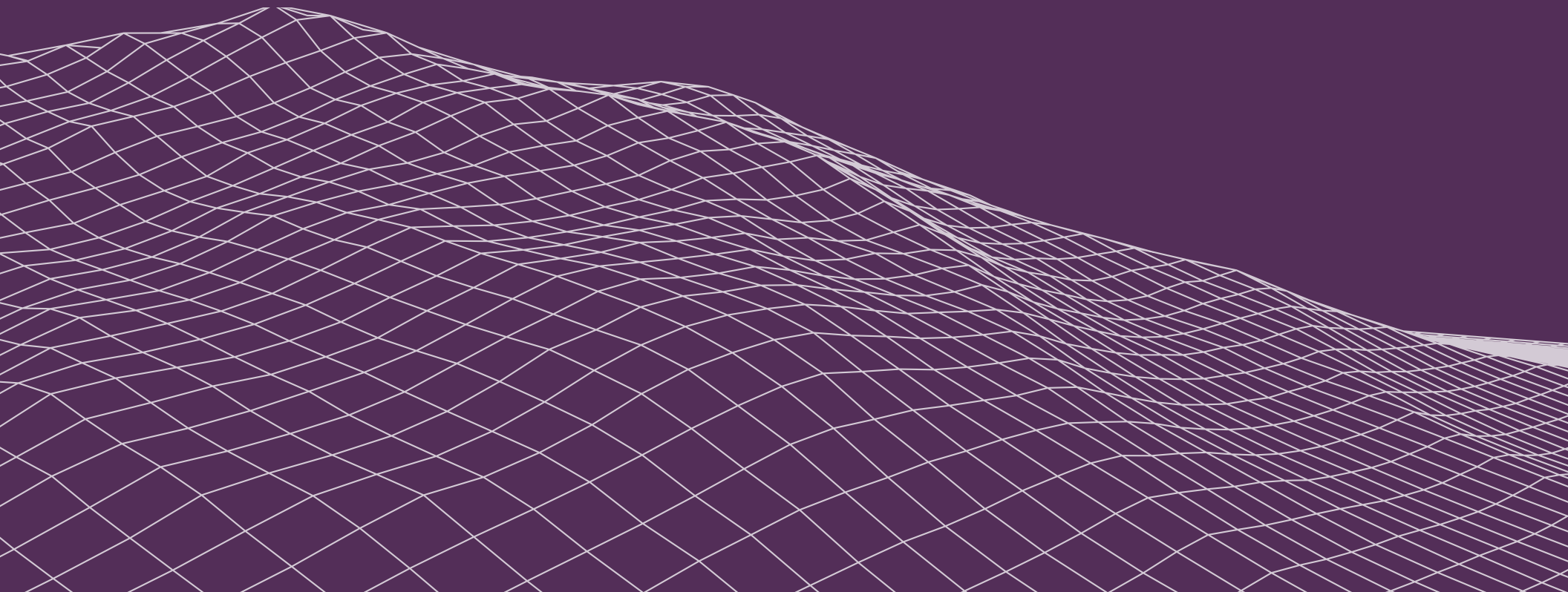
Eliminating Malaria in Sri Lanka

REACH PROJECT



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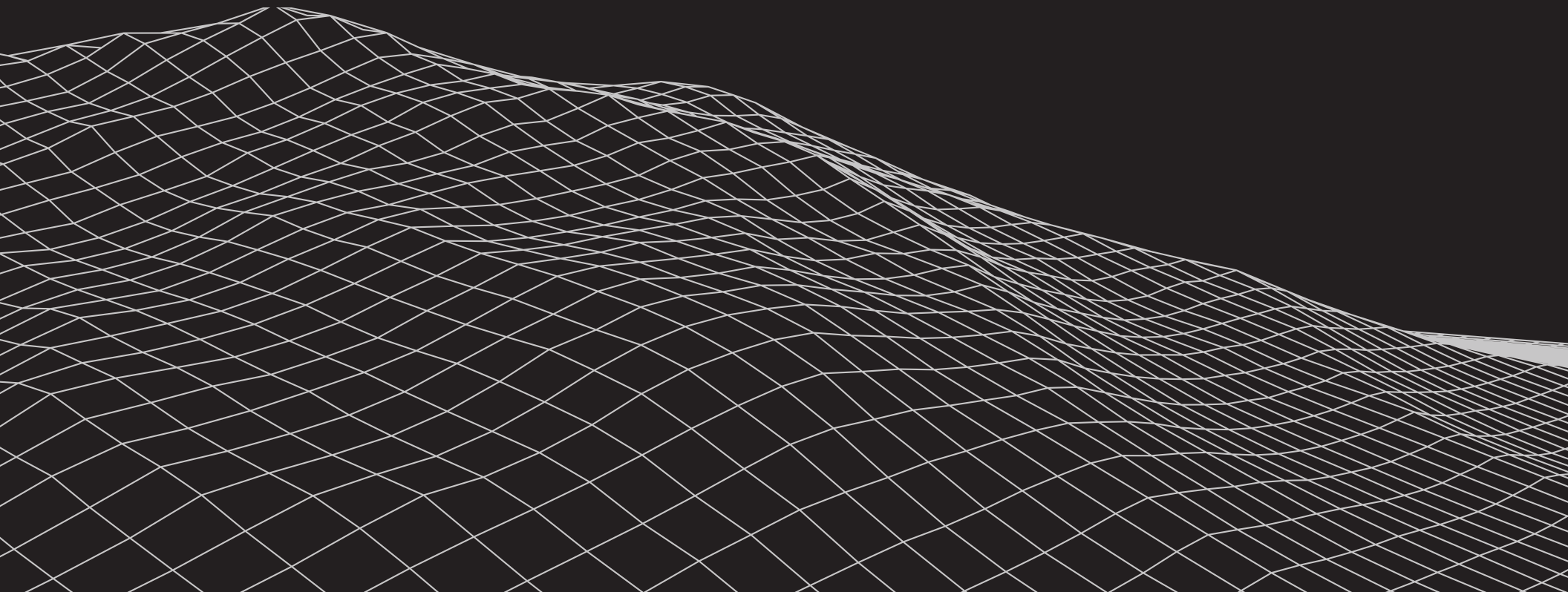


After enduring centuries of devastating malaria epidemics, Sri Lanka was certified malaria-free by the World Health Organization in 2016. It is one of two tropical nations to eliminate malaria (the other is the Maldives). A malaria epidemic arose during the country's civil war during the 1980s and 1990s, affecting more than 600,000 people. How did the country eliminate malaria over a relatively short period of time, especially given the severity of the epidemic during the war? What can the world learn from the elimination of malaria in Sri Lanka?

The literature indicates that both the 1980–1990s epidemic and the county's subsequent elimination of malaria were intertwined with social, economic, and military developments. The motivation, process, and consequences of malaria elimination reflected complex incentives and capabilities that arose during the war. To achieve as detailed an understanding as possible of these incentives and capabilities, our team conducted a series of interviews with experts from the fields of health care, political science, history, and the biological sciences.

We then developed research tools to use during a field visit to Sri Lanka in June of 2018. These included interview instruments and a convergence matrix to assess the character and quality of evidentiary claims made by interviewees.

The elimination of malaria was a result of (1) both the central government and provincial ministries' commitment to a strong public healthcare system; (2) the informal and indirect collaboration between the Liberation Tamil Tigers of Eelam (LTTE) and the health workers employed in war zones to fill gaps in services as a consequence of the conflict; and (3) the engagement of individuals, especially in the North, to promote malaria detection, prevention, and treatment. This three-pronged approach reflected and created overlapping motivations across stakeholders and opposing groups to combat malaria. The resulting adoption of technical strategies during the late 1980s and 1990s focused on the surveillance of patients. Patients with fevers were tested for malaria. If they were found to be malaria positive, they were treated with antimalarial drugs.

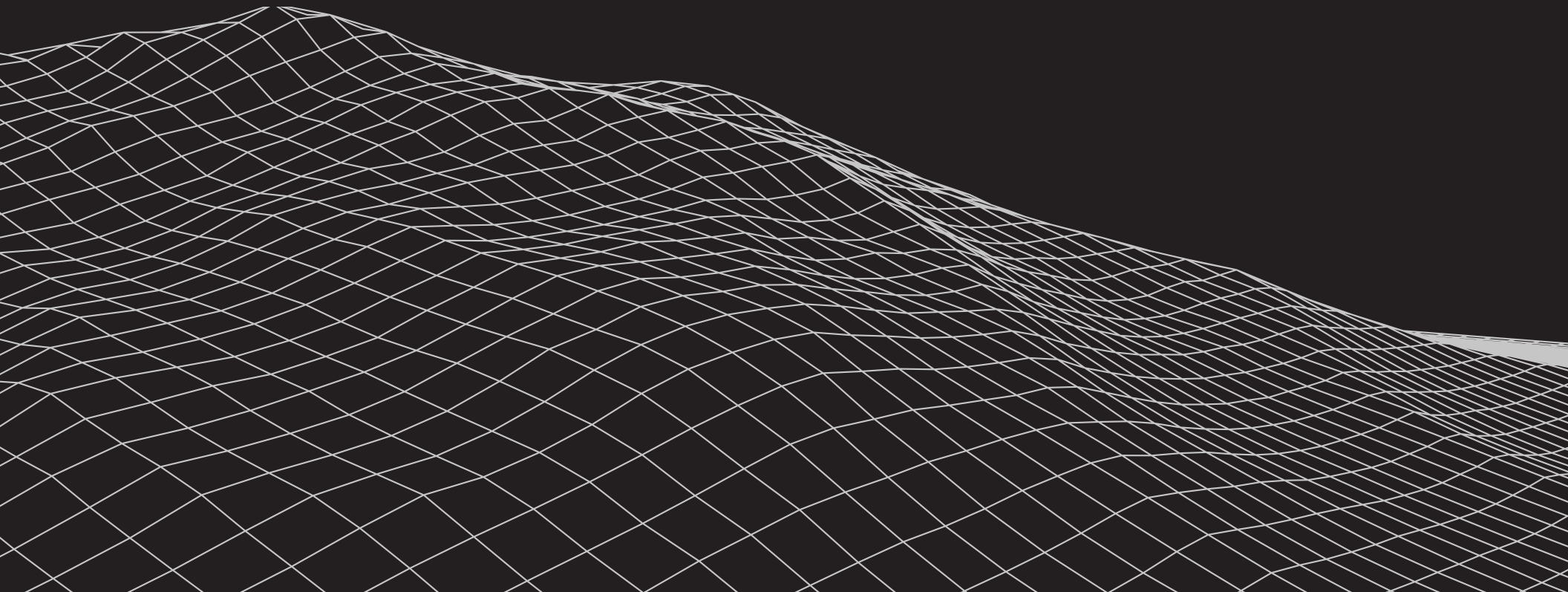
These strategies included educational interventions as well as engagement in the industrial and commercial sectors to fight malaria. As a result of collaboration and the implementation of antimalarial strategies, especially during the war, the number of malaria cases in the country decreased by the 2000s to a level that allowed targeted interventions. The country did not see a resurgence of malaria after a devastating tsunami hit the island in December 2004. By 2016, the country was declared malaria-free.

TABLE 1. Timeline of significant events in the elimination of malaria in Sri Lanka

Context (history)	Year	Milestones and roadblocks in malaria elimination
	1911	The first anti-malaria center was established under British rule.
Establishment of welfare state in response to drought and cycles of malaria epidemics	1931	
	1934–35	A major malaria epidemic occurred, killing 1.5–2% of the population (80,000 to 100,000 people).
There were 68 government hospitals, 95 government central dispensaries, and 710 branch dispensaries and temporary treatment centers.	1935	
	1945	Introduction of dichlorodiphenyltrichloroethane (DDT), an insecticide. DDT was used for indoor residual spraying as part of the malaria-elimination strategy.
Sri Lanka gained independence from British rule.	1948	
	1963	Malaria was almost eliminated, with only 17 cases detected nationwide.
	1967	An epidemic arose following decreased public interest in malaria and new resettlement and irrigation schemes.
Creation of the Liberation Tamil Tigers of Eelam (LTTE)	1976	
Beginning of a 30-year conflict between LTTE and government	1983	
	1987–88	Malaria epidemic, beginning in the district of Polonnaruwa and spreading nationwide
State-imposed embargo in the conflict zone until 2002	1991	Decentralization of Anti-Malaria Campaign, with each province taking on more significant malaria-control responsibilities
	1997	Introduction of active case detection—asymptomatic individuals screened for malaria
Ceasefire declared and signed between the government of Sri Lanka and the LTTE	2002	
Tsunami killed over 30,000 people within minutes, displacing close to 500,000—destroying 22 hospitals and 9 administrative buildings	2004	Introduction of long-lasting insecticidal nets through a round 1 grant by the Global Fund to Fight AIDS, Tuberculosis and Malaria
Post-tsunami operational management structure high-level committee consisting of nominees from the government, the LTTE, and Muslim parties	2005	
Ceasefire between the government and the LTTE broke, and the A9 road was closed	2006	
End of conflict between the LTTE and government generating between 500,000 and 1 million internally displaced people and 800,000 emigrants	2009	Tropical and Environmental Diseases Health Associates, a private partner, commenced work on entomological and parasitological surveillance. This work ended in 2014.
	2012	Last case of indigenous malaria in Sri Lanka detected. Reintroduction through migration highlighted need for improved surveillance and individual follow-up.
	2016	Sri Lanka certified malaria-free by the World Health Organization

Context

Past epidemics influenced the public's priorities and contributed to the development of healthcare infrastructure. The failure of the public and private health systems was central to the most recent malaria resurgence beginning in the 1980s and persisting through the 1990s. However, the systems' foundations were robust enough to support relatively quick reconstruction once malaria control became a priority in the late 1990s and early 2000s.



BIO-ENVIRONMENTAL CONTEXT

Malaria is transmitted between humans by mosquito vectors: a mosquito bites a person infected with a malaria parasite, picks up the parasite, and can then pass the malaria parasite to the next person it bites. The incidence of malaria in Sri Lanka follows the distribution of its main vector, the *Anopheles* mosquitoes, which carry parasites causing malaria infection. The most common malaria parasites in Sri Lanka are *Plasmodium falciparum* and *Plasmodium vivax*.[1]

The dry zone is located in the northeast of the country (see the left-hand panel of Figure 1). During the rainy seasons, stagnant pools of water collect, forming ideal breeding grounds for these mosquitoes. Historically, the highest incidence of malaria has been in the dry zone. The wet zone, in the southern part of the country, receives a high volume of rain, which flushes out rivers and streams and interferes with mosquito breeding grounds. Consequently, the wet zone is not malaria endemic. The intermediate zone, located between the dry and wet zones, receives a moderate amount of precipitation. It sometimes experiences droughts, creating breeding grounds for *Anopheles* mosquitoes, which have caused occasional outbreaks in this zone. As the right-hand panel of Figure 1 demonstrates, the areas of greatest vulnerability to malaria outbreaks were districts in the dry zone where the highest levels of conflict occurred during the civil war.

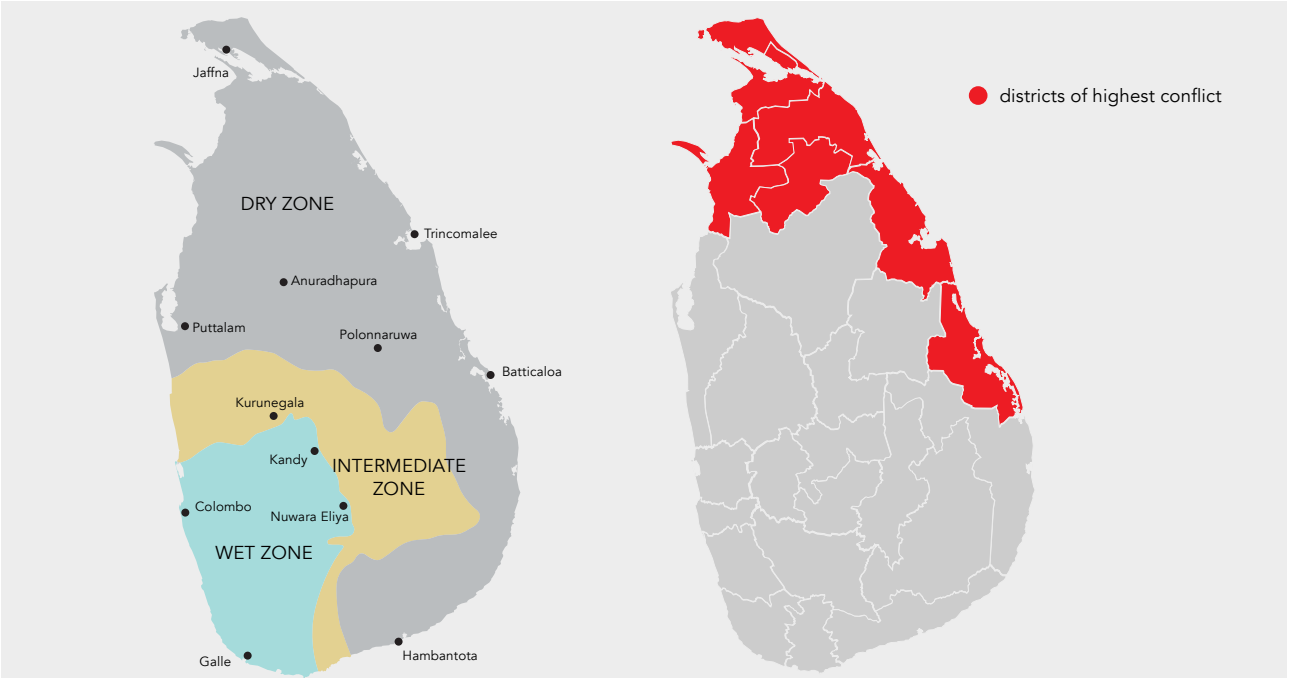


FIGURE 1. Comparison of malaria-endemic and conflict-affected districts[2]

GEOGRAPHY AND HISTORY

Geography shapes how disease enters the nation. As an island country, Sri Lanka may receive fewer imported cases compared to countries bordered by malaria-endemic states. The country also had only one international airport until 2014. With only one way to enter the country by air, Sri Lanka may have had an advantage over other countries in documenting the flow of migrants and visitors, including those carrying malaria.

Malaria has played a unique role in Sri Lankan history and society. The disease has existed in Sri Lanka for hundreds of years, appearing as fevers, aches, and chills. The very first anti-malaria center was created as early as 1911 when the country was under British rule. Epidemics broke out every three to five years in the first half of the century. In 1934–35, a major malaria epidemic ravaged the country. Between 80,000 and 100,000 people died, representing 1.5 to 2 percent of the population. This epidemic occurred during a major food shortage in the country related to the global depression. Droughts in the wet zone caused rivers to dry up, leaving small, stagnant pools of water that acted as ideal breeding grounds for mosquitoes. The droughts in turn worsened the food

[1] Unlike some malaria-endemic countries in Africa and South America, Sri Lanka lacks zoonotic malaria parasites that spread from monkeys or apes to humans via mosquitoes. This poses a challenge for malaria elimination because a reservoir remains in the primates. The country did not confront the challenge of eliminating zoonotic malaria. (Dilkushi Wijesundere and Ranjan Ramasamy, "Analysis of Historical Trends and Recent Elimination of Malaria From Sri Lanka and Its Applicability for Malaria Control in Other Countries," *Frontiers in Public Health* 5 (2017).

[2] These maps are modifications of "Sri Lanka" by amCharts, used under CC-NC 4.0. Left panel reproduced from Wijesundere and Ramasamy, "Analysis of Historical Trends" (open access).

shortage, contributing to the high mortality rate.

In the decades following this major epidemic, the number of malaria cases started to decline. The introduction of Dichlorodiphenyltrichloroethane (DDT) in 1946 significantly contributed to the fall in the number of reported cases.[3] The major 1934–35 epidemic also followed a shift in power from British colonists to an elected governmental system beginning in 1931. Most elected councilors were part of the Sinhalese ethnic majority who had been hardest hit by the 1934 epidemic. With their recent memory of the epidemic, the new democratically elected government emphasized health care. The health infrastructure developed during this time paved the way for Sri Lanka's universal healthcare system.[4]

By the early 1960s, Sri Lanka was close to eliminating malaria. This success was in part a result of its five-year elimination program beginning in 1958, which established the Anti-Malaria Campaign in Colombo. That program intensified entomological surveillance and resumed DDT spraying in the dry zone. The number of malaria cases reached a low of seventeen in 1963. Unfortunately, the numbers sharply rose by 1967, with 1.5 million cases detected between 1967 and 1969.[6] This hike in reported cases was in part caused by increasing vector resistance to DDT and decreased public interest in malaria control, which led to the disbanding of indoor residual spraying (IRS) teams. Significant development work in the dry zone beginning in the 1930s also brought irrigation schemes to support rice production. This irrigation work provided breeding grounds for *Anopheles* mosquitoes. Meanwhile, extensive resettlement schemes in the dry zone during the 1960s and 1970s brought large numbers of malaria-naive people to this malaria-endemic area.[7]

The most recent malaria resurgence began in the 1980s and led to an epidemic in 1987–88, with approximately 600,000 cases of malaria detected.[8]

[3] People we interviewed emphasized the importance of DDT.
[4] Kalinga Silva, *Decolonisation, Development and Disease: A Social History of Malaria in Sri Lanka* (London: Orient Blackswan, 2014).
[5] Ministry of Health Sri Lanka, World Health Organization, and the University of California, San Francisco, *Eliminating Malaria: Case-study* 3 | Progress Towards Elimination (Sri Lanka and Geneva: WHO, 2012).
[6] Rajitha Senaratne and Poonam K. Singh, "Against the Odds, Sri Lanka Eliminates Malaria," *The Lancet* 388, no. 10049 (2016): 1038–39.
[7] Silva, *Decolonisation, Development and Disease.*
[8] Julia Simac, Sayema Badar, Jessica Farber, et al., "Malaria Elimination in Sri Lanka," *Journal of Health Specialties* 5, no. 2 (2017): 60–65.

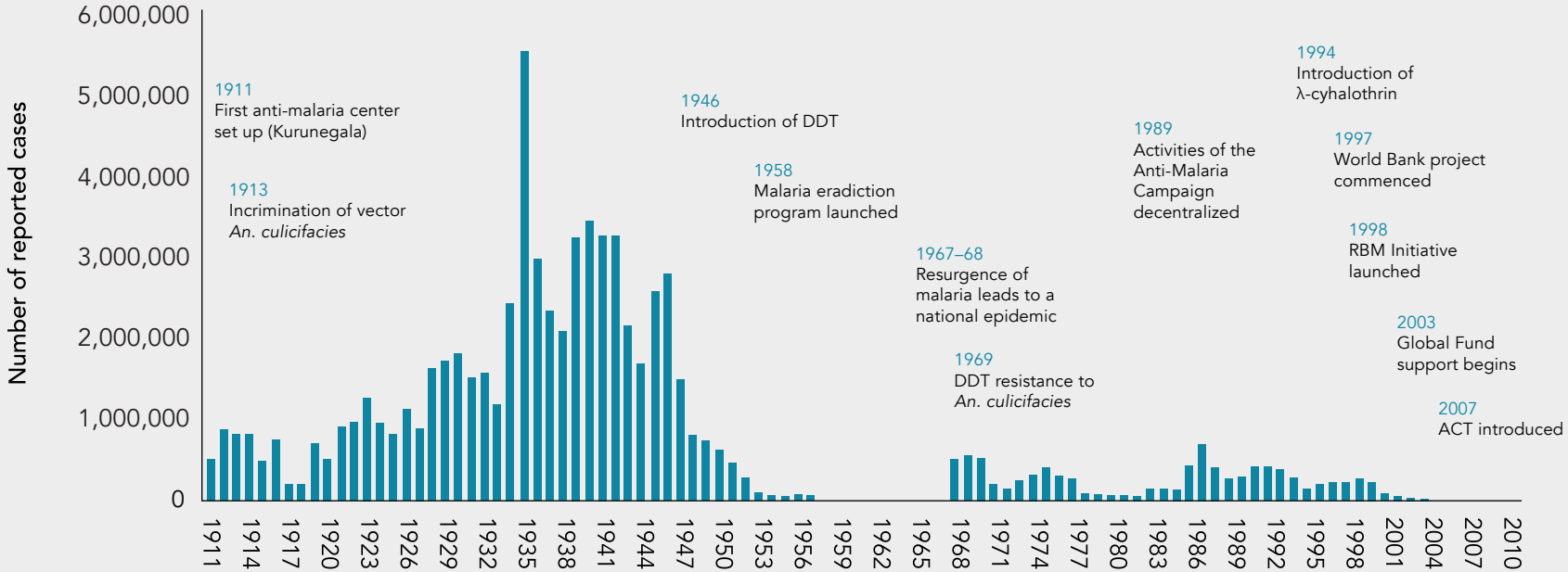


FIGURE 2. Number of malaria cases over time[5]

Mortality attributed to malaria peaked in 1998 with 115 deaths.[9] The epidemic originated in Polonnaruwa district in North Central Province. It was likely related to the Mahaweli resettlement program's irrigation schemes, which created ideal mosquito breeding grounds. In addition, a fire in the malathion storage plant in 1986 led to low supplies of the insecticide, interfering with IRS. The epidemic spread nationwide as the operations of healthcare services, insecticide spraying, and other malaria-control efforts were impeded by the war that broke out between the government of Sri Lanka (GoSL) and the Liberation Tamil Tigers of Eelam (LTTE) in 1983. This war did not end until 2009. Its highest level of conflict occurred in Batticaloa, Jaffna, Kilinochchi, Vavuniya, Mannar, Mullaitivu, and Trincomalee districts. Many of these districts were malaria endemic, further exacerbating malaria control efforts (Figure 1).[10]

Despite the conflict, the number of confirmed cases began to fall once more in the early 2000s, with a reduction by almost 70 percent across the country between 2000 and 2001.[11] Once Sri Lanka reached zero cases of malaria in 2012, it was certified malaria-free by the World Health Organization (WHO) in 2016.

OBSTACLES TO MALARIA ELIMINATION

There were several obstacles that Sri Lankan health officials had to overcome in the process of eliminating malaria. These included:

1. **Civil War**. The conflict from 1983 to 2009 between the GoSL and the LTTE arose as the LTTE fought to establish an independent Tamil state in the north and east of the island. Conflict was greatest in malaria-endemic areas. The war disrupted vector-control efforts, health services, and the supply chain of medications to the north. Detecting malaria among those displaced by the war became challenging.

2. **Natural Disaster**. In 2004, Sri Lanka and neighboring countries experienced a devastating tsunami that put them at risk of disease outbreak following population displacement, shortages of clean water, reduced health services, and failed sanitation facilities.

3. **Migration**. Sri Lanka experienced (a) internal migration during the civil war, (b) nationals returning from malaria-endemic nations, (c) travelers from malaria-endemic nations, and (d) military personnel returning from malaria-endemic nations. All four complications hindered elimination efforts in the 1980s and 1990s. The latter three remain obstacles to maintaining elimination status today.

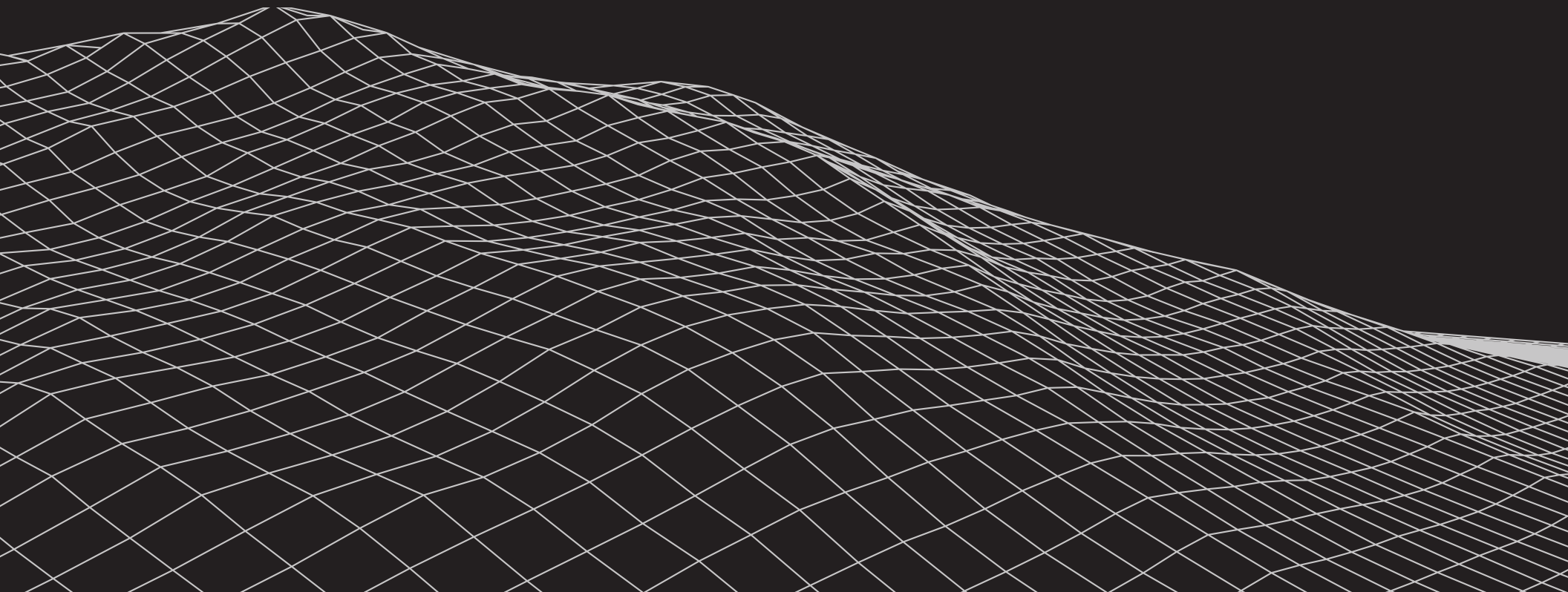
Essential to overcoming these obstacles was the country's strong public healthcare system and various key stakeholders' actions.

SUMMARY

The rise and fall of malaria in Sri Lanka is closely linked to the country's ecology and geopolitics. After a drought led to a major malaria epidemic in 1934–35, Sri Lanka was motivated to develop a strong healthcare system, which still stands today. Since then, malaria-elimination efforts have been complicated by a civil war, a tsunami, and the flux of migrants. Sri Lanka has overcome these barriers, with its last case of malaria in 2012. The country was certified malaria-free by the WHO in 2016.

[9] Rabindra Abeyasinghe, Gawrie Galappaththy, Cara Smith Gueye, James Kahn, and Richard Feachem, "Malaria Control and Elimination in Sri Lanka: Documenting Progress and Success Factors in a Conflict Setting," *PLoS One* 7, no. 8 (2012): e43162.
[10] Sandy Johnson, "The Cost of War on Public Health: An Exploratory Method for Understanding the Impact of Conflict on Public Health in Sri Lanka," *PloS One* 12, no. 1 (2017): e0166674.
[11] Wijesundere and Ramasamy, "Analysis of Historical Trends."
[12] John Watson, Michelle Gayer, and Marie Connolly, "Epidemics after Natural Disasters," *Emerging Infectious Diseases* 13, no. 1 (2007): 1–5.

Heatlh Care in Sri Lanka



THE PUBLIC SECTOR

The country's heritage of a strong public health-care system—the result of universal health care's implementation following the 1934 epidemic—was critical to malaria elimination in the late 1990s and early 2000s despite its breakdown in conflict areas during the war. The highly centralized public sector consists of the federal ministry of health and provincial health departments and provides most preventative health services. Both the public and private sector deliver services, although the public system is much larger than the private. According to a report by the World Bank, by 2011, more than 1,000 public hospitals and facilities delivered outpatient services.[13] Approximately 90 percent of all healthcare professionals (physicians and nurses) are employed by the government in the public health system. The average Sri Lankan resides 1.4 kilometers from a clinic, and less than five kilometers away from a government-sponsored healthcare facility. This is an impressive density given that the country spends only 3.5 percent of gross domestic product (GDP) on health care.[14]

The central Ministry of Health (MOH) oversees larger hospitals, including teaching and specialized facilities. It also oversees policy guideline development and programing including the Anti-Malaria Campaign, family planning, and dengue control. Delivery and coordination of preventative health services are organized through provincial departments of health in nine provinces, which include twenty-six health regions. There is one health region per district, with the exception of Ampara district which has two. Provincial authorities are responsible for coordinating health services through a Regional Director of Health Services (RDHS) in the districts. Each RDHS region has one regional malaria office led by a regional medical officer of the Anti-Malaria Campaign (see Figure 3). Districts are further divided into smaller units called "health areas" overseen by medical officers of health. For example, fourteen medical officers serve in the district of Jaffna in the Northern Province. In total, there are 342 medical officers. Each has a public health team of midwives, health workers, and public health inspectors. The construction of this system under a centralized chain of command, but with decentralized local officers, was critical to detecting and reporting malaria cases during the elimination period.

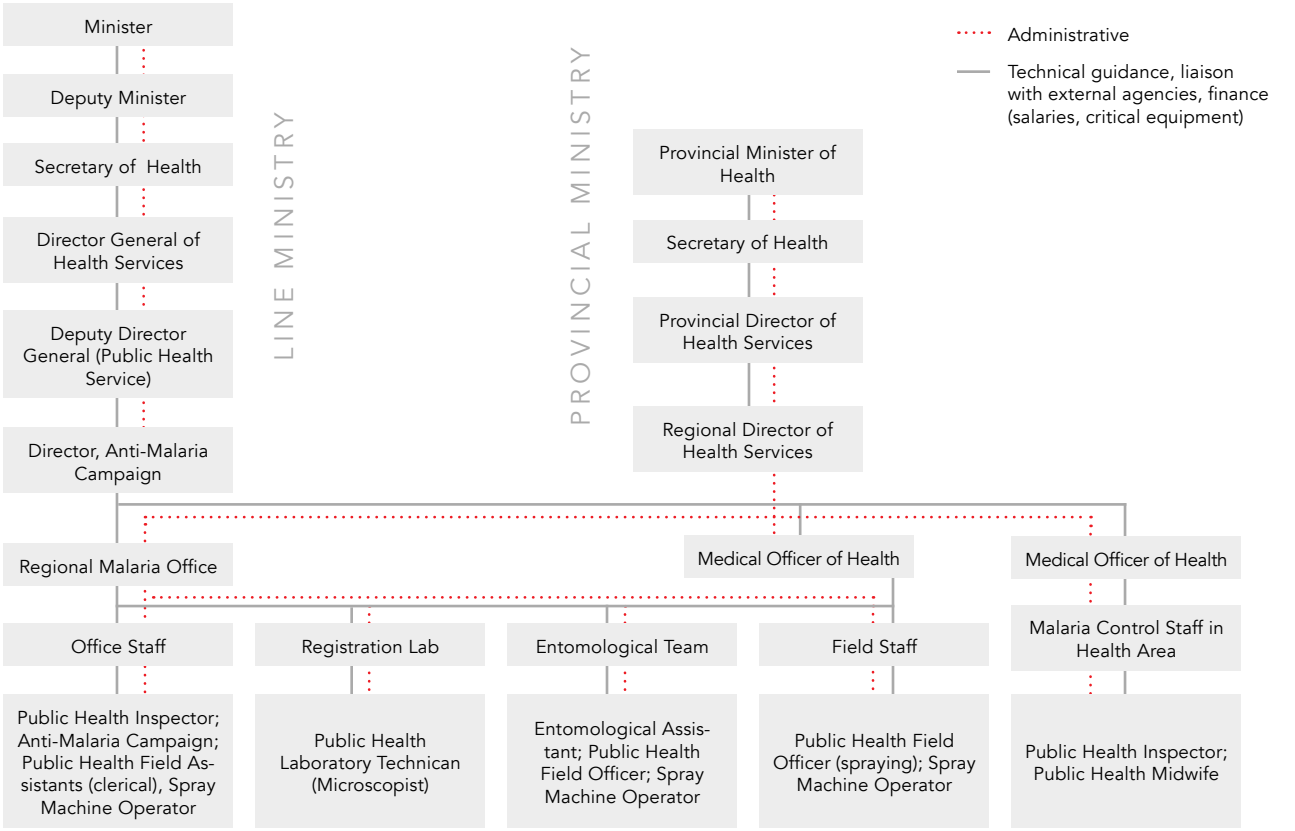


FIGURE 3. Overview of governmental responsibilities for malaria control[15]

THE PRIVATE SECTOR

Although the public health sector played an essential role in the elimination of malaria, the private sector contributed in several important ways, especially in the diagnosis and treatment of cases among migrants.[16] Links between the public and

[13] Ramesh Govindaraj, Kumari Navaratne, Eleonora Cavagnero, and Shreelata Rao Seshadri, "Health Care in Sri Lanka: What Can the Private Health Sector Offer?" HNP Discussion paper, June 2014.
[14] Sri Lanka, WHO.
[15] Abeyasinghe et al., "Malaria Control and Elimination" (Open Source Image).
[16] R. Mintcheva, C. Hugo, K. Palmer, and C. Revankar, "WHO Independent Evaluation Mission for Certification of Sri Lanka as Malaria Free," 2016.

private sector were also robust during the elimination period, particularly as the government's Anti-Malaria Campaign (AMC) sought to provide comprehensive training, medication, diagnostic tools, and technical guidance to the operators of private-sector facilities.

About 98 percent of private facilities are owned by private companies, organizations, or individuals. Private-sector health facilities are typically general or specialized hospitals, laboratories, and specialized or general clinics. The vast majority are in the Western Province and in urban areas where both population density and per capita income are high. Approximately a quarter of the nation's population resides in the Western Province and generates two-fifths of the nation's GDP.[17]

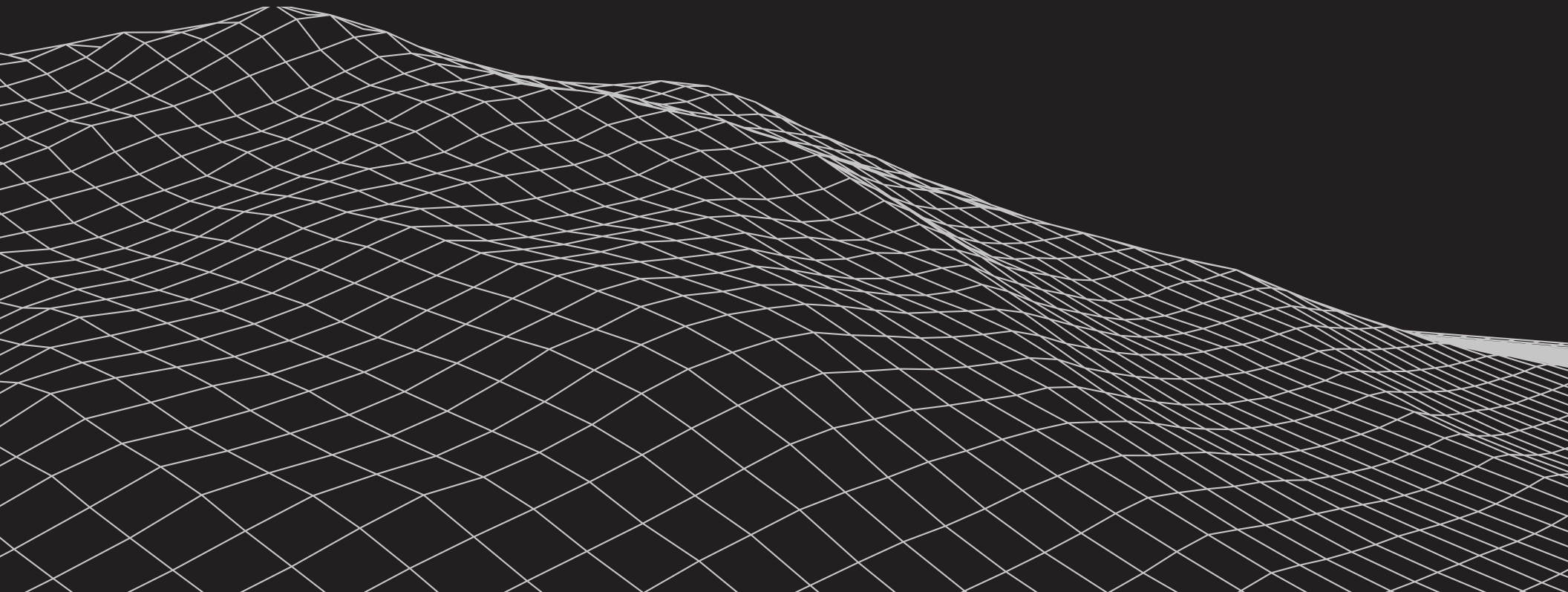
Revenue to private-sector healthcare organizations comes from: patients' direct payments (86% of the total revenue to the private-sector system), private health insurance (6% of the total), private companies, the President's Fund (a program to aid those in need to cover the cost of surgical procedures offered by the private sector), and other sources. The majority of private-sector revenue is produced through out-of-pocket expenditure. These are payments that households make for health services and include fees for physician consultation and medication.[18]

SUMMARY

Sri Lanka's universal and highly centralized public healthcare system has been critical to malaria elimination. The country spends 3.5 percent of its GDP on health care through the public and private sectors. The central Ministry of Health (MOH) develops, coordinates, and implements policies and programs through its nine provincial counterparts in twenty-six health regions. The construction of this centralized chain of command, but with decentralized local officers, was critical to detecting and reporting malaria cases. In addition, the private sector specifically contributed in the diagnosis and treatment of malaria cases among migrants. Public and private sector collaboration played a key role in malaria elimination, particularly as the government's Anti-Malaria Campaign (AMC) provided training and equipped the operators of the private-sector facilities to treat malaria patients.

[17] Ramesh Govindaraj, Kumari Navaratne, Eleonora Cavagnero, and Shreelata Rao Seshadri, "Health Care in Sri Lanka: What Can the Private Health Sector Offer?" HNP Discussion paper, June 2014.
[18] Ibid.

Stakeholders



Political commitment, sustained and adequate finance, and good centralized management of stakeholders and their activities led to malaria elimination. Despite ongoing conflict, governmental leaders engaged and cooperated with various stakeholders. This involved centralizing education and health sectors, informal and indirect collaboration between the Liberation Tamil Tigers of Eelam (LTTE) and the government, and individual efforts, particularly in the Northern and Eastern Provinces, to fill the gaps in services that resulted from the conflict.

Various public- and private-sector stakeholders were ineffective in their efforts to control malaria when the civil war broke out in 1983. Infrastructure in the North and East district crumbled and health facilities became less accessible. The number of malaria cases increased sharply. The conflict decreased indoor residual spraying (IRS) efforts in conflict-affected areas, vector breeding sites were poorly controlled, and there was no entomological surveillance in conflict areas till the 1990s. In the following years, the Anti-Malaria Campaign's (AMC) centralized approach and phased elimination strategy ensured that resources were distributed appropriately and malaria-elimination activities were targeted effectively.

Cooperation may also have been an opportunity to bring opposing stakeholders together after a twenty-six-year-long conflict for a cause that affected everyone. Malaria was considered a common enemy for combatants and civilians on both sides of the conflict.

Malaria-elimination efforts were coordinated by the AMC (under the Ministry of Health) which took charge of the AMC in all nine provinces.[19] Malaria elimination required strong political leadership and stakeholder investment in the AMC.

Malaria was considered a common enemy for combatants and civilians on both sides of the conflict.

MALARIA-CONTROL PROGRAM AND THE AMC

The AMC was established in 1958 but the malaria epidemic of 1967–69 raised questions about whether it was effective. In 1989, as a result of an amendment to the constitution, all public health programs were decentralized and provincial councils were established. Targeted activities such as diagnostics and the administration of treatment were coordinated through the nine provincial health authorities under the technical guidance of the National Anti-Malaria Campaign Directorate and World Health Organization (WHO).

Under the new structure, the AMC's role at both the national and provincial levels developed and deepened. Its directorate in Colombo coordinated all malaria-control activities, administered the national malaria-control policy, monitored national malaria trends, provided technical guidance to subnational malaria-control programs, supervised interdistrict coordination, and coordinated training and research activities. It also undertook entomological and parasitological surveillance. This decentralization meant health services were managed regionally by the regional director of health services (RDHS). Each district had a regional malaria officer (RMO) whose office worked in close coordination with the medical officers of health (MOHs) providing malaria and vector-control activities.

Indoor residual spraying (IRS) was a critical AMC initiative that emerged from this new organizational model. The WHO recommends it for eliminating malaria. Because IRS used a number of insecticides, it is more efficient and effective than insecticide-treated nets. The wide range of insecticides allowed the AMC to better manage insecticide resistance through insecticide rotation across districts in 1998. The WHO praised the AMC for its rotation of insecticides to ensure vector control's long-term sustainability and to lessen the risk of insecticide resistance.[20]

[19] National Malaria Control Programme of Sri Lanka, Strategic Plan for Phased Elimination of Malaria (2010–2014), Ministry of Health, Colombo, 2010.

[20] Potentially adverse effects of insecticides used for IRS, especially DDT, is an important issue but beyond the scope of this report. Bianca Pluess, Frank C. Tanser, Christian Lengeler, and Brian L. Sharp, "Indoor Residual Spraying for Preventing Malaria," Cochrane Database Systematic Review 4, no. 4 (2010).

As malaria elimination progressed by district, the AMC's National Malaria Control Programme planned for the phased elimination of malaria in those districts where it remained. The AMC was responsible for monitoring progress and accountable for this monitoring as part of its responsibilities under a grant from the Global Fund to Fight AIDS, Tuberculosis and Malaria. It also monitored all stakeholders and malaria-related activities through monthly progress reviews. Between 2005 and 2010, IRS was discontinued progressively across districts where malaria was eliminated. IRS coverage steadily declined as it moved from full coverage of risk areas to focal IRS and outbreak response. As the program succeeded by district, total population coverage dropped from 23 percent in 2005 to 6 percent in 2010.[21]

An *Anopheles* mosquito breeding ground. (Photo courtesy of Dr. P. Karthikeyan)

TROPICAL AND ENVIRONMENTAL DISEASE AND HEALTH ASSOCIATES (TEDHA)

TEDHA was the primary private-sector stakeholder in malaria-elimination efforts. It had a small but focused role within malaria control, and operated between 2009 and 2014. TEDHA was responsible for strengthening entomological and parasitological surveillance-related activities in conflict-affected and remote districts in the Northern and Eastern provinces (Eastern Province: Ampara, Trincomalee, and Batticaloa; Northern Province: Mannar and Killinochchi).[22]

Through funding from the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) TEDHA partnered with the AMC. For the hardest-to-reach populations, the AMC set up mobile malaria clinics with TEDHA's support. These clinics primarily targeted the most vulnerable groups in the North and high-risk populations, including gem miners and pregnant women. TEDHA was also involved in data collection and its integration into the national malaria database. By the end of TEDHA's operations, it had achieved all targets of the Global Fund's performance framework.[23]

THE GLOBAL FUND TO FIGHT AIDS, TUBERCULOSIS AND MALARIA (GFATM)

The Global Fund provided USD 17.3 million to Sri Lanka for malaria control, which was invested in health equipment, outreach efforts, and ameliorating the health sector's infrastructure. The GFATM launched in 2002 and provided the country with three grants for malaria control and elimination between 2003 and 2018.[24]

Initially, very little funding was earmarked for public health infrastructure. Part of the funding was used to train staff and distribute insecticide-treated mosquito nets and anti-malarial drugs. Following the 2004 tsunami, international organizations such as the GFATM played a critical role

[21] Cara Smith Gueye, Gretchen Newby, Roland Gosling, Maxine Whittaker, Daniel Chandramohan, Laurence Slutsker, and Marcel Tanner, "Strategies and Approaches to Vector Control in Nine Malaria-Eliminating Countries: A Cross-Case Study Analysis," *Malaria Journal* 15, no. 1 (2016).
[22] Deepika Fernando, Pandu Wijeyaratne, Rajitha Wickremasinghe, et al., "Use of a Public-Private Partnership in Malaria Elimination Efforts in Sri Lanka: A Case Study," *BMC Health Services Research* 18, no. 1 (2018).
[23] Fernando et al., "Use of a Public-Private Partnership."
[24] Risintha Premaratne, Leonard Ortega, L., Navaratnasingam Janakan, and Kamini Mendis, "Malaria Elimination in Sri Lanka: What It Would Take to Reach the Goal," *WHO South-East Asia Journal of Public Health* 3, no. 1 (2014): 85–89.

in ensuring that the surveillance and prevention programs for malaria were sustained.[25] However, GFATM funding for malaria made up a limited percentage of the total funding required for malaria control in the country; the remainder was provided through the AMC. The GFATM supported the activities of TEDHA, Sarvodaya, and other NGOs. To sustain the country's malaria-free status, the GFATM has assured support for 2018 and onward. However, the government is expected to provide supplementary support. Ongoing surveillance operations require approximately USD 12 million per year to sustain malaria-free status.

LANKA JATHIKA SARVODAYA SHRAMADANA SANGAMAYA (SARVODAYA)

Sarvodaya is a leading civil society organization that was instrumental in scaling up public education and awareness activities to facilitate elimination. It also contributed to strengthening malaria-vector control by distributing long-lasting insecticidal nets (LLINs).[26] Sarvodaya was one of the principal recipients of funds from the GFATM along with the AMC. In the North, entomological services and malaria-control activities, including surveillance, were possible through Sarvodaya funding. Sarvodaya was also pivotal in distributing approximately half a million bed nets during ceasefires in the North. Because it was perceived as neutral it could reach areas inaccessible to others. It worked closely with both state and nonstate actors (including the LTTE).

Sarvodaya staff also filled up abandoned pits to eliminate potential breeding sites and introduced larvae-eating fish in open water bodies to control vectors. Across the country, Sarvodaya mobilized volunteers and staff to run malaria-awareness programs that encouraged the general population to seek early treatment. Sarvodaya education campaigns produced leaflets, billboards, "malaria day walks," and radio messages (in English, Tamil, and Sinhalese) to ensure the message was wide reaching and accessible.

UNITED NATIONS (UN) AGENCIES AND INGOS

UN agencies in Sri Lanka elevate issues of high importance, including malaria elimination, to the central government's agenda. Some UN agencies involved in malaria-elimination efforts included the UN High Commissioner for Refugees (UNHCR), UN Children's Fund (UNICEF), and the International Organization of Migration (IOM).

UNICEF and the World Health Organization (WHO) distributed LLINs in 2004.[27] By 2005, the 15 percent of the population most at risk of malaria had received LLINs (i.e., approximately 440,000 people). LLINs distribution reached 35 percent of people in Sri Lanka by 2010. LLINs and IRS played an integral role in eliminating malaria there.[28]

The IOM was involved with relief work and primary healthcare work for migrants and displaced people. Although it did not lead any efforts specifically for malaria elimination, it was the organization that first identified the issue of migration and imported malaria cases toward the end of the elimination period. As the number of cases approached zero it was critical to the implementation of a humane and evidence-based approach to screening travelers with the development of Sri Lanka's national migration policy. Today, even after elimination, the IOM continues to receive information about high-risk migrants and alerts the AMC of their presence in the country. Through its public health units at airports, the AMC screens for malaria through interviews and blood tests.

UN agencies as well as other organizations such as Oxfam, the International Committee of the Red Cross (ICRC), World Vision, Wellcome Trust (UK), USAID, and Médecins Sans Frontières provided support, particularly in distributing bed nets, to the central government and AMC.[29] The ICRC played a critical role in transporting medications and supplies across the territories during active conflict.

TAMIL EELAM HEALTH SERVICES

During active conflict, Tamil Eelam Health Services (TEHS) provided healthcare services to populations in the North. TEHS was a contingent of the Liberation Tamil Tigers of Eelam (LTTE), a militant organization aiming to create an autonomous Tamil state in the Eastern and Northern provinces. Although hospitals continued to run during the war, TEHS ran clinics in Internally Displaced Persons (IDP) camps and in remote villages with the assistance of medical students and NGOs. TEHS also led spraying activities. International agencies including the World Bank and UN agencies coordinated TEHS activities with the LTTE authorities in areas controlled by the LTTE.[30]

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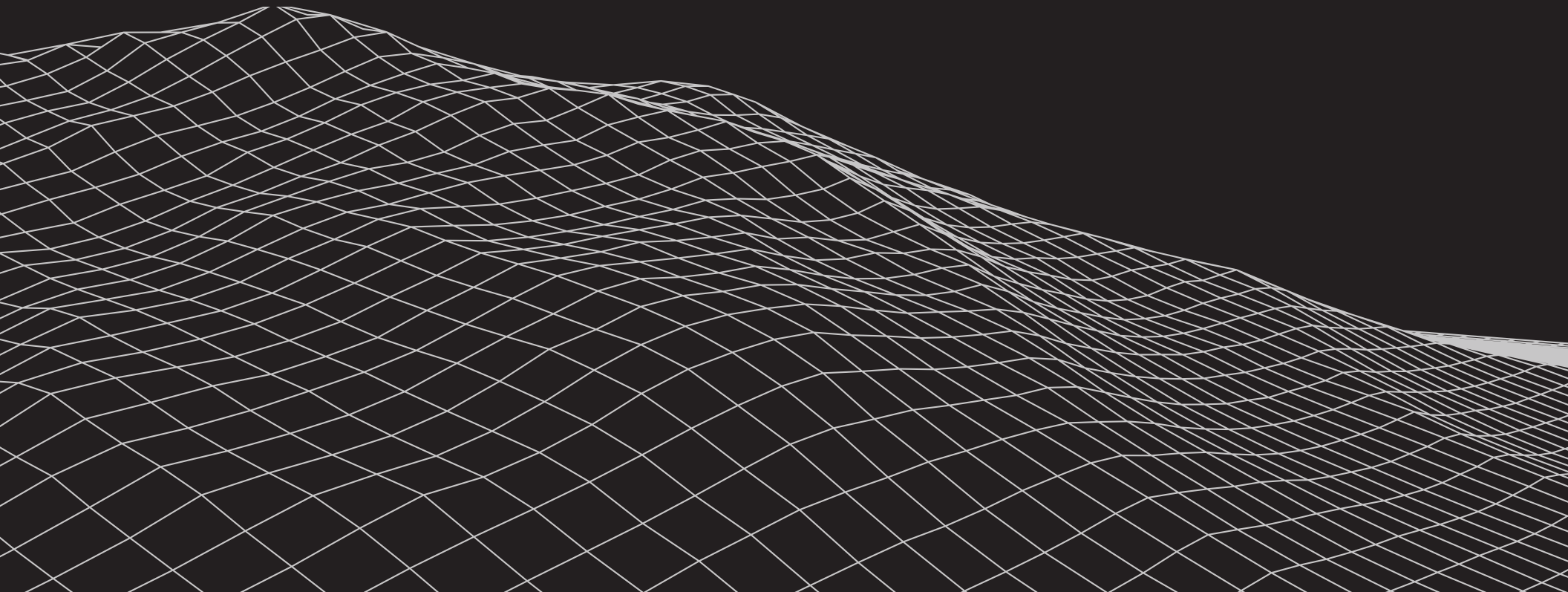
[25] "WHO Certifies Sri Lanka Malaria-free."
[26] Kalunga Tudor Silva et al., "Malaria Control Through Community Action at the Grass-Roots: Experience of the Sarvodaya Malaria Control Research Project in Sri Lanka from 1980 to 1986."
[27] Abeyasinghe et al., "Malaria Control and Elimination."
[28] Smith Gueye et al., "Strategies and Approaches to Vector Control."
[29] Piers Blaikie and Ragnhild Lund, eds., *The Tsunami of 2004 in Sri Lanka: Impacts and Policy in the Shadow of Civil War* (New York: Routledge, 2013).
[30] Sharryn Aiken and Rudhramoorthy Cheran, "The Impact of International Informal Banking on Canada: A Case Study of Tamil Transnational Money Transfer Networks (Undiyal), Canada/Sri Lanka," Law Commission of Canada, Government of Canada Publications, 2005.

SUMMARY

Malaria elimination in Sri Lanka, especially during ongoing conflict from 1983 to 2009, has been successful because of the broad, multisectoral collaboration and coordination between different levels of government and various public and private sector stakeholders. Under the leadership of the Malaria-Control Program and the Anti-Malaria Campaign (AMC), various stakeholders—including international and national nongovernmental and donor agencies as well as the Liberation Tamil Tigers of Eelam (LTTE)—coordinated their efforts to eliminate malaria.

Programs

The malaria-control-and-elimination strategy began with the creation of the country's first Anti-Malaria Center in 1911 during British rule. After separating from Britain in 1948 as the Dominion of Ceylon, the independent state that would become Sri Lanka created the Anti-Malaria Campaign under the purview of the national government.[31] The 1958 malaria program included strategies that continued through elimination, including indoor residual spraying (IRS) and entomological surveillance. Between 1983 and 2009, the administration of these strategies was disrupted by the long conflict and the 2004 tsunami.



PARASITOLOGICAL SURVEILLANCE

Sri Lanka uses three main types of parasitological surveillance: (1) passive case detection, (2) active case detection, and (3) activated passive case detection (APCD).[32] Active case detection involves screening asymptomatic individuals, while passive case detection and activated passive case detection both involve screening symptomatic patients. In activated passive case detection, all patients with fever are screened even if malaria is not suspected. This approach is used at medical institutions staffed by public health laboratory technicians or field officers. Capacity for APCD increased in the 1990s, with the near doubling of microscopists in the country. APCD, unique to Sri Lanka, was important in detecting cases prior to the elimination phase between 2000 and 2005: approximately 90 percent of all malaria cases were identified using APCD.[33] Two other aspects of the country's surveillance system were also critical: (1) the harmonization of data across regional and national systems, and (2) the ability to distinguish between imported and indigenous cases.

ENTOMOLOGICAL SURVEILLANCE

Entomological surveillance first began shortly after the epidemic of 1934–35. It was strengthened with the introduction of entomological teams as part of an extensive malaria-control program between 1977 and 1982.[34] Sri Lanka used multiple strategies for entomological surveillance, including sentinel surveillance, spot checks, and case-based entomological surveys. Sentinel surveillance occurred at sites known to be *Anopheles* breeding grounds, while spot checks occurred at sites that had experienced environmental changes or an influx of high-risk populations. Case-based entomological surveys occurred in areas where one or more cases had been documented. Although the government played a primary role in entomological surveillance, from 2009 to 2014 TEDHA screened 994,448 individuals for malaria, comparable to the 1,102,054 individuals screened by the AMC.[35]

INTEGRATED VECTOR CONTROL

Sri Lanka was the first adopter of indoor residual spraying (IRS) in the region, which contributed to the early decline in malaria cases in the 1960s. IRS involves spraying an insecticide indoors, including in homes and public buildings, to kill mosquitoes that carry malaria.

Dichlorodiphenyltrichloroethane (DDT) was the first insecticide used. In 1975, DDT was replaced with malathion.[36] In 1993, malathion spraying was discontinued in most of the country except war-affected areas. It was replaced with λ-cyhalothrin, a synthetic pyrethroid, and other insecticides such as cyfluthrin, deltamethrin, and etofenprox.[37] Pyrethroids had two main advantages. First, there was higher acceptance of them for indoor spraying because, unlike malathion, they were odorless, nonstaining, and had to be sprayed only every six months. Second, they came in premeasured sachets, providing more consistent protection against mosquitoes.

Decades later, Sri Lanka added nets to its anti-malaria strategy with insecticide-treated nets introduced in 1999 and long-lasting insecticidal nets (LLINs) introduced in 2004.[38] In war-affected areas, these nets were primarily distributed by the Sarvodaya Movement with assistance from the United Nations Children's FUND (UNICEF) and WHO. LLINs were important for vector control during the conflict. Other environmental strategies, such as the introduction of larvae-eating fish to vector-breeding sites, also played an important role.

CONTROL OF ANTIMALARIAL DRUGS

In Sri Lanka, the AMC alone is involved in acquiring, storing, and distributing anti-malarial drugs. Anti-malarial drugs are distributed to public hospitals only. Private healthcare providers must approach the AMC to obtain anti-malarial drugs. Since 2008, the AMC has required a microscopy-confirmed diagnosis of malaria prior to providing anti-malarial treatment.[39] This policy helps to strengthen surveillance by preventing individuals from taking antimalarial drugs without first receiving a diagnosis.

SUMMARY

Sri Lanka's malaria-control strategies date back to 1911. Entomological surveillance and integrated vector-control support preventative efforts, while parasitological surveillance bolsters diagnosis and management of malaria cases. The AMC maintains control of the country's anti-malarial drugs to strengthen parasitological surveillance efforts.

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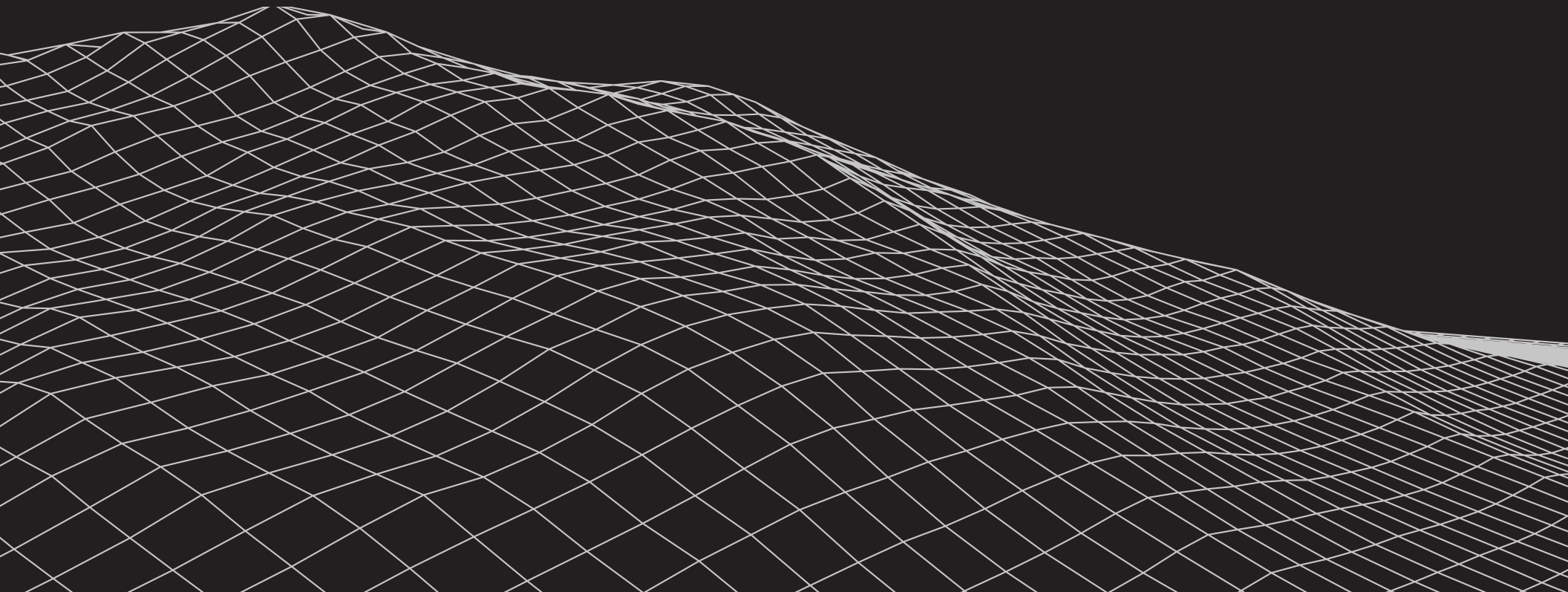
[31] Nadira Karunaweera, Gawrie Galappaththy, and Dyann Wirth, "On the Road to Eliminate Malaria in Sri Lanka: Lessons from History, Challenges, Gaps in Knowledge and Research Needs," *Malaria Journal* 13, no. 1 (2014): 59.
[32] "Parasitological Surveillance," Anti Malaria Campaign, Sri Lanka, 2018.
[33] Abeyasinghe et al., "Malaria Control and Elimination."
[34] "Entomological Surveillance," Anti Malaria Campaign, Sri Lanka, 2018.
[35] Fernando et al., "Use of a Public-Private Partnership."
[36] Abeyasinghe et al., "Malaria Control and Elimination."
[37] Wijesundere and Ramasamy, "Analysis of Historical Trends."
[38] Abeyasinghe et al., "Malaria Control and Elimination."
[39] "WHO Certifies Sri Lanka Malaria-free."

Malaria Elimination During the Conflict and Tsunami



The conflict between 1983 and 2009 arose between the Government of Sri Lanka (GoSL) and the Liberation Tamil Tigers Eelam (LTTE), a nonstate actor, over the northeastern and predominantly Tamil part of the country. Both sides recognized the significance and importance of malaria control, especially as the 600,000-person epidemic escalated. Stakeholders sought to restore antimalarial activities through three primary methods: communication and coordination; supplies; and health service delivery.

COMMUNICATION BETWEEN STATE AND NONSTATE ACTORS

Motivation

While malaria control across the country had been disrupted by the conflict, the most intense and consequential disruptions were concentrated in Tamil areas of the northeast. The health system organized by the federal government continued to operate under disruption.[40] By 1996, 41 percent of total malaria cases in Sri Lanka occurred in the North Eastern Province, which was primarily Tamil.[41] In other areas, malaria was much less prevalent and decreasing. The conflict's greatest impact on malaria control occurred in the dry areas of the northeast.

It is difficult to identify precisely the inception of communication between members of the national government and the LTTE that gave rise to improved coordination to control malaria after the epidemic had become widespread. Certainly the incentive to coordinate was clear. The threat affected everyone on the island, including soldiers in the government military and in the LTTE. The central government's goal of eliminating malaria via the Anti-Malaria Campaign remained a priority, including in the Northern and Eastern provinces. If this harder-to-reach population was not targeted, malaria would continue to be a risk for the rest of the country because the northeastern cases would reintroduce the disease into the South.

By 1996, 41 percent of total malaria cases in Sri Lanka occurred in the North Eastern Province, which was primarily Tamil.

LTTE soldiers were at high risk as fighting intensified in forests with significant exposure to *Anopheles* vectors.[42] The LTTE's motivation to reduce malaria was strategic (sick people make poor fighters) and political—the LTTE's capacity to offer as fundamental a service as malaria control reflected on its legitimacy as a potential government. These considerations were acutely relevant to the population across the country, as Sri Lanka acquired a high level of literacy which cultivated understanding of both malaria and the claims of each side in the conflict regarding malaria control.

Communication

Although there was never any official coordination or agreement between the government and the LTTE, direct communication across medical officials and personnel in districts facilitated malaria control. Individuals on the ground in both the Northeast and the South, including government employees, public health inspectors, and midwives, communicated regularly to coordinate services.[43]

One example of this coordination occurred on National Immunization Days. With the aid of individuals working in LTTE territory as intermediates, ceasefires or "Days of Tranquility" were arranged on one day per year between 1995 and 1999 to deliver polio vaccines across LTTE-held territory. This required negotiation between healthcare professionals and leaders of the LTTE. Although the LTTE initially rejected the idea, it eventually agreed when confronted with the threat to children's survival in the Northern and Eastern provinces. With a common goal, both parties were able to agree to a course of action.

[40] Government salaries continued to be paid to employees working in the North, including to Tamils in LTTE-controlled territory. The education and health system operated with limited capacity even in the Northeast during the conflict.
[41] N. Sivarajah, *Health in Wartime North of Sri Lanka: A Felicitation Volume in Honour of Dr. N. Sivarajah*, edited by N. Selvarajah and Kalpana Chandrasekar (Colombo: Ayothy Library Services and Kumaran Book House, 2013).
[42] Abeyasinghe et al., "Malaria Control and Elimination."
[43] There is very limited literature on this communication, although field interviews generated significant convergence on its importance. Our examples were captured through semi-structured interviews with individuals working both in government and nongovernment sectors across Colombo and previously LTTE-held territories in the North.

When the AMC's regional malaria officers (RMOs) in the North traveled to Colombo for monthly review meetings with their counterparts from the southern provinces, they conveyed information about malaria incidence despite the disruption to entomological surveillance between the early 1980s and early 1990s. Later in the conflict, as entomological surveillance was restored, RMOs stationed in the North applied to the AMC for supplies such as medicines and pesticides through the Regional Director of Health Services (RDHS). These applications were complicated because the pesticides used for malaria control were thought to be a threat that could be diverted to create explosives. Because government officials may have been suspicious of direct requests from the LTTE for malaria-control pesticides, and because of concerns about inaccuracies in the reporting of malaria incidence, reports arose about government officials providing too few supplies to LTTE-held regions. In 2006, the GoSL began to relieve constraints on the movement of anti-malarials and other supplies to the Northeast through the development of the Consultative Committee on Humanitarian Assistance and the appointment of a Commissioner General of Essential Services.[44]

ROLE OF NGOS DURING THE CONFLICT

Two NGOs played a critical role in the elimination of malaria: the International Committee for the Red Cross (ICRC), which arrived during the conflict, and Sarvodaya, the national NGO described earlier that was founded during the 1950s.

The ICRC transported medications and supplies across the territories, particularly between the Northeast and the South. With the road connecting the North to the South, the A9 highway, blocked by the military and the LTTE, the ICRC served as the primary intermediary ensuring that anti-malarial supplies sent from the central government entered LTTE-held territory. This occurred between 2006 and 2009 at the Ommanthai crossing, where both parties inspected the supplies. After 2009, the ICRC arranged transportation by ship through the Trincomalee port in the East.

Sarvodaya, the national NGO, focused its efforts on distributing nets. Initially, the LTTE sought to tax the nets in LTTE-held territory. Through negotiation, they allowed Sarvodaya to distribute nets tax-free. Sarvodaya implemented a number of initiatives to ensure that long-lasting insecticidal nets (LLINs) would reach the people of the North, and also provided modified nets for those living in nonpermanent housing. These nets could be hung and effective in a nontraditional design. Sarvodaya also sought to sustain preventive services in the 1980s by training young people in the early identification of malaria. Sarvodaya's legitimacy as a neutral actor allowed it to travel across the A9 highway when other humanitarian groups were refused access. Sarvodaya's role transitioned in the 2000s to support education and provide rapid diagnostics, with a focus on organizing Malaria Day for schools. Children still learn about malaria through a field trip to *Anopheles* breeding sites, for example. The event is now jointly organized with the AMC.

VARIATIONS BY GEOGRAPHY

Military Camps

Government military camps were particularly vulnerable to malaria. The Sri Lankan military distributed anti-malarial supplies in the camps based on AMC guidelines and the technical guidance that emanated from the monthly AMC review meetings. Six hot spots of military malaria, all but one concentrated in the North, experienced challenges that were characteristic of the civilian populations in LTTE-held territories. The sixth camp was located in Yala, where a battalion was transferred from the North, most likely bringing malaria with it.

Following AMC guidelines, public health inspectors inspected each month for breeding sites and gave lectures on a variety of topics, including malaria. Indoor residual spraying (IRS) occurred every six months and included the bunkers on the front lines. The military struggled to obtain nets because NGOs did not want to provide them to the army. The military also used repellant, which had to be odorless so their opponents would not know their location.

For a time each military person took two tablets of chloroquine under observed conditions every Sunday. When a case was detected, there was both a vertical and horizontal notification to the regional malaria officer in both the camp district and their home district. The infected person's travel was sometimes curtailed, although detection often took place after the infected person had exposed others. Thus, the military took a large number of precautions and individualized approaches to meet the needs of the deployed population, although often with limited effect.

[44] Much more research is required to determine whether and how anti-malarial pesticides were used, and to understand how suspicions that they might be diverted for military use affected their dissemination. "Report of the OHCHR Investigation on Sri Lanka," Office of the United Nations High Commissioner for Human Rights, 16 September 2015.

A blood smear used in the diagnosis of malaria. (Photo courtesy of Dr. P Karthikeyan)

Following the conflict, a high proportion of the country's malaria cases were attributed to military personnel—88 percent of cases nationwide in 2010 were among military members. To address this, the military introduced Directly Observed Therapy, Short Course (DOTS). As with chemoprophylaxis (medication to prevent disease), this involved military personnel taking anti-malarials under supervised conditions. However, DOTS was novel—it subjected the patient to direct observation over the administration of treatment rather than only prophylaxis; daily treatments lasted a period of weeks.

Elephant Pass

The Elephant Pass is a strategic area connecting mainland Sri Lanka to the northern district of Jaffna. The pass was first controlled by the British, then the Dutch. It was under Sri Lankan control until 2000 when the LTTE gained control. The pass saw an increase in civilian traffic in the early 1990s, which brought an increase in cases of malaria. Traveling over the Elephant Pass requires crossing through the Vanni region, sometimes by boat. When travelers cross in the dark to avoid confrontations between the LTTE and the Sri Lankan navy, they are surrounded by *Anopheles* mosquitoes, which are known for biting at night. Thus, travelers crossing at night brought malaria to Jaffna, their travel destination. Malaria cases in Jaffna district increased to the point where one in ten people had the disease. The province was responsible for 62.3 percent of the country's total cases in 1998.[45] Later, the Elephant Pass's closure led to a drop in cases with a decrease in travelers. The pass was not used for two decades, except for a few years during the ceasefire. It is not clear whether the closure was meant for malaria elimination, but its effect was critical to that outcome.

A9 Blockade

The A9 is the main highway connecting Colombo to the Vanni, and the Vanni to Jaffna. It closed a number of times throughout the conflict. It closed in 1984 on both sides, reopened in 2002 after the ceasefire, closed on the Jaffna side in 2006, and reopened in 2009–10 on both sides. When the road was open, both the government and LTTE required a clearance process. People crossing waited from one to two weeks to gain clearance from both sides, although this time could be shortened and facilitated by networks of individuals who were connected and perceived as neutral. This neutrality was extended to certain physicians practicing in the north through NGOs. The clearance process was also required for the transport of goods, including malaria-control supplies such as medications and pesticides, all of which were transferred from one vehicle to another at the Elephant Pass once approval was granted. The efficiency of this process was influenced by the weather, with great delays during the monsoon season. The ICRC was often responsible for

[45] Sivarajah, *Health in Wartime North.*

transporting government supplies, specifically the medications that were used for treating malaria.

ACCESS TO SUPPLIES

Malaria elimination requires a multipronged approach in any context. In Sri Lanka, the AMC's activities depended on access to medications, indoor-residual-spraying equipment and chemicals, and bed nets. During the conflict, access to each of these supplies was disrupted, particularly in the North and Northeastern provinces where malaria was prevalent.

Medications

Medications are key to treating malaria. During the conflict, medications were requested of the government through the RMOs and underwent review by the Ministry of Defense and Ministry of Health before journeying across the A9 blockade facilitated by the ICRC, and if road transport was not an option, then by plane or ship. When there was a shortage of anti-malarials, they were brought in by small-scale businesses. The medications were to be sold only to the LTTE and not directly to the public. At other times, medicines were purchased in India and brought through the small fisheries port in Mannar, Northern Sri Lanka. There are multiple reports of treatment being given at gunpoint by LTTE members.

Indoor Residual Spraying

Indoor Residual Spraying (IRS) is one vector-control method to reduce the amount of mosquitoes in indoor quarters. Depending on the pesticides used, various spraying schedules are used in different parts of the country. IRS is managed by the AMC directorate across the country. In LTTE-held territory during the conflict period, AMC staff living in the LTTE territory, most of them from the Tamil minority group, administered IRS using an authoritative and militaristic approach. The chemicals were updated over time as new pesticides were determined to be more effective than older pesticides, many of which were diminished as vector mosquitoes developed resistance. There were periods when no IRS or entomological surveillance was conducted, such as between 1990 and 1995.

Bed Nets

Mosquitoes tend to be most active at dusk, in darkness, and at dawn. Bed nets reduce the number of mosquito bites that people are exposed to, especially during the night when certain vectors are most active. Nets were provided mainly by NGOs, including Sarvodaya, the ICRC, UNHCR, World Vision, Wellcome Trust UK, and Oxfam. They became much more readily available after the tsunami in 2004 when foreign aid was sent to Sri Lanka.

Access to bed nets varied during the conflict. During the final battles in 2009, supplies were very limited. Throughout the conflict period, supplies entered LTTE-held areas in a variety of ways.

HEALTH CARE DELIVERY

With a lack of public health lab technicians in the North, there were few trained personnel to process blood smears for diagnosing malaria. Between 1983 and 2009, some districts had empty RMO positions. Conflict was also associated with a decrease in the number of doctors, community-based public health specialists, and diagnostic technicians because specialized health workers sought safer and better living conditions.

Academic and healthcare leaders in the North developed programs for training health workers during the conflict. For example, academic leaders at the University of Jaffna developed a shortened program that recruited ten laborers who had completed the equivalent of high school to study basic microscopy and parasitology. These students graduated to work in the rural North. Around this time, the LTTE was developing a supplementary health service to provide malaria care. Because this system was completely dismantled at the end of 2009 and its workers were released from their responsibilities, it's difficult to obtain information about it. Physicians who worked then told us the structure included a medical unit with a battleground branch and a public service branch for civilians. The civilian branch was further subdivided into (a) the Tamil Eelam Health services branch, which provided general services including spraying and malaria treatment, and (b) the Thileepan medical services branch that provided mobile units for more remote regions, including Batticaloa and Trincomalee. The Tamil Eelam Health Service was in contact with the AMC through volunteers, midwives, and other providers, although never in any official capacity.

As medical personnel left the northern region during the conflict, the LTTE and leaders at the University of Jaffna developed a makeshift medical program that graduated three dozen graduates who had entered the program with six to seven years of formal schooling. Students were taught basic skills in community medicine. A number of interviewees recalled how the curriculum demonstrated suturing protocols on tires wrapped around

trees. Graduates were referred to as "medics" or "medis" who worked side by side with government physicians to provide care. There was a good relationship between government employees in the North and the LTTE-trained medics. None of these individuals continued to practice after 2009.

Rudimentary health care in the North was championed by individuals acting as intermediaries between patients, employers, and other stakeholders. Continuity in the salaries of those government-employed healthcare workers who stayed on the job in the North supported the continuing operation of the health system at a reduced capacity. The combined efforts of dedicated health providers brought the number of malaria cases down before the end of the conflict, but more than 600,000 were affected by malaria.

THE 2004 TSUNAMI

Although natural disasters are generally associated with increased risk of disease outbreak,[46] no evidence suggests that the incidence of malaria in Sri Lanka increased following the 2004 tsunami. Remarkably, in the immediate aftermath of the tsunami, the GoSL, the LTTE, NGOs, and the healthcare community intensified coordination to deploy malaria-control strategies in tandem across the country.

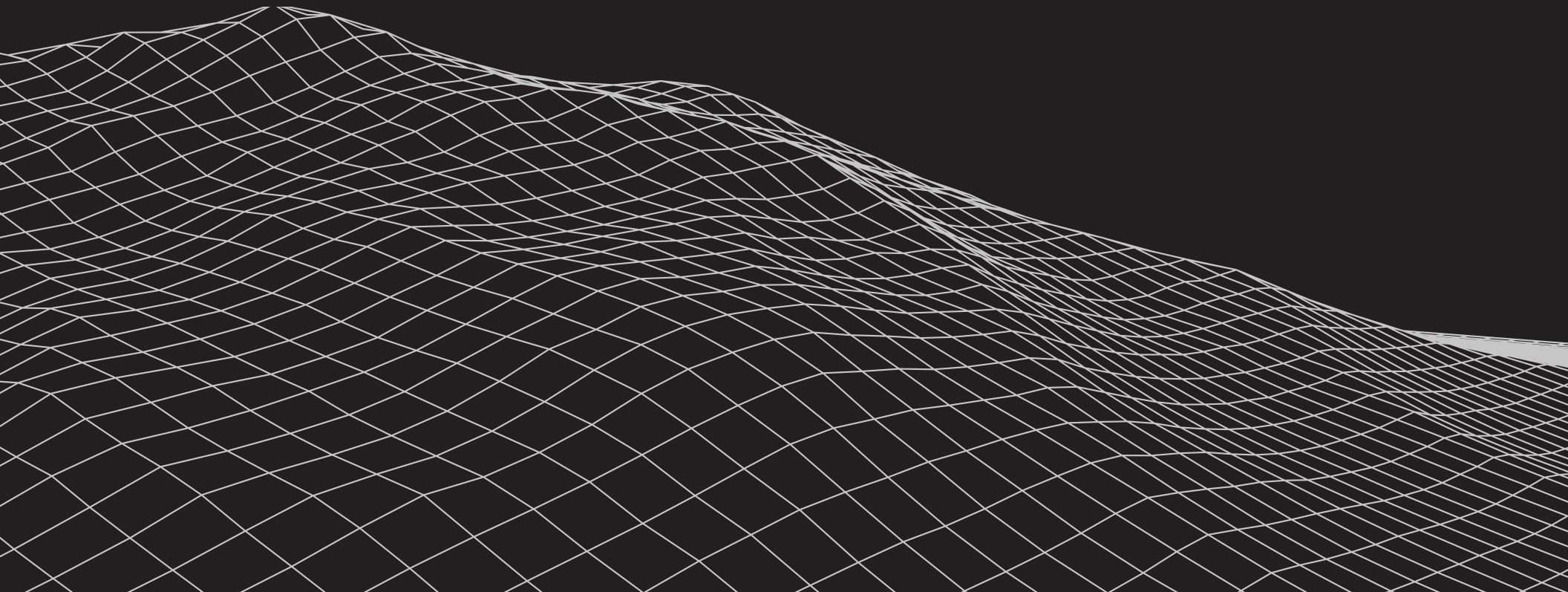
Members of the Sri Lankan Military and LTTE cadre cooperated to conduct immediate rescue and relief work in the Northern and Eastern provinces. NGOs helped to create disease-awareness programs, and provided fogging machines to kill mosquitoes in areas known for malaria infestation. The government fogged and chlorinated wells close to settlement camps. In select camps, RMOs conducted IRS. Mobile clinics traveled to camps for displaced people and performed active case detection. The government provided antimalarial drugs such as chloroquine, proguanil, and sulphadoxine/pyrimethamine.[47] Government warehouses were well stocked with medications prior to the tsunami. The collaboration between actors led outside observers to conclude that the country had achieved a strong public health infrastructure even under the most adverse circumstances.

SUMMARY

The malaria threat affected soldiers in the national military and in the LTTE. Thus, the goal of elimination was a high priority. Accomplishing this goal required the assistance of international and domestic NGOs to distribute supplies and medication throughout the country. It also required direct communication across the healthcare community in war-affected districts to facilitate malaria control. This coordination was especially critical in preventing an outbreak in cases after the tsunami.

[46] Watson, Gayer, and Connolly, "Epidemics after Natural Disasters."
[47] Ibid.

Getting to Zero Cases



For a country to be declared free of malaria, it needs certification from the World Health Organization (WHO). This involves shifting the country's emphasis in its malaria strategy from control to elimination. While the control phase emphasizes controlling the malaria vector (the *Anopheles* mosquito), elimination requires detecting the few remaining cases in the country. Two criteria must be met for WHO-certified malaria elimination:

a. "The chain transmission of malaria via the *Anopheles* mosquitoes in the country must be completely impeded for a minimum of three consecutive years."
b. "A country must have implemented a fully functional surveillance and response system, capable of preventing the reintroduction of malaria and the re-establishment of transmission."[48]

Even after achieving zero indigenous cases in 2012, Sri Lanka was not yet eligible for WHO certification because it had yet to develop the screening programs necessary under criteria b.

CERTIFICATION PROCESS

Between 2012 and 2016, the country concentrated on developing the surveillance system necessary for certification by entering into an elimination phase of malaria control. Throughout this phase, the WHO sent three missions to monitor the process and to determine the nation's readiness to manage imported cases.

Following the first mission's conclusion, Sri Lanka officially requested the WHO's office of the Director General to apply for certification in April 2016. After the second mission, another draft of the national report was submitted in July 2016. The WHO-required external evaluation by independent consultants was to be conducted that same month. The final mission concluded that the country had successfully met the WHO criteria to be designated as malaria-free though certain aspects of the system required improvement.

The AMC needed to engage in case-based surveillance and response. The advisory group recommended that the entomological surveillance system should be reviewed and improved to incorporate best practices in the maintenance of elimination. They also recommended that the AMC should intensify malaria vigilance through more timely diagnosis and treatment.

The last case of malaria was detected in the Hambantota district, in the south. The accomplishment was interpreted as evidence of the importance of community engagement at grassroots levels to achieve public health goals. The cooperation achieved by the previously warring government and LTTE to control malaria, particularly after the 2004 tsunami, had been sustained through certification in 2016. Every Sri Lankan, regardless of ethnicity, had access to diagnostic services and treatment. The declaration of malaria elimination constituted an important moment of national healing following the long war that divided the country.

CHALLENGES AND THREATS

Migration and Malaria

Sri Lanka's national migration health policy is evidence based and effective in screening travelers arriving from malaria-endemic countries, which is critical to sustain malaria-free status. To mitigate the risk of reintroduction by migrants and visitors, AMC officials screen high-risk people at the international airport. This process occurs with the support of the International Organization of Migration (IOM) who informs the AMC when people from a malaria-endemic nation will be traveling to Sri Lanka. Malaria incidence in returnees from source countries has proven to be an important predictor of malaria risk, specifically with regard to subnational transmission. In 2014, thirty-two cases of *P. falciparum* were detected in 534 irregular migrants who returned to Sri Lanka from West Africa after failed human smuggling attempts.[49]

Tracking and reporting malaria in migrants is critical because malaria incidence in migrants using irregular modes of travel is significantly high (60 cases per 1,000) compared to the risk of contracting malaria for regular travelers returning from West Africa at three per 1,000.[50] Furthermore, migrants become more vulnerable because of their "illegal" status and discrete nature of their movement, having little or no access to healthcare facilities. Since the end of conflict in 2009, there has been a rapid increase in the volume of travelers to malaria-endemic countries, with the majority (97% of the 4,500) departing to West Africa making reintroduction of malaria a high risk.[51]

The largest number of migrants returned to districts with the highest Annual Parasite Index (API) indexes reported nationally. Reintroduction and

[48] "Certification Process," WHO, 13 March 2018.
[49] Sophie Cousins, "Sri Lankans Vigilant after Bidding Farewell to Malaria," *Bulletin of the World Health Organization* 95, no. 3 (2017): 170.
[50] Kolitha Wickramage, Risintha G. Premaratne, Sharika L. Peiris, and Davide Mosca, "High Attack Rate for Malaria through Irregular Migration Routes to a Country on Verge of Elimination," *Malaria Journal* 12, no. 1 (2013), 276.
[51] Ibid.

Indoor residual spraying of pesticides. (Photo courtesy of Dr. P. Karthikeyan)

risk of spreading the parasites occur when there is a long-term return into areas of endemicity with presence and prevalence of the mosquito vector.[52] Therefore, AMC and IOM field teams' monitoring activities have been key to mitigating malaria reintroduction.

Although the parasite has been eliminated, the *Anopheles* mosquito has not been so it remains an accessible vector for transmission. The risk of reintroduction has escalated since 2016 as immigrants and refugees from malaria-endemic nations enter the country, and as Sri Lankan nationals return from malaria-endemic nations (i.e., labor migrant workers, armed forces personnel from UN peacekeeping missions, and returning students). These returnees are more likely to be exposed to mosquito bites and are more likely to contribute to the spread of malaria upon return to their homes within locally endemic regions.

In recent years, AMC officers have been testing irregular migrants as well as returning peacekeepers with rapid diagnostic tests when they enter the country. Risk of reintroduction can be reduced by developing a strategy to investigate inbound travel patterns and by closely monitoring migrants from malaria-endemic zones. The tourism industry, travel operators, and Sri Lankan embassies all over the world can also alert travelers about the risk of reimporting malaria. The IOM suggests that more resources need to be dedicated to the risk of re-importation because the actual number of imported cases is probably underestimated.[53]

A cluster of malaria infections was detected among Ahmadiyyan (Islamic minority group) asylum seekers from Pakistan. Cases were first detected when two children from families seeking asylum were admitted into a district general hospital located in the non-endemic Western Province of the country on 8 and 12 July 2013. Following the children's diagnosis with *Plasmodium vivax* malaria, the AMC launched a widespread outbreak investigation. It learned that the UNHCR had already registered the asylum seekers. In the next six months, four active case-detection programs were carried out among asylum seekers arriving in the country. Each of the screening programs employed microscopy and rapid diagnostic kits. By the end of December of 2013, seventeen cases of malaria were detected among Pakistani asylum seekers. These individuals were all treated with chloroquine and primaquine and recovered, and the presence of malaria in the country was again eliminated.

The country's elimination status is also threatened by the return of military personnel taking part in UN peacekeeping missions in malaria-endemic nations. To prevent reintroduction, the military has cooperated with the AMC since 2010 to provide malaria-awareness training to members of each of the three parts of the military. Senior military personnel are trained through predeployment modules offered by the AMC. These senior officers in turn train other military personnel. The military

[52] Cousins, "Sri Lankans Vigilant,"170.
[53] Ibid.

also participates in monthly meetings among the AMC's regional malaria officers (RMOs).

The military uses indoor residual spraying (IRS) to prevent the resurgence of malaria within army camps. The camps employ active case detection through blood smears. Military personnel residing in the camps receive training in public health lectures conducted by the area's public health inspector (PHI). These inspectors are not associated with the AMC, but are employed by the military and assigned to each camp. The PHI visits his or her designated camp on a monthly basis to monitor compliance, conduct analysis, and deliver additional training.

One of the most intractable challenges associated with sustained elimination is government health organizations and administrative bodies' increasing reluctance to commit time, financing, and staff to maintain malaria elimination. As in 1963, malaria control has lost salience in the national imagination. Malaria experts warn that the disease could become "forgotten" and the diagnostic skills such as microscopy may be lost.

To mitigate this risk, the AMC conducts malaria training programs at the district level to ensure that physicians keep up their screening and treatment skills. Malaria remains part of the curriculum for fourth- and fifth-year medical students in their parasitology courses.

Dengue vs. Malaria

Sri Lanka's elimination of malaria was heralded internationally as a public health victory but another mosquito-based disease, dengue, broke out as an epidemic. The Ministry of Health's epidemiology unit reported 80,732 cases of dengue fever, including 215 deaths from the disease between January and July of 2017. This total is 4.3 times greater than the average number of cases diagnosed within the same seven-month period in each of the years between 2010 and 2016. Urbanization plays a role in the outbreak because the *Aedes* mosquito, the dengue vector, prefers to lay its eggs in clean bodies of water. Efforts to control dengue complement malaria control in theory, but in practice confusion in diagnoses may have led to delays in the malaria diagnosis. That is, physicians may delay in considering a fever case to be malaria because the focus is now dengue.

Other problems associated with controlling dengue have contributed to concerns about malaria elimination efforts. Fogging of habitats with pesticides to reduce the *Aedes* mosquito might be effective for dengue but not for malaria. Thus, the country is at risk of reduced fogging, which could amplify the risk of reintroducing malaria.

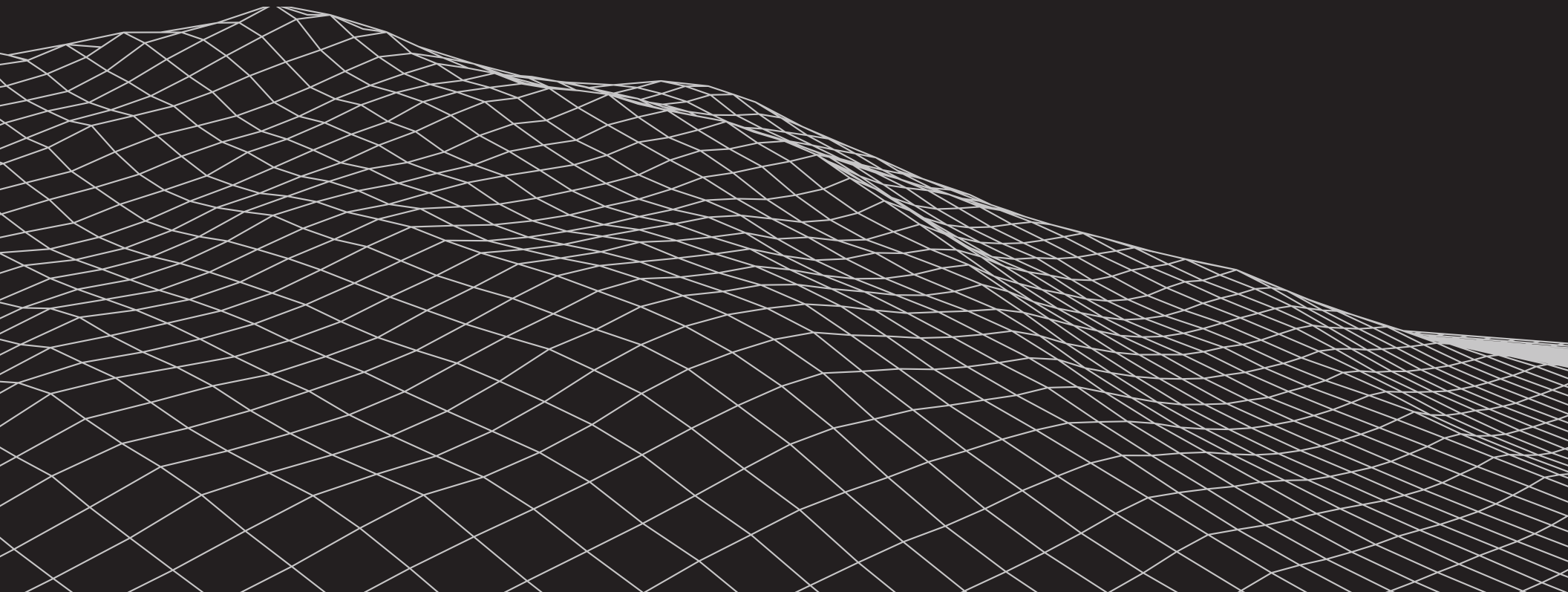
Despite these problems, complementarities in the diagnosis of malaria and dengue have also arisen. The public health inspectors who play a critical role in controlling the dengue vector work with local police to inspect houses and government institutions for mosquito breeding grounds. Homeowners may be fined between 1,000 and 5,000 Sri Lankan rupees if a breeding ground such as an open source of water is found. The military is also involved in dengue control. According to Colonel Dr. Semage, a consultant community physician with the Sri Lankan Army Health Services, the military is a part of the presidential task force for dengue. Under the task force, military personnel are involved with helping to clean up public spaces to reduce the number of larvae breeding grounds. These efforts likely combat malaria as well as dengue.

SUMMARY

Sri Lanka required a shift in strategy from malaria control to malaria elimination to receive elimination certification from the WHO. Despite having received the certification in 2016, the country faces challenges that threaten to reintroduce malaria. These challenges include reintroduction by migrants and visitors from malaria-endemic nations. Additionally, the outbreak of dengue coupled with low malaria incidence could result in delays in the malaria diagnosis.

Lessons Learned

Despite the challenges posed by the twenty-six-year conflict, the tsunami of 2004, and the flow of people into and across the country, Sri Lanka has successfully eliminated malaria. Its long history of malaria epidemics led to unified leadership and a strong healthcare system.



During the tsunami of 2004, the government refused donated anti-malarial drugs that did not accord with its drug policy. This approach ensured that treatment regimens were administered consistently to support patient care and prevent resistance to medications.

STRATEGIC PLANNING

From the 1980s to the present, Sri Lanka has maintained centralized leadership of elimination efforts, enabling the country to make several strategically important decisions. In accordance with the national strategy, anti-malarial drugs are distributed routinely to public hospitals only. Private clinics must approach the Anti-Malaria Campaign (AMC) to acquire medications. This strategy helped ensure a centralized AMC database of individual diagnoses. During the tsunami of 2004, the government refused donated anti-malarial drugs that did not accord with its drug policy.[54] This approach ensured that treatment regimens were administered consistently to support patient care and prevent resistance to medications.

The private sector has had a small but significant role in Sri Lanka's malaria-elimination success story. During the conflict, a private partner, Tropical and Environmental Diseases Health Associates (TEDHA), collaborated with the AMC to strengthen entomological and parasitological surveillance. Encouraged by the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM), the AMC collaborated with TEDHA to enable services to reach conflict-affected areas under the purview of the government. NGOs such as the International Committee for the Red Cross (ICRC) and Sarvodaya were also critical in supporting malaria control during the conflict, particularly in LTTE-held areas in the North.

Sri Lanka's approach to malaria elimination was highly centralized through the AMC on matters of policy, but it administered programs through decentralized regional malaria officers (RMOs) beginning in 1991. Each province took on significant responsibility for malaria-control activities led by RMOs. Sri Lanka's centralized control of drugs, programs, and funding may have enabled a more coordinated and deliberate response to the obstacles it faced, including the conflict and the tsunami. The decision to hold monthly meetings among RMOs enabled interprovincial collaboration even during the conflict, while the decision to employ RMOs as representatives of the central government in LTTE-held areas was critical to malaria control and elimination.

OVERLAPPING MOTIVATIONS

During the conflict, the government of Sri Lanka and the Liberation Tamil Tigers of Eelam (LTTE) collaborated to address the malaria epidemic that emerged during the earliest years of the war. The first known instance of this collaboration occurred during polio vaccination days, which both the government and the LTTE supported. Perhaps influenced by Sri Lanka's strong education system and universal healthcare system, both parties appeared to be motivated toward the goal of malaria control.

[54] "Briët et al., "Malaria in Sri Lanka."

Alignment between the government and the LTTE on malaria control was persistent if irregular throughout the middle and later years of the conflict. For example, the LTTE did not disrupt government healthcare services in the Northeast and the government continued to pay the salaries of local healthcare workers of Tamil origin on assignment in the Northern and Eastern provinces. Government staff working in conflict-affected areas were dedicated to local civilians' health and communicated through their RMOs with leaders in other provinces. The government was motivated to deliver health services in conflict-affected areas to remain active and visible in these areas, while the LTTE participated in malaria-control activities to legitimize its governance authority and reduce the impact of malaria on its fighters.

The collaboration between the government and the LTTE was imperfect. Human resource and supply shortages in conflict areas led to epidemics during the earliest years of the war. As commitment to malaria control increased, the gaps in government resources were often filled by individuals and small groups motivated by beliefs about the importance of health. Examples include the work of the ICRC in facilitating the delivery of medications at the A9 blockade; the work of the Sarvodaya movement in distributing nets and in developing awareness campaigns at schools; the role of the LTTE in creating a medical school to train alternative health providers; and commitments to train lay microscopists to support malaria diagnostics in the face of a decreased workforce.

NOVEL TECHNICAL APPROACHES

Perhaps because of its extensive history of malaria-control programing, Sri Lanka was able introduce the new pyrethroid insecticides for IRS throughout much of the country during the conflict. With the help of Sarvodaya, UNICEF, and the WHO, Sri Lanka successfully introduced long-lasting insecticidal nets (LLINs) in 2004.

It also used novel approaches to control the incidence of malaria in the military. Strategies to reach soldiers included administering IRS in military camps every six months; laboratories on-site at military camps for malaria testing; and chemoprophylactic (i.e., preventative) use of two tablets of chloroquine every Sunday under observed conditions. In 2010, one year after the war ended, approximately 88 percent of all cases of malaria nationwide were among military personnel. The introduction of "Directly Observed Therapy, Short Course" (DOTS) was introduced as a result of the high burden of malaria in 2010 among troops. Through DOTS, each dose of anti-malarials among affected individuals had to be observed as it was administered.[55]

[55] DOTS was originally used for the treatment of tuberculosis, and was used during the conflict for the chemoprophylaxis among the troops on Sundays. However, its use for prolonged, daily treatment for malaria was novel.

RESEARCH TEAM

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Joseph Wong is the vice provost and associate vice president, International Student Experience, at the University of Toronto. He is also the Ralph and Roz Halbert Professor of Innovation at the Munk School of Global Affairs and Public Policy and a professor of political science. He held the Canada Research Chair in Democratization, Health, and Development for two full terms, ending in 2016. Wong was the director of the Asian Institute at the Munk School from 2005 to 2014.

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Kirstyn's research examines the delivery of services to marginalized populations. She is particularly interested in the delivery of services to populations affected by violent conflict. Through her role with the Reach Project, Kirstyn has led research teams in India, Jordan, Rwanda, Sri Lanka, and Tunisia. Kirstyn holds a BA (honors) from McGill University, and a master of global affairs from the Munk School of Global Affairs and Public Policy at the University of Toronto.

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REACH PROJECT

Development is about delivery—the will and ability to deliver interventions to very poor and vulnerable people to help improve their lives. The development "space" is filled with great ideas and innovative solutions, from technological interventions to new policy initiatives. But the effects of these potentially game-changing ideas are severely mitigated if they do not actually get to the people they are intended to benefit. We think of this challenge in terms of "reach." Solutions can solve problems only if they reach those who need them most.

The Reach Project focuses on the delivery of services and interventions to those who are hardest to reach. We are a research initiative supported by a partnership between the Munk School of Global Affairs and Public Policy at the University of Toronto and the Mastercard Center for Inclusive Growth. The Reach Project is led by Professor Joseph Wong. The commitment of student researchers and faculty mentors from across the University of Toronto drives our work. Together, we examine the delivery of services and interventions to those who are hardest to reach in countries around the world.

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