THE STORY OF

0

Malaria-Free Sri-Lanka

MINISTRY OF HEALTH, NUTRITION & INDIGENOUS MEDICINE
Sri Lanka

World Health Organization
REGIONAL OFFICE FOR South-East Asia

The story of

Malaria-Free Sri-Lanka

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Foreword

This report describes one of the most important of all recent regional and global health achievements – the elimination of malaria in Sri Lanka. The country has grappled with the scourge of malaria since ancient times. However, Sri Lanka has reported no indigenous cases of malaria for the past four years, and in 2016, the World Health Organization certified the country as malaria-free.

An achievement of this magnitude is by itself a cause for celebration, but Sri Lanka's experience also highlights especially important lessons for the push in South-East Asia to eliminate malaria. Sri Lanka experienced numerous disappointments in its malaria control efforts, leading to a resurgence of the disease at several points over the past century. Yet, in the face of these disappointments, Sri Lanka did not abandon its malaria control efforts.

A key transition in Sri Lanka's successful fight against malaria occurred when the country coupled its historic investments in vector control with an equally robust commitment to prompt diagnosis and treatment of malaria cases. Strengthened surveillance and case follow up contributed to the elimination of malaria in Sri Lanka and will continue to play a pivotal role in preventing a re-emergence. Sri Lanka also overcame considerable challenges to malaria control, including a lengthy spell of civil unrest in the North which lasted almost three decades.

Of particular value to other countries, this case study also describes the transition in Sri Lanka's approach from malaria control to malaria elimination. In its successful move to eliminate malaria, Sri Lanka intensified its efforts to use surveillance to focus on a combination of prevention and treatment approaches on the communities and populations with the greatest need.

The intensified, data-driven, combination approach that led to elimination of malaria in Sri Lanka is precisely the approach recommended in WHO's Global technical strategy for Malaria 2016–2030, adopted by the World Health Assembly in May 2015. It is our hope that colleagues and partners both in South-East Asia and in other regions will take on board the important lessons of Sri Lanka's malaria elimination efforts. By doing so, we can move closer to a malaria-free region and to a world in which malaria is no more a public health threat.

Hon. Dr. Rajitha Senaratne
Minister of Health, Nutrition and Indigenous Medicine
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Abbreviations

ABER	annual blood examination rate
ACD	active case detection
ACT	artemisinin-based combination therapy
ACTMalaria	Asia Collaborative Training Network for Malaria
AMC	Anti-Malaria Campaign
API	annual parasite index
APLMA	Asia Pacific Leaders Malaria Alliance
DDT	dichlorodiphenyltrichloroethane
GIS	geographical information system
Global Fund	Global Fund to Fight AIDS, Tuberculosis and Malaria
IOM	International Organization for Migration
IRS	indoor residual spraying
ITN	insecticide-treated net
LLIN	long-lasting impregnated net
MLT	medical laboratory technician
MoD	Ministry of Defence
PCD	passive case detection
PHFO	public health field officer
PHLT	public health laboratory technician
QA/QC	quality assurance/quality control
RDT	rapid diagnostic test
RMO	Regional Malaria Officer
TB	tuberculosis
TSG	technical support group
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
WHO	World Health Organization

“There is no royal road to malaria control and success is only to be achieved by means of a co-operative effort in which the Government and the People both have an important part to play. It rests with the Medical Science to supply the knowledge, with Government and the medical department to provide the machinery and with the People to contribute to motive power”.

-Colonel C A Gill[1]

SUMMARY

The history of malaria control in Sri Lanka

Malaria has been common and widely spread in Sri Lanka since ancient times. P. falciparum and P. vivax malaria were prevalent in Sri Lanka and P. malariae transmission was interrupted in the late 1960s. The primary vector is Anopheles culicifacies.

The first malaria control measures were initiated in 1910. The Anti-Malaria Campaign (AMC) at the Ministry of Health was established in 1911. In the past, several major epidemics have been recorded. The largest was the epidemic of 1934–1935, during which approximately 1.5 million individuals contracted the disease and 80 000 deaths were reported. The epidemic was contained by applying mainly larviciding (oiling of rivers and streams, application of Paris green), as well as quinine treatment and chemoprophylaxis. In November 1945, dichlorodiphenyltrichloroethane (DDT) spraying was started. The intensive indoor residual spraying (IRS) contributed to a drastic decrease in the number of cases from 1947 onwards, with the incidence rate falling from 413 in 1946 to 11.0 per 1000 population in 1953. The government decided to launch a malaria eradication programme in 1957 based on WHO recommendations. A full-scale attack phase with blanket DDT spraying in endemic areas, as well as accelerated malaria surveillance, treatment and reporting were conducted, resulting in only six indigenous cases of a total of 17 cases reported in 1963. However, several reasons, including the withdrawal of DDT spraying with the reduction in cases, insufficient surveillance in the scattered residual foci in jungle areas and a lack of funding, led to a massive epidemic in 1967–1969 distributed across nearly three fifths of the country, with a peak of 538 000 reported cases in 1969. Around 99.9% of infections were caused by P. vivax. The epidemic was contained by scaled-up vector control (reintroducing DDT) and surveillance interventions but in 1969, DDT resistance was reported.

A subsequent rise in malaria incidence was documented in 1987, with a major epidemic of 687 599 cases spread across the country. Between 1995 and 1999, malaria cases rose from 142 294 to 264 549, with the national annual parasite index (API) increasing from 11.86 per 1000 population at risk to 22.05, and the slide positivity rate from 13.0% to 16.7%. In 1995, malaria transmission was concentrated mainly in the northern areas affected by conflict, as well as in the north-central and south-east areas, while by 1999, concentration was limited to five districts of the northern region and in one district in the south-east (Moneragala).

With failure of the elimination attempt, Sri Lanka resumed a malaria control policy in 1972 largely driven by IRS, case detection and treatment with choloroquine and primaquine. Malathion was introduced countrywide in 1977. Resistance to malathion was detected in 1992, and pyrethroids (lambda-cyhalothrin) have been used since 1994. From 1996, the vector-control strategy was changed from universal coverage to targeted spraying in high-risk areas. Entomological surveillance teams were used extensively to monitor vector abundance and ecology.

In 1984, P. falciparum chloroquine resistance was first reported in the country and in the mid-1990s, the first line treatment for falciparum malaria was changed to sulfadoxine/pyrimethamine.

In 1994, Sri Lanka adopted the WHO Global Malaria Control Strategy, giving more importance to early diagnosis and prompt treatment, with mobile malaria clinics scaled up between 1998 and 1999. Treatment protocols were in line with current WHO recommendations considering the data on parasite resistance. The first-line treatment for P. falciparum infections was changed to artemisinin-based combination therapy (ACT) in 2008. The country applied selective vector control with targeted IRS. With funding from the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund), distribution of long-lasting impregnated nets (LLINs) commenced in 2004 and more intense larval control was also conducted.

Due to intensive AMC interventions, a dramatic drop in the number of cases and malaria incidence began in 2000. By 2005, the number of cases drastically decreased to 1640 nationwide and incidence to 0.083 per 1000 population. The majority (more than 75%) of cases were due to P. vivax infections. This stable trend continued in the subsequent years as well. Incidence was maintained at a very low level – 0.01–0.03 per 1000 population between 2006 and 2010. No deaths due to indigenous malaria have been reported in Sri Lanka since 2007. A stable shrinking of the malaria map has been reached. The last major focus of P. vivax was in Hambantota, Southern Province of Sri Lanka (2009–2011), in a cluster of military camps located in and around the Yala National Park – 137 cases due to an internal malaria importation from the northern areas.

Although according to the WHO criteria, Sri Lanka achieved pre-elimination status by 2004–2005, 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. The final path to elimination was set out in two subsequent five-year plans covering the periods 2005–2009 and 2008–2012. The separatist conflict ended in May 2009 and Sri Lanka embarked on the malaria pre-elimination phase in September 2009 with financial assistance from the Global Fund.

Achieving zero

In the years before cessation of transmission (2008–2011), the vast majority (66%–88%) of malaria cases occurred in military personnel. Pockets of persistent transmission were mostly confined to military camps in the vicinity of forested areas where the principal vector of malaria An. culicifacies breeds. The northern districts (Mullaitivu, Jaffna, Vavuniya, Killinochchi and Mannar) most affected by the civil conflict were the last areas of transmission.

In 2012, the number of indigenous cases in Sri Lanka was 23. Of these, 19 were due to P. vivax, of which three were classified as relapses and four due to P. falciparum. The last indigenous case in Sri Lanka was reported in Victory Army Hospital, Anuradhapura in October 2012.

According to the Strategic Plan, 2008–2012 the National Malaria Programme was reoriented from a successful control programme to a pre-elimination and elimination phase programme with the goal of elimination of indigenous malaria from Sri Lanka by the end of 2014. The programme moved to the elimination phase in 2011.

The applied strategic directions for malaria elimination helped in reaching the target of elimination.

Malaria elimination was guided by elimination policies, strategies and interventions, based on an integrated and comprehensive approach.

The conflict/post-conflict situation posed severe challenges that have been overcome with great determination, creativity and perseverance. Even during the war, programme staff applied complex control interventions.

Efficient epidemiological surveillance contributed greatly to success, as follows.

- Timely detection of malaria cases by active case detection (ACD) and passive case detection (PCD), and prompt and adequate treatment in accordance with national policies and guidelines brought about elimination of the sources of infection. An efficient, specific approach in Sri Lanka was carrying out ACD by mobile malaria clinics.
- Laboratory support was strong. Testing in quality assurance/quality control (QA/QC) laboratories supervised by AMC national and regional laboratories was important for the confirmation of every clinical case of malaria.
- The comprehensive epidemiological investigation of cases and foci provided correct epidemiological classification of cases and a basis for planning an adequate response. The strengthened and improved malaria information system meant prompt transmission of information and adequate decision-making. A malaria database was set up and maintained at all levels.
- Regular monitoring of changes in the level of malaria receptivity and vulnerability was critical for formulating the correct polices and approaches for fast containment or prevention of epidemics.

Integrated and cost effective vector-control and entomological surveillance also played an important role.

- Integrated vector management was conducted through rational use of insecticides in rotation for IRS, limited to areas with continued transmission in the northern and eastern provinces and focal responses to outbreaks. Larviciding, LLINs and environmental modifications were also applied. Using larvivorous fish appeared to play an efficient supplementary role in vector control in Sri Lanka.
- The intensive entomological surveillance provided important information on mosquito species, density, bionomics and breeding sites vital for planning effective vector control. Extensive monitoring of mosquito insecticide resistance was carried out.

The high level of political commitment and governmental support is worthy of special mention. Crucial to achieving malaria elimination was a strong health system and upgraded, motivated and dedicated AMC staff with a high level of malaria expertise. High-quality coverage of implementation, including service delivery to hard-to-reach populations, was provided.

A typical Sri Lanka approach that played a key role in malaria elimination was strong intersectoral collaboration, especially with the army and police. Collaboration with many other sectors was crucial, including immigration and religious organizations, as well as partnerships, such as with the International Organization for Migration (IOM), Office of the United Nations High Commissioner for Refugees (UNHCR), WHO and the Global Fund. The malaria elimination programme also benefited greatly from community mobilization.

Maintaining zero

Sri Lanka transitioned to the prevention phase of reintroduction of malaria in November 2012. Since then, all detected cases have been classified as imported.

Presently, there appears to be a high level of receptivity in many areas of the country. Vulnerability is at a medium level with a moderate number of imported cases (180 cases in 2013–2015) registered predominantly in areas with no or a low level of receptivity. However, in the future, the situation may change and a potential increase in the level of vulnerability may occur related to new global trends of increased migration, a possible rise of asylum seekers or foreign workers in new development projects or tourists, who tend to visit tourist sites in the dry zone of the country where receptivity is still high. Hence, sustained vigilance is required.

A National Malaria Strategic Plan for Elimination and Prevention of Re-introduction – Sri Lanka, 2014–2018 was developed and implemented by the AMC, Ministry of Health, with the following strategic directions: strengthening surveillance for early detection and effective treatment of malaria cases; maintaining expertise and capacity for the diagnosis and treatment of malaria cases; strengthening outbreak preparedness, prevention and response to focal malaria outbreaks; and strengthening entomological surveillance and response through integrated vector management. Special effort is required for the prevention of onward transmission from imported cases.

Current surveillance is functioning well across the country as evidenced by performance since November 2012, in effectively detecting a total of 180 cases in 2013–2015 and the fact that no secondary transmission has taken place from imported cases.

Passive case detection by a vigilant general health services is conducted, supported by ACD (reactive and proactive) when needed, similar to activities undertaken during elimination. Screening high-risk populations is a key component of the surveillance system, which has shown its value in detecting imported cases among these groups. A good average annual blood examination rate (ABER) of 4.8–5.4% has been maintained in the country over the past three years. An improved and more comprehensive national QA/QC system for malaria microscopy is in place. Malaria diagnosis and treatment are free of charge.

The majority of detected cases are treated, notified and investigated within 24 hours.
Efforts to prevent malaria importation and its consequences benefit greatly from free chemoprophylaxis for citizens of Sri Lanka travelling to endemic countries, as well as from maintaining strong collaboration with a wide range of internal and international partners, such as the armed forces, the Sri Lanka Police, the IOM and UNHCR.

The strong system of entomological surveillance continues and is able to provide information on where vector control is required during periods of increased vector abundance or increased influx of people in a receptive area, and to assess the transmission potential of areas where an imported case has been reported.

Vector control activities are mainly directed to a larviciding programme using locally available larvivorous fish, LLINs (over 100 000 new LLINs were distributed in 2015) and conducting environmental management.

The programme for prevention of malaria reintroduction in Sri Lanka is financially supported by the government and assures the sustainability of the interventions.

Sustaining zero cases for more than three consecutive years, Sri Lanka applied for official WHO certification. An assessment team of independent experts assigned by WHO in August 2016 concluded that Sri Lanka had, beyond a reasonable doubt ,met the criteria for designation by WHO as being malaria-free. In September 2016, Sri Lanka became the second country in the WHO South-East Asia Region to achieve a malaria-free status.

The outlook for the future

Sri Lanka has made enormous efforts to achieve malaria elimination and the country has maintained zero autochthonous cases for the past four years. Lessons learnt show that neglect of malaria interventions at this stage may result in a rapid resurgence of malaria, requiring substantial efforts and financial support to combat malaria once again. Efforts to remain malaria-free should continue to follow the national strategic plan for prevention of malaria reintroduction. In Sri Lanka, there is strong political commitment and operational and technical capacity for robust maintenance of a malaria-free status.

Photo Credit: Dr Risintha Premaratne, Sri Lanka

Introduction

Photo Credit: Dr Risintha Premaratne, Sri Lanka

INTRODUCTION

The WHO Global technical strategy for malaria 2016–2030 adopted by the World Health Assembly in May 2015 highlighted the importance of scaling up malaria responses and moving towards elimination. By adopting this strategy, WHO Member States have endorsed the bold vision of a world free of malaria, and set the ambitious new target of reducing the global malaria burden by 90% by 2030.

Sri Lanka, having reached zero malaria cases in November 2012 and successfully maintained a malaria-free status for three consecutive years thereafter, is the first country to be officially certified by WHO as malaria-free after the launch of the Global technical strategy.

This case study summarizes the long road to malaria elimination in Sri Lanka. Applied strategies and polices for malaria control and elimination that achieved this historic milestone and subsequently prevented the reintroduction of the disease have been analysed and evaluated. This document describes the strong political commitment, technical leadership, enormous efforts of the Anti-Malaria Campaign (AMC), general health services, other organizations and the entire population, as well as the essential funding to set up and implement malaria control and elimination programmes. The lessons learnt could be a helpful guide for other countries from South-East Asia and other regions embarking upon elimination or making efforts to prevent malaria re-establishment in areas where local transmission has been interrupted.

For this case study, data were collected from various sources.

- Country data were collected, including from country publications and manuals, the AMC and Ministry of Health, Nutrition and Indigenous Medicine, reports, regulations, orders and guidelines. A number of documents or reports found on the websites of various entities based in Sri Lanka were also consulted.
- WHO publications, guidelines and reports were used.
- The two following documents were found to be especially useful sources of information:
  . Malaria elimination in Sri Lanka. National report for WHO certification. Colombo: Ministry of Health, Nutrition and Indigenous Medicine, Sri Lanka; 2016.
  . Mintcheva R, Hugo C, Palmer K, Revankar C. Independent evaluation of Sri Lanka's request to be certified as malaria free, 2016 (WHO Registry file).
- Scientific publications on malaria in Sri Lanka were identified using PubMed (United States National Library of Medicine) using the keywords "malaria", "Sri Lanka", "elimination" and/or "eradication", and by screening scientific journals and other sources.
- Senior officials of the institutions involved (Ministry of Health, universities, research centres and health-care facilities) were interviewed in Sri Lanka.

All data collected were epidemiologically analysed, aiming at characterization of the malaria situation in different periods and the effect of interventions, using the main epidemiological parameters and indicators, such as the annual number of cases (autochthonous and imported); malaria incidence and mortality; distribution of cases by age, sex and other parameters; geographical distribution of malaria; and parasites and vectors.

The main focus of this case study was to recognize and highlight more recent events, achievements and contributory factors leading to malaria elimination and prevention of reintroduction until WHO certification was granted. Detailed descriptions on the history of malaria in Sri Lanka can be read in Eliminating malaria: case study 3. Progress towards elimination in Sri Lanka.

Photo Credit: Dr Risintha Premaratne, Sri Lanka

The epidemiology of malaria in Sri Lanka

Both P. falciparum and P. vivax malaria were prevalent in Sri Lanka. The transmission of P. malariae was interrupted in the late 1960s.

There are 23 known species of anophelines in Sri Lanka. The primary vector is Anopheles culicifacies sE, belonging to the culicifacies species complex. Species E can breed in a broad range of aquatic habitats in Sri Lanka, reflecting the significant environmental adaptability of this malaria vector. An. culicifacies sl is known to feed on both humans and animals, indoors and outdoors, but it is An. culicifacies E, which is the vector of importance due to its high anthropophilic tendencies.

An. subpictus, also belonging to species complex (A–D), is considered to be a secondary vector in Sri Lanka. Species B predominates in coastal areas, while species C is more present in inland areas. Species C and D are indoor-resting and indoor-feeding, while species B is outdoor-resting with no significant preference for indoor- or outdoor-resting. Species B, C and D can feed on humans as well as cattle.

Other secondary or potential vectors of malaria in different settings in various parts of the country include: An. annularis, An. varuna, An. vagus, An. tessellatus. An. jamesii, An. barbirostris, An. nigerimus, An. peditaeniatus, An. pallidus and An. aconitus.

Malaria transmission did not take place in areas above 2500–3000 feet above sea level. The climate of Sri Lanka is conducive to vector mosquito breeding and malaria transmission. The mean monthly temperatures differ slightly and the relative humidity in the plains, consistently high throughout the year, contribute to creating favourable conditions for the vector.

Some of the rivers and the vast number of small irrigation systems may become dry during the dry season, giving rise to the formation of pools – ideal breeding sites for mosquitoes. Rainfall is favourable for malaria transmission, as the vector breeds extensively in stagnant pools of clear, sunlit water.

In the past, when the transmission levels were high, the dry zone experienced malaria of a stable nature with little yearly fluctuation, whereas in the intermediate zone, malaria of an unstable nature was encountered, with the incidence rising during years of dry weather.

In Sri Lanka, malaria epidemics were a common feature in the past, especially before indoor residual spraying (IRS), which began only in 1947. These early periodical epidemics were due to climatic conditions that supported high vector densities.

Photo Credit: Dr Risintha Premaratne, Sri Lanka

History

Photo Credit: Dr Risintha Premaratne, Sri Lanka

THE HISTORY OF MALARIA CONTROL IN SRI LANKA

Malaria has been common and widespread in Sri Lanka since ancient times. It was once one of the most important communicable diseases in the country and had devastating effects, both economically and socially. It was a leading cause of hospital admission, especially in malaria-endemic areas, and its control cost as much as two thirds of the national public health budget.

The documented history of malaria in the medical literature cites the first study on the vector made by Dr A.J. Chalmers in 1905, who identified 10 anopheline species in the country. The following year, Sir Allen Perry published a sessional paper on malaria, and in 1908, carried out the first recorded spleen survey in the island, which was limited to schoolchildren, and to children and young persons (up to the age of 15 years) attending dispensaries for treatment. In 1910, the government appointed a committee to recommend the first malaria control measures in Kurunegala, which were initiated under the direction of Dr S.T. Gunasekera in 1911. In 1913, it was established that An. culicifacies was the malaria vector.

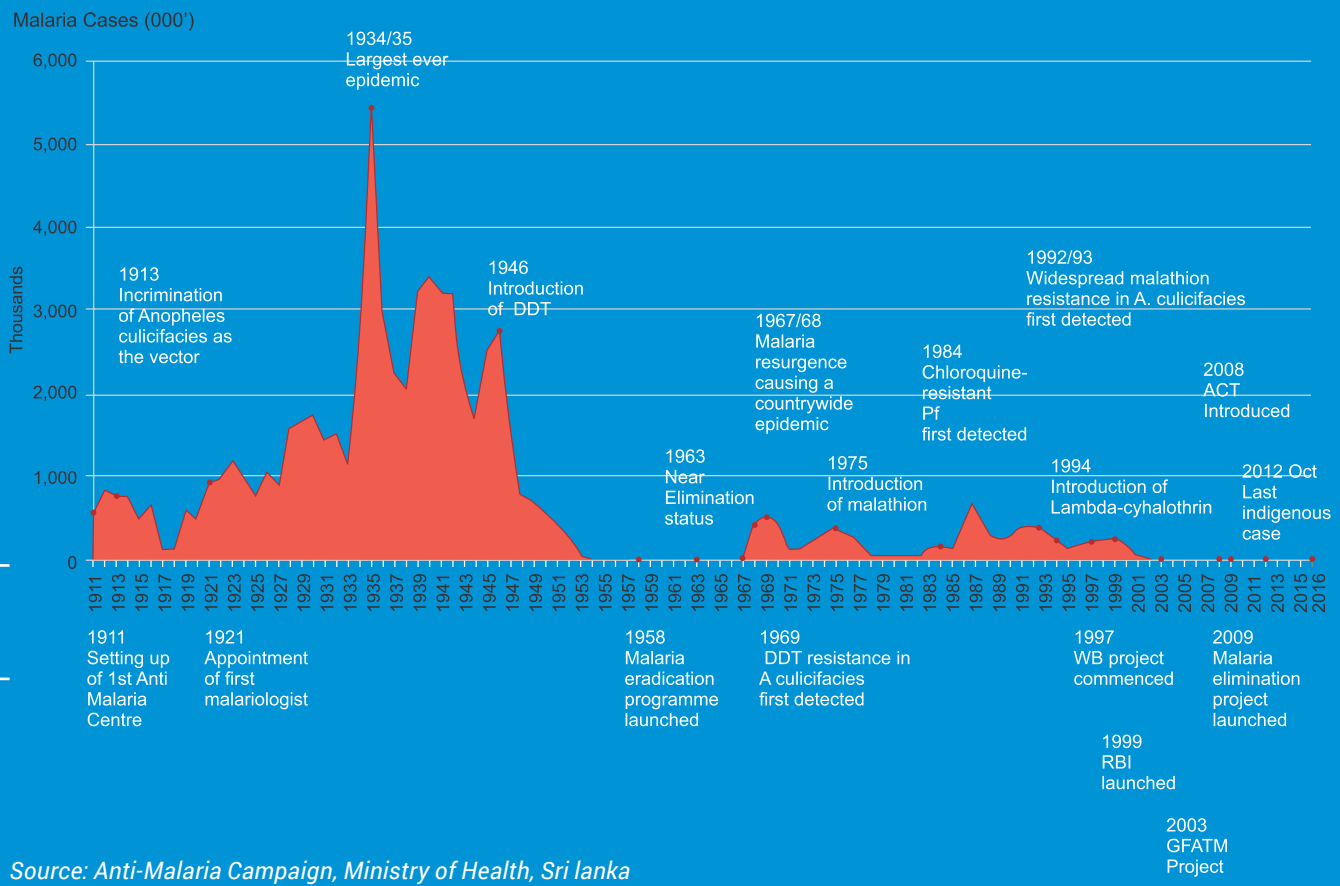
The early malaria control measures included vector control (larviciding – Paris green in paddy fields and irrigation channels, and Shell Mariol for oiling of rivers and streams, as well as larvivorous fish), treatment of infected persons and prevention (biweekly chemoprophylaxis using quinine bisulphate and educating the public).

However, several major epidemics have been recorded. The largest of these was the epidemic of 1934–1935, during which approximately 1.5 million individuals contracted the disease and 80 000 deaths were reported (Fig. 1). The outbreak affected both malarious areas and traditionally non-malarious areas in the wet and intermediate zones of the country.

As a response to the epidemic, control activities were scaled up and extended. Vector control interventions were applied – larviciding (oiling of rivers and streams, application of Paris green), as well as quinine treatment and chemoprophylaxis, and epidemiological and entomological surveillance. In November 1945, limited DDT spraying was started in the Kekirawa area of Anuradhapura district and extended in phases to other parts of the country by 1947.

In 1955, IRS was interrupted in many regions. However, epidemiological and entomological surveillance was continued and radical cure of malaria patients (P. vivax – amodiaquine at 600 mg, 400 mg and 400 mg on three successive days, and primaquine 15 mg daily for 14 days; P. falciparum – amodiaquine plus a single dose of 15 mg of primaquine for 5 days) was started in the 1950s. In addition to passive case detection (PCD), vigilance units were deployed to investigate cases using active case detection (ACD) in cleared foci and to ensure that transmission was interrupted. Malaria was made a notifiable disease in April 1961.

Fig. 1
Malaria burden and control activities in Sri Lanka, 1911–2016



Source: Anti-Malaria Campaign, Ministry of Health, Sri lanka

With the dramatic reduction in the number of cases after the introduction of DDT spraying in the country in 1945, the government decided to launch a malaria eradication programme in 1957 based on WHO recommendations. A full-scale attack phase with blanket DDT spraying in endemic areas, as well as accelerated malaria surveillance (PCD, treatment and reporting) were conducted, resulting in only six indigenous cases out of a total of 17 cases reported in 1963. With the reduction in the number of cases, DDT spraying was gradually withdrawn and in the following years (1967–1969) a massive epidemic was registered (Fig. 1). The number of reported cases reached 538 000 in 1969. Around 99.9% of infections were caused by P. vivax. It is likely that subsequent peaks were due to relapses as the regimen for primaquine to prevent relapses was reduced from 14 days to 5 days. The epidemic enveloped nearly three fifths of the country, which had a population of over 5 million spread over the entire dry zone and a large part of the intermediate zone with localized outbreaks in the wet zone.

The reasons for the resurgence of malaria can be summarized as follows: insufficient surveillance in the scattered residual foci in jungle areas where some of the cases were not detected, premature cessation of IRS, insufficient epidemiological surveillance, population mobility, abnormal climatic conditions and a susceptible population, weekend entomological surveillance especially of breeding areas, and a lack of domestic and foreign funding. In 1969, DDT resistance was also reported.

The epidemic was contained by scaled up vector-control (reintroducing DDT) and surveillance interventions.

Resurgence of malaria led to resumption of the malaria control programme in 1972. As a result, an 81.8% decline in the number of malaria cases was reported between 1975 and 1978 (from 390 943 to 71 176 cases). However, a gradual increase in recorded malaria cases, which began from 1983, led to a major widespread epidemic throughout the country with 687 599 cases in 1987 (Fig. 1). It is assumed that the epidemic was caused by several factors: insufficient regional malaria staff, climatic factor (relatively low rainfall in that year), replacement of around 1 million settlers from non-endemic areas of the country to the malaria-endemic, eastern part of the country that had established irrigated rice lands, and where an irrigation and dam construction project on the Mahaweli River was completed in 1987.

The next rise in malaria incidence was documented between 1990 and 1999. The number of confirmed malaria cases rose from 142 294 in 1995 to 264 549 in 1999 (Fig. 1); the national annual parasite index (API) rose from 11.86 per 1000 population at risk in 1995 to 22.05 in 1999; the slide positivity rate from 13.0% in 1995 to 16.7% in 1999; and the number of deaths due to malaria from 14 in 1990 to a peak of 115 in 1998. In 1995, malaria transmission was concentrated mainly in the northern areas affected by conflict, as well as in the north-central and south-east areas.

By 1999, there was a high level of transmission in five districts of the northern region and in one district in the south-east (Moneragala).

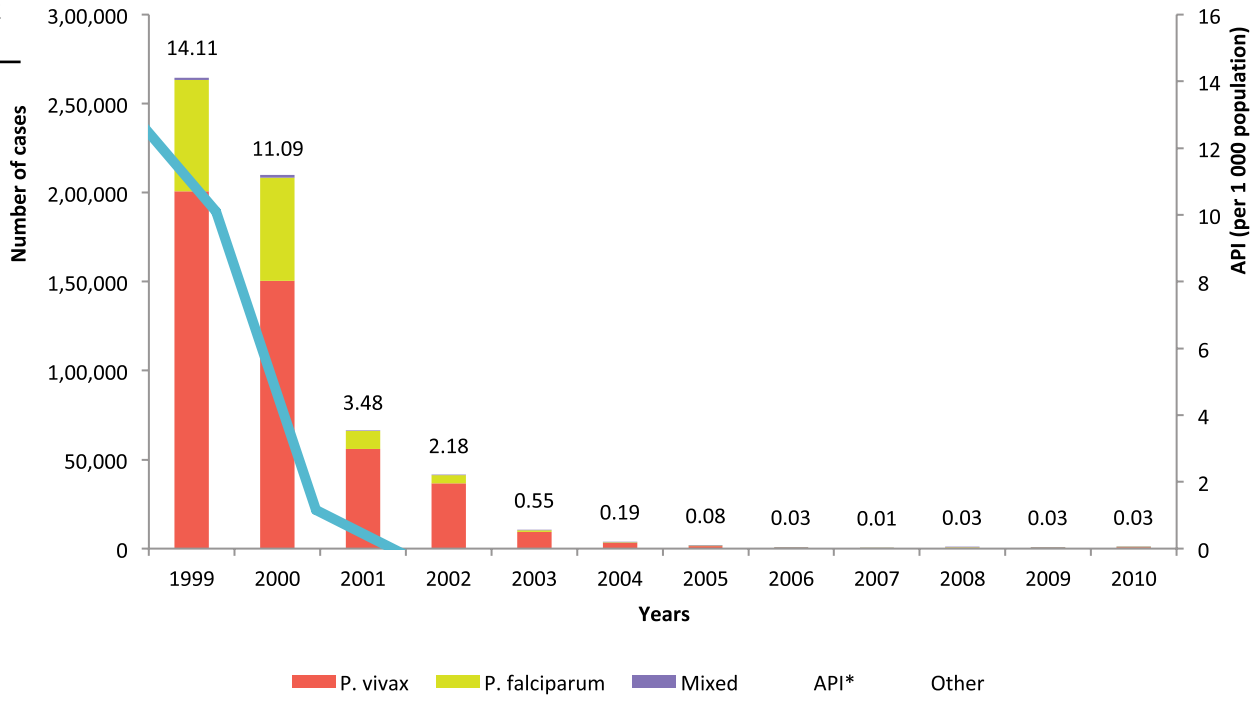
The malaria control policy since 1972 has been largely driven by IRS, and detection and treatment of cases with choloroquine and primaquine. This strategy was continued till 2008 with changes in policy based on the current WHO guidelines.

Entomological surveillance teams were used extensively to monitor vector abundance and ecology. Malathion was introduced countrywide in 1977. Resistance to malathion was detected in 1992 and pyrethroids (lambda-cyhalothrin) have been used since 1994. From 1996, the vector-control strategy was changed from universal coverage to targeted spraying in high-risk areas.

In 1984, chloroquine resistance of P. falciparum was first reported in the country and in the mid-1990s, the first-line treatment for falciparum malaria in areas where drug resistance was reported was changed to sulfadoxine/pyrimethamine.

Due to the intensive AMC interventions, a dramatic drop in the number of cases and incidence of malaria started in 2000 (Fig. 1 and 2). In seven years, the number of cases drastically decreased from 264 549 in 1999 to 1640 in 2005. The majority of cases were due to P. vivax infections (more than 75%). There was a dramatic decline in the incidence, from 14.11 per 1000 population in 1999 to 0.08 per 1000 population in 2005. This stable trend continued in subsequent years. Incidence was maintained at a very low level – 0.01–0.03 per 1000 population during 2006–2010.

Fig. 2
Number of malaria cases and API, 1999–2010



Source: Anti-Malaria Campaign, Ministry of Health Sri Lanka

Males were affected by malaria more often than females, especially in the last four years before elimination, which may be explained by their activities, such as army service, agricultural work and visits to the jungle.

Malaria was detected predominantly among the adult population above the age of 15 years. Infections in children were very few and declined further from 2004 onwards, indicating that the level of local transmission was progressively decreasing.

Most infections in Sri Lanka were symptomatic. The number of deaths attributed to malaria has decreased since 1998. No deaths due to indigenous malaria have been reported in Sri Lanka since 2007.

A stable shrinking of the malaria map has been reached. In 1999, the majority of areas in the country had an annual number of cases above 1000; however, by 2005 most of the regions reported 1–200 cases. Traditionally, malaria was non-endemic in Colombo, Gampaha and Kalutara districts of the Western Province. Breeding of the principal vector was not common in these districts.

Although according to the WHO criteria, Sri Lanka had achieved pre-elimination status by 2004–2005, 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 at the time.

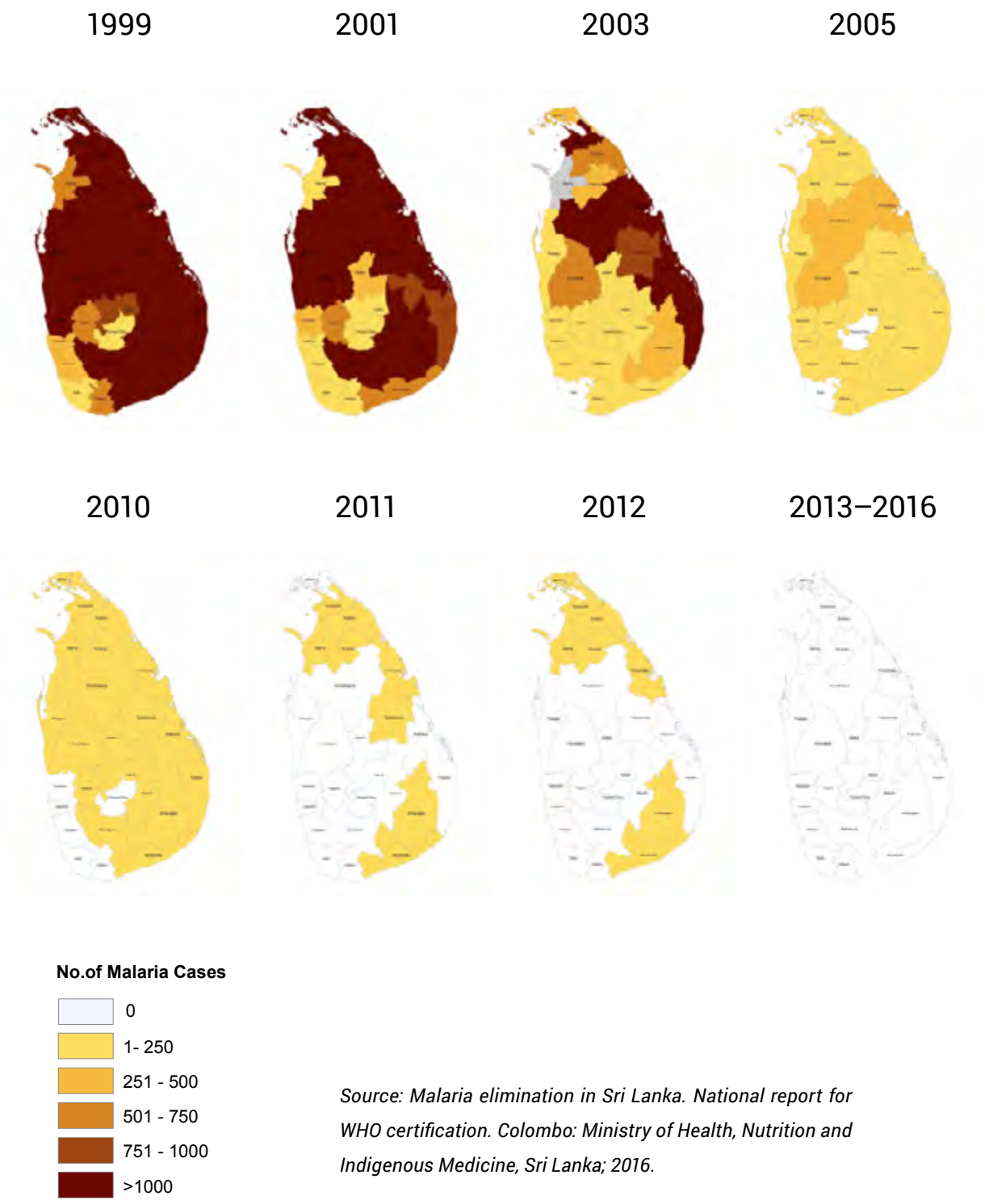
The last major focus of P. vivax transmission (2009–2011) was registered in Hambantota District, Southern Province, in a cluster of military camps located in and around the Yala National Park, which is one of the country's two main wildlife sanctuaries. The army camps were located along two main waterways – the river Menik Ganga, and the large stream Kumbukkan Oya – that dry up during the dry season leading to the formation of multiple pools, which are the favoured breeding sites of the main vector of malaria in Sri Lanka, An. culicifacies. The period of focus coincided with the last few years of the separatist civil conflict in the north and east of the country.

In the years before the cessation of transmission (2008–2011), a vast majority (66–88%) of malaria cases occurred in military personnel. Pockets of persistent transmission were mostly confined to the military camps located in the vicinity of forested areas where the principal vector of malaria An. culicifacies breeds.

Sri Lanka planned to commence pre-elimination in 2008. The separatist conflict ended in May 2009 and Sri Lanka embarked on the malaria pre-elimination phase in September 2009, with financial assistance from the Global Fund to Fight AIDS, Tuberculosis and Malaria (the Global Fund). The objectives of the elimination programme were to interrupt the local transmission of P. falciparum by the end of 2012 and of P. vivax by the end of 2014, focusing on intensified surveillance. With the reduction in the number of indigenous malaria cases, the

Fig. 3

Distribution of microscopically confirmed malaria cases in Sri Lanka, 1999–2016



Source: Malaria elimination in Sri Lanka. National report for WHO certification. Colombo: Ministry of Health, Nutrition and Indigenous Medicine, Sri Lanka; 2016.

proportion of imported cases increased. On the eve of elimination of malaria in Sri Lanka, it was likely that infection was mostly encountered among travellers who returned from endemic areas and among the military who served in the uncleared northern areas.

There was a significant decrease in the number of indigenous malaria cases in 2010–2011. Transmission of malaria in 2011 was confined to the northernmost, eastern and the southernmost parts of the country. The northern districts (Mullaitivu, Jaffna, Vavuniya, Killinochchi and Mannar), most affected by civil conflict, were the last areas of transmission. With the destruction of infrastructure and displacement of residents, malaria control operations in these districts faced the most serious difficulties. Full rehabilitation and restoration of these areas took time, and although malaria control operations were maintained throughout, it took as long as four years after cessation of the civil conflict to fully restore malaria staff and for operations to resume at scale.

Among the 124 cases of locally acquired malaria in 2011, 99 were in military camps, all of them in military personnel, except for a few civilians working in the camps. P. vivax transmission was evident that year, all but one of them in military premises. Based on the analysis of the situation, the key interventions were conducted in military bases under the direct guidance of the AMC, leading to a rapid decline in cases and to the interruption of malaria transmission (Fig. 3).

In 2012, there were 23 indigenous cases. A couple of foci of P. vivax malaria, and several sporadic cases of P. vivax and P. falciparum were identified in the country until transmission ceased in October 2012. Of these infections, 19 were due to P. vivax, of which three were classified as relapses, and four were due to P. falciparum.

The last indigenous case in Sri Lanka was reported in the Victory Army Hospital Anuradhapura in October 2012.

The last occurrences of transmission were in the northern districts – Mullaitivu and Kayts in Jaffna, and in the intervening districts of Vavuniya and Killinochchi. The absence of further transmission from these cases would have been due to the rigorous response measures taken, such as parasitological screening and vector-control operations in the areas following case investigations. The sporadic cases of malaria in the southern districts towards the end of the period of transmission are more difficult to explain. They were quite separate spatially and there was no history in any of them that could suggest a clear origin of infection. This, coupled with the fact that there were only these single cases and no further cases in their neighbourhood, could mean that they were either relapses or recrudescences of previous infections, although none were forthcoming in the past medical history or records.

In most countries that have achieved malaria elimination, P. falciparum has been the first species to be eliminated, with P. vivax persisting longer. This has been attributed to P. vivax being the more tenacious species owing to several of its biological features, such as the ability to remain dormant in the liver and give rise to relapses. In Sri Lanka, both P. falciparum and P. vivax were eliminated at the same time. This could be due to the fact that a rigorous control programme for P. vivax was deployed using the directly observed therapy, short-course (DOTs) strategy for radical cure with primaquine and the rapid response to cases. This is further supported by the fact that P. vivax was eliminated a couple of years ahead of target. The targeted time period for elimination were 2012 for P. falciparum and 2014 for P. vivax, but the transmission of both species was interrupted in 2012.

Sri Lanka transitioned to the prevention phase of reintroduction of malaria in November 2012. As the caseload began to decrease to low levels from 2008 onwards, reliable data on case classification, as per WHO guidelines, have been available based on detailed case investigations. Since November 2012, all cases reported in Sri Lanka have been classified as imported.

A National Malaria Strategic Plan for Elimination and Prevention of Re-introduction – Sri Lanka, 2014–2018 was developed and introduced by the AMC, Ministry of Health, Nutrition and Indigenous Medicine. Special effort is taken to prevent onward transmission from imported cases. The surveillance system for malaria operates throughout the entire country (regardless of the level of risk), and is aimed at prompt detection and reporting of all detected malaria cases (imported or of possible renewed malaria transmission). Up till now, the programme has reported zero introduced and indigenous cases as a consequence of malaria importation into the country. In September 2016, Sri Lanka was successfully certified as a malaria-free country by WHO.

Photo Credit: Dr Risintha Premaratne, Sri Lanka

Achieving zero – how did Sri Lanka successfully eliminate malaria?

ACHIEVING ZERO – HOW DID SRI LANKA SUCCESSFULLY ELIMINATE MALARIA?

The AMC at the Ministry of Health, Nutrition and Indigenous Medicine was established in 1911. It formulates the national malaria control and elimination strategies and policies; monitors national malaria trends and plans; coordinates and conducts malaria control and elimination activities; provides technical guidance to subnational malaria control programmes; ensures interdistrict coordination, and intersectoral collaboration and cooperation with partners; and coordinates training and research activities.

Operationally, the AMC had a centralized structure until 1989 and functioned as a vertically run programme. However, in 1989, the programme was transformed into a decentralized campaign, which was implemented by nine provincial programmes under the technical guidance of the National AMC Directorate. The AMC headquarters continued under the central Ministry of Health, Nutrition and Indigenous Medicine, and was responsible for national policy development and providing technical guidance to the provinces.
At the intermediate level, the regional malaria offices conduct antimalarial activities guided by the national level. They manage district health services and perform malaria control and surveillance. Health area medical officers manage prevention and curative services at the subdistrict level.

The AMC coordinates the work of the general health services. Primary health-care centres at the district level refer patients to regional hospitals and ultimately to the national referral hospital in Colombo.

The AMC has played a key role in the successful control and elimination of malaria in Sri Lanka and now coordinates interventions targeting the prevention of malaria reintroduction.
In 1994, Sri Lanka adopted the WHO Global Malaria Control Strategy giving more importance to early diagnosis and prompt treatment. During the malaria control and eradication campaigns of the 1960s, the AMC relied heavily on IRS, but later the country moved towards selective vector control with targeted IRS. With funding from the Global Fund, long-lasting insecticidal nets (LLINs) were distributed since 2004, and more intense larval control was conducted.

Between 1998 and 1999, the number of mobile malaria clinics was increased and their activities intensified. The aim was to achieve early case detection and reduce the reservoir of malaria infections, which resulted in a stable gradual decline in the incidence of malaria since 2000.

The treatment protocols were in line with the current WHO recommendations considering the data on the parasite resistance. Sulphadoxine/pyrimethamine was adopted as first-line treatment for P. falciparum infections.

The final path to elimination was set out in two subsequent five-year plans covering the periods 2005–2009 and 2008–2012.

The AMC interventions prior to 2005 led to a drastic decline in the malaria burden and the country reached pre-elimination levels by 2003–2005, when the caseload was less than 1 per 1000 population, but a pre-elimination programme was not launched due to the ongoing separatist war at that time.

The objectives of the Five-Year Strategic Plan, 2005–2009 were as follows:

- to reduce the national API by 2009 to a level 50% below that of 2003;
- to eliminate mortality caused by malaria by 2009;
- to reduce the nationwide morbidity due to P. falciparum to a level 50% below that of 2003 by 2009;
- to eliminate malaria among pregnant women by 2009;
- to reduce malaria in children below the age of 5 years to a level 50% below that in 2003 by 2009.
- The country reached these targets by applying the following strategies:
- All cases were detected early and treated promptly, including asymptomatic parasite carriers.
- Vector-control measures were selectively applied, based on the principles of integrated vector management – gradual reduction of IRS since 2001, rational use of insecticides in rotation for IRS, distribution of LLINs, larviciding or use of larvivorous fish, and environmental modifications by filling abandoned gem and quarry pits used in gem mining areas. Space spraying has been applied for special situations. Mosquito control was intensified by the Prevention of Mosquito Breeding Act. No. 11 of 2007, focusing on prevention of mosquito-transmitted malaria, dengue, filariasis and Japanese encephalitis.
- Entomological surveillance activities were conducted at random or on an ad-hoc basis, depending on the plan of the Regional Malaria Officer (RMO).
- Forecasting, early detection, containment and prevention of outbreaks.
- Partnership-building and community participation were conducted.
- Human resources development and capacity-building activities were carried out.
- The programme was regularly assesses and changes effected if and when required.
- Operational research was promoted.

In cases of malaria outbreaks, rigorous response measures were taken, including parasitological screening and vector-control operations in the affected areas following case and focus investigations, resulting in their containment.

The objectives of the 2005–2009 Strategic Plan were achieved before 2009. In most of the 25 districts in the country, malaria transmission rates were lower than those stipulated by WHO as necessary for launching an elimination programme; therefore, a revised Strategic Plan for the period 2008–2012 was developed. Under

that Plan, the National Malaria Programme was reoriented from a successful control programme to a pre-elimination and elimination phase programme with the goal of elimination of indigenous malaria from Sri Lanka by the end of 2014. Sri Lanka launched the malaria pre-elimination phase in 2009. The programme moved to the elimination phase in 2010.

The specific objectives were as follows:

- Eliminate indigenous P. falciparum malaria by 2012.
- Eliminate indigenous P. vivax malaria by 2014.
- Maintain zero mortality from malaria.
- Prevent the reintroduction of malaria into the country.
- Strategic directions for malaria elimination were applied in line with the WHO recommendations to reach the target of elimination. These were as follows:
- Strengthening the malaria surveillance system. This comprised ensuring 100% case detection, including of asymptomatic parasite carriers and confirmation by microscopy or rapid diagnostic tests (RDTs), and strengthening the typical Sri Lanka tool of mobile clinics.
- Notification and investigation of all cases to ensure radical cure and prevention of secondary transmission. Case-based surveillance was initiated in 2008 and all cases have since been investigated extensively.
- Implementation of a radical treatment policy. All P. vivax infections were given radical treatment.
- A major change was made in treatment policy, making artemisinin-based combination therapies (ACTs) the first-line drug of choice for the treatment of falciparum malaria. The gametocyte treatment policy was continued for P. falciparum.
- Quality control and quality assurance were implemented for diagnostic and treatment services.
- An integrated vector management strategy was ensured and implemented, including total IRS coverage in and around each malaria case, distribution of LLINs and insecticide-treated nets (ITNs), where appropriate, to control vector density and interrupt disease transmission.
- An outbreak preparedness and rapid response strategy was implemented for early containment of outbreaks.
- The consequences of imported malaria in travellers were prevented as well as reintroduction of malaria.
- Public and private health sector staff were reoriented towards the new goals of malaria elimination.
- Human resources were developed and capacity built in programme management, planning and implementation.
- Research was promoted and research institutions engaged in operational research.

For each of the strategies, detailed activities, tasks, timetable for their accomplishment, responsible officers/offices and approximate cost were developed and planned.

Epidemiological surveillance and case management

As elimination approached, case-based surveillance was set up. It has been the key activity of the AMC since 2008, supported by strong entomological surveillance, good-quality laboratory services and an evolving information system.

Lessons learnt from the malaria "eradication" campaign in the past showed that surveillance is the key component of an elimination strategy. Thus, the major focus of the AMC has been to detect malaria cases as early as possible to conduct epidemiological investigation and respond as indicated by the investigation, and treat cases promptly in accordance with the national treatment guidelines. This approach is followed for the prevention of reintroduction of malaria.

Case detection

Achieving elimination tasks required a comprehensive contemporary case detection (passive and active) management system and providing all malaria services free to the public.
In Sri Lanka, case detection is divided into a number of different types.

Passive case detection, which consisted of screening for malaria at a health facility, was usually directed at identifying evident clinical cases.

Two types of passive case detection were formulated:

- passive case detection (PCD), which included medical institutions where there is no public health laboratory technician (PHLT) or public health field officer (PHFO); and
- activated passive case detection (APCD), which included a medical institution with either a PHLT and/or a PHFO.

PCD was the responsibility of all health facilities – governmental and private, all care-workers, regardless of their medical specialty, general practitioners, internists, paediatricians, specialists in infectious diseases and parasitology.

ACD was carried out through mobile malaria clinics with a facility for microscopic examination of blood smears collected on the same day, which operated in malarious areas, situated far from medical institutions. It should be emphasized that the mobile clinic played a core role in malaria elimination in Sri Lanka. There were also walk-in units, which operated in easy-to-access malarious areas. ACD facilitated early detection of malaria cases (including asymptomatic parasite carriers), thereby reducing the possibility of transmission. This method was employed for proactive as well as reactive case detection. About 30% of the total blood smears screened in the country were collected through ACD.

- Reactive case detection related to a detected case was conducted through blood screening of the population within a radius of 1 km of the detected malaria case.
- Proactive case detection
    - through house-to-house visits and mobile malaria clinics in high-risk localities, as well as among high-risk population groups. Detection of cases by home visits was done under special circumstances, for example, during outbreaks.
    - through screening potential blood donors and donor blood for malaria, which was another important function of the PHLTs attached to the AMC. This accounted for approximately 30% of the total blood films screened.

Diagnosis

Testing free of charge by QA/QC laboratories to confirm every clinical malaria case was an important part of the surveillance system. It was followed by confirmation from the regional laboratories and the national reference laboratory at the AMC headquarters.

Since 2008, the beginning of the pre-elimination phase, a conformation of the primary diagnosis of malaria in both the public and private health sectors has been mandatory prior to providing antimalarial treatment. Treatment for malaria on the basis of a clinical diagnosis (without a confirmatory diagnosis) was permitted only as a life-saving measure.

The diagnosis was based on either microscopic examination of blood smears and/or RDT before treatment. If only RDT was performed, the result was confirmed by microscopy.

Laboratory diagnosis services for malaria were widely available in public sector health institutions, as well as in the private health sector, in private hospitals and private laboratories throughout the country.

Quality assurance and quality control of the laboratory diagnosis of malaria

Cross-checking of all positive slides and 5% of negative slides has been the standard for maintaining the quality of malaria microscopy since re-initiation of cross-checking at the AMC headquarters in 1999. Slides received from the periphery were examined by senior PHLTs attached to the Central Laboratory of the AMC.

Treatment

The national protocol includes the following treatment for malaria.

- Uncomplicated P. falciparum monoinfection – ACT and a single dose of primaquine
- P. vivax malaria – chloroquine and a 14-day course of primaquine
- Severe and complicated P. falciparum malaria – parenteral artesunate for a minimum of 24 hours followed by a full course of ACT (the first-line ACT) when the patient can take oral medication, and a single dose of primaquine. Supportive treatment is given consistent with the WHO Guidelines (WHO, 2015).

Patients are treated free of charge and hospitalized for the first three days. In patients infected with P. vivax and P. ovale, antirelapse treatment with primaquine is started on day 3, and is provided as supervised treatment during follow-up visits after discharge from the hospital.

Follow up of malaria patients includes control microscopic examinations conducted daily over the first three days. If parasitaemia persists, blood smears are taken daily until the parasitaemia clears. Subsequently, microscopic examination is repeated: (a) P. vivax/P. ovale malaria infections on days 7, 14, 21, 28, 42 and then monthly for one year; (b) P. falciparum malaria infections on days 7, 14, 21, 28 and 42.

In Sri Lanka, antimalarial medicines are procured and stocked solely by the AMC and are distributed only to public sector health institutions. The exceptions to this are chloroquine and primaquine, because they have therapeutic uses other than for malaria. When a patient is detected to have malaria in the private sector, the AMC is informed and the appropriate antimalarial medicines are issued (within a few minutes to hours) to the attending physician or hospital by the AMC headquarters or the Regional Malaria Office in the area.

Case and focus investigation, response and follow up

The WHO elimination surveillance approach for field/epidemiological investigation of each confirmed malaria case and focus, with filling of unified forms, has been applied since 2008. The main objective of the field investigation was to determine the source and place of infection, and to understand whether there was ongoing local transmission of malaria. Cases have been classified according to the standard WHO criteria (indigenous, introduced, imported, induced or relapsing). Case investigation and response were conducted by either the RMO or AMC headquarters. All forms were kept at district offices and copies were sent to the AMC headquarters where they were recorded in the National Malaria Register and in district registers.

It should be noted that the practice has been to investigate each case rather than grouping the cases into a focus. This is a unique approach used by Sri Lanka. Although this is labour intensive, it has been highly effective, as evident from the rapid and significant decline in the malaria burden.

Information from the investigation was a basis for decision-making on the malaria response, including vector control and ACD among the population (areas near the residence of the case, breeding sites, other places of residence, place of employment and areas of travel).

An efficient strategic approach in Sri Lanka was setting up a technical support group (TSG) chaired by the Director-General of Health Services and a subcommittee to guide and monitor AMC activities and report to the TSG, as well as a case review committee (CRC) comprising independent members who would review all cases and confirm their epidemiological classification.

Foci were monitored and mapped using a geographical information system (GIS). The standard focal response covered a radius of 1 km around the home of each case. Slides (or RDTs) were taken from all members of the community, entomological surveys were done, and based on the results, appropriate vector control measures were applied. All details were documented in individual files of cases, and investigation of foci in regional and national registers and in the electronic database.

Information system

Malaria is a notifiable disease in Sri Lanka. A standard notification card (Form H 544) is used that is forwarded to the Ministry of Health, Nutrition and Indigenous Medicine, which maintains a notification register. Notifications are referred to the public health inspector for investigation and confirmation.

During Sri Lanka's malaria elimination phase, the malaria information system was strengthened and improved as a result of applying measures in line with the Strategic Plan and other related regulations. A legal basis for regulating weekly, monthly and annual reporting of communicable diseases, including malaria, was in place. A malaria database was set up and maintained at all levels. Flow of information across levels is generally simple and well defined.

The data are disseminated each year in the AMC Annual malaria report. In addition, data are presented in the Quarterly Epidemiological Bulletin published by the Epidemiological Unit of the Ministry of Health, Nutrition and Indigenous Medicine, and the Annual Health Bulletin published by the Medical Statistics Unit of the Ministry of Health, Nutrition and Indigenous Medicine.

Photo Credit: Dr Risintha Premaratne, Sri Lanka

Entomological surveillance and vector control

Photo Credit: Dr Risintha Premaratne, Sri Lanka

ENTOMOLOGICAL SURVEILLANCE AND VECTOR CONTROL

Routine entomological surveillance has always been an integral part of AMC since the late 1960s, and it continues to be a key component in the overall strategy for control and elimination of malaria in Sri Lanka.

The entomological surveillance activities of the AMC are aimed at determining species composition, abundance/densities, temporal and spatial distribution; monitoring biting (including blood meal preferences) and resting behaviour of the vector species, and mapping the distribution of larval habitats for targeted implementation of larval source management (larviciding, biological and source reduction); assessing the susceptibility status of the vector to different classes of insecticides; and monitoring the residual efficacy of insecticides where this is appropriate. Depending on the situation, the programme performed different types of entomological surveys as follows.

- Sentinel surveillance is carried out in selected sites where the risk of malaria transmission is present or where the potential for vector breeding is well established. Each region under an RMO maintains at least two sentinel sites per year.
- Spot checks are carried out in areas not covered by sentinel surveillance to determine the receptivity of the area, particularly when there is an influx of vulnerable populations or when there are changes in the environment that may favour vector breeding, such as development projects, disasters and gem mining.
- Case-based entomological surveys (as part of the investigation of a focus) or reactive surveys are carried out to determine the presence of vectors in the area where a malaria case is detected or reported.

During the surveys, at least one or a combination of the following entomological techniques were performed: adult collection using cattle-baited huts and nets, indoor and outdoor human landing catches, indoor resting hand collection, pyrethrum spray sheet collections, window exit traps and larval collection to determine breeding habitats.

The above-mentioned activities were performed by entomological teams of the AMC and in regions under the guidance and supervision of RMOs and the AMC.

In 2010–2011, vector surveillance was expanded to include sentinel monitoring, and focal investigations related to the investigation of cases. In 2012, the 57 sentinel surveillance and spot checks carried out by central and regional entomological teams were augmented by the Tropical and Environmental Disease and Health Associates (TEDHA) to cover the Eastern and Northern Provinces.

Monitoring of insecticide resistance has been carried out extensively in Sri Lanka. In 2010–2015, insecticide susceptibility testing was conducted for the 11 vectors (primary, secondary and potential vector species) against 10 insecticides belonging to four

classes of insecticides (one organochlorine, one carbamates, two organophosphates and six pyrethroids).

Integrated vector management carried out in the last phase of malaria control was continued in the elimination phase as well, as the AMC's approach to malaria vector control was through the rational use of insecticides in rotation for IRS, distribution of LLINs, larviciding or use of larvivorous fish and environmental modifications.

IRS was limited to some of the areas with continued transmission in the Northern and Eastern provinces and as focal responses to outbreaks. As transmission decreased, so did the use of IRS, from 728 789 people covered in 2008 to only 75 354 in 2012. Distribution of LLINs was expanded in 2011 and 2012 in some areas of the Northern and Eastern provinces, where they had not been distributed during the period of conflict.

Larval source management carried out over the years included environmental manipulation or modification by filling in of abandoned gem and quarry pits, and seeding of larvivorous fish into wells. These activities were carried out by the AMC and Sarvodaya, a nongovernmental organization working on village-level development, as part of Global Fund-supported activities in the community.
Limited space spraying and chemical larviciding were conducted in areas with reported outbreaks. Larviciding was also done in locations with unusually high anopheline abundance, where it was not feasible to introduce larvivorous fish.

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Photo Credit: Dr Risintha Premaratne, Sri Lanka

Enabling environment

Photo Credit: P H D Kusumawathie, Sri Lanka

ENABLING ENVIRONMENT

Intersectoral collaboration

During malaria control and elimination, the AMC worked closely with sectors other than the health sector, such as the Ministry of Defence (MoD) – the Sri Lankan Army, Navy, Air Force and Police. This collaboration was critical for the elimination effort, particularly in the past 10 years.

In the past decade, one of the key partners of the AMC was the MoD. The reason was the civil conflict in the north and east of the country, which spanned over 30 years (1983–2009), the last decades of which also happened to coincide with the most active phase of the AMC. As mentioned before, a vast majority of malaria infections were reported among armed forces personnel, most of these in personnel from the army who served in jungle areas in conflict-affected districts. This called for close collaboration between the AMC and MoD to reduce the reservoir of infection, which was effectively done.

High-level officers of all three armed forces (namely, the Sri Lanka Army, Navy and Air Force) attended monthly review meetings of the AMC, which provided training for the laboratory staff of the medical corps on malaria diagnosis, treatment and follow up of malaria patients, and provided guidance on policies and strategies for malaria control and elimination in the forces. Armed Forces personnel provided enormous support and assistance to the AMC in conducting vector surveillance and control operations in and around malaria foci in camps. The sharp reduction in malaria cases from 684 in 2010 to 124 in 2011 is largely believed to be due to the armed forces implementing the DOTS strategy for anti-relapse primaquine treatment of patients with P. vivax, and keeping their malaria patients in the camp for the 14-day duration of treatment, a switch from the previous practice of allowing malaria patients to complete radical treatment at home

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Some examples of intersectoral cooperation with the AMC are given in Table 1.

Socioeconomic development

The link between poverty, socially marginalized populations and malaria is an important historical consideration. Reduction in poverty and social equity are two factors that contributed to malaria elimination. Rapid socioeconomic developments, such as an increased national literacy rate (estimated at 95.6% in 2012), expanded the social discourse on malaria. The strong transportation and communication systems enhanced access to health services, even in remote areas and islands. Jaffna, an area of conflict for over 20 years, rebuilt its transport and communication infrastructure in a relatively short time.

Political commitment

The high level of political commitment to, and governmental support for, the AMC are worthy of special mention. The Government of Sri Lanka provided continuous and substantial support for malaria control and elimination operations. Provincial governments were also strongly committed to achieving the elimination of malaria. Malaria control and elimination

Table 1.
Examples of intersectoral and international collaboration in malaria elimination and prevention of reintroduction

International agency/Government department	Population group on which information is relayed to the AMC	Examples
International Organization for Migration (IOM)	Migrant labourers stranded in other countries brought to Sri Lanka	In June 2012, a group of over 150 irregular migrants who went to Benin and Ghana were screened on arrival and 16 were positive for malaria. They were diagnosed and managed by the AMC because of prior notification by the IOM.
United Nations High Commissioner for Refugees (UNHCR)	Refugee groups, asylum seekers from other countries to Sri Lanka	In 2013, a large group (n=1050) of Pakistani asylum seekers who were hosted at Negombo were screened and 30 found positive. All were regularly followed up by the AMC with repeat screenings.
Sri Lanka Navy	"Boat people" rescued at sea and brought to the shores of Sri Lanka; Indian fisherman poaching on Sri Lankan waters	In 2014, two groups of asylum seekers from Myanmar and Bangladesh were rescued by the Navy and brought ashore. The AMC was immediately informed and they were screened and followed up ashore thereafter.
Sri Lanka Army, Navy, Air Force and Police Department	UN Peacekeeping Forces returning from service in malaria-endemic countries	From 2012 onwards, every year, all military forces and the police force informs the AMC of personnel returning after missions abroad, and they are screened and followed up by AMC. The medical teams of the respective forces are trained in screening, provided information, education and communication (IEC) on preventive measures and on testing after arrival, and thereafter repeated screening. The AMC also conducts awareness programmes for outgoing missions.
Civil Aviation Authority	All departing and arriving passengers are kept abreast of the risks of malaria	From December 2010 onwards, the AMC has been allowed to display boards/fliers with information for passengers, and has a malaria screening service (free-of-charge) at the airport for any passenger.
Colombo Dockyard	Migrant labour employed on a short-term basis	The dockyard employs foreign labour mainly from India, on short-term contracts, and several have been found to be infected with malaria. A regular link established with the dockyard officials enables patient referral to the AMC as well as allows the AMC to conduct ad-hoc blood screening of foreign labourers.
Private industries – steel companies	Migrant labour employed on a short-term basis	Several steel companies regularly employ foreign labour, and links with them have enabled the AMC to perform regular blood screening. In addition, febrile patients among the workers are referred directly to the AMC for blood testing and management.
Travel agencies	Travellers to endemic countries	Guidelines on prevention and information for travellers are provided.

interventions were supported by policies and strategic plans, decrees and guidelines endorsed by the Ministry of Health, Nutrition and Indigenous Medicine. Activities of the AMC have been backed by adequate and consistent funding provided by the government.

Financing

The total government budget for malaria control in 2012 was Sri Lanka Rupee (LKR) 414 million (US$ 3.2 million) (Central and provincial budget statements); and in 2013, LKR 429 million (US$ 3.3 million) (Central and provincial budget statements).

The Global Fund, International Development Aid, and World Bank (indirect) provided additional funds.

Capacity development

Continuing medical education of doctors has been carried out in collaboration with the Sri Lanka Medical Association through joint sessions with regional medical associations in different parts of the country. The AMC has done much to strengthen capacity for malaria laboratory diagnosis, disease management, case notification and investigation, and information and reporting systems. Physicians, laboratory staff and other field health personnel have been trained in malaria surveillance. Clinician awareness programmes in 25 districts in the country were conducted over the past five years with the support of the Global Fund. In 2012, 44 entomological assistants, 200 PHLTs and 183 laboratory technicians had been trained/retrained. Regular training programmes have been conducted for all grades of field staff throughout the country to motivate staff and keep them updated and abreast of recent developments.

Time has been allocated to malaria in all undergraduate programmes in medicine in the country. AMC staff routinely visit faculties of medicine and make presentations on malaria.

Role of international partners

Several international partners (WHO Sri Lanka Country Office, the WHO Regional Office for South-East Asia and WHO headquarters in Geneva, the Global Fund, the World Bank, UNHCR, IOM, United Nations Children's Fund [UNICEF] and others) have played important roles in the control and elimination of malaria in Sri Lanka throughout the past decades, and some are now helping to prevent the reintroduction of malaria.

WHO has been a key partner in Sri Lanka's fight against malaria, beginning with the Malaria Eradication Programme of the 1950s. WHO was particularly important in supporting malaria elimination, providing technical guidance, assistance in capacity-building and financial support to the AMC through the Country Office.

The Global Fund, through three grants (2003–2008; 2009–2014 and 2015–2018) provided critical funding for enhanced operations against malaria to supplement the national malaria budget, and especially for enhanced staff allowances and training, mobile malaria clinics, equipment for regional malaria offices, GIS and information technology (IT) support.

The expansion of mobile malaria clinics, which greatly contributed to the sharp decline in malaria incidence in Sri Lanka, was supported by the World Bank through International Development Association (IDA) funding.

Health education and community awareness-raising

Sri Lanka has done much to improve the health education of the population. Community mobilization, through the building up of community-level intervention channels, has strengthened the participation of the entire population in malaria elimination and prevention.

Simple messages on how malaria is transmitted, the importance of early diagnosis and treatment, the need to use LLINs and allow IRS have formed the basis of community-based health education and awareness programmes. School awareness programmes have been also carried out.

Research

Intensive research on malaria has been carried out for nearly three decades in Sri Lanka with approximately 31 PhD degrees, four MPhil degrees and one MD degree in the fields of epidemiology, immunology, pathology, diagnosis and vector-related aspects of malaria. The main topics can be summarized as follows:

- challenges in parasitological surveillance and response for malaria elimination, including delayed diagnosis and engagement of the private sector;
- field challenges in vector surveillance and response for malaria elimination;
- economic aspects of malaria: relevant research topics; and
- sociological aspects of malaria.

A total of 11 operational research projects were conducted, with four studies completed and published. All research information collected supported malaria control, elimination and prevention of its reintroduction in Sri Lanka.

Photo Credit: Lalanthika Peiris, Sri Lanka

Maintaining zero – how is Sri Lanka preventing re-establishment?

Photo Credit: WHO

MAINTAINING ZERO – HOW IS SRI LANKA PREVENTING RE-ESTABLISHMENT?

Sri Lanka transitioned to the phase of prevention of malaria reintroduction in November 2012. The reintroduction of malaria in the country faces many challenging factors – ecological, climatic, sociodemographic, epidemiological, entomological and others. The combined effect of these factors creates a risk of malaria resurgence. Therefore, the definition of risk and its components and their relationship are of core practical and scientific importance for health-care facilities.

Preventing re-establishment of malaria transmission requires proper management of receptivity and vulnerability. The interaction of these two main factors determines the magnitude of the malariogenic potential, and each of the factors and their combination can be assessed.

Vulnerability

Analysis of malaria importation is key in evaluating the level of vulnerability. Imported cases of malaria are a priority for intervention by the Malaria Programme in Sri Lanka. Cases are carefully classified after a comprehensive case investigation. Most of the imported malaria cases were contracted in South-East Asian countries – India and Pakistan. Travel between India and Sri Lanka is extensive, with Sri Lankan business travellers to India and Indian migrant labour to Sri Lanka constituting most of the travellers. Nearly all asylum seekers from Pakistan to Sri Lanka brought in imported malaria. The second largest and a significant source of imported malaria is Africa, with several countries contributing.

The majority of imported malaria cases were Sri Lankan nationals returning from travel abroad, and foreign nationals coming to Sri Lanka constituting 28–38% of imported malaria cases between 2013 and 2015. The profile of people with imported malaria included businessmen, seamen, asylum seekers, technician/skilled labourers, students, pilgrims, tourists, and army and police forces (Table 2).

Table 2.

Occupational categories of imported malaria cases among foreign and Sri Lankan nationals, 2013

Occupation category	Sri Lankan nationals	Foreign nationals
Armed Forces/Police	4	
Business/trade	20	2
Seamen	13	2
Technician/skilled labourers	6	4
Manual labourers	-	3
Professionals	6	
Students	4	
Tourists	3	5
Pilgrims	3	
Asylum seekers		19

Source: Anti Malaria Campaign, Ministry of Health, Nutrition and Indigenous Medicine, Sri Lanka

Prominent among imported malaria were two clusters, one in 2013 among Pakistani asylum seekers resident in Sri Lanka and the other among a group of Sri Lankan fisherman returning from Sierra Leone after a four-month stay in 2014. The AMC was alerted to the Pakistani group when two of their children were admitted to a state hospital and diagnosed with P. vivax malaria. Subsequently, four ACD programmes were carried out by the AMC among this group of asylum seekers between July and December 2013, the largest being the initial programme screening of 839 individuals. This led to the identification of 17 P. vivax malaria infections.

Similarly, nine malaria infections were detected in the group of 14 fishermen returning from Sierra Leone through contact tracing and screening, prompted by the first case of infection detected in one of them by the health system in August 2014.

For both the Pakistani refugees and the seamen, the AMC responded and took appropriate action rapidly, thereby preventing or at least reducing the risk of secondary transmission from the infected individuals. There are other risk groups that are routinely reported to AMC, such as workers at large industrial sites, including large steel plants, which are screened on arrival or as soon as possible thereafter and their movement monitored.

Receptivity

Although historical information on malaria transmission is a good starting point in assessing the malaria receptivity risk of an area, entomological information derived from systematic vector surveillance should provide a sound basis for preventing re-establishment of malaria. Entomological surveillance is a core component of the AMC's post-elimination strategy.

Results of entomological monitoring and investigation around cases has shown that favourable climatic conditions, the tendency of vectors to feed on humans both indoors and outdoors, and the abundance of potential vector breeding habitats is likely to sustain receptivity in most parts of the country.

Spot checks conducted in areas that are not covered by sentinel site monitoring includes mapping of potential larval habitats. Larval surveys have shown An. culicifacies breeding in wells, river and stream margins and temporary water collections. Irrigation canals, ponds, various types of pits (gem pits, burrow pits, clay pits and quarry pits), tanks and paddy fields have also been reported as breeding sites of this vector. The main breeding sites of the secondary vector, An. subpictus, are temporary water collections, marshy lands, riverbed pools and various kinds of mud pits. The breeding sites of An. varuna are river and stream margins while An. annularis is abundant in the margins of reservoirs (tanks).

Sentinel site monitoring of the outdoor and indoor biting behaviour of vectors collected from human landing catches further confirms the receptivity of most of the areas with the collection of local vectors from human landing catches, both indoors and outdoors. Although entomological surveillance data show a high level of receptivity in former endemic areas, most of the cases of imported malaria were diagnosed in, and reported from, the Western Province, which contains the districts of Gampaha, Kalutara and Colombo, there being hardly any malaria vector breeding there. Only a few cases were registered in the former malaria-endemic areas. Thus, the highly vulnerable districts and those that are receptive to malaria are quite distinct and show little overlap.

In conclusion, presently in Sri Lanka, the receptivity of many areas appears to have remained high. Vulnerability is at a medium level with a moderate number of imported cases registered predominantly in areas of no or a low level of receptivity. However, in the future, the situation may change and a potential increase in the level of vulnerability should be considered, related to the new global trends of increased migration, a possible rise in the number of asylum seekers or foreign workers in new development projects, or tourists who tend to visit tourist sites in the dry zone of the country where receptivity is still high. Hence, a state of sustained vigilance is required.

The experience gained during the elimination of malaria and the lessons learnt after the resurgence of malaria in the 1960s formed the basis for the development and implementation of the new programme strategies and policies that aimed to prevent reintroduction and re-establishment of malaria. The malaria programme realized that transition from elimination to prevention of malaria reintroduction could be accomplished only by conducting continuous, adequate and effective surveillance, thus providing strong vigilance in the country. In order to maintain a stable malaria-free status, prevent the resumption of local malaria transmission and establish effective mechanisms for the post-elimination period, a National Malaria Strategic Plan for Elimination and Prevention of Re-introduction – Sri Lanka, 2014–2018, in line with the WHO recommendations, was developed and implemented by the AMC.

The implementation of the Plan was supported by additional routine administrative circulars issued by the Director-General of Health Services, which are applicable to all government and private-sector health facilities.

Epidemological surveillance and case management

Epidemiological surveillance to prevent re-establishment of malaria in Sri Lanka is similar to the one in the elimination phase, but is more difficult because vigilance needs to be maintained when malaria is no longer a health priority in the country. Special effort is taken to prevent the onward transmission from imported cases. The surveillance system for malaria operates throughout the entire country (regardless of the level of risk), in order to promptly detect and report all detected malaria cases (imported or of possible renewed malaria transmission).

The malaria programme has correctly identified groups of the population at higher risk, so that preventive operations can be targeted at them. These high-risk groups presently include the following:

- foreigners, especially Indians, Pakistanis, Koreans and Chinese. These include workers from India who are employed in various parts of Sri Lanka at massive development projects, migrants, refugees and asylum seekers who pose a potential threat for the reintroduction of malaria in Sri Lanka;
- Sri Lankans with a recent travel history (up to six months) to a malaria-endemic country;
- Armed Forces personnel – returning from peacekeeping missions/training;
- travellers returning from Africa for occupation or after leisure tours;
- travellers returning from Asia after pilgrimages, leisure and study tours, and businessmen;
- any individual with a history of contact with a malaria-positive patient;
- any individual who presents with fever without an obvious cause.

The current surveillance is functioning well throughout the country, as evidenced by its performance since November 2012 in effectively detecting imported cases and the fact that no secondary transmission has taken place from imported cases.

Efforts are now directed toward timely detection of each imported malaria case and possible introduced or indigenous cases. PCD by a vigilant general health services is conducted, supported by ACD (reactive and proactive) when needed, similar to the activities during elimination. At present, over 200 medical institutions, located predominantly in the dry and intermediate zones of the country, have been activated through the presence of a PHLT and/or a PHFO.

Active screening has been a key component of the surveillance system. It has shown its value in detecting imported cases among high-risk populations such as Pakistani asylum seekers. Agencies such as UNHCR notify the AMC of the arrival into Sri Lanka of refugees/asylum seekers and other groups or individuals so that they can be screened by the AMC.

Screening of foreign workers (mainly from India) on their arrival and periodically after that also contributes to the timely detection and treatment of malaria cases, and prevention of the consequences of malaria importation.

Screening of all donor blood for malaria before transfusion is mandatory in Sri Lanka at present. In high-risk areas, pregnant mothers attending antenatal clinics are also screened.

A good average annual blood examination rate (ABER) of 4.8–5.4% has been maintained in the country over the past 3–4 years by PCD and ACD. It should be stressed that these good rates were achieved despite the difficulties of maintaining a high referral rate of fever patients for a diagnosis of malaria (because malaria is now a rarely encountered disease). The rates indicate that the programme makes strong efforts to avoid missing any imported case.

Diagnosis

In the public sector, microscopy is performed by: PHLTs at government hospitals (n=250); medical laboratory technicians (MLTs) at government hospital laboratories (n >1000); APCD centres, regional malaria offices; and the AMC headquarters. At present, over 200 medical institutions, located predominantly in the dry and intermediate zones of the country, have been activated through the presence of a PHLT and/or a PHFO.

Malaria RDTs are provided to health institutions, public sector hospitals and health institutions where PHLTs are not available. They are also supplied to medical centres at ports of entry where malaria diagnostic services are available 24 hours a day, seven days a week.

Malaria diagnostic services using microscopy and RDTs are also widely available in the private health sector, in private hospitals and private laboratories that make significant contributions towards case-finding. A large number of imported malaria cases are reported from the Western Province, which contains the capital city of Colombo (Colombo District) where a majority of private health facilities are situated. The number of annually examined blood slides for malaria is impressive. For example, in 2015, over 1.14 million slides were examined.

Based on the recommendations of WHO (Regional Workshop on Quality of Malaria Microscopy, Saraburi, 26–28 November 2012), measures were taken to improve the QA/QC mechanism of malaria microscopy in Sri Lanka. Now, improved and more comprehensive, the national QA/QC system for malaria microscopy is in place. It was initiated in 2015 and conducted in accordance with the standard operating procedures for malaria microscopy. The system includes: validation of positive blood smears at district and national levels (AMC); monthly cross-checking of negative slides at the intermediate and central levels; and proficiency assessment conducted twice a year by sending a panel of 50 blind slides by the AMC, and on-site supervisory and monitoring visits. The AMC conducts training programmes for laboratory technicians in malaria microscopy.

Treatment

All malaria patients in the public and private health sectors are treated in accordance with the National Guidelines on Malaria Chemotherapy and Management of patients with malaria issued by the AMC, the Ministry of Health, Nutrition and Indigenous Medicine and

WHO guidelines, as follows: uncomplicated P. falciparum infections – with ACT (artemether–lumefantrine and a single dose of primaquine; P. vivax infections – with chloroquine and a 14-day course of primaquine; severe and complicated P. falciparum malaria – with parenteral artesunate. In case of drug resistance, a second-line antimalarial medicine (dihydroartemesinin–piperaquine or quinine plus doxycycline/clindamycin) is administered. Follow up of malaria patients is conducted by repeated microscopic examination of blood as follows: (a) P. vivax/P. ovale: days 7, 14, 21, 28, 42, and then monthly for one year; (b) P. falciparum: days 7, 14, 21, 28 and 42.

Analysis of the data on 2013–2015 treatment timelines of patients following a diagnosis of imported malaria (Fig. 4) revealed that treatment was started in less than 24 hours in the majority of malaria cases (97.22%, n=175). This is in line with the WHO standard.

Chemoprophylaxis

The choice of chemoprophylaxis depends on current WHO information on parasite resistance reported in malaria-endemic countries and areas to be visited. Chloroquine and mefloquine are prescribed for standard prophylaxis against malaria for Sri Lankans travelling outside the country. Doxycycline is used as an alternative to mefloquine.

Malaria prophylaxis is issued to travellers by the AMC headquarters and at the regional malaria offices free of charge for a period of up to six months.

The existing collaboration between the AMC and the Sri Lanka Army, Sri Lanka Air Force, Sri Lanka Navy and Police ensures that security forces personnel travelling to malaria-endemic countries on United Nations peacekeeping missions receive chemoprophylaxis.

Case and focus investigation, response and follow up

The AMC continued the WHO elimination surveillance approach for epidemiological investigation of each malaria case and focus initiated in 2011.

Every malaria case and focus is investigated in a timely manner. In 2013–2015, 174 (96.66%) cases were investigated within 24 hours of notification, three cases within 48 hours and only two cases were investigated more than 48 hours after notification (Fig. 5).

As a rule, response is also prompt. For example, in 2015, in 25 (73.5%) of 34 cases, the focal response (considering the first date of screening or/and entomological surveillance) occurred within 24–48 hours after the case investigation was done. There was no focal response considered for two cases reported from Colombo (Fig. 6).

Information system

A strong system is maintained for malaria reporting and recording, as well as malaria databases at all administrative levels. There is an electronic version of the national database of the malaria case register from 2013 onwards. Online reporting has been introduced but requires further development.

Fig. 4
Timelines between malaria diagnosis and the start of treatment of patients with imported malaria, 2013–2015 (n=180)

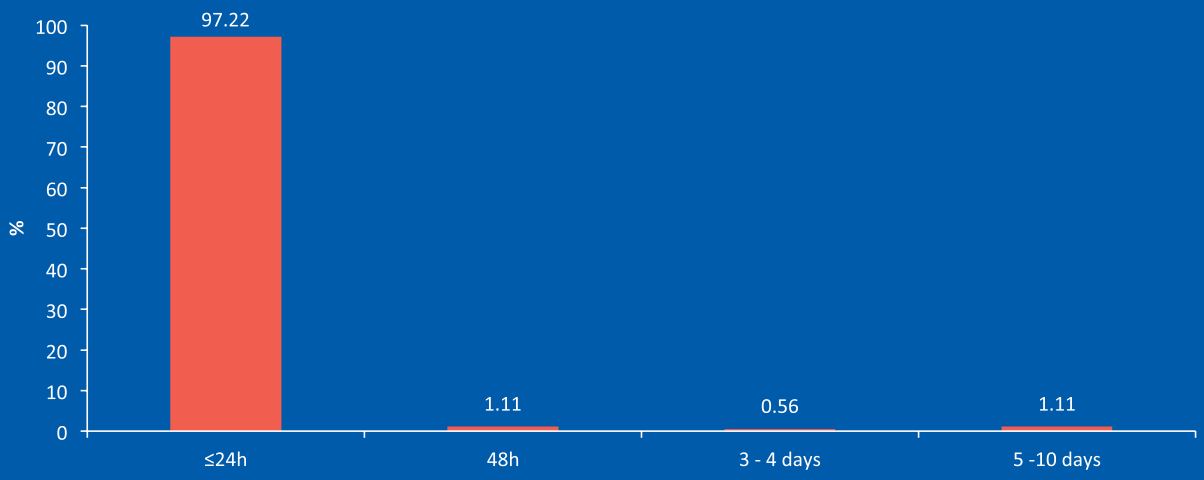


Fig. 5
Time between notification and case investigation, 2013–2015 (n=180)

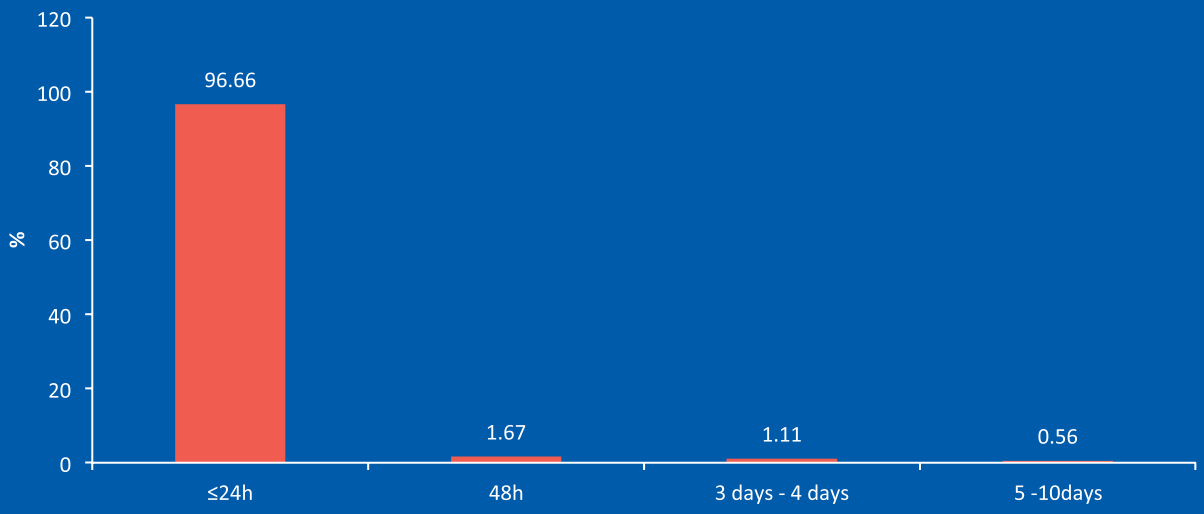
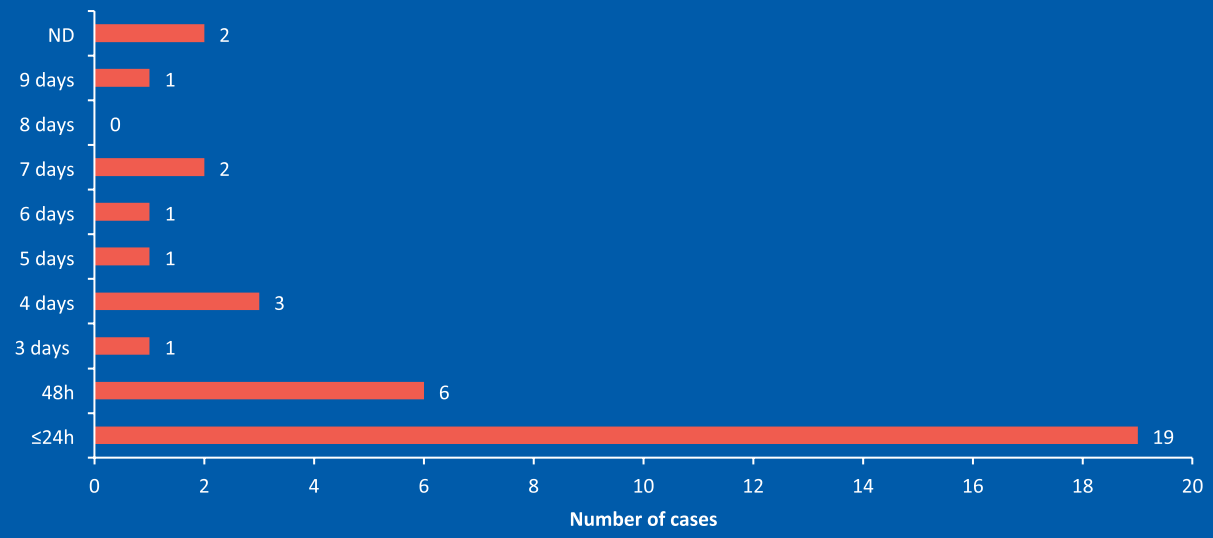
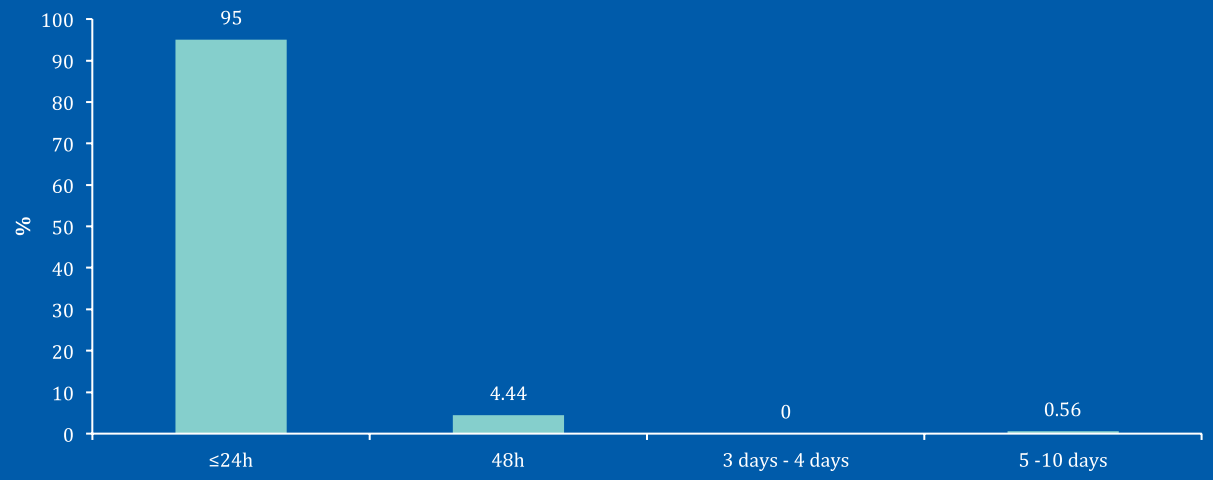


Fig. 6
Time between case investigation and focal response, 2015



The programme considers the timely notification of cases as key to an efficient response. In 2013–2015, 95% (n=171) of the total reported imported cases were notified within 24 hours after diagnosis, meeting the WHO criteria. Of the nine remaining malaria cases, eight were notified by the 48th hour and one was notified within 5–10 days (Fig. 7).

Fig. 7
Timelines between malaria diagnosis and notification, 2013–2015



Entomological surveillance and vector control

The effective system of entomological surveillance continues to operate with strong dedication and capacity. In 2013–2015, more than 50 investigations were conducted per year covering predominantly most of the previous transmission areas. Entomological surveillance activities became better organized in 2015, when the AMC developed the national guidelines for entomological activities to be conducted and vector-control measures to be applied in the event that a malaria case is detected. Standard operating procedures were also developed to assist the entomology teams in the performance of various entomological techniques.

In 2015, the mean duration between case investigation to entomological investigation was shortened to approximately three days (ranging from 0 to 13 days). Entomological investigations were conducted for 89% (n=32) of the cases investigated. Only the cases detected at the airport, and two other cases from Colombo were not considered for entomological investigation.

Vector-control activities are mainly directed at a larviciding programme using locally available larvivorous fish from stock tanks for rearing Poecilia reticulate in selected regional malaria offices, using LLINs (over 100 000 new LLINs were distributed in 2015) and environmental management. In the post-elimination phase, IRS is conducted only when an imported case is detected in areas of high receptivity as determined by entomological surveillance.

Insecticide susceptibility tests conducted according to the WHO standard have been continued for An. culicifacies (used in tests in seven areas in 2013, nine in 2014 and one in 2015) and An. subpictus (used in tests in 15 areas in 2013, 18 in 2014 and seven in 2015). Possible resistance has been detected to permethrin of An. Culicifacies, and to lambda cyhalothrin, permethrin, deltamethrin, malathion, cyfluthrin and propox of An. subpictus.

Enabling environment

Realizing that the national malaria network, created in the early years of malaria control and upgraded and expanded over the years, plays a leading part in all malaria interventions, and considering the integral role of primary health-care services, the government aims to maintain malaria expertise. Programmes are carried out to continue malaria education.

As mentioned previously, creating and maintaining strong collaboration with a wide range of internal and international partners is efficient and specific to the Sri Lanka malaria programme's prevention of malaria resurgence. This has enabled the AMC to secure advanced information on high-risk groups that are either returning to the country or are rescued and brought to the country. The AMC then conducts an extremely prompt response and ensures that the individuals are screened for malaria on arrival, and followed up for malaria thereafter in areas of settlement. The AMC collaborates closely with the Armed Forces, the Sri Lanka Police, and other agencies such as UNHCR to

screen persons who return from peacekeeping missions, refugees and other migrants coming from malaria-endemic countries. A good example is contact with religious leaders, which also contributes to monitoring and examination of migrants from Pakistan, as well as relations with travel agencies. All these activities have ensured that in the past four years since the cessation of local transmission, malaria infections among those who return to the country are promptly diagnosed and treated.

Sri Lanka is a partner in many international initiatives and regional networks, such as the South East Asian Regional Collaboration for Malaria Elimination (SAARC), Asia Pacific Leaders Malaria Alliance (APLMA) and Asia Pacific Malaria Elimination Network (APMEN).

The programme for prevention of reintroduction of malaria in Sri Lanka is financially supported by the government and assures the sustainability of interventions. The total government budget for the malaria programme by year is presented below.

2012 – LKR 414 million (US$ 3.2 million) (Central and provincial budget statements);
2013 – LKR 429 million (US$ 3.3 million) (Central and provincial budget statements);
2014 – the estimated government budget is LKR 640 million (US$ 4.9 million);
2015 – the estimated government budget is LKR 703.3 (US$ 5.4 million), (Ministry of Finance assumption based on 2013 provincial budget);
2016 – the estimates are LKR 771.5 (US$ 5.9 million), (Ministry of Finance; assumption based on 2013 provincial budget).

Additional funds are from the Global Fund, International Development Aid and World Bank (indirect).

After sustaining zero cases for more than three consecutive years, Sri Lanka applied for official WHO certification. An assessment by a team of independent experts assigned by WHO in August 2016 concluded that Sri Lanka had, beyond a reasonable doubt, met both of the following criteria for designation by WHO as malaria-free: (i) the chain of local malaria transmission by Anopheles mosquitoes has been fully interrupted throughout the country for the past three consecutive years; and (ii) an adequate surveillance and response system for preventing malaria reintroduction and possible re-establishment of local transmission is fully functional across the entire country. In September 2016, Sri Lanka became the second country in the WHO South-East Asia Region to achieve a malaria-free status.

Photo Credit: Dr Risintha Premaratne, Sri Lanka

Outlook for the future

Photo Credit: Dr Risintha Premaratne, Sri Lanka

OUTLOOK FOR THE FUTURE

Sri Lanka has made enormous efforts to achieve malaria elimination. After reaching the goal of interrupting local malaria transmission, the malaria programme transitioned to prevention of reintroduction and the country has maintained zero autochthonous cases for the past five years. Lessons learnt show that any neglect of malaria interventions at this stage may cause a swift resurgence of malaria, requiring renewed substantial efforts and financial support to combat malaria once again. Efforts to keep malaria at bay should continue in accordance with the National Malaria Strategic Plan for Prevention of Malaria Reintroduction. In Sri Lanka, there is strong political commitment, and operational and technical capacity for robust maintenance of a malaria-free status.

Sri Lanka has no land borders but human migration, both legal and illegal, and extensive air and sea travel in and out of the country, particularly (but not only) from the neighbouring countries, makes the island nation highly vulnerable to imported malaria. This, combined with high receptivity in many parts of the country, makes the risk of malaria reintroduction very real.

Continued attention should be drawn to the prevention of consequences of malaria importation in order to prevent resurgence of the infection. This topic is already addressed but the country should maintain a high level of vigilance in the coming years and focus on the following main strategic directions.

A good surveillance mechanism with full coverage of all geographical areas and at-risk populations is crucial. Even though the current system of case detection appears to be comprehensive and efficient, the AMC and staff of health facilities should be increasingly vigilant, making use of every possible means to identify groups at higher risk and new arrivals as soon as possible.

The continued capacity to detect, treat and follow up imported cases will depend on the capacity of both government and private health facilities to accurately diagnose malaria. The existing national QA system contributes greatly to the quality of malaria microscopic diagnosis, and should be continued and further developed. Adequate health services for disease management of imported malaria cases should be in place. Treatment and follow up of imported malaria cases should be conducted on time in line with the latest national treatment guidelines, and provided free of charge by both public and private clinics, hospitals or other health facilities. Updated protocols for managing both uncomplicated and severe malaria should be regularly circulated to all health facilities and training on malaria should be part of the curricula in all medical schools and of continuing medical education.

It is important that the AMC keeps up to date with the current information on artemisinin-resistant P. falciparum, and always has on hand the latest combination therapies for treatment of cases coming from countries in the Great Mekong Subregion. Antimalarials for the radical

treatment of malaria caused by all Plasmodium species must be stocked by the AMC and made available to all health facilities at no cost.

Continuing epidemiological investigation of every new case and focus, reviewed and properly interpreted, will be key to preventing secondary transmission from imported cases. Investigations should be done quickly, ideally within 24 hours of notification. The review and the proper interpretation of data collected should provide a correct epidemiological classification of cases, determined further by the Case Review Committee, and be a basis for response planning. Foci monitoring with their classification in real time and maintaining a database will be crucial. A national malaria case register, notification and full immediate reporting by public and private health services is of great importance.

A continued system for prevention of consequences of malaria importation will play a key role. The AMC should sustain the developed mechanism for dissemination of information on malaria prevention and providing chemoprophylaxis for travellers through travel agents, hoteliers, and other persons from the travel trade. It should also continue to work closely with the military, including personnel traveling to malarious areas for training or who serve as members of United Nations peacekeeping forces to provide information on prevention and use of chemoprophylaxis. It is essential to continue partnerships with a number of sectors.

There should also be active community involvement to detect and report possible imported cases. Public awareness about malaria should be strengthened, especially among travellers to endemic countries, in order to reduce the risk of imported cases and the possible consequences.

Sustaining a malaria-free Sri Lanka will require a great deal of regional cooperation and Sri Lanka participates in several regional initiatives on malaria elimination.

Ongoing surveillance operations will require funding. Sustained and effective advocacy is needed at the political and international partners' level to mobilize adequate funds needed for a sensitive and robust surveillance and information system in view of other emerging diseases, including outbreaks such as dengue.

Photo Credit: Dr Risintha Premaratne, Sri Lanka

Lessons learnt

Photo Credit: Dr Risintha Premaratne, Sri Lanka

LESSONS LEARNT

Eliminating malaria

Comprehensive strategies and polices applied and good programme management

The malaria elimination programme in Sri Lanka benefited greatly from the elimination policies, strategies, and interventions applied, based on an integrated and comprehensive approach to guide malaria elimination, well formulated in the Strategic Plan for Elimination of Malaria 2008-2012.

Country experience showed that malaria elimination could be achieved using existing strategies and tools (surveillance, disease management and vector control).

The programme has provided strong guidance and plans from the central level, which were translated into action plans at intermediate and primary levels.

The programme at all levels implemented a targeted approach, based on evidence (from surveillance and research), with great willingness to adopt and innovate.

The conflict/post-conflict situation posed severe challenges that have been overcome with great determination, creativity and perseverance. It should be underlined that even during the war programme staff applied complex control interventions.

Efficient epidemiological surveillance

- The programme benefited much from a timely detection of malaria cases by ACD and PCD and conducting prompt and adequate treatment in accordance with the national policies and guidelines contributing to the elimination of sources of infection. An efficient specific approach in Sri Lanka was carrying out ACD by mobile malaria clinics with a facility for microscopic examination of collected blood smears on the same day, which operated in malarious areas, situated far from medical institutions and groups at higher risk.
- Laboratory support that is crucial for reaching elimination was strong. Testing in QA/QC laboratories supervised by the AMC national and regional laboratories was important for the confirmation of every clinical malaria case. Functioning of the national QA/QC system for malaria microscopy assured a diagnosis of malaria cases of high quality.
- As elimination approached, case-based surveillance was set up. All individual malaria cases were subjected to comprehensive epidemiological investigation providing correct epidemiological classification of cases and a basis for planning an adequate response. By 2008, the AMC had started classifying cases as indigenous and imported.
- A system for investigation and management of malaria foci was in place.
- A strengthened and improved malaria information system with compulsory notification, weekly/monthly and annually reporting of communicable diseases,

including malaria, and a feedback mechanism meant prompt transmission of information and adequate decision-making. A malaria database was set up and maintained at all levels.

- Regular monitoring of changes in the level of malaria receptivity and vulnerability was critical for formulating correct polices and approaches and for the fast containment or prevention of epidemics.

Integrated and cost-effective vector-control and entomological surveillance

- Integrated vector management was conducted through a rational use of insecticides in rotation for IRS, limiting IRS to some of the areas with continued transmission in the northern and eastern provinces and focal responses to outbreaks. Larviciding using chemical agents and larvivorous fish, LLINs and environmental modifications were applied, too. The interventions led to a reduction of mosquito density and longevity, the number of breeding places, the extent of human-vector contact and malaria transmission. The use of larvivorous fish appears to play an efficient supplementary role in vector control in Sri Lanka.
- The intensive entomological surveillance provided important information on mosquito species, density, bionomics and breeding sites vital for planning good vector control.
- Extensive monitoring of mosquitoes insecticide resistance was carried out in Sri Lanka.

Enabling environment

- The high level of political commitment to and governmental support for the national malaria programme are worthy of special attention. Malaria control and elimination interventions were supported by necessary legislation and adequately funded by the government and later on, supported by the Global Fund as well.
- The role of a strong health system and of an upgraded, motivated and dedicated AMC staff with high expertise in reaching malaria elimination was crucial. High quality and coverage of implementation, including service delivery to hard-to-reach populations, were provided.
- A typical Sri Lanka approach that played a key role in malaria elimination was strong intersectoral collaboration, especially with the army and police. Armed Forces personnel provided enormous support and assistance to AMC in conducting vector surveillance and control operations, as well as case detection and treatment.
- Collaboration with many other sectors, including immigration and religious organizations and partnerships with the International Organization for Migration, the UNHCR and WHO, and financial support from the Global Fund, were strong and efficient.
- The rapid socioeconomic developments of the country and cross-border collaboration contributed greatly to success.
- The malaria elimination programme benefited significantly from committed community mobilization.

- Intensive research carried out for nearly three decades in Sri Lanka provided new information in the fields of malaria epidemiology, immunology, pathology, diagnosis and vector-related aspects.

Preventing malaria re-establishment

After malaria elimination, the main goal of the National Malaria Programme was to sustain results achieved and prevent onward transmission from imported cases in the country. A plan for prevention of malaria reintroduction operates throughout the entire country (regardless of the level of risk) aimed at a prompt response to changes in the receptivity and vulnerability of areas within the country, maintaining a high vigilance, timely detection of any malaria case (imported or possible renewed malaria transmission) and undertaking the necessary actions. Applying the following strategic directions brought about sustaining "Zero" in the past four years.

Surveillance interventions on response to challenges for malaria reintroduction

- A strong surveillance and response system, targeting prevention of malaria reintroduction, has been in place for four years. The capacity to rapidly mobilize resources, making of use drug stocks, insecticides, laboratory consumables and transport, exists at central, intermediate and peripheral levels.
- Maintaining high vigilance among health providers is key assuring timely detection of any malaria case and epidemics and an adequate response.
- After the interruption of local malaria transmission and realizing the potential risk of the consequences of malaria importation, efforts are directed at timely identification and effective treatment of imported cases.
- Groups within the population at higher risk have been identified to target them with preventive operations. These include people traveling overseas to malaria endemic countries (or arriving from them), including tourists from various countries; foreign workers, mainly from India and China, who are employed in Sri Lanka to work in massive development projects in various parts of the country and who are a potential threat for the reintroduction of malaria in Sri Lanka; returning peacekeeping forces; migrants and refugees; asylum seekers; and pilgrims to India.
- Timely case detection is assured by applying PCD and ACD. Passive case detection by vigilant general health services continues. ACD is mainly used to facilitate the early detection of malaria cases among risk groups, described above, and as a response to the detection of an imported case when needed.
- There is an extensive network of quality assured laboratories in public facilities and in some private facilities able to accurately and promptly diagnose malaria using malaria microscopy and RDTs. National quality assurance/quality control (QA/QC) system

for malaria microscopy maintains good diagnostic practices.

- A comprehensive case investigation carried out for every malaria case by a trained malaria or health worker is key for an adequate response and to prevent secondary transmission from imported cases.
- Post elimination, a single malaria case is treated as a focus and managed accordingly
- Strict recording of cases, real-time notification and reporting by both the public and private sectors are in place, providing the basis for adequate and timely decision-making and response.

Entomological surveillance, integrated vector-control and epidemic preparedness

- Routine entomological surveillance continues as a key component in the overall strategy of prevention of malaria re-establishment in Sri Lanka.
- Monitoring of insecticide resistance is in place.
- Larval source management includes environmental manipulation or modification by filling in abandoned gem and quarry pits, and seeding of larvivorous fishes into wells.
- Epidemic preparedness is in place with adequate stocks of insecticides, antimalarial drugs and laboratory consumables.

Enabling environment

- Special attention is paid to maintaining strong intersectoral collaboration and cooperation with partners of AMC, such as the police and military, UNHCR, International Organization for Migration, WHO, immigration, nongovernmental organizations, the private sector and other government departments, which all contribute to efficient efforts in maintaining a malaria-free Sir Lanka. AMC works with travel agencies, hotels, businesses and the military to provide advice on malaria prevention and free chemoprophylaxis. It also works with refugee agencies and employers to identify and screen foreign workers and other travellers arriving from malarious areas. An effective approach in Sri Lanka is close contact with religious leaders of migrants which contributes greatly to preventive measures.
- Awareness programmes are being implemented regarding malaria in the community, stressing the fact that although malaria has been eliminated in the country, the risk of reintroduction exists and requires vigilance among the population and preventative measures for travellers to endemic countries.
- Funding for preventive operations is currently available, and the malaria expertise of staff remains high, but both need to be sustained.

Bibliography

Abeyasinghe RR, Galappaththy GN, Smith Gueye C, Kahn JG, Feachem RG: Malaria control and elimination in Sri Lanka: documenting progress and success factors in a conflict setting. PLoS One. 2012,7:e43162.

Anti Malaria Campaign. Guidelines on malaria chemotherapy and management of patients with malaria. Colombo: Ministry of Health, 2014.

Anti Malaria Campaign. National Malaria Strategic Plan for Elimination and Prevention of Re-introduction-Sri Lanka (2014-2018). Anti Malaria Campaign, Ministry of Health, Nutrition and Indigenous Medicine. Colombo, 2014.

Anti Malaria Campaign. Standard Operating Procedures for malaria microscopy, Anti Malaria Campaign. Colombo: Ministry of Health,2015.

Anti Malaria Campaign. Strategic plan for malaria elimination 2008–2012. Colombo: Ministry of Health Care and Nutrition, 2008.

Dharmawardena P, Premaratne RG, Kumudunayana WM, Gunasekera TDAW. Characterization of imported malaria, the largest threat to sustained malaria elimination from Sri Lanka. Malar J. 2015;14:144.

Fernando P, Warusavithana S. 100 years of malaria control efforts in Sri Lanka 1911-2011. Colombo: M & S Associates, 2011.

Ministry of Health Sri Lanka, World Health Organization & the Global Health Group of University of California, San Francisco. Eliminating Malaria: Case-study 3: Progress towards elimination in Sri Lanka. Geneva: World Health Organization, 2012.

Ministry of Health Sri Lanka, World Health Organization and the Global Health Group of University of California, San Francisco. Maintaining zero: An update to the Sri Lanka malaria elimination case study. Geneva: World Health Organization, 2015.

Ministry of Health, Nutrition & Indigenous Medicine Sri Lanka: Malaria Elimination in Sri Lanka: National report for WHO certification. Colombo: Ministry of Health, Nutrition & Indigenous Medicine Sri Lanka, 2016.

Premaratne R, Ortega L, Janakan N, Mendis KN. Malaria elimination from Sri Lanka: What it would take to reach the goal. WHO South-East Asia J Public Health. 2014 Jan-Mar;3(1):85-89.

Senaratne R & Singh PK. Against the odds, Sri Lanka eliminates malaria. The Lancet. 2016 Sep 10;388(10049):1038-1039.

Silva KT. Decolonisation, development and disease: a social history of malaria in Sri Lanka. Oriental Blackswan, 2014.

World Health Organization, Regional Office for South-East Asia. 0. Malaria-Free Sri Lanka. New Delhi, 2016.

World Health Organization. Global technical strategy for malaria 2016– 2030. Geneva, 2015.

Wickramage K, Galappaththy GN. Malaria burden in irregular migrants returning to Sri Lanka from human smuggling operations in West Africa and implications for a country reaching malaria elimination. Trans R Soc Trop Med Hyg. 2013 May;107(5):337-40.

Wickramage K, Premaratne RG, Peiris SL, Mosca D. High attack rate for malaria through irregular migration routes to a country on verge of elimination. Malar J. 2013 Aug 6;12:276.

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