Elimination of malaria from Sri Lanka and beyond; lessons for other countries in elimination phase

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Abstract
Elimination of malaria in 2012 was a major achievement in post-independent Sri Lanka. Sri Lanka missed a golden opportunity in 1963 when only 17 cases of malaria were reported in the country, but could not sustain the momentum resulting in a major resurgence in 1967/69. With the resurgence, the then malaria eradication programme was reverted back to a control programme that lasted for another 30 years. The WHO’s Roll Back Malaria Initiative launched in 1998 provided a renewed interest in malaria control and subsequent elimination. With targeted control activities, the burden of malaria started to decrease since year 2000. Although Sri Lanka had reached pre-elimination status as early as 2004, the ongoing separatist war at that time prevented a country-wide elimination drive being implemented. With cessation of hostilities in 2009 and Global Fund financing, both of which were crucial inputs, an elimination drive was launched in September 2009 which eventually eliminated indigenous malaria in November 2012 with malaria-free certification by WHO being obtained in September 2016. Since malaria elimination, the country forged on to the prevention of re-establishment phase primarily focusing on good public health practice that included intensified surveillance, both parasitological and entomological; quality assured diagnostic and treatment services; and advocacy at various levels including doctors. Despite these measures, an introduced case and a transfusion induced case of malaria have been reported. A new vector of urban malaria, *Anopheles stephensi*, was reported in December 2016. Prevention of re-establishment of malaria should be kept in the radar of public health until malaria is eradicated.

Introduction
Post-independent Sri Lanka has achieved many important milestones in the health sector. Sri Lanka is a leader in delivering excellent healthcare at minimal cost. Compared to countries in the region and those with similar economies, Sri Lanka stands tall in its health-related achievements which are comparable to developed high income countries. Sri Lanka has completely eliminated polio, malaria, congenital rubella syndrome, neonatal tetanus, and mother-to-child transmission of HIV; in addition, the country has eliminated measles, rubella, filariasis and leprosy as a public health problem [1].

The elimination of malaria is one of its greatest achievements as it was done without any vaccine but with good public health practice. This was achieved after over 100 years of organized malaria control activities which started with the establishment of the malaria unit in Kurunegala in 1911 and a previous missed opportunity in 1963 when only 17 cases were reported in the country, of which, only six cases were indigenous due to local transmission; it took another 50 years to finally eliminate the disease [2]. The last indigenous case of malaria was reported in October 2012 and Sri Lanka was certified as malaria-free by the WHO in September 2016. The country remains receptive to malaria as vectors incriminated for malaria transmission are prevalent in large parts of the country, especially in previously malarious areas.

The purpose of this manuscript is to document the experiences of Sri Lanka in malaria elimination and prevention of its re-establishment which may be important lessons for other countries in the region and elsewhere that are targeting elimination.

Historical perspectives
It is believed that malaria was introduced into the country from South India during frequent invasions and subsequent damage to the extensive irrigation network in the country which resulted in establishing vector breeding
sites in an environment conducive to vector longevity and the sporogonic cycle of the parasite in the mosquito. It is recorded in the Mahavamsa, the ‘Great Chronicle’, that repeated foreign invasions causing destruction of irrigation systems from 300 A.D. have been followed by the changing of the ancient capital cities due to a “depopulating sickness” [3]. During Dutch occupation in the 17th century, a “fever pestilence” led to depopulation of the southern part of the country [4].

The world-famous malaria epidemic in 1934-35 where over 1.5 million cases of malaria and 80,000 deaths due to malaria in a population of about 5 million were reported during a nine-month period was described by Gill as the greatest pestilence in the recorded history of the country [5]. Following the epidemic, quinine prophylaxis was started and, in 1945, indoor residual spraying was introduced first on a limited scale and then extended to other areas. In 1958, Sri Lanka embarked on a malaria eradication programme that culminated in only 17 cases being reported in 1963, and a resurgence from 1967-1969 during which time it has been estimated that 1.5 million people contracted the disease [6]. After the resurgence, the country moved back into a control phase. In 1993, the control strategy was changed where early detection and prompt treatment, and targeted vector control were focused on following the global Ministerial Conference on Malaria to draw up a global strategy for a renewed attack on malaria given the deteriorating global situation of malaria [7].

In 1998, WHO’s Roll Back Malaria Initiative was rolled out and Sri Lanka adopted the intensified strategy. Since 1999, a marked reduction in malaria was seen in the country (Table 1). Even though Sri Lanka had achieved pre-elimination status by 2004/05 (<1 case per 1000 population as reflected by the Annual Parasite Incidence (API)), based on WHO guidelines at that time, the country was not in a position to plan for elimination because of the ongoing separatist war in the North and East of the country.

In 2008, Sri Lanka embarked on a pre-elimination phase after making a strategic change in treatment policy with Artemisinin-based Combination Therapy (ACTs) being made the first line drug for the treatment of *P. falciparum* malaria and classifying cases as indigenous and imported. With funding from the Global Fund to fight AIDS, Tuberculosis and Malaria (GFATM), Sri Lanka continued in the pre-elimination phase in September 2009, the Anti Malaria Campaign partnering with 2 other principal recipients of the Global Fund Grant, namely Sarvodaya, a prominent community based non-governmental organization in Sri Lanka, and Tropical and Environmental Diseases and Health Associates (TEDHA), a private sector organization [8]. The objectives of the elimination programme were to interrupt local transmission of *P. falciparum* by the end of 2012 and that of *P. vivax* by end 2014 through intensified surveillance [3]. In 2011, the national programme entered the elimination phase [3] with the last indigenous case being reported in October 2012, well ahead of the original target of end 2014.

**Factors contributing to the success of the elimination drive**

The single most important factor that contributed to the success of the malaria elimination drive was the end of the separatist war in May 2009. The end of the separatist war opened up areas for intensified surveillance that were previously restricted in the North and East of the country. During the pre-elimination and early elimination phase most of the cases were reported from the war-torn areas of the country [3].

GFATM funding for the pre-elimination and elimination phases were crucial to galvanise support from other stakeholders such as the private sector and community based non-governmental organisations who were better suited to fill the void in state sector services in a timely manner in areas previously devastated by the war. These organisations established services in these areas which were later absorbed by the public health services [3].

Funding from the Global Fund post-elimination up to end 2021 ensured the gradual transition of the programme; this transition included a programme transition and a financial transition that the Government of Sri Lanka (GoSL) was able to accommodate over a period of time. This was achievable due to conditions imposed by the Global Fund for continuing performance-based financing [9]. GFATM funding was provided to accommodate services and personnel that could not be included under government funding or budgets such as recruiting staff grades like surveillance officers and Geographic Information Systems (GIS) experts, and for training and extension of entomological surveillance [9].

**The last mile**

With the end of the separatist war in 2009, most of the cases were reported from war torn areas and among armed forces personnel. After the war, the armed forces personnel were stationed in different parts of the country and were responsible for initiating foci of transmission in receptive areas. A major strategy that was then initiated was to keep military personnel who were diagnosed with malaria within the camp until radical cure of malaria was completed [3]; previously such personnel were given treatment and sick leave which they spent visiting their homes in different parts of the country, some of which were very receptive for malaria transmission.

A persistent focus of transmission emerged along a 16-kilometre stretch on the banks of the ‘Menik’ river in the Hambantota and Moneragala districts with deployment of military personnel, who had served previously in war affected areas, in small camps to keep vigilance on possible separatist cadres hiding in the Yala jungle just after the cessation of hostilities [3]. Most of the last few cases were reported from this focus.
### Table 1. Malariousm indices in Sri Lanka 1999-2012

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Number examined</th>
<th>Total</th>
<th>Positive</th>
<th>P.vivax</th>
<th>P.falciparum</th>
<th>Other</th>
<th>Mixed infections</th>
<th>Deaths</th>
<th>API</th>
<th>ABER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>18,754,185</td>
<td>1,582,111</td>
<td>264,549</td>
<td>200,671</td>
<td>62,679</td>
<td>1,199</td>
<td>102</td>
<td>14.106</td>
<td>8.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>18,941,730</td>
<td>1,781,372</td>
<td>210,039</td>
<td>150,389</td>
<td>57,915</td>
<td>1,735</td>
<td>76</td>
<td>11.089</td>
<td>9.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>19,131,147</td>
<td>1,353,386</td>
<td>66,522</td>
<td>55,922</td>
<td>10,241</td>
<td>359</td>
<td>53</td>
<td>3.477</td>
<td>7.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>19,007,000</td>
<td>1,391,386</td>
<td>41,411</td>
<td>36,563</td>
<td>4,661</td>
<td>187</td>
<td>30</td>
<td>2.179</td>
<td>7.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>19,252,000</td>
<td>1,192,259</td>
<td>10,510</td>
<td>9,237</td>
<td>1,198</td>
<td>75</td>
<td>4</td>
<td>0.546</td>
<td>6.2</td>
<td></td>
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<tr>
<td>2004</td>
<td>19,502,098</td>
<td>1,198,181</td>
<td>3,720</td>
<td>3,171</td>
<td>500</td>
<td>49</td>
<td>1</td>
<td>0.191</td>
<td>6.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>19,668,000</td>
<td>973,861</td>
<td>1,640</td>
<td>1,506</td>
<td>94</td>
<td>1 (Po)</td>
<td>39</td>
<td>0.083</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>19,686,000</td>
<td>1,076,121</td>
<td>591</td>
<td>564</td>
<td>18</td>
<td>9</td>
<td>0</td>
<td>0.030</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>20,159,641</td>
<td>1,044,115</td>
<td>198</td>
<td>191</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>0.010</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>20,217,000</td>
<td>1,047,104</td>
<td>670</td>
<td>623</td>
<td>29</td>
<td>1 (Pm)</td>
<td>17</td>
<td>0</td>
<td>0.033</td>
<td>5.2</td>
<td></td>
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<tr>
<td>2009</td>
<td>20,460,000</td>
<td>909,632</td>
<td>558</td>
<td>529</td>
<td>21</td>
<td>8</td>
<td>0</td>
<td>0.027</td>
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<td>2010</td>
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<td>1,001,107</td>
<td>736</td>
<td>704</td>
<td>17</td>
<td>5</td>
<td>0</td>
<td>0.036</td>
<td>4.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>20,653,000</td>
<td>994,546</td>
<td>175</td>
<td>158</td>
<td>12</td>
<td>5</td>
<td>0</td>
<td>0.008</td>
<td>4.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>20,263,723</td>
<td>948,250</td>
<td>93</td>
<td>45</td>
<td>42</td>
<td>2 (Po)</td>
<td>4</td>
<td>0</td>
<td>0.005</td>
<td>4.7</td>
<td></td>
</tr>
</tbody>
</table>

1 Po refers to *Plasmodium ovale*; Pm refers to *Plasmodium malariae*.

2 API refers to Annual Parasite incidence; number of malaria cases reported per 1000 population.

3 ABER refers to Annual Blood Examination Rate; percentage of population examined for malaria.

Source: Adapted from the report “Malaria Elimination in Sri Lanka: National report for WHO certification” [2]
Access to these camps was a major barrier to interruption of transmission in the country. The then Regional Malaria Officer adopted innovative strategies to control the epidemic. As access was difficult, she taught the service personnel how to control breeding of *An. culicifacies*, the principal vector of malaria in the country, along the edges of the river, a preferred breeding site of the vector, by application of the chemical larvicide Temephos [3]. Health education was also provided and rapid diagnostic test kits and treatment provided with instructions on its administration. The focus was finally cleared after 22 months.

**Strategies used in pre-elimination, elimination and prevention of re-establishment of malaria phases**

During the elimination and prevention of re-establishment of malaria phase, the key strategy was intensified surveillance. This involved immediate notification by telephone, case investigation and response within 5 days [10, 11]. This system was linked with the private health sector from where many of the malaria cases were notified. The link was established to ensure that no cases were missed. It took a lot of effort and the Anti Malaria Campaign (AMC) provided training to private health sector personnel on microscopy and regular updates on malaria.

Once the AMC was notified of a case by the private health sector, the AMC confirmed the diagnosis using microscopy, rapid diagnostic tests (RDTs) and polymerase chain reaction (PCR) testing and the species was identified. AMC provided directly observed treatment that was based on National Treatment Guidelines and administered after hospital admission [12]. With the dwindling number of malaria cases since about the early part of the first decade of this century, the private sector did not carry antimalarial medicines in their inventory as it was not profitable; this made the AMC the sole importer of antimalarials which greatly contributed to the elimination effort as possible counterfeit medicines were eliminated from the market [3].

The AMC provided quality assured diagnostic and treatment services. All malaria commodities were prequalified by the WHO. Regular cross checking of blood smears and RDTs ensured accuracy of diagnoses [3]. Public Health Laboratory Technologists (PHLTs) were regularly evaluated, both internally and externally, and provided refresher in-service training, if needed. The AMC followed WHO guidelines on pre-elimination, elimination and prevention of re-establishment of malaria programmes.

The transitioning from pre-elimination to elimination to prevention of re-establishment of malaria phases led to malaria becoming a “forgotten disease”. Doctors failed to elicit a travel history and did not consider malaria in the differential diagnosis of fever. Some patients were accidentally identified by blood picture examination [13]. Even some Public Health Laboratory Technologists (PHLTs) (microscopists) had not seen a malaria parasite under the microscope for many years; blood smears are cross checked by experienced PHLTs and regular training programmes are conducted by the AMC to ensure that their diagnostic skills are maintained. For doctors, regular updates are carried out in collaboration the professional and clinical associations, and colleges. When diagnosis of a patient has been missed by a clinician, (s)he is informed of the error; when a diagnosis has been made correctly without delay, the clinician is commended.

A subcommittee of the Technical Support Group (TSG), a committee appointed and chaired by the Director General of Health Services established in 2012 to advise the AMC on prevention of re-establishment of malaria in Sri Lanka, reviews all cases and classifies them. The Technical Support Group comprises independent experts from the academia and other institutions in addition to key members of the Ministry of Health and functions independently [14]. The TSG has been able to keep re-establishment of malaria in the radar through advocacy for political and financial commitment; it also has guided and collaborated with the AMC in carrying out important operations research which have contributed to the global literature on prevention of re-establishment of malaria as very few tropical countries have achieved elimination within the last two decades.

**Implementation of anti-malarial activities**

Prior to the enactment of the 13th amendment to the second republican constitution of Sri Lanka, health services, including the AMC which functioned as a vertical programme, were considered under the central government administered line ministry of health. With devolution of power, the health sector came under the Provincial Health Authority. Despite this transition, the Anti Malaria Campaign Headquarters (AMCHQ) in Colombo provided technical guidance for antimalarial activities; still all Regional Malaria Officers were linked to AMCHQ as a vestige of the vertical programme that ensures a coordinated approach throughout the country for elimination and beyond to prevention of re-establishment of malaria.

Maintaining the organizational structure of the AMC was critical in detecting *An. stephensi*, an urban vector of malaria in neighbouring India and a potential threat to prevention of re-establishment of malaria in the country [15], and in mounting a rapid and effective response when the introduced case was reported [10]. While there are arguments to incorporate antimalarial activities with the general public health services of the country, this structure has proved useful in maintaining Sri Lanka malaria-free for over a decade. A previous analysis has shown that eliminating malaria and maintaining Sri Lanka malaria-free has a 13:1 return on investment [16]. Currently, some Regional Malaria Offices also engage in dengue control.
activities, thus, further reducing the government contribution towards antimalarial activities.

Risk groups

Since the elimination of malaria in the country, major risk groups for imported malaria have been identified. Most imported malaria infections reported in Sri Lanka have been among Sri Lankan travelers who have visited malaria endemic countries [17]. Some occupational groups include persons engaged in various businesses, gem traders, fishermen, seafarers, military and police personnel engaged in UN peacekeeping missions in malaria endemic countries, pilgrims, and migrant workers. Among foreign nationals, tourists, migrant labour from malaria endemic countries and refugees pose the biggest threat [17].

The AMC has identified these risk groups and has established a close rapport within these communities. For example, among gem traders in Beruwala and Eheliyagoda, who frequently visit Africa on business, there exists a link with the AMC by which information is passed onto the AMC. The AMC offers them free diagnostic and treatment services and provides them with chemoprophylaxis before travel.

The AMC has established close links with other sectors as well. With the armed forces and the police department, close links are maintained; the military medical corps inform the AMC about movements of returning troops from overseas and permit the troops to be screened for malaria. Links have been established with the Buddha Sasana Ministry and travel agents targeting Buddhist pilgrims visiting India; here, the focus is on preventing being bitten by mosquitoes and using chemoprophylaxis which is provided free of charge by the AMC.

Introduced case of malaria

In December 2018, two years after malaria-free certification, a single malaria infection due to local transmission was detected in a male residing in Colombo who had never travelled overseas [10]. He had visited a construction site, that had employed Indian labour, in Moneragala district in the Uva province 12 days earlier and stayed overnight. Subsequently, one of the Indian workers at the same construction site developed fever and was diagnosed as having a \( P. vivax \) infection. Eliciting the visit to the construction site enabled the AMC to detect a possible connection between the two cases [10].

An immediate focused response was launched that included intensified entomological surveillance, reactive case detection and widespread vector control that included indoor residual spraying and distribution of long-lasting insecticidal nets. Circulars were issued immediately by the Director General of Health Services requesting all hospitals in the adjoining areas to test all fever patients for malaria and requesting other agencies such as the Police department and other institutions for assistance; literally, a state of health emergency was promulgated [10]. The success of the operation was that it did not lead to any further infections. All foreign workers at the site were radically treated for malaria [18].

Case of transfusion induced malaria

In 2021, a 16-year-old student in Polonnaruwa, who had never been overseas, was detected with malaria [19]. He revealed that he received a blood transfusion a few days back. On further probing, it was revealed that the donor was a military serviceman who had returned from duty in an UN peacekeeping mission in Africa 3 months earlier. The donor had been screened on arrival but not followed up. It also transpired that this infectious blood was also missed by the Blood Bank during its regular screening for malaria. Both the donor and the introduced case were treated based on national treatment guidelines [19].

Malaria during the COVID pandemic

The COVID pandemic provided some relief in terms of reducing the importation risk of malaria due to an embargo on international travel, but brought in fresh challenges in terms of conducting routine prevention of re-establishment of malaria activities due to lockdowns and, fuel and internal travel restrictions which continued even beyond the pandemic into the economic crisis that followed. The controlled international travel during the initial stages of the pandemic and the quarantine regulations made it possible for the AMC to identify travellers from malaria endemic countries and screen them while in quarantine centres. All travellers from malaria endemic countries were followed up later. Despite the difficulties in investigating cases, entomological surveillance and vector control activities were carried out around quarantine centres located in receptive areas.

Lessons learned

Given the high receptivity and potential risk of importation of malaria into the country that is envisaged with the increased travel following the COVID pandemic, it is clear that there is a chance of malaria infections falling through the net even with a very good surveillance system as was evident in the detection of an introduced case and a transfusion induced case. The major factor that prevented the re-establishment of malaria after the detection of the introduced case was the targeted rapid response that ensued. Even our experiences during the COVID pandemic highlights the importance of response which is part of good public health practice, the foundation for which was laid in Sri Lanka in 1926 with the establishment of the concept of “health unit” in Kalutara.

Future challenges

Maintaining a rigorous surveillance programme is challenging. Medical practitioners have to be alert to the
possibility of re-establishment of malaria as they are the first contacts of patients within the health system. Likewise, maintaining quality of diagnostic services with so few cases being detected is another challenge to obtain funding for training programmes for a disease that has been eliminated from the country. In addition, the malarial expertise in the country needs to be ensured to deal with an unexpected resurgence as what happened in Europe in the late 1980s and early 1990s with the re-establishment of malaria in some countries during which there was a lack of technical expertise.

Political and financial commitment by the government is another challenge to sustain the prevention of re-establishment of malaria programme given competing interests and the financial crunch that the country is facing today. Integrating with other vector borne disease control programmes may be a way out.

The organizational structure and implementation plan of prevention of re-establishment of malaria activities need to be restructured in the future. In doing this, it should be borne in mind that malaria needs to be in the radar of public health priorities and prevention of re-establishment of malaria activities have to be carried out in the country until malaria is eradicated, to prevent déjà vu of 1963 when malaria was almost eliminated. Vertical programmes require more resources and need to coordinate with other disease control programmes; however, there is accountability with a dedicated budget and resources. Sri Lanka’s experience with integrating vertical disease control programmes with general public health services has not been very successful [24]. In 1996, Sri Lanka reached the leprosy-elimination target stipulated by the World Health Organization, of less than one case per 10,000 population, and, thereafter, supported by eloquent policy arguments and a seemingly sound structural basis for integration, district-level anti-leprosy services were integrated into the general health services in 2001/2002 [24]; this move is likely to have delayed elimination of transmission of the disease with the new case detection decreasing only after about another 15 years probably due to the integration being too premature with a dearth of dermatologists in the country. Integrated services are likely to be more cost effective but their focus may change depending on the needs of the health system which is then likely to make eliminated diseases lose their focus; in addition, there is no accountability and focus, and decisions are likely to be based on political influence.

Take home message

Eliminating and preventing the re-establishment of malaria have had major impacts not only on the health of its citizens but also on the economy. It has been reported that malaria has resulted in lower cognitive levels of children at school entry, school absenteeism and loss of productivity [21-24]. In a broader perspective, elimination of malaria has resulted in access to tourism in previously malarious areas that have an archeological value; there have been no travel advisories regarding malaria for tourists in the recent past with no requirement for chemoprophyaxis. It has also been reported that malaria elimination did not cost more than malaria control in Sri Lanka [9]. Sri Lanka maintaining malaria-free status is likely to have benefits for the future generations of our country; it is the duty of policy makers and administrators to ensure that it is achieved or be ever accountable for its failure.

Funding
None.

Conflicts of interest
None.

References


