditures for malaria control in Sri Lanka, 2012–2017

Source of Funding	Actual funds spent (US $)			Projected funds (US $)		
	2012	2013	2014	2015	2016	2017
Government spending*	3,265,175	3,629,955	5,060,546	5,487,360	6,116,084	6,765,291
Global Fund support**	2,906,586	3,129,799	3,724,106	9,600,000		
Total budget for malaria control	6,171,761	6,759,754	8,784,652	27,968,735		
Total Government spending on health	758,116,585	841,509,409	934,075,444	1,036,823,743	1,150,874,355	1,277,470,534
% of health budget allocated for malaria	0.43	0.43	0.54	0.53	0.53	0.53

* Based on data published by the Central Bank of Sri Lanka (www.cbsl.gov.lk)
** Global fund support amounting to USD 9.6 million has been requested for the period October 2014-2017; for simplicity, this amount has been allocated to 2015-2017 projected funds.

Sustaining entomological surveillance
Entomological surveillance will be key for assessing receptivity during PoR. *An. culicifacies*, the principal vector of malaria in Sri Lanka, has been detected in all parts of the country. In the past, sudden increases in the adult densities of *An. culicifacies* have resulted in major epidemics. Keeping *An. culicifacies* adult densities well below threshold levels for transmission and proactively using vector control interventions in the event of density increases are critical for preventing re-introduction of malaria. Entomological surveillance is labor-intensive and time consuming. Thus, identifying and adopting the optimal techniques and entomological metrics is essential for maintaining surveillance and intensified vigilance in well-defined risk areas. In the future, broadening the scope of entomological surveillance activities to encompass other vector borne diseases may become necessary. However, at this critical juncture, entomological surveillance for malaria should be carried out as a dedicated activity until such time when techniques and metrics are optimized to generate reliable and accurate receptivity maps.

Improving diagnostic uptake
Although there have been no deaths due to indigenous malaria since 2007, the number of severe malaria cases has increased significantly (12 out of 95 imported cases in 2013 were severe), primarily a result of delayed diagnosis and treatment [10]. The uptake of diagnostics by clinicians has been poor in recent years, despite their widespread availability. Because cases are now so rare, malaria is no longer routinely considered in the differential diagnosis of patients who present with fever at health facilities. A sustained effort to convince clinicians to refer fever patients for malaria diagnosis has already been made through communication with professional associations and colleges, and the AMC and Sarvodaya have conducted awareness-raising activities among clinicians directly. This strategy will be scaled up under the new strategic plan for PoR.

Engaging the private sector
Malaria has been a notifiable disease since 1961, yet convincing the private sector to routinely report malaria cases to the national public health surveillance system remains a major challenge. Attempts have been made to engage the private sector through the establishment of focal points at the AMC and at private sector institutions; a dedicated medical officer at AMC headquarters will directly liaise with assigned officers at private sector institutions.

As private sector engagement continues to build, there is an indirect way of ensuring that all malaria cases are reported to the AMC: all health facilities, both public and private, must obtain antimalarial drugs through the AMC, as it is the sole importer of artemether/lumefantrine in the country. Private pharmacies in Sri Lanka do not currently stock or sell antimalarial drugs—they have little incentive to market them since malaria has become such a rare disease.

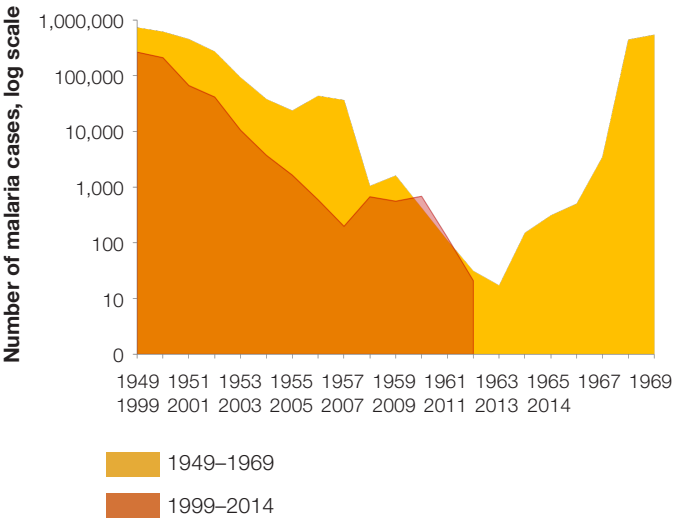
Because the private sector tests patients for malaria, engagement is also necessary for quality assurance of diagnostic services. Training of private sector microscopists and engaging them in accreditation programs will facilitate their engagement during the PoR phase. Since 2012, the AMC has conducted training courses on malaria diagnosis, including both microscopy and rapid diagnostic tests, for medical laboratory technicians from major private hospitals free-of-charge. In addition, the AMC has initiated the establishment of an accreditation system for microscopists with assistance from the Asian Collaborative Training Network for Malaria (ACTMalaria). In the new strategic plan for PoR, this system will be extended to the private sector.

Maintaining human resources and building capacity
Maintaining a competent work force into the future remains a major challenge for the AMC. The PoR phase of a malaria control program requires trained personnel and capacity to meet any eventuality, particularly in the event of an outbreak. It requires re-defining roles of personnel and their scopes of work necessary to meet the requirements of the new strategies that will be adopted. In 2013, the AMC revised its cadre requirements in light of the move toward PoR, but more work needs to be done to realign and re-define scopes of work for existing staff and newly created cadre positions. This is a priority activity identified in the new strategic plan, as is the provision of annual in-service training courses for all staff.

AMC operating as a vertical program
Sri Lanka's recent experience with an unsuccessful leprosy elimination drive serves as a stark reminder that proposals for integration of malaria control activities with the general health services or with any other disease control program must be carefully evaluated before being implemented. In 1996, Sri Lanka reached the leprosy elimination target stipulated by the World Health Organization of less than 1 case per 10,000 population. Thereafter, supported by eloquent policy arguments and a seemingly sound structural basis for integration, district level anti-leprosy services were integrated into the general public health services in 2001/2002. The vertical infrastructure of the leprosy control program was dismantled and case detection and case management activities were entrusted to Dermatologists, while contact tracing became the responsibility of general public health services staff [10]. The focus of the control program was severely derailed through a lack of leadership and ownership, which facilitated the resurgence of leprosy.

Maintaining political and financial commitment
With a decrease in the malaria case load there is always the tendency to divert resources and funds from malaria control to other disease control programs such as dengue, which is currently the most important communicable disease problem in Sri Lanka. Although elimination of malaria has been a focus of the national development agenda, remaining malaria-free must be a high priority in future agendas to ensure ongoing allocation of adequate resources. In order to ensure continued political and financial commitment, the AMC plans to conduct a cost benefit study showcasing the economic advantages of malaria elimination as compared to the costs of malaria resurgence and its control. In addition to this study, using the example of continuous immunization program funding when a vaccine-preventable disease burden is low or zero may help to convince policy makers that funding PoR is a worthwhile investment that will reap rich dividends for years to come.

Figure 15. An opportunity not to be missed—comparison of current malaria situation with that in the 1960s



Conclusion

Sri Lanka has achieved a laudable outcome in maintaining prevention of re-introduction of indigenous malaria transmission for almost two years, a goal that was elusive and which failed fifty years ago. The reasons for this may be manifold; it is likely that factors other than preventive actions taken by the AMC may have contributed to this situation. Factors such as general improvement of socioeconomic and living standards of the population, high national literacy levels, female education and empowerment, and improvement and accessibility of health care services through a free health service are likely to have contributed to this success. Nevertheless, the trajectory of malaria cases from 1999–2012 mimics the trend observed from 1949–1962 (Figure 15). With the political and financial commitment endorsed by the government, the globally-recognized expertise available in the country, and continuation of international funding, Sri Lanka is likely to sustain malaria-free status and be eligible for WHO certification in 2015, despite the enormous threat of being surrounded by malarious countries. The challenge lies in preventing re-introduction in a tropical setting in the absence of a global strategy and context-specific guidelines. The Sri Lankan experience may serve as a framework for formulating necessary guidelines for malaria elimination in the future.

Appendix: Incidence of malaria cases by district and type of transmission, 2009–2013

District	INDIGENOUS															IMPORTED													
	2009			2010			2011			2012			2013			2009			2010			2011			2012			2013		
	+VES	*P.v.*	*P.f.*	+VES	*P.v.*	*P.f.*	+VES	*P.v.*	*P.f.*	+VES	*P.v.*	*P.f.*	+VES	*P.v.*	*P.f.*	+VES	*P.v.*	*P.f.*	+VES	*P.v.*	*P.f.*	+VES	*P.v.*	*P.f.*	+VES	*P.v.*	*P.f.*	+VES	*P.v.*	*P.f.*
Colombo	1	1		4	3	1										7	4	3	29	18	11	30	25	5	15	12	3	19	11	8
Gampaha																2	2		6	3	3	6	4	2	7	3	4	32	20	12
Kalutara																			1	1					3	1	2	7	4	3
Kandy	4	4		1		1										5		5	1		1	3	2	1	3		3	5	3	2
Matale				1		1										2	1	1				2	2					1	1	
N' Eliya																									1	1				
Galle																1		1	1	1		1	1		1		1	2		2
Matara																									1	1				
Hambantota	88	86	2	89	88	1	13	10	3	2	1	1																2	1	1
Jaffna	9	9		4	3	1	1	1		4	3	1				3	2	1	2	1	1	1		1	19	2	17	3	1	2
Kilinochchi	99	94	5	86	84	2	13	13		2	2								1		1	1	1		1		1	4	3	1
Vavuniya	40	39	1	75	74	1	24	24		3	3					1	1								3	1	2	1	0	1
Mannar	29	27	2	101	98	3	23	23		1		1																1	1	
Mullativu	120	118	2	176	175	1	43	42	1	8	8														2	1	1			
Batticaloa	5	5		2	2											1	1		1	1		2	2		6	1	5			
Ampara	5	4	1	9	9																							1		1
Kalmune																1	1		4	4					2	1	1	3	2	1
Trincomalee	10	9	1	6	6		2	2		1		1				1		1	2	2					2		2	1	1	
Kurunegala	4	3	1																1		1	1	1		1		1	1	1	
Maho	2	2		2	2																									
Puttalam	3	3		4	4											1	1		1	1					1	1		3	1	2
Anuradhapura	7	7		22	19	3										1		1	1	1								2	1	1
Polonnaruwa	3	3		6	5	1	2	1	1													1		1	1		1	1	1	
Badulla	2	1	1	3	3																				1	1		1		1
Moneragala	97	97		93	93		3	3		2	2																	1		1
Ratnapura	2	2																				3	1	2				3		3
Kegalle	1	1														1	1		1	1								1		1
Total	531	515	16	684	668	16	124	119	5	23	19	4	0	0	0	27	14	13	52	34	18	51	39	12	70	26	44	95	52	43

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