



# MALARIA IN THE MEKONG DELTA

**Rationale, Implementation and Interim Effectiveness  
of Việt Nam's Control, Prevention and Elimination  
Program, 2015-2030**

Andrew W. Taylor-Robinson and Nguyen K. Quan



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## Foreword

### David Bangsberg, MD MPH

Dean of College of Health Sciences, Provost of VinUniversity

*“This book provides expert insights on combating malaria in the Mekong Delta, a region of Southeast Asia in which this mosquito-transmitted parasitic disease has long been a public health scourge. It clearly emphasizes the critical roles of the World Health Organization, the National Institute of Malaria, Parasitology, and Entomology, and global campaigns in countering this and other arthropod-borne infectious diseases. Advances in malaria surveillance through collaborative research and community engagement initiatives have established effective ways to prevent, detect and respond to outbreaks. As VinUniversity traverses the complex intersection of medical school and clinical practice, let us strengthen our commitment to tackling infectious illnesses with skill, integrity, and compassion. This encouraging tale of malaria control motivates us to work together to achieve health justice for all in Việt Nam.”*

### Le Cu Linh, MD PhD

Executive Vice Dean, College of Health Sciences, VinUniversity

*“According to the World Health Organization, Việt Nam has achieved significant progress in malaria control over the last 15 years. The number of malaria cases and deaths have reduced by at least 60% and 76%, respectively. There are still, however, some priority areas that Việt Nam wants to improve. The Mekong River Delta is a key battle ground in the fight against malaria, where Việt Nam and other countries in the region are working together to eradicate the disease. This book discusses their combined efforts, pointing out both successes and unresolved issues. Even though the incidence of malaria has dropped significantly since the start of this century, drug resistance has emerged as a problem that demands creative solutions and long-term commitment. Readers will learn about the complicated world of resistance and treatment, which exemplifies the enormous challenge to rid the Mekong Delta of malaria. Even so, there is reason for optimism: by sharing knowledge, pooling resources and following robust methods, this joint project shows the power of collaborating across borders for the common public health benefit of the many communities whose livelihoods are dependent on the Mekong River.”*

**Le Van Phuoc, MD MPH**

Vice Dean of Clinical Education, College of Health Sciences, VinUniversity

*“This informative book explains the difficulties Vietnamese healthcare professionals encounter in curbing malaria in southern provinces of the country. A range of tools is introduced to handle real-life situations through exploring the multifactorial issues of disease transmission and treatment adherence, each with an eye to interdisciplinary collaboration. From a medical education perspective, this highlights how to face complex public health challenges, especially valuable for young people who aspire to become doctors, nurses, and other health professionals. Hence, this story may inspire a new generation to address health disparities with an unwavering dedication and commitment to teamwork.”*

## Preface

This perspective provides a critical appraisal of the ongoing impact on Việt Nam of the Mekong Malaria Elimination Program that was proposed in 2015, inaugurated in 2017 and is set to continue throughout the 2020s. This is an ambitious public health strategy orchestrated by the World Health Organization in partnership with the six countries of the Mekong Delta Subregion. It aims to effectively combat the scourge of malaria, a major risk to human health since prehistory. This tropical infectious disease is caused by a mosquito-borne microscopic protozoan parasite called *Plasmodium*. From a Vietnamese viewpoint, the program sets twin targets: to reduce to zero the national incidence of malaria by 2030; to instigate robust surveillance and vector control measures to prevent its re-introduction to the Mekong Delta region of southern Việt Nam, traditionally the country's hotspot for outbreaks of infection. The Vietnamese Government's Ministry of Health has overall responsibility for meeting these goals.

The motivation for writing this perspective arose from a discussion between the two co-authors, one a recent medical graduate and junior academic, and the other a seasoned infectious diseases faculty with a longstanding interest in malaria. We had the shared responsibility of preparing, delivering and assessing a pre-clinical course on medical microbiology to the pioneering cohort of students enrolled on the Medical Doctor program offered by the College of Health Sciences at VinUniversity. In reflecting on how best to assess the parasitology component of the new curriculum we sought a team-based activity that would demand a higher level of learning than is provided by multiple-choice or short-answer questions. This exercise would also require individuals to harness their collaborative, organizational and time management skills, each a core professional attribute for a hospital physician. We struck upon the idea of inviting students to perform a literature search in both English and Vietnamese, scientific evaluation of the data, critical analysis, and group presentation of the first 5 years of the Mekong Malaria Elimination Program, appraising its successes and failures to date, and highlighting areas for attention.

What transpired was a pedagogically stimulating project for us as teachers of higher education, but which was intellectually challenging for the learners for whom we have responsibility. Sitting at the nexus of teaching and research, this monograph marks a culmination of this work – written by the co-authors with the assistance of a selection of our beloved VinUnian students.

**Andrew W. Taylor-Robinson and Nguyen K. Quan**

December 2023.

## I. Abstract

Malaria is a potentially fatal infectious disease that poses a persistent global public health threat. The vast majority of mortality and morbidity in humans is the consequence of infection with either of two species of *Plasmodium* parasite, *P. falciparum* and *P. vivax*, that invade red blood cells. Transmission of these microscopic pathogens occurs via the bite of infectious female *Anopheles* spp. mosquitoes in tropical regions, including those neighboring the Mekong River. In response to widespread resistance to the first-line antimalarial drug artemisinin in Southeast Asia, in 2015 the World Health Organization proposed the Mekong Malaria Elimination Program. Launched in 2017, this aims to coordinate and advance the six Greater Mekong subregion countries towards malaria-free status by 2030. Việt Nam has been particularly visionary, as long ago as 1991 implementing the National Malaria Control and Elimination Program to address the chronic burden of malaria outbreaks in the country's southwest corner. Over time, epidemiological factors such as geography, socioeconomic status, and demographics have significantly influenced the stratification of malaria in the Mekong Delta. Therefore, it is imperative to conduct a comprehensive critical evaluation of the efficacy of the ongoing program by comparing national and regional perspectives. Over the past decade, Việt Nam's national program has demonstrated significant progress in achieving the globally established goals for malaria eradication. However, persistent challenges related to resource allocation, staffing by trained personnel, and financial support highlight the need for further improvement if the ambitious 2030 target of malaria elimination is to be met.

**Key words:** Malaria; *Plasmodium*; Việt Nam; Mekong Delta; Control; Prevention; Elimination

**Abbreviations:** ACT, artemisinin-based combination therapy; AR, artemisinin-resistant; GMS, Greater Mekong Subregion; IRS, indoor residual spraying; ITN, insecticide-treated nets; LLHN, long-lasting insecticide-treated hammock net; LLIN, long-lasting insecticide-treated bed net; MME, Mekong Malaria Elimination; MoH, Ministry of Health; NIMPE, National Institute of Malariology, Parasitology and Entomology; NMCEP, National Malaria Control and Elimination Program; SPR, slide positivity rate; WHO, World Health Organization

## II. Introduction

Malaria is thought to have exerted more influence on the history of humankind than any other infectious or metabolic disease due to its notably high morbidity and mortality rates extending over millennia of coevolution (Garcia, 2010). Despite multiple control measures and treatments, malaria remains an alarming global health issue, affecting millions of people worldwide. The World Health Organization (WHO, 2023) reported for 2022 an estimated 249 million malaria clinical cases and 608,000 fatalities in 85 malaria-endemic countries. The greatest burden was in sub-Saharan Africa, which contributed 82% of global incidence and 94% of deaths, followed by Southeast Asia with 10% of cases and 3% of fatalities. Consistently, the most susceptible groups are children under 5 years of age, pregnant women, and immunocompromised individuals, such as patients with HIV/AIDS. The causative agents of malaria are protozoan parasites of the genus *Plasmodium* that are transmitted via the bite of infectious female *Anopheles spp.* mosquitoes. These insect vectors require freshwater bodies, commonly in many tropical and subtropical countries, as primary sites for reproduction (Hamza & El Rayah, 2016). Among six plasmodial species that are known to naturally infect humans, *P. vivax* and *P. falciparum* are responsible for the vast majority of clinical cases worldwide, with the latter accounting for more than 80% of all recorded incidence in Việt Nam (Thanh et al., 2015).

The Mekong Delta is the world's youngest but third largest river basin. Spanning an area of over 40,000 km<sup>2</sup> of southwestern Việt Nam between Hồ Chí Minh City and Cambodia, it is connected by a network of tributaries to the last 250 km of the Mekong River before emptying into the East Sea (also known as the South China Sea). Home to 18 million people, the Delta yields half of Việt Nam's rice output and 65% of its aquaculture produce, contributing 17% of the country's gross domestic product (General Statistics Office of Việt Nam, 2023). During the past decade, this "rice basket of Việt Nam" has seen major socioeconomic development, resulting in rapid changes in malaria vector ecology. As recently as 1992 it was considered a malaria-endemic region, with over 360,000 confirmed diagnoses and 516 deaths (Erhart et al., 2004a). However, following concerted prevention, detection and treatment efforts both incidence and mortality rates reduced considerably, with the implementation of the National Malaria Control and Elimination Program (NMCEP) in the 1990s serving as a significant milestone. More recently, underpinned by strong political commitment and driven by advances in malaria control, the Greater Mekong Subregion (GMS), consisting of nations intersected by the 4,909 km-long Mekong River, ratified a malaria elimination plan to eradicate the disease by 2030 (Cui et al., 2018). The six countries involved are China (Yunnan Province), Myanmar, Laos, Thailand, Cambodia and Việt Nam. However, this demanding but



admirable objective has confronted a slew of obstacles that necessitates a multifaceted and collaborative approach.

Since the Mekong Delta is a regionally important economic and diplomatic crossroads (Việt Nam Chamber of Commerce and Industry, 2023), it is of the utmost importance to understand existing issues in order to develop or refine social, economic or public health initiatives. This article evaluates the rationale, implementation, and current effectiveness of Việt Nam's ongoing malaria-eradication program in the Delta by drawing cross-regional and national comparisons – with a view towards future implementation.

### III. About the Mekong Delta

#### Geographical Characteristics

The Mekong Delta encompasses 13 Việt Nam provinces: Cần Thơ, An Giang, Đồng Tháp, Long An, Tiền Giang, Vĩnh Long, Bến Tre, Trà Vinh, Sóc Trăng, Hậu Giang, Bạc Liêu, Cà Mau, and Kiên Giang. Bordering Cambodia to the west, it is directly adjacent to the East Sea and the Gulf of Thailand. Given these geographical features, the region plays a pivotal role in the maritime transportation of passengers and cargo, as well as being enormously productive agriculturally and aquaculturally (Garschagen et al., 2012). However, these interrelated factors make the Mekong Delta very prone to trans-boundary transmission of malaria (Trung et al., 2004; Suwonkerd et al., 2013; Geng et al., 2019). Hence, the risk of introducing drug-resistant parasites and insecticide-resistant mosquito vectors and thereby of re-establishing the foothold the disease has maintained in the region is ever present.

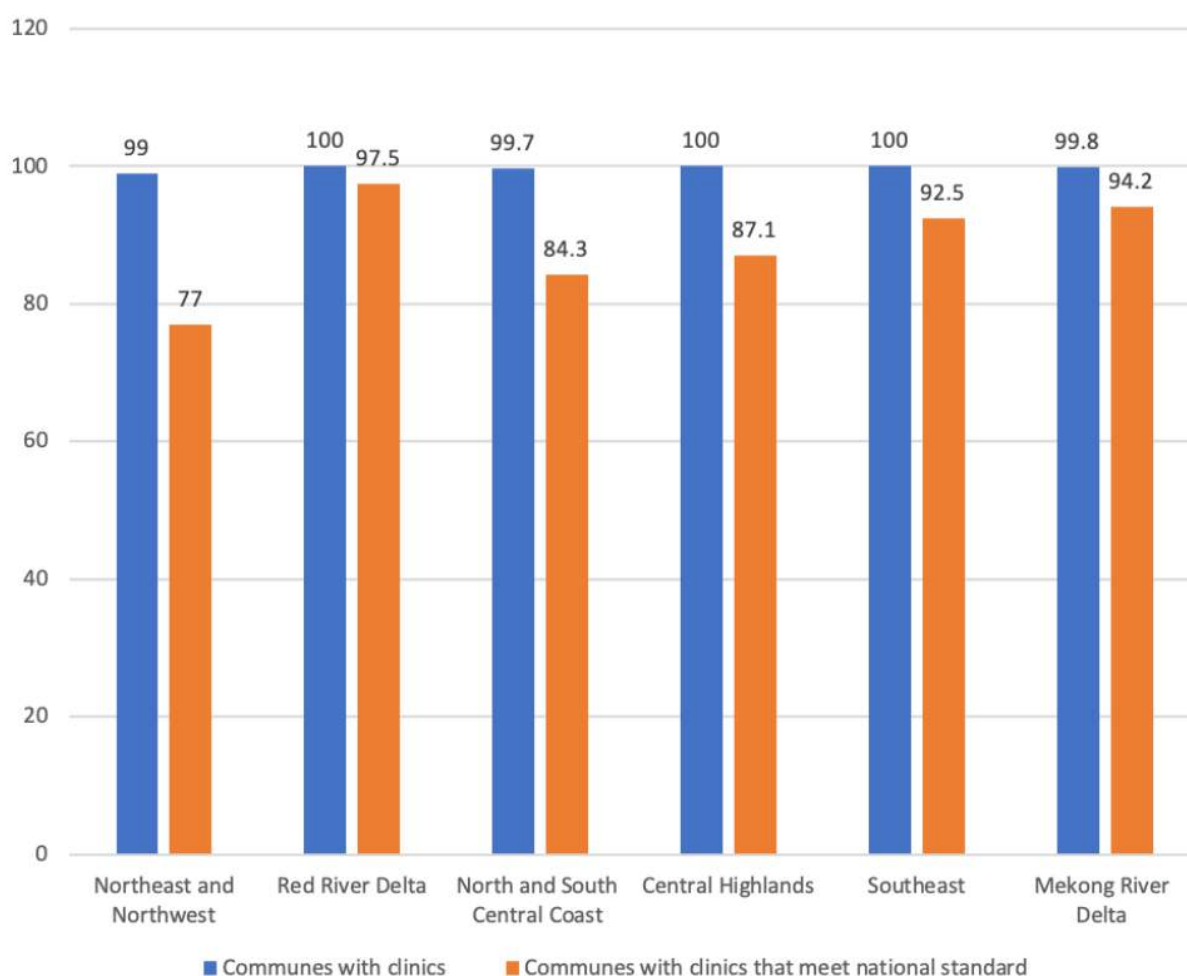
Despite its geographical diversity, the Mekong Delta is predominantly blanketed by flat plains. The forest coverage of this region, 7.7%, is also the lowest nationally and concentrated mainly in the southernmost parts, especially Cà Mau and Kiên Giang provinces (General Statistics Office of Việt Nam, 2012). Due to the tropical climate and a high level of salinization, mangrove forests and swamps cover most habitats of this terrain. An awareness of these features is critical to understanding the epidemiology of malaria in the Mekong Delta.

#### Socioeconomic and Demographic Characteristics

Besides geographical features, socioeconomic and demographic characteristics are determining factors that should be considered to evaluate the possibility of eliminating

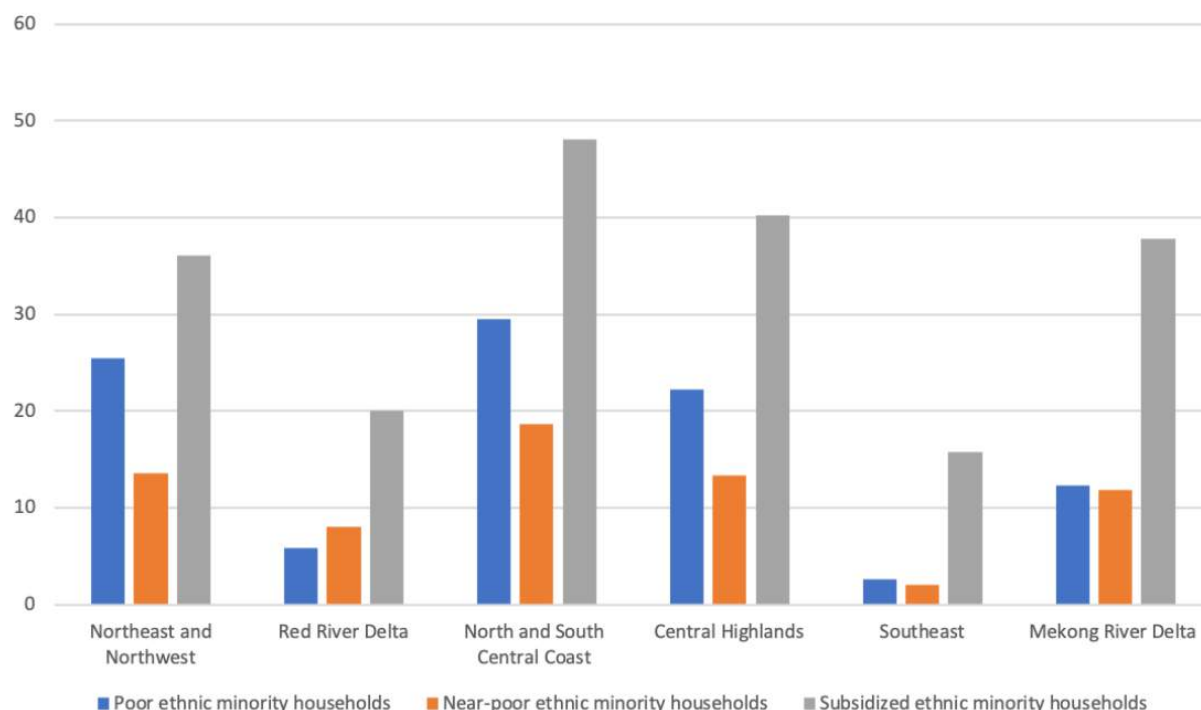
malaria. Specifically, the poverty rate and provision of healthcare infrastructure illustrate the capacity of the Mekong Delta to adopt new malaria prevention and control guidelines, whereas rates of immigration and economic development are indicators of the region’s susceptibility to importation of cases and new vector species. These factors directly explain why malaria is currently a health burden to isolated, mountainous, and forested areas as these are often remote, inadequately facilitated, and home to low-educational and poor communities (Manh et al., 2011; Hewitt et al., 2013).

Several socioeconomic and demographic indicators favor an optimistic outlook regarding malaria transmission in the Mekong Delta. It ranks second of six regions of Việt Nam for the proportion of communes with national-standardized clinics, indicating that vulnerable populations residing in the Mekong Delta can access good quality healthcare and updated interventions more conveniently (Figure 1).



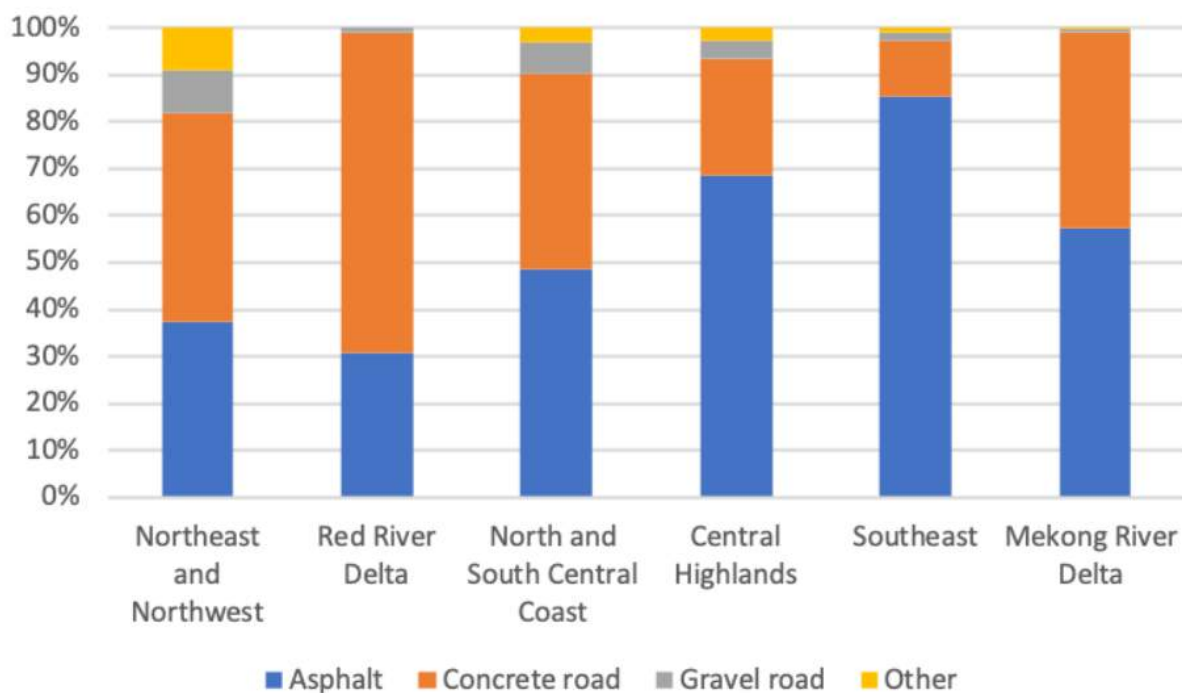
**Figure 1. Commune clinic coverage and quality in different regions of Việt Nam in 2019.** Secondary analysis of data from “*The findings of a survey conducted in 2019 to collect information on the socioeconomic status of 53 ethnic minorities*”, Ethnic Committee and General Statistics Office, 2020, Statistical Publisher, p. 119. Values expressed as percentages.

The proportion of poor, near-poor and subsidized ethnic households in this region, an index that is strongly associated with malaria incidence, is also among the three lowest in Việt Nam (**Figure 2**).



**Figure 2. Poverty situation of ethnic minority households in different regions of Việt Nam in 2018.** Secondary analysis of data from “*The findings of a survey conducted in 2019 to collect information on the socioeconomic status of 53 ethnic minorities*”, Ethnic Committee and General Statistics Office, 2020, Statistical Publisher, p. 131. Values expressed as percentages.

In relation to timeliness of support for vulnerable groups in the Mekong Delta, transportation infrastructure promises easier access than in most regions as more than half of roads from ethnic villages to the central area are made of asphalt, with gravel roads only comprising 0.6% (**Figure 3**). Finally, the current continuous negative immigration rate indicates a lower risk of importing cases and new vectors of malaria (General Statistics Office of Việt Nam, 2023). However, the rapid economic development of the Mekong Delta may reverse this trend by attracting short-term laborers and seasonal workers to the region (Việt Nam Chamber of Commerce and Industry, 2023). This unregulated influx is a risk factor for reintroducing the disease (Kitvatanachai et al., 2003; Van Nam et al., 2005; Cui et al., 2018).



**Figure 3. Road types to ethnic villages in different regions of Việt Nam in 2019.** Secondary analysis of data from “*The findings of a survey conducted in 2019 to collect information on the socioeconomic status of 53 ethnic minorities*”, Ethnic Committee and General Statistics Office, 2020, Statistical Publisher, p. 113. Values expressed as percentages.

## Epidemiology of the Region

Following the introduction of the NMCEP in 1991, malaria transmission in all regions of Việt Nam saw a strong decline in both reported incidence and deaths (Goldlust et al., 2018). However, since implementing the guidelines there have been two notable features for the Mekong Delta, a sudden drop of cases in 2000–2001 and an overall promising trend for all indicators (Erhart et al., 2007). Along with the Northeast, the Mekong Delta is the fastest region to direct all its provinces and cities to fulfil the requirements of Zone 1 classification, indicating no malaria transmission (MoH, 2020).

Identifying and analyzing the vectors and parasites of the region may help to resolve the recorded epidemiological data. The main vector for malaria transmission along the Mekong River and its tributaries is *Anopheles epiroticus*, a species of the Sundaicus complex (Hii & Rueda, 2013). Due to ecological changes, *An. epiroticus* has an extremely low infectious rate (Erhart et al., 2004a; Trung et al., 2004) as well as a reduced vectorial capacity (Dusfour et al., 2004a; Dusfour et al., 2004b; Trung et al., 2004), which explains the substantial regional drop in malaria frequency from 2000 to 2001 (Goldlust et al.,

2018). The dominance of this species also determines the local pattern of malaria transmission, the peak of which occurs during the dry seasons (April–May and October–November) when salinity is highest (Erhart et al., 2004b). From a historical perspective, *An. subpictus* was established as a secondary vector during the early 2000s, but dramatic socioeconomic changes including the expansion of brackish waters due to shrimp farming has since contributed to the complete disappearance of this species.

Although drug-resistant malaria parasites were first documented for Việt Nam in the GMS, the Mekong Delta itself has remained free of these variants up until now. In 2022, the number of drug-resistant *P. vivax*, *P. falciparum* and mixed malaria cases of every province in the region was zero. As the species, strain and sensitivity to treatment of a parasite is an accurate predictor of the severity of illness and mortality rate that it might cause, the ongoing situation in the Mekong Delta's is not considered as complex. However, with its proximity to locations with high levels of resistance to first-line antimalarial drugs, such as the Việt Nam Central Highlands and neighboring Cambodia, there is a very real risk of introducing new cases and vectors to this region (Delacollette et al., 2009). Hence, existing public health surveillance must remain vigilant.

## IV. Mekong Malaria Elimination Program – Rationale and Implementation

### National and Regional Program Overview

Initiated in partnership with the WHO in 2017, the Mekong Malaria Elimination (MME) Program is the most wide-ranging and detailed action plan ever instigated to target malaria in the region. This program is followed by all six countries of the GMS, with the vision of each becoming free of malaria and recurrent threats by antimalarial drug resistance (WHO, 2015). Its primary goal is eradication of *P. falciparum* by 2025 and of all malaria by 2030. The rationale behind the urgency to eliminate *P. falciparum* is the emergence of multidrug resistance by this species, particularly to the first-line artemisinin-based combination therapy (ACT), that has been spreading throughout Southeast Asia (Ashley et al., 2014; Packard, 2014). To emphasize this point, up to 55% of *P. falciparum*-infected cases in GMS are fatal, while *P. vivax* is also considered a potent threat as it is identified in most malaria-endemic GMS districts (WHO, 2015). At the outset of the program, two other objectives were to minimize infection rates to less than one case per 1,000 exposed individuals in high-transmission areas by 2020 and



to prevent the reintroduction of malaria in areas where it has been already eliminated. In order to achieve these targets, regional and country-level interventions have been customized predicated on local epidemiology, with two successive phases: transmission reduction; and elimination. The WHO provides a framework for communication between GMS partners, advocates cross-country collaboration, facilitates training, offers technical support, and enables monitoring and evaluation of national malaria plans.

North Việt Nam initiated its first unofficial Malaria Eradication Program between 1958–1975 (MoH, 2011). After the 1975 reunification with South Việt Nam, the program was expanded nationwide. Thereafter, it underwent several amendments to its targets, from eradication to elimination due to post-war effects, then downgrading to a control strategy after several malaria outbreaks in 1991 (Hung et al., 2002). Subsequent to these emergency responses, the program was given its current name – the NMCEP – by the Ministry of Health (MoH), with an aim to eliminate malaria by 2020 through strict adherence to WHO guidelines. This program applied vector control, combining long-lasting insecticide-treated bed nets (LLINs), long-lasting insecticide-treated hammock nets (LLHNs), conventional insecticide-treated nets (ITNs), and indoor residual spraying (IRS) (WHO, 2018). Recently, under the supervision of the 2017 MME Program, the MoH revealed an extension of the NMCEP to operate from 2021 to 2025, targeting new goals and building on to the accumulated successes of previous years. With five specific objectives and 13 targets, this program is devoted to eliminating locally-acquired *P. falciparum* by the end of 2023, which demands more intensive interventions and necessitates additional proactive measures (MoH, 2020).

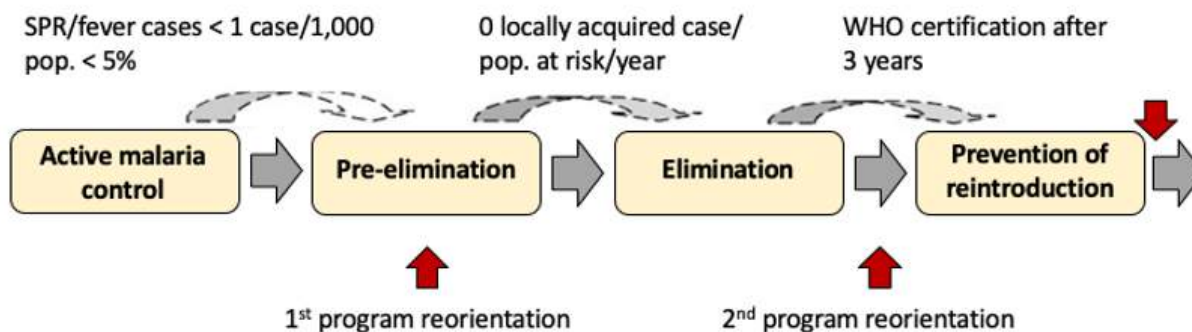
## Program Implementation

The action phases for the NMCEP parallel the MME Program's two implementation stages (WHO, 2015). The latter's transmission reduction stage corresponds to the NMCEP's active malaria control and pre-elimination phase, while the elimination stage is compatible with elimination and prevention of re-introduction (**Table 1**). Applicable to both phases, rapid diagnostic tests or light microscopical examination of Giemsa-stained blood films are used to diagnose malaria at many health facilities (WHO, 2015). For treatment, the first-line ACT is administered for *P. falciparum* cases in both transmission reduction and elimination phases, while *P. vivax* cases require chloroquine or ACT, combined with a 14-day primaquine course for elimination.

	TRANSMISSION-REDUCTION PHASE	ELIMINATION PHASE
Purpose	Early diagnosis of symptomatic cases and effective treatment of all detected cases to reduce transmission, morbidity, and mortality.	Early detection and treatment of all cases to prevent onward transmission.
Diagnosis policy	All suspected cases should be examined by RDT or microscopy.	All suspected cases must be examined by RDT or microscopy.
Treatment policy	<i>P. falciparum</i> : ACT as defined by national policy; single dose of PQ is recommended.  <i>P. vivax</i> : CQ, provided that efficacy is confirmed by TES, otherwise ACT.	<i>P. falciparum</i> : ACT as in transmission-reduction phase; single dose PQ is mandatory.  <i>P. vivax</i> : CQ or ACT as in the transmission reduction phase; PQ is mandatory; G6PD status should be used to guide administration of primaquine for preventing relapse. When G6PD status is unknown and testing not available, decision must be based on assessment of risks and benefits of adding primaquine.
Service delivery	All public health services.  Private medical practitioners.  Not-for-profit sectors (NGOs).  Informal private sector.  Community-based services.	Same as transmission-reduction phase, but over-the-counter sale of antimalarial agents prohibited, and informal private sector not allowed to treat malaria cases; service provision by other sectors (e.g. military, corporate sector) follows national norms and is monitored.  Largely, universal coverage has been achieved.
Standby treatment	May be considered for certain migrant groups if it is impossible to provide diagnosis.	The same as in transmission-reduction phase, but this should be exceptional and be monitored.

ACT, artemisinin-based combination therapy; CQ, chloroquine; G6PD, glucose-6-phosphate dehydrogenase; NGO, nongovernmental organization; PQ, Primaquine; RDT, rapid diagnostic test; TES, therapeutic study.

**Table 1. Case management in transmission-reduction and elimination phases of the Mekong Malaria Elimination Program.** Adapted from “*Strategy for malaria elimination in the Greater Mekong Subregion: 2015-2030*”, World Health Organization, 2015, WHO Press, p. 13.



**Figure 4. Implementation phases of malaria elimination in Việt Nam.** Adapted from “*National strategy for malaria control and elimination in the period 2011-2020 and orientation to 2030*”, Government of the Socialist Republic of Việt Nam, 2011, Publication Decision No. 1920/QĐ-TTg, p. 28.

As an index used as by the NMCEP, slide positivity rate (SPR) is defined as the percentage of suspected cases that is clinically confirmed to be malaria-infected (Jensen et al., 2009). This metric is particularly useful for continuously changing malaria incidence and therefore is often utilized to identify the transition point between phases (MoH, 2011)

(Figure 4). In order to advance from the pre-elimination phase, SPR needs to be less than 5% of confirmed malaria cases (MoH, 2011). Once SPR is determined as zero, the elimination phase is considered to be completed, thereby instigating the final phase of preventing re-introduction of malaria to the region. In settings where there is no recorded case of malaria for three successive years, a certification of malaria-free status is issued by the WHO (MoH, 2011).

In 2017, the MoH approved the Malaria Elimination Roadmap (Table 2), which plots three zones of malaria management for 63 Việt Nam provinces from 2016 to 2025. Zone 1 suggests stable control of malaria cases. Zone 2 indicates the eradication of malaria for that region. Zone 3 designates provinces that can avert re-establishment of malaria. The roadmap serves as an annual objective for local authorities to implement preventive strategies and proposals for their respective provinces (MoH, 2020).

Province	Malaria Elimination Roadmap (1 = malaria control; 2 = malaria elimination; 3 = prevention of malaria re-establishment)									
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Hồ Chí Minh City	2	2	2	3	3	3	3	3	3	3
Long An	2	3	3	3	3	3	3	3	3	3
Tiền Giang	3	3	3	3	3	3	3	3	3	3
Bến Tre	2	2	2	2	3	3	3	3	3	3
Đồng Tháp	3	3	3	3	3	3	3	3	3	3
An Giang	1	2	2	2	3	3	3	3	3	3
Vĩnh Long	3	3	3	3	3	3	3	3	3	3
Trà Vinh	3	3	3	3	3	3	3	3	3	3
TP. Cần Thơ	3	3	3	3	3	3	3	3	3	3
Hậu Giang	3	3	3	3	3	3	3	3	3	3
Sóc Trăng	1	1	1	2	2	2	2	3	3	3
Kiên Giang	2	2	2	2	3	3	3	3	3	3
Bạc Liêu	1	1	2	2	2	2	3	3	3	3
Cà Mau	1	1	1	2	2	2	2	3	3	3

**Table 2. Malaria elimination roadmap for the Mekong Delta, showing targets by Việt Nam province, 2016-2025.** Data from the “*National strategic plan on malaria control and elimination 2021-2025*”, Government of the Socialist Republic of Việt Nam, 2020, Ministry of Health Publication pp. 41-42.

Vector control and personal protective measures, both focusing on mosquitoes, are major components of the NMCEP (WHO, 2018). The goal of the MME Program’s transmission reduction phase is to encompass at-risk populations with LLINs or IRS, explicitly migrant and mobile populations (WHO, 2015). For the subsequent elimination phase, besides incorporating prior objectives, all populations in active foci of malaria receive coverage to target early interruption of transmission.

Before the introduction of LLINs and LLHNs in 2009 (CDC, 2019), the ITN that provides an outer protective layer, enveloping each person sleeping under one, was the most popular protective measure in Việt Nam against mosquito bites (Canavati et al., 2021). Although LLINs are similar to ITNs, they differ in the scale of distribution to households, allowing for extensive coverage of communities residing in areas of transmission (WHO, 2015). LLHNs function to protect forest workers, migrants and high-risk mobile groups. This preventive method has been adapted to southern Việt Nam's tropical climate, harnessing the already popular hammock (WHO, 2015). In addition, the Government also offers retreatment for those who prefer to use their own nets or who reside in less endemic areas, depending on the types of insecticide available in each location (WHO, 2018). Furthermore, IRS is considered a crucial aspect of vector control in Việt Nam. IRS with an alpha-cypermethrin formulation is carried out as a routine mass preventive measure in high-risk areas and as a focal responsive initiative in the event of an outbreak (WHO, 2018). However, a descriptive scheme for IRS has yet to be developed, nor has the plan for appropriate use of insecticides or the action to be taken in the case of insecticide resistance (WHO, 2018).

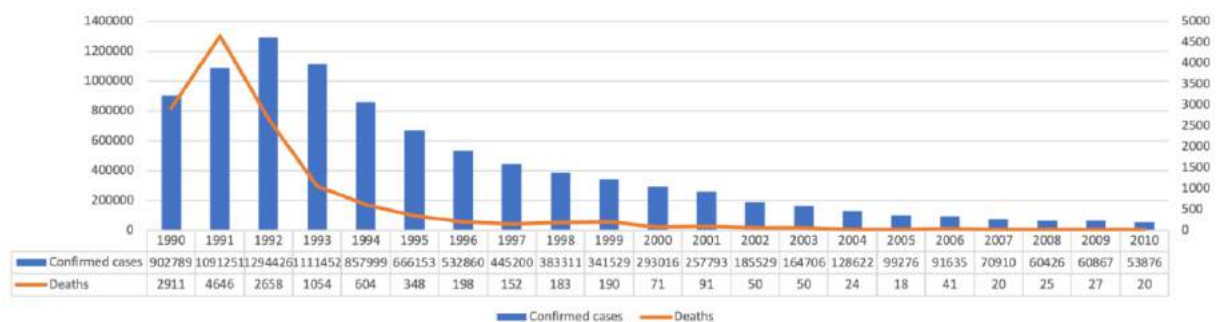
In 2015, the NMCEP was reviewed for its effectiveness, which resulted in several modifications to improve implementation. First, the Action Plan for Information, Education & Communication was developed to provide knowledge about malaria control and elimination (MoH, 2011). Second, a preventive plan to hinder the development and spread of artemisinin-resistant (AR) malaria parasites domestically and internationally was also initiated by the MoH (2011). From 2016 to 2020, the NMCEP was reviewed repeatedly for stronger interventions. It was determined that the "artemisinin-resistance containment" model should be more rigorous in preventing drug-resistant parasite isolates. Studies of drug resistance management were conducted, with action taken to delay the growth of AR malaria parasites (MoH, 2020). Tafenoquine and primaquine is each proven to be a safe and currently an effective anti-malaria drug for the treatment of *P. vivax* in Việt Nam. The initial step is to assess the drug's effect on glucose-6-phosphate dehydrogenase-deficient patients as introducing an untested protocol may lead to a serious repercussion of hemolysis (WHO, 2015; MoH, 2020).

## V. Evaluation of the Program's Efficacy

### National Program Efficacy During 1990–2020

In the two decades prior to the NMCEP's implementation in 1991, Việt Nam had experienced uncontrolled malaria outbreaks due to multiple factors including insufficient

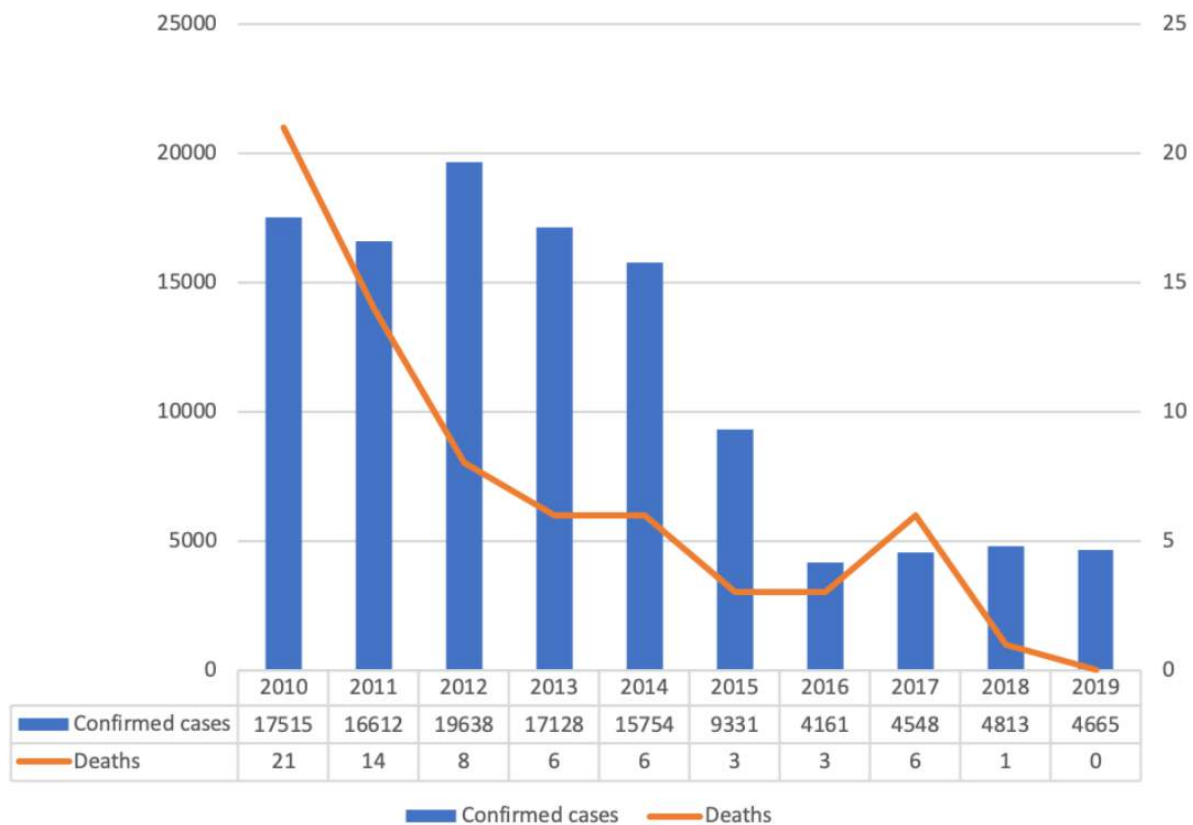
resources and infrastructure, migration after the American War ended in 1975, and a litany of shortcomings of an overstretched public healthcare system (**Figure 5**). Extensive efforts were made over the years to maintain regulation of malaria transmission, involving organizational committees at national and regional levels, national as well as global funding, and the provision of dedicated resources. It is critical to periodically evaluate the efficacy of the program in order to refine future interventions to optimize efficiency and effectiveness.



**Figure 5. Confirmed malaria cases and deaths in Việt Nam during the period 1990-2010.** Secondary analysis of data from “*National strategy for malaria control and elimination in the period 2011-2020 and orientation to 2030*”, Government of the Socialist Republic of Việt Nam, 2011, Publication Decision No. 1920/QĐ-TTg, p. 19.

From 2011 to 2020, Việt Nam achieved notable results in malaria control and elimination, which was attained over two 5-year periods: phase 1 (2011–2015) and phase 2 (2016–2020). The first phase’s main objective involved lowering incidence and mortality rates, adopting the policy proposed in 2009 to prevent reintroduction of outbreaks in 16 provinces and to achieve eradication in 14 provinces categorized as of low endemicity (MoH, 2011). Sustaining this aim, the second phase devoted more attention to resources for other areas with persisting malaria status, together with re-evaluating the previously targeted 16 and 14 provinces to ensure that control and elimination is maintained. According to the NMCEP, across the decade 2010–2019 there was a significant 73.4% and 100% decline in confirmed cases and malaria-related deaths, respectively (MoH, 2020) (**Figure 6**). Despite the overall downward trend, 2017 saw a slight rise in confirmed cases. This may be attributed to a combination of factors such as a sudden outbreak of malaria, population migration, and failure to restrict the proliferation of malaria through dihydroartemisinin-piperaquine treatment.





**Figure 6. Confirmed malaria cases and deaths in Việt Nam during the period 2010-2019.** Secondary analysis of data from “*National strategic plan on malaria control and elimination 2021-2025*”, Government of the Socialist Republic of Việt Nam, 2020, Ministry of Health Publication, p. 2.

## National Program Efficacy During 2021–2025

In assessing its current effectiveness, the NMCEP should be reviewed and compared to present day-oriented objectives for malaria control operations. In order for the country to progress steadily towards the 2030 global target of extensive malaria reduction, the Việt Nam National Institute of Malariology, Parasitology and Entomology (NIMPE) has been appointed to oversee efforts to reduce mortality and morbidity rates in alignment with specific province strata: zero provinces in active malaria control; 40 preventing re-establishment of transmission; and 15 in the process of eliminating malaria. Data recorded to the end of 2019 reveal that Việt Nam has not only attained these goals early but also achieved the dramatic successes of a morbidity rate of 0.07/1,000 people (compared to a targeted < 0.15/1,000) and a 0.001/100,000 mortality rate (targeted < 0.02/100,000) (MoH, 2020). Moreover, Việt Nam attained an outbreak-free status in the 5-year span 2015–2019. During the same time, confirmed cases of malaria per 1,000 people fell from 0.10 to 0.048 in 2015 and 2019, respectively (MoH, 2020). In

managing the control program, the NIMPE has sought to strengthen budgeting to ensure a sufficient supply of resources to historically underserved provinces that are still burdened by malaria via mobilizing varied revenue sources including national and provincial governments, non-government organizations, loans and donations from other countries, and in collaboration with global health agencies. Cumulatively, an average annual sum of US\$17.7 million has been allocated to the project, divided into proportions of 53.4% contributed by international support, 45.8% from national government, and 0.85% met by local budgets (MoH, 2020).

Notwithstanding the remarkably favorable outcomes in the immediately preceding period, a new plan was devised for 2021–2025. Specific to this ongoing 5-year period, several targets have been set to be attained by 2025. These are: < 0.015/1,000 morbidity rate; < 0.002/100,000 mortality rate; elimination of malaria in 55 provinces without an outbreak occurrence (MoH, 2020). While the program is current, official data remain unavailable. However, by compiling information from publicly accessible databases held by the NIMPE and WHO, Việt Nam’s projection towards a negligible to no morbidity and mortality rate from malaria is predicted. The NIMPE has documented many changes to the national plan evaluated as effective, the implementation of which is helping the country to surpass set targets across multiple provinces.

## National Program Efficacy Compared to Other GMS Countries

Benchmarking against the Việt Nam-specific MME Program for comparison, a key milestone for each GMS region is to enter the elimination phase for all first subnational level entities by 2020, with an annual parasite incidence of < 1/1,000 (WHO, 2015). In the aggregate report of the national plan for 2020, the parasite rate per 1,000 was identified as 0.038 (MoH, 2020), demonstrating the capability of Việt Nam’s malaria control strategy to surpass the minimum target established by the MME. In accordance with this accomplishment, the MME Program revealed a three-fold decline in malaria incidence in Việt Nam over a 12-month period – from 1,421 confirmed cases in 2020 to 459 one year later (Tables 3 & 4).

Country	Surveillance Indicator	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Cambodia	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Suspected cases tested	57 427	65 860	70 339	60 513	65 192	72 725	76 484	79 350	82 160	77 257	73 185	72 113	852 605	
	Confirmed cases	1 346	1 097	890	704	672	906	828	796	600	561	518	493	9 411	
	<i>P. falciparum</i> cases	166	101	47	40	62	156	91	100	55	36	48	59	961	
	<i>P. vivax</i> cases	1 173	985	840	662	610	746	727	694	543	522	469	414	8 385	
	Mixed cases	7	11	3	2	0	4	10	2	2	3	1	20	65	
	Other cases	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Imported cases	0	0	0	0	0	1	0	0	1	0	0	0	2	
China	Deaths	1	0	0	0	0	0	0	0	0	0	0	0	1	
	Suspected cases tested	7 350	6 639	7 074	8 286	9 411	10 846	11 904	10 643	11 211	10 717	9 548	9 616	113 245	
	Confirmed cases	7	6	7	8	17	39	22	6	8	10	2	5	137	
	<i>P. falciparum</i> cases	2	0	0	0	0	0	0	0	0	0	0	0	2	
	<i>P. vivax</i> cases	5	6	7	8	17	39	22	6	8	10	2	5	135	
	Mixed cases	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Other cases	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Imported cases	7	6	7	8	15	38	22	6	7	9	2	3	130	
Lao People's Democratic Republic	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Suspected cases tested	46 534	44 059	47 927	36 677	39 958	47 092	50 721	53 728	53 373	57 038	51 249	48 147	576 503	
	Confirmed cases	322	206	173	143	139	115	260	304	408	489	410	536	3 505	
	<i>P. falciparum</i> cases	118	62	63	32	44	48	126	147	212	280	201	218	1 551	
	<i>P. vivax</i> cases	198	139	108	111	94	67	131	157	194	206	199	312	1 916	
	Mixed cases	6	5	2	0	1	0	3	0	2	2	10	6	37	
	Other cases	0	0	0	0	0	0	0	0	0	1	0	0	1	
	Imported cases	0	0	0	0	0	0	0	0	0	0	0	0	0	
Myanmar	Deaths	1	0	0	1	1	0	4	0	1	1	1	0	10	
	Suspected cases tested	260 792	291 737	301 643	232 348	257 619	328 891	376 790	378 149	348 134	303 733	295 553	289 850	3665 239	
	Confirmed cases	2 558	1 855	1 716	2 552	4 479	9 523	11 709	7 372	4 794	3 885	4 551	3 842	58 836	
	<i>P. falciparum</i> cases	889	501	349	517	902	1 762	2 406	2 109	1 558	1 307	1 726	1 141	15 167	
	<i>P. vivax</i> cases	1 640	1 345	1 353	2 021	3 566	7 708	9 234	5 212	3 210	2 543	2 774	2 658	43 264	
	Mixed cases	29	9	14	14	11	53	69	51	26	35	51	43	405	
	Other cases	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Imported cases														
Thailand	Deaths	Data not available <sup>a</sup>													3
	Suspected cases tested	69 090	68 858	67 471	50 500	64 390	86 543	81 946	75 482	61 149	53 810	54 102	48 636	781 977	
	Confirmed cases	209	171	179	198	526	915	772	367	186	145	143	193	4 004	
	<i>P. falciparum</i> cases	14	12	10	6	39	50	25	13	11	6	3	5	194	
	<i>P. vivax</i> cases	189	150	162	183	477	846	728	341	170	132	132	182	3 692	
	Mixed cases	2	2	1	0	2	5	4	1	0	1	3	0	21	
	Other cases	4	7	6	9	8	14	15	12	5	6	5	6	97	
	Imported cases	38	39	34	25	53	173	183	93	34	12	11	20	715	
Viet Nam	Deaths	0	0	0	1	0	0	0	0	0	0	0	0	1	
	Suspected cases tested	107 335	128 121	139 800	128 144	153 905	170 206	167 131	168 788	181 778	163 644	162 321	140 214	1 811 387	
	Confirmed cases	219	272	167	106	128	70	62	78	95	84	73	67	1 421	
	<i>P. falciparum</i> cases	155	192	97	54	55	29	29	33	61	52	36	27	820	
	<i>P. vivax</i> cases	60	76	68	51	71	40	33	45	33	32	37	39	585	
	Mixed cases	3	4	1	0	1	0	0	0	1	0	0	1	11	
	Other cases	1	0	1	1	1	1	0	0	0	0	0	0	5	
	Imported cases	0	64	52	27	34	27	18	29	14	21	8	9	303	

**Table 3. Monthly malaria cases and deaths by Mekong Delta country in 2020.** Adapted from “*Mekong Malaria Elimination: epidemiology summary*”, volume 16, World Health Organization, 2022, WHO Press, p. 8.

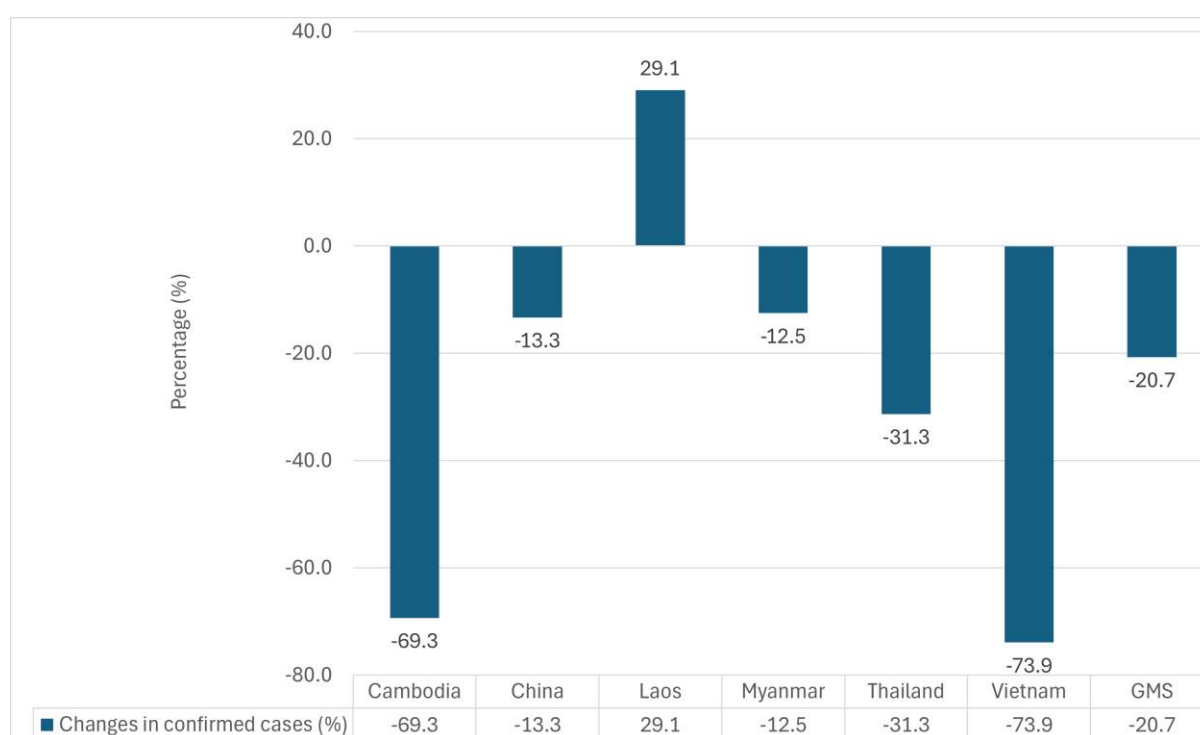


Country	Surveillance indicator	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Cambodia	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0
	Suspected cases tested	64 563	69 240	73 576	64 730	68 611	69 433	68 631	68 928	68 963	62 412	68 951	70 691	818 729
	Confirmed cases	545	383	338	241	270	339	373	369	377	325	373	396	4 329
	<i>P. falciparum</i> cases	68	30	19	7	16	22	24	26	17	25	29	58	341
	<i>P. vivax</i> cases	477	351	319	219	253	315	349	343	360	300	344	338	3 968
	Mixed cases	0	2	0	15	1	2	0	0	0	0	0	0	20
	Other cases	0	0	0	0	0	0	0	0	0	0	0	0	0
	Imported cases	0	0	0	0	0	0	0	0	0	0	0	0	0
China	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0
	Suspected cases tested	6 366	6 752	7 044	7 697	8 994	11 001	10 178	9 451	10 769	10 524	6 593	8 631	104 000
	Confirmed cases	4	3	8	10	12	25	30	8	4	7	4	3	118
	<i>P. falciparum</i> cases	0	0	0	0	0	0	0	0	0	0	0	0	0
	<i>P. vivax</i> cases	4	3	8	10	12	25	30	8	4	7	4	3	118
	Mixed cases	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other cases	0	0	0	0	0	0	0	0	0	0	0	0	0
	Imported cases	3	3	5	9	11	25	30	7	4	7	4	3	111
Lao People's Democratic Republic	Deaths	0	0	0	0	0	0	0	0	1	0	0	0	1
	Suspected cases tested	40 893	40 013	44 544	44 390	47 777	57 134	59 933	57 608	67 299	60 269	64 881	59 398	644 139
	Confirmed cases	296	158	161	161	211	429	372	340	558	386	479	374	3 925
	<i>P. falciparum</i> cases	110	78	63	87	98	246	112	89	206	90	101	59	1 339
	<i>P. vivax</i> cases	185	79	95	73	111	183	258	245	352	296	375	310	2 562
	Mixed cases	1	1	3	1	2	0	2	6	0	0	3	5	24
	Other cases	0	0	0	0	0	0	0	0	0	0	0	0	0
	Imported cases	1	4	2	7	2	12	7	1	2	1	3	7	49
Myanmar	Deaths	0	0	0	0	0	2	2	1	0	0	0	0	5
	Suspected cases tested	170 105	121 325	116 577	117 731	141 602	163 489	176 293	135 622	130 038	122 218	126 345	112 800	1 634 145
	Confirmed cases	3 067	2 094	2 278	4 048	6 775	12 150	12 917	6 973	4 848	4 830	4 397	3 827	68 204
	<i>P. falciparum</i> cases	735	403	277	495	772	1 455	2 243	1 552	1 256	1 185	1 339	1 189	12 901
	<i>P. vivax</i> cases	2 307	1 671	1 985	3 515	5 980	10 665	10 609	5 372	3 560	3 611	3 004	2 585	54 864
	Mixed cases	25	20	16	38	23	30	65	49	32	34	54	53	439
	Other cases	0	0	0	0	0	0	0	0	0	0	0	0	0
Thailand	Suspected cases tested	51 072	49 972	60 443	49 339	56 010	66 982	61 924	57 638	41 628	40 594	51 569	52 817	639 988
	Confirmed cases	132	133	141	179	418	525	406	271	223	202	224	362	3 216
	<i>P. falciparum</i> cases	5	4	8	3	8	7	2	5	1	6	6	6	61
	<i>P. vivax</i> cases	119	121	114	164	404	504	391	262	213	191	214	345	3 042
	Mixed cases	2	2	0	0	1	0	3	1	0	0	0	0	9
	Other cases	6	6	19	13	5	14	10	3	9	5	4	11	105
	Imported cases	9	13	23	17	79	106	142	76	64	62	83	128	802
Viet Nam	Deaths	0	0	0	0	0	0	0	0	0	0	0	0	0
	Suspected cases tested	98 937	92 798	125 048	130 068	129 902	137 760	100 607	94 499	101 726	107 008	100 678	94 617	1 313 648
	Confirmed cases	39	18	36	33	37	71	37	26	15	62	61	24	459
	<i>P. falciparum</i> cases	19	10	22	20	12	19	12	8	7	23	33	20	205
	<i>P. vivax</i> cases	19	8	14	13	25	52	25	18	8	37	28	4	251
	Mixed cases	1	0	0	0	0	0	0	0	0	0	0	0	1
	Other cases	0	0	0	0	0	0	0	0	0	2	0	0	2
	Imported cases	5	6	7	7	6	3	3	3	0	0	5	7	52

**Table 4. Monthly malaria cases and deaths by Mekong Delta country in 2021.** Adapted from “*Mekong Malaria Elimination: epidemiology summary*”, volume 16, World Health Organization, 2022, WHO Press, p. 9.

In general, all six GMS countries are working well towards the malaria elimination target set by the most recent strategy for the period 2015–2030. Encouraging results also

provide motivation for this subregion to make progress in preventing the spread of malaria through concrete actions such as drug efficacy monitoring and local modifications to the national plan. In the most recent WHO statistics for the status of MME countries, only nine months (January–September) in 2021 are available; hence, the same period of 2020 was used as a comparator. A combined 20% reduction in malaria incidence, from 61,307 in 2020 to 48,647 cases in 2021 (Figure 7), was significantly achieved by the entire GMS region (Tables 3 & 4). Focusing on Việt Nam, the NMCEP brought malaria cases to a minimum, with only 312 cases reported in the first nine months of 2021. This number is roughly one-third of the previous year’s figure, marking the largest step among all the GMS countries for total confirmed cases (Figure 7).

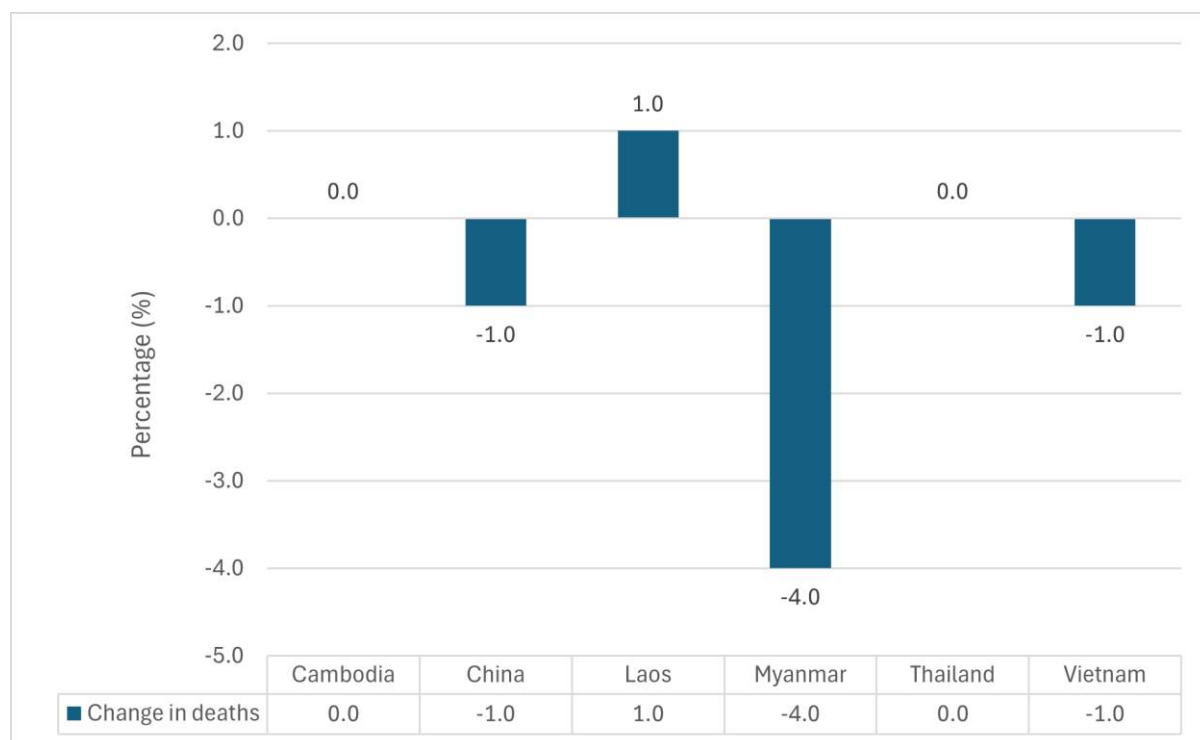


**Figure 7. Change in confirmed cases of malaria in countries of the Greater Mekong Subregion from 2020 to 2021.** Secondary analysis of data from “*Mekong Malaria Elimination: epidemiology summary*”, volume 16, World Health Organization, 2022, WHO Press, pp. 8-9.

In addition to reducing malaria incidence, curbing malaria-related deaths is also considered a priority by all GMS countries. Mirroring the trend of confirmed cases, the death toll also experienced a 50% reduction, from 10 to 5 between 2020 and the following year. By reducing from one death to none, Việt Nam was one of three countries, together with Cambodia and China, to reach the zero death target. Myanmar, which recorded the highest number of deaths in 2020, experienced a significant improvement

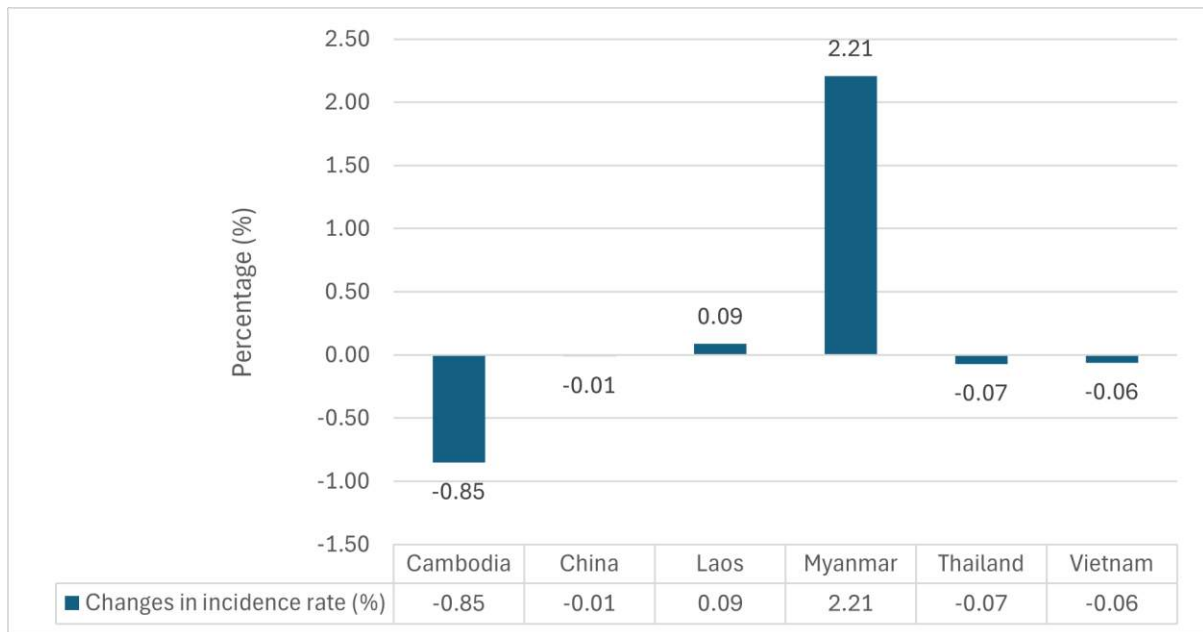


by halving its death toll in 2021. In contrast, in Laos malaria mortality increased by one in 2021 (Figure 8).



**Figure 8. Change in confirmed deaths from malaria in countries of the Greater Mekong Subregion from 2020 to 2021.** Secondary analysis of data from “*Mekong Malaria Elimination: epidemiology summary*”, volume 16, World Health Organization, 2022, WHO Press, pp. 8-9.

It should be noted that in 2020, the effectiveness of the program stagnated across GMS countries as malaria-related conditions did not experience a drop in accordance with previous recent years (WHO, 2021a). This could be attributed to external factors, not least the COVID-19 pandemic (WHO, 2021b). Concerning incidence rate, Figure 9 shows a sharp downturn in Cambodia (-0.85%), while China (-0.01%), Thailand (-0.07%) and Việt Nam (-0.06%) all saw a more modest change. Although Myanmar reported improvements in managing mortality from malaria, this country’s rising incidence rate of 2.21% remains a major cause for concern.



**Figure 9. Change in malaria incidence rate in countries of the Greater Mekong Subregion from 2020 to 2021.** Secondary analysis of data from “*Mekong Malaria Elimination: epidemiology summary*”, volume 16, World Health Organization, 2022, WHO Press, pp. 8-9.

As previously noted, *P. falciparum* shows an extensive capacity to evolve under the selective pressure of suboptimal treatment with antimalarials to become drug-resistant. Notwithstanding this concerning characteristic, in five out of six GMS countries the number of *P. falciparum* infections declined by 61.4% from 2020 to 2021 (Figure 10). China achieved the *P. falciparum* elimination goal in 2021 and was closely followed by Việt Nam with an 81% drop. Likewise, incidence of *P. vivax* also experienced an overall downturn, despite being easily transmissible and challenging to control (Howe et al., 2016). Cambodia’s national strategy limited the spread of *P. vivax*, demonstrated by a substantial contraction by 69.1% in case numbers, and similarly successful in Việt Nam, which observed a 61.8% decrease. While the proportion of *P. falciparum*-related cases decreased in 2021 compared to 2020, the reverse was true for *P. vivax* infections. This pattern demonstrates that *P. falciparum* elimination is well-focused and achievable by 2025. Nonetheless, it is recommended that the Vietnamese Government invests more attention to combat *P. vivax*, an extremely hard-to-control species. Combining all available data as a measure of efficacy, the NMCEP is working well towards achieving WHO targets. Furthermore, since most GMS nations are approaching the malaria elimination phase, collaborative support through continuous integration of cross-border surveillance systems is necessary, together with efficient local processes for investigation and emergency responses within each country.



Figure 10. Changes in *Plasmodium falciparum*, *P. vivax*, and mixed cases of malaria infection in countries of the Greater Mekong Subregion from 2020 to 2021. Secondary analysis of data from “*Mekong Malaria Elimination: epidemiology summary*”, volume 16, World Health Organization, 2022, WHO Press, pp. 8-9.

## Program Efficacy in the Mekong Delta

Since the introduction of the NMCEP, the number of malaria cases in the Mekong Delta has experienced a steep decline, falling from 5,803 in 1992 to 94 cases in 2010 (Peak et al., 2015). **Table 2** shows promising results in these provinces and their respective levels of malaria control over time. During 2016–2020, most provinces were in Zone 3, suggesting strong prevention against malaria. There are three provinces remaining at Zone 1, but a positive trend is shown temporally. The extensive use of ITNs, insecticides, and vector control measures, alongside continuous implementation of ACT, enables the region to curb a possible outbreak of AR malaria (WHO, 2011).

The Mekong Delta achieved minimal incidence of malaria from 2018 to 2020, even during the active malaria season, while other regions experienced continuous fluctuations

(Figure 11). This may be explained by the NMCEP’s success in applying factors that allow for more effective implementation and control. First, ethnic minority groups living in the Mekong Delta are smaller in size compared to others resident elsewhere, such as in the Central Highlands (Målqvist et al., 2013). The MoH suggests that ethnic minorities living in remote areas are among the highest at-risk groups for malaria. Populations in the Mekong Delta, despite their rural existence, still live in reasonable proximity to urban areas and major cities. This enables better access to therapies and resources like ITNs and insecticides. Next, the Mekong Delta is sandwiched between the major cities of Cần Thơ and Hồ Chí Minh City, which are categorized as Zone 3 (preventing re-establishment), potentially inducing a trickle-down effect on the Mekong Delta for malaria control. In relation to this point, there is “a strong association between *P. falciparum* malaria and the population living below the poverty line ” (Manh et al., 2011). Thus, being surrounded by two metropolitan hubs generates a domino effect on the Mekong Delta to inherit complementary economic growth.

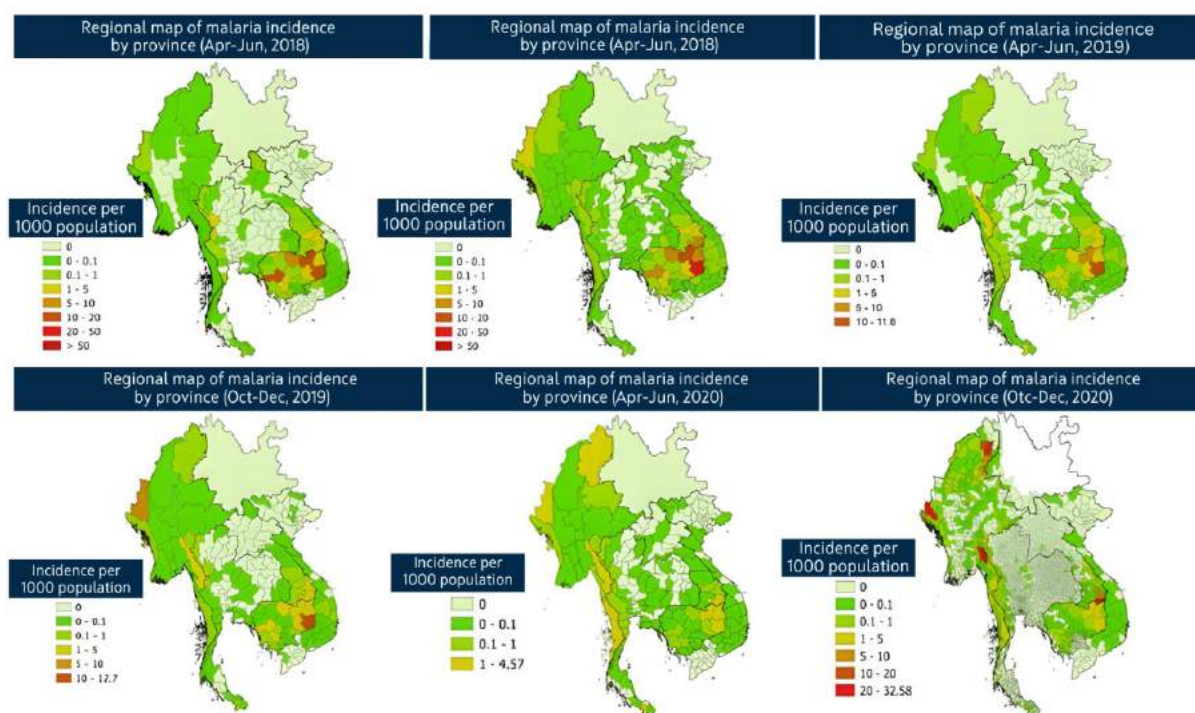


Figure 11. Mapping malaria incidence by province in countries of the Greater Mekong Subregion during April-June and October-December during the three-year period 2018-2020. Adapted from “*Mekong Malaria Elimination: epidemiology summary*”, volume 16, World Health Organization, 2022, WHO Press, pp. 8-9.

## VI. Discussion

With Việt Nam's many recent achievements in combatting malaria come different challenges in the present decade. In line with a successful intervention effort, coordination between different levels of organization, from municipalities down to villages, is required – an issue faced in the latter of the two phases of the NMCEP's current 5-year plan. From a MoH report, organizational problems stem from budgetary issues arising from delayed government approval. This is often responsible for the obstacles to providing necessary interventions like ITNs and supplying insecticides that are encountered by communities residing in highly endemic areas. Apart from financial constraints, suboptimal communication and management at the local authority level lead to ineffective delivery to the community, especially minority groups living in mountainous and other remote locations (MoH, 2020). For the studied region in the catchment of the Mekong River, declaration of a malaria-free status might also have the undesired effect of desensitizing people to the potential severity of the disease. Perhaps counterintuitively, therefore, the success of the elimination strategy may negatively affect the long-term prevention efficacy.

Recognizing these shortcomings, the MoH has set more aggressive goals for the current 5-year period to combat malaria: to “ eliminate locally acquired *P. falciparum* by 2023 ” (MoH, 2020). The most effective methods in use at present are ACT, vector control interventions, ITNs, and insecticide IRS. Thus, intensifying these efforts are crucial to enabling the introduction of new strategies for screening and detection that aim to address the challenges of the previous phase. Since the budget shortfall over that period placed a noticeable strain on resources, the approved financial support for 2021–2025 is approximately US\$30.7 million per year, doubling the previous plan of US\$17.6 million annually (Table 5). In order to raise efficiency further, the plan should be adjusted annually so that flexible funding is available to increase staffing numbers, vector control interventions and treatment provision.

This extra budgetary commitment displays the Vietnamese Government's intention to assure adequate resources and equipment are made available for all communities to combat malaria. Aside from ITNs and insecticides, extra facilities and appropriately trained staff are also key assets essential for comprehensive coverage and further scientific research (Hung et al., 2002). Additionally, the NMCEP also strives to ensure a more cohesive and unified prevention effort from local authorities by means of thorough instructions to refine, replace and remove the program's drawbacks (MoH, 2020). Better



public education and community engagement can also encourage ethnic groups to participate and thereby suppress malaria transmission.

National Strategic Plan	Target	Budget
2011-2020	Reduce morbidity to < 0.15/1000  Mortality to < 0.02/100,000  No provinces in active malaria control  40 provinces in prevention of re-introduction  15 in elimination  8 in pre-elimination by 2020	\$176,317,061 over 10 years  \$17,631,706/year  Government: \$80,860,318 (45.8%) \$8,086,031/year  Local budget: \$1,500,048 (0.85%) \$150,004/year  Other sources: \$93,935,911 (53.4%) \$9,393,591/year
2021-2025	Morbidity < 0.015/1,000  Mortality < 0.002/100,000  Eliminate malaria in 55 provinces  No malaria outbreaks	\$153,379,179 over five years  \$30,675,836/year

**Table 5. Targets and budgets of the National Malaria Control and Elimination Program in Việt Nam over the periods 2011-2020 and 2021-2025.** Adapted from the “*National strategic plan on malaria control and elimination 2021-2025*”, Government of the Socialist Republic of Việt Nam, 2020, Ministry of Health Publication p. 30; and “*National strategy for malaria control and elimination in the period 2011-2020 and orientation to 2030*”, Government of the Socialist Republic of Việt Nam, 2011, Publication Decision No. 1920/QĐ-TTg, pp. 18-19.

Since most Mekong Delta provinces have now reached the phase of preventing malaria re-establishment, specific initiatives should be designed and adopted to maintain this status. Considering the influx of short-term, seasonal workers and predicted distraction of residents from malaria prevention, greater emphasis should be placed on educational activities. These outreach activities will not only nurture local authorities’ and inhabitants’ competency to tackle unfavorable situations but also protect high-risk, vulnerable laborers from malaria infection.

## VII. Conclusions

Given the emergence of drug-resistant malaria in the GMS, it is a public health imperative to understand the current local contexts as well as to determine the efficacy of past and present interventions in Việt Nam in order to establish a foundation for future guidelines in transmission control and disease prevention. In considering the NMCEP and related policies, this review evaluates the rationale, practice, and impact of the current iteration of the national program on malaria epidemiology, with a focus on the Mekong Delta.

Developed and implemented in accordance with the MME Program, the NMCEP was adopted nationwide in 1991, since when it has achieved numerous beneficial outcomes. For all indicators including incidence rate, confirmed clinical cases, confirmed deaths from malaria, numbers of *P. falciparum* and *P. vivax* infections, the data followed a favorable downward trend in all provinces and cities. Established goals and targets of each phase were also achieved with flying colors, indicating that the program was well-adopted and has positive effects. For the Mekong Delta, its results are among the best in the country, implying the profoundly positive impact that the program has made in this historically malaria-endemic region. However, due to the general lack of multi-sided data and detailed reports, it is recommended that further primary research should be conducted to provide a better overview of the situation.

Despite recent notable successes, hindrances persist to disrupt the progression towards malaria elimination in Việt Nam and the prevention of the disease's re-establishment in the Mekong Delta. These obstacles include budgetary issues, organizational problems, and potential for desensitized attitudes of the public towards treatment, control and prevention. Aligning to future strategic directives, additional financial commitment, enhanced education, and better communication channels are all required to accelerate Việt Nam's final push towards achieving malaria elimination. If there is sustained commitment from all relevant stakeholders during the 2020s, this remains a realistic goal to achieve by the WHO target date of 2030.

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