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From Strategy to Impact: A Holistic Approach to Dengue Prevention in Thailand



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Contents

- 3 About the report**
- 4 Executive summary**
- 6 Introduction**
- 12 Complexities, gaps and innovation: dengue prevention in Thailand**
- 17 Seizing opportunity: a holistic approach to dengue prevention**
- 23 Conclusion: commit to a single, coordinated, holistic strategy**
- 25 References**

About the report

From strategy to impact: a holistic approach to dengue prevention in Thailand is an Economist Impact report, sponsored by Takeda. The report provides an independent analysis of dengue prevention strategies in Thailand and identifies opportunities for enhancing dengue control. It further highlights both successful practices and challenges associated with dengue prevention in the country. Finally, it identifies opportunities for the development of a comprehensive and integrated dengue prevention strategy.

The findings in this report are based on a literature review and workshop discussions with relevant clinical experts, scientific leaders and policy stakeholders from Thailand. The editorial team at Economist Impact would like to thank the following individuals (listed alphabetically by last names) for generously contributing their time and insights:

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Economist Impact bears sole responsibility for the contents of this report. The findings and views expressed in the report do not necessarily reflect the views of the sponsor. The research was led by Neeladri Verma, with support from Nuriesya Saleha. The research team consisted of Cassandra Cheung and Aashi Garg. The report was written by Paul Tucker and Neeladri Verma and edited by Maria Ronald. While every effort has been made to verify the accuracy of this information, Economist Impact cannot accept any responsibility or liability for reliance by any person on this report or any of the information, opinions or conclusions set out within.

Executive summary

Dengue affects hundreds of millions of people globally, and its burden is rising, partly due to climate change, which both expands the habitats of disease-carrying mosquitoes and drives people into dengue-affected areas. The severity of dengue infection varies — it may be asymptomatic, can cause various degrees of a fever, or in severe instances, result in dengue shock syndrome, a potentially fatal manifestation characterised by septic shock and organ failure.

Dengue fever is the leading vector-borne disease in Thailand, and efforts to fight it are hindered by the absence of specific antiviral treatment, as well as limited prevention and vector control efforts. Dengue is hyperendemic in Thailand, with all four serotypes in active circulation, posing a constant threat of reinfection to individuals. Dengue outbreaks are frequent, taking place every two to three years; most recently, an outbreak began in 2023, infecting tens of thousands and increasing the infection rate by 4.2-fold of 2022 levels.¹

In this report, we assess dengue in Thailand, with a particular focus on uncovering strategies to improve and expand dengue prevention and ways to lower the impact of the disease on the health, lives and livelihoods of people in the country. Building on the findings of a literature review and expert workshop, we assess the epidemiology, impact and prevention

of dengue in Thailand. We identify the areas of opportunity to holistically improve dengue prevention across the country and ultimately arrive at the following calls to action:

1. Implement a national strategy to increase awareness of dengue risks, transmission and prevention measures.

- Increase individual risk perception and educate people about dengue transmission and prevention.
- Ensure that education and awareness efforts are based on best practices and the most current information.

2. Empower local governments, foster community engagement, and promote inter-sectoral collaboration.

- Empower local governments to implement effective measures such as vector control, awareness campaigns and procurement of supplies.
- Motivate individuals and communities to take ownership of dengue management, with a focus on six key settings: schools, temples, workplaces, hotels and resorts, public-sector offices, and hospitals.
- Foster public-private partnerships and work closely with the scientific community to effectively scale up promising innovations.

3. Leverage technology and data to improve surveillance and planning.

- Support dengue prevention through active surveillance and early-warning systems.
- Harness data and technology such as artificial intelligence (AI) to create predictive models, improve planning, implement effective countermeasures and monitor the impact of interventions.

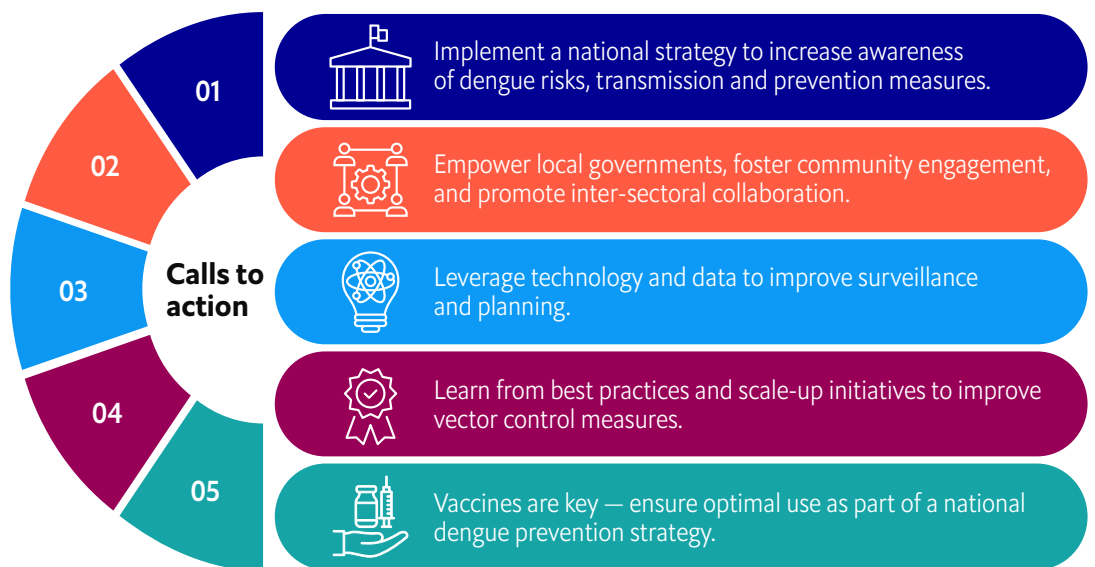
4. Learn from best practices and scale-up initiatives to improve vector control measures.

- Learn from successful practices in the country for dengue prevention, which are often confined to local initiatives or pilot studies, and scale them up for nationwide impact.

- Ensure funding and political will to scale-up effective new prevention strategies.
- Facilitate communication and coordination among stakeholders at all levels, ensuring integrated efforts to track and fight dengue and develop new approaches.

5. Vaccines are key — ensure optimal use as part of a national dengue prevention strategy.

- Integrate vaccination as part of the national dengue prevention strategy
- Ensure vaccines are accessible to all through public health programmes.
- Support the development of safer, more effective vaccines to reach a wider patient pool.



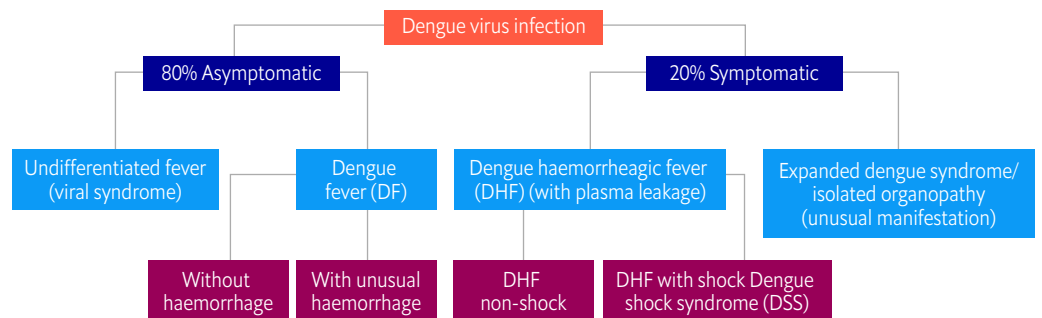
Introduction

Dengue is on the rise globally.^{2,3} An unprecedented 5.2m cases were reported in 2019, a 900% increase since the year 2000.³ By 2080, dengue will impact an estimated 60% of the world’s population.⁴ As of August 2023, over 3.7m cases and more than 2,000 dengue-related deaths have been reported across 70 countries and territories.⁵ South-East Asia hosts more than 37% of the 3.9bn people living in dengue-endemic areas.^{2,6,7} A global peak in 2019 featured a significant surge of infections in South-East Asia, with case numbers skyrocketing and deaths increasing by 60%.⁷ In this report, we review approaches to dengue prevention, with a specific focus on Thailand, where dengue fever has become the leading vector-borne disease.⁸

Dengue in action

The virus that causes dengue has four different serotypes; although infection confers lifelong immunity against that particular serotype, it offers little cross-protection against the others.⁹ Severity varies—infection may be asymptomatic but can also cause undifferentiated febrile illness, dengue fever or dengue haemorrhagic fever, characterised by bleeding symptoms including skin haemorrhages, nose bleeds and bleeding gums, among others (Figure 1).¹⁰ Individuals are at greatest risk for severe dengue when they experience two sequential infections with two different serotypes within 18 months.¹¹

Figure 1: Manifestations of dengue infection



Source: A road map for neglected tropical diseases 2021–2030 and Comprehensive Guideline for Prevention and Control of Dengue and Dengue Haemorrhagic Fever. WHO reports.²⁻¹⁰



Although the symptoms of dengue fever (fever, muscle and joint pain, headaches, nausea, rashes, and vomiting) are typically mild to moderate, inappropriate treatment and secondary infection with a different serotype can lead to dengue haemorrhagic fever. This can result in dengue shock syndrome, a potentially fatal complication characterised by septic shock and organ failure.^{8,10}

Severe dengue complications often require lengthy hospitalisation, and can result in long-term side effects and death—around 36,000 people die of dengue every year.^{12,13,14} Long-term symptoms make up a substantial proportion of the overall burden and are often overlooked—a study in Mexico found that persistent symptoms added 28.2 disability-adjusted life years (DALYs) per million people to the 65.1 DALYs per million caused by acute illness.¹⁵ Dengue resurgence has widely impacted the burden of disease, particularly in regions where it is hyper-endemic (i.e., where multiple serotypes are actively circulating), raising the constant threat of reinfection.¹⁶

Dengue transmission, conducted through the bite of infected female *Aedes aegypti* and *Aedes albopictus* mosquitoes, has been exacerbated by climate change, which influences the biological and ecological dynamics of both vector and virus (Figure 2). Dengue occurs during rainy seasons, when the hot and humid climate allows for optimal vector breeding and survival. Warmer temperatures increase the reproductive capacity of both the virus and the mosquitoes that carry it, and also cause the mosquitoes to bite more frequently. Both drought and increased rains can drive population growth in *Aedes* mosquitoes.¹⁷ The increased movement of people in climate change-impacted regions also brings them into closer contact with the geographical expansion (also driven by climate change) of mosquito habitats.

Figure 2: Dengue transmission exacerbated by climate change



Source: adapted from Meena P et al. Environmental change, changing biodiversity, and infections.¹⁸

A global approach to dengue prevention

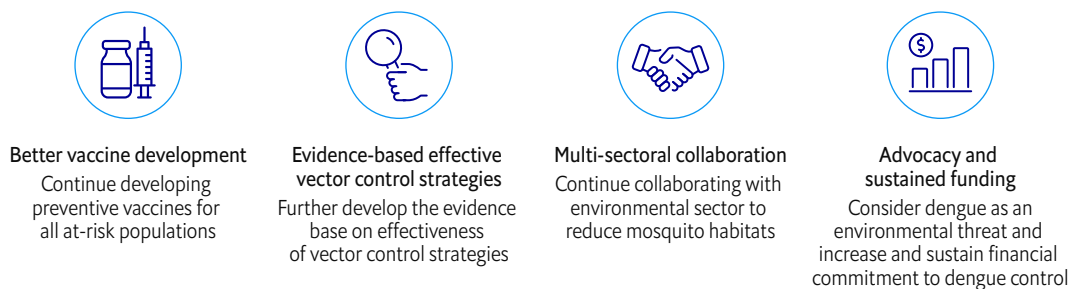
Core strategic interventions recommended by the World Health Organization (WHO) in its Roadmap for Neglected Tropical Diseases 2021-2030 include water, sanitation and hygiene (WASH) programmes, mosquito control for habitat reduction, restriction of mosquito entry into homes, improved case-management, and the use of vaccines for previously infected patients.² The WHO identifies dengue as a rapidly emerging threat in an increasingly urbanised world, and has outlined critical actions (Figure 3) to achieve the 2030 targets² set for the disease:

- 0% case-fatality rates;
- 75% of countries able to detect and respond to dengue outbreaks; and
- 25% reduction in disease burden and incidence from 2010-2020 levels, to 2.35m cases by 2030.

There is a lack of dengue-specific antiviral medication, which makes prevention, particularly through vector control, critical. In South-East Asia, barriers to controlling the spread of Aedes mosquitoes include poor water supply and storage and improper waste-management systems.¹⁹ In addition to building a strong vector control programme and optimising the implementation of country-wide vaccination strategies (something lacking in Thailand), the development of a vaccine that confers immunity against all four serotypes would be a major advancement towards achieving the 2030 WHO targets.²⁰

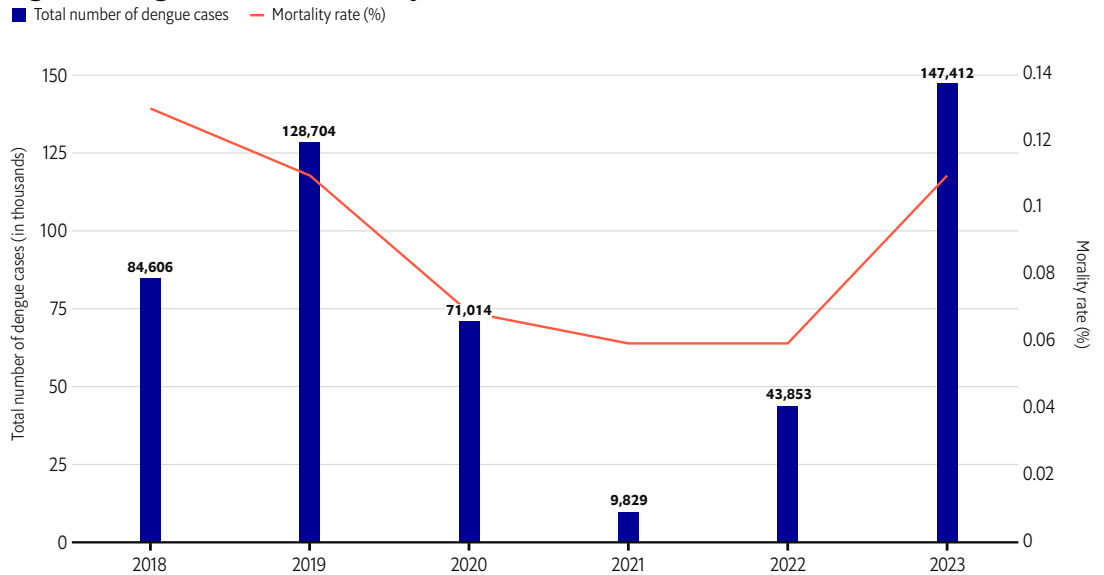
A complex relationship between biological, ecological and environmental factors—research reveals a clear link between climate change phenomena and increased dengue incidence—and socioeconomic determinants influence the epidemiology of dengue.²¹ This means that dengue cannot be handled by the health sector alone. Cross-sectoral collaboration is vital, necessitating a holistic vector-management strategy.²²

Figure 3: Critical actions recognised by WHO to control the threat of dengue



Source: Ending the neglect to attain the sustainable development goals: a road map for neglected tropical diseases 2021–2030: overview. WHO report.²

Figure 4: Dengue cases and mortality rate in Thailand, 2018-2023



Source: Epidemiological Disease Surveillance Report (506). Department of Disease Control²³

Tackling rising dengue in Thailand

Thailand’s high burden as seen in Figure 4, coupled with the absence of specific anti-viral treatment, comprehensive vector control and successful prevention interventions, poses a formidable challenge. All four serotypes have been reported in every province.^{7,8} Peak transmission occurs in the summer and rainy season between May and October, with outbreaks every two to three years. In recent peak years, annual incidence rates have been four times higher than the national target of 40 cases per 100,000 population in half of the country’s provinces.²⁴

The latest dengue outbreak began in early 2023. By June, over 24,030 infections and 20 deaths were reported, marking a 4.2-fold increase in the infection rate compared to 2022.¹

Asymptomatic and mild cases are often under-reported, and the reliability of epidemiological data is further impacted by inconsistent reporting from private clinics and hospitals. Regional and socioeconomic disparities further impact the consistency of reporting.⁷

In recent peak years, annual incidence rates have been four times higher than the national target of 40 cases per 100,000 population in half of the country’s provinces.

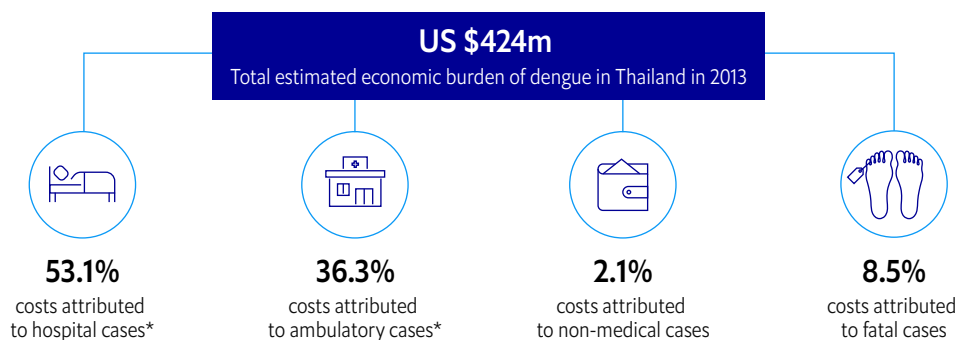


The economic impact of dengue in Thailand is significant. In 2013 costs reached US\$424m, with about US\$379m attributed to medical costs (Figure 5).⁸ The average societal cost per non-fatal hospital case of dengue in one provincial hospital was estimated at US\$573 in 2010.²⁵ Of the direct economic burden, 28% comprises vector control, and the remaining 72% relates to illness.²⁶ The high share of the latter demonstrates a clear case for strengthening dengue control.

Dengue also has clear impacts on Thailand’s economy in other ways. For example, dengue cost Thailand’s tourism industry US\$1.8bn (0.33% of GDP) in 2019.²⁶ Dengue infection in children also causes disruptions in schooling and parental wage earning. A study in Thailand found that dengue is responsible for 465.3 DALYs per 1m school-age children (15% of the DALYs for all school-age febrile illnesses).²⁷

In this report, we evaluate existing strategies in Thailand and uncover new measures that can be implemented to limit the spread of dengue. Building on the findings of a literature review and workshop, we assess dengue-prevention efforts in Thailand. We also explore essential elements of a holistic prevention strategy, including vector control and vaccination, as well as cross-cutting factors such as governance, awareness, collaboration, data and surveillance, technology, and innovation. Finally, we highlight the opportunities available to build an effective dengue prevention system in the country.

Figure 5: Economic burden of dengue in Thailand



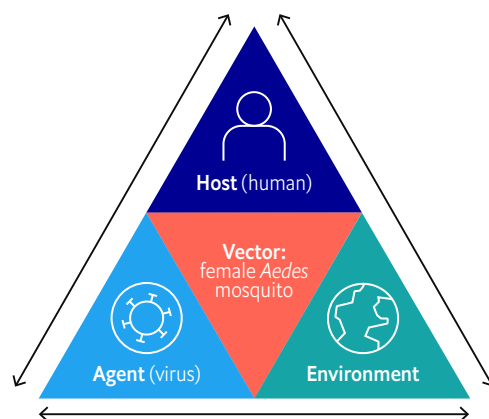
*Hospital and ambulatory (outpatient) cases are together reported as medical cases.

Source: Epidemiology and costs of dengue in Thailand: A systematic literature review.⁸

Complexities, gaps and innovation: current dengue prevention in Thailand

Dengue prevention requires a comprehensive approach that considers various factors such as the virus, the vector, the host and the environment (Figure 6). In this section, we address the current state of play regarding dengue in Thailand. We then go on to highlight strategies that can be implemented or optimised to improve outcomes in the country's fight against dengue.

Figure 6: Epidemiology triad for dengue control



Prevention strategies:

- i. **Vector control:** chemical and biological vector control
- ii. **Environmental management:** elimination of mosquito breeding grounds and standing water, coverage of water containers
- iii. **Protection against virus:** vaccination
- iv. **Host protection:** mosquito repellants and nets, full-sleeved clothes, etc.

Source: adapted from Understanding the Epidemiologic Triangle through Infectious. Centers for Disease Control and Prevention. U.S. Department of Health and Human Services.²⁸

One key factor when it comes to dengue control in Thailand is the decentralised health system. Each province is composed of three levels of municipality (city, town and subdistrict) and two levels of Local Administrative Organisations (LAOs) (province and subdistrict). The Ministry of Public Health (MoPH) is the national health authority, while Provincial Public Health Offices (PPHOs) and Subdistrict Administrative Organisations (SAOs) respectively act as the provincial and local health authorities.²⁹

Dengue prevention and control, including vector surveillance and control, are the responsibility of SAOs and municipalities. However, disease surveillance and awareness-raising are primarily undertaken by the MoPH. This division of responsibilities often leads to coordination challenges.³⁰

Traditionally, strategies for controlling dengue have focused on reducing mosquito numbers, shortening the lifespan of adult mosquitoes and preventing mosquito-human contact.³⁰ However, there is an increasing shift towards integrated vector management, which involves social mobilisation, environmental management, epidemiological and entomological surveillance, and chemical and biological control—as recommended by the WHO.³¹

There is also growing optimism around the use of vaccines in dengue prevention, although concerns linger regarding their safety and efficacy. Current policies limit vaccines to high-risk populations such as children and individuals living in endemic areas.

Thailand actively promotes research and development in dengue prevention, including control strategies, new technologies for vector control, and clinical trials for vaccines.³¹

Integrated vector management

Dengue's epidemiology is influenced by a mix of biological, ecological, environmental and socioeconomic factors. Therefore, managing this disease requires an integrated, multi-sectoral strategy that includes non-health actors.²² Several integrated vector management (i.e., mosquito control) initiatives exist in Thailand—but there is no comprehensive national strategy.

The 3-3-1 strategy

In an attempt to prevent the spread of new infections, Thailand adopted the 3-3-1 strategy. Through this grassroots initiative, dengue cases should be reported within three hours, infected mosquitoes eliminated from the patient's house within three hours and insecticides sprayed within a 100-metre radius within one day.⁷

Although the 3-3-1 strategy has immense potential to play a key role in dengue prevention, it currently faces several challenges, including data recording, limiting its effectiveness and efficiency. Efforts must be made to improve its impact (see Box 1).

Box 1: Optimising 3-3-1

In Yasothon Province, issues with recording information linked to the 3-3-1 strategy were addressed by integrating the system into Google Drive. This allowed for accessible real-time results, which had a significant impact.³²

Complete and accurate disease reports were achieved in 84.8% of cases. About 47.7% of dengue cases were reported within three hours, up from 35.7%; the elimination of dengue-infected mosquitoes from patients' homes within three hours rose from 58.2% to 72.2%; and insecticide spraying was conducted within one day in 94% of cases, up from 63.8%.³³

Volunteers and vector surveillance

Given the decentralised nature of Thailand's health system, dengue control is largely reliant on Subdistrict Health Centres (SDHCs) and a network of Village Health Volunteers (VHVs). Each SDHC is responsible for primary healthcare in 10-15 villages, while the more than 1m VHVs are each responsible for the primary healthcare of 10-15 households in their respective districts.³³

The combination of SDHCs and VHVs has proven effective as a ground-up approach to dengue prevention. For example, volunteers in Phichit province have helped to keep one subdistrict free of dengue fever for three years.³⁴ However, the impact of VHVs varies geographically, with evidence suggesting that VHVs in higher-risk areas have better knowledge of dengue than those in other regions. In general, VHVs need more education and standardised training.³⁵

Box 2: The Lansaka Model: the impact of community-based active surveillance

Active vector surveillance has demonstrated effectiveness across multiple indicators—an active system trialled in the Lansaka district, covering 11,427 households and 44 villages, showed a decrease in both the larval indices level and morbidity rates in 2014-16.³⁶ Moreover, knowledge of both dengue and larval indices among VHVs increased significantly. The model consisted of seven surveillance steps at the household level and four at the district level. This community-based model demonstrates the impact of integration on local knowledge and skills and could serve as a blueprint for a national strategy if optimised to the specific needs of different regions.

Figure 7: Communities take the lead in the Lansaka Model

VHV – village health volunteer PCSC – primary care surveillance centres SAOs – subdistrict administrative organisations



VHVs carried out vector surveillance and informed households how to manage their home environment.



PCSCs* provided the knowledge and skill support to control dengue.



Schools spread dengue awareness among children and families.



SAOs managed the budget to support PCSCs and VHVs.

* including nine primary care units and a district hospital in Lansaka district

Source: adapted from Suwanbarmung C et al. The use of the "Lansaka Model" as the larval indices surveillance system for a sustainable solution to the dengue problem in southern Thailand.³⁷

Vector control using Wolbachia-infected mosquitoes

Some small-scale initiatives for vector management have been successful and are being expanded. In 2016 a pilot project in Chachoengsao Province sterilised male *Aedes aegypti* mosquitoes using a two-step method: introducing *Wolbachia* bacteria into male mosquitoes, which blocks viruses such as dengue from growing in *Aedes* mosquitoes, and then sterilising them.³⁷ This reduced the number of natural *Aedes* mosquitoes by up to 97% in six months.

The challenge with this initiative is scaling it up. "We have limitations to coordinate with non-government sectors to produce more sterile or *Wolbachia* mosquitoes," explains Darin Areechokchai, deputy director of the Bureau of Vector-Borne Diseases at the MoPH's Department of Disease Control. "We lack the budget as well."



Vaccine use must be optimised as part of a multi-pronged approach to dengue prevention

“A key tool [in the fight against dengue] is ‘vaccine,’” says Supamit Chunsuttiwat, advisor at the MoPH’s Department of Disease Control. “But there is a need to develop a vaccine that is not constrained by certain technical conditions or operational limitations.”

Delivering an effective dengue vaccine has proven difficult. Although the first dengue vaccine was approved in 2015, due to the risk of causing severe disease reported among seronegative people (those who have never been infected by dengue), many countries have restricted its use to seropositive individuals (those with a previous dengue infection).¹¹

“Any viral infection should be controlled using vaccines—covid-19 serves as a prime example of this. Vaccines won’t provide 100% prevention, but [they] will make dengue cases milder.”

Tawee Chotpitayasunondh, senior medical officer and paediatric infectious diseases specialist consultant at Queen Sirikit National Institute of Child Health, Ministry of Public Health

In Thailand, this vaccine was licensed in 2017.³⁸ More recently, a second vaccine became available, which is reportedly safe for individuals regardless of prior exposure to dengue infection; it has stronger efficacy for dengue serotypes DENV1 and DENV2 than DENV3 and DENV4.³⁹

“Any viral infection should be controlled using vaccines—covid-19 serves as a prime example of this,” says Tawee Chotpitayasunondh, senior medical officer and paediatric infectious diseases specialist consultant at Queen Sirikit National Institute of Child Health, Ministry of Public Health. “Vaccines won’t provide 100% prevention, but [they] will make dengue cases milder ... The available dengue vaccines work, but are not perfect, so we need subsequent versions of the vaccines.”

More dengue vaccines are at different phases of clinical trials, with positive and safe, albeit limited, results.¹¹ Until a vaccine that is safe for all and works equally well against all four serotypes becomes available (see Box 3), vaccination is just one tool in a holistic, multi-pronged approach to dengue prevention.¹¹

Box 3: The next dengue vaccine: what would the ideal future dengue vaccine look like?

The four dengue serotypes can interact immunologically—including when antibodies are introduced by vaccination—worsening the disease’s impact, particularly in seronegative individuals.⁴⁰ This makes dengue vaccine development fraught with challenges.

Vaccine effectiveness can also vary by age and serotype.⁴¹ Vaccine administration is another critical aspect—individuals must take all required doses— as is the vaccine’s ability to prevent the spread of dengue.

Taking all these considerations into account, studies suggest that ideal properties of dengue vaccine should include the features shown in Figure 8.^{41, 41, 42}

Implementation and access are key

Beyond the specific features of a vaccine, a major factor is putting systems in place to ensure that vaccines can be rolled out widely

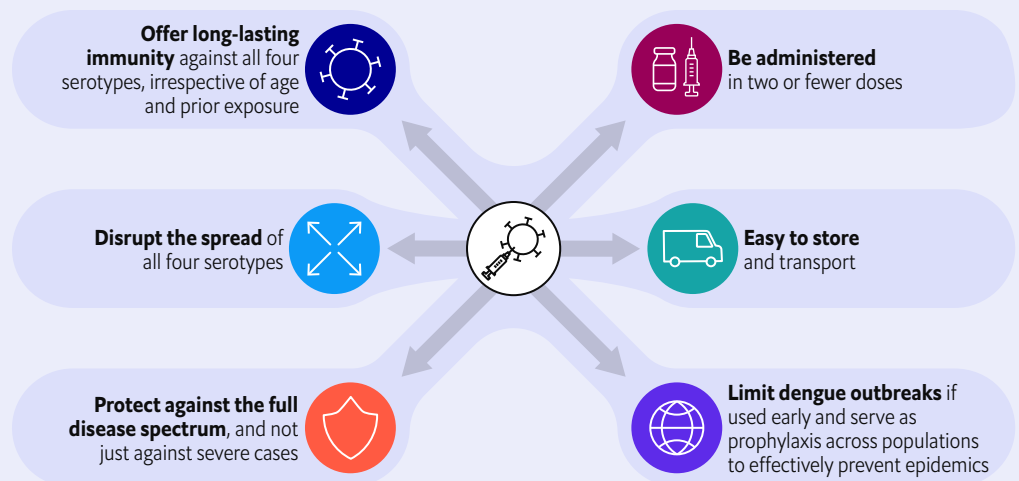
enough to truly tackle dengue on a national scale. When it comes to dengue vaccination, Thailand has “lacked a national policy for wide implementation [for first-generation dengue vaccine],” says Punnee Pitisuttithum, professor emeritus in Mahidol University’s Department of Clinical Tropical Medicine. “For effective use of new vaccines, we must communicate their benefits and risks, raise awareness, and devise an integrated strategy for optimal use in dengue prevention and surveillance. That’s very important.”

Dengue vaccination also works best when conducted alongside vector control—the use of Wolbachia mosquitoes and insecticides that target adult mosquitoes have both been shown to be cost-effective when combined with vaccination.^{32, 43}

Finally, accessibility is key: for a vaccine to be truly effective in preventing outbreaks and incidence of dengue, it must be accessible and affordable for everyone.

Figure 8: Ideal properties of dengue vaccine⁴¹⁻⁴³

Ideal properties that a dengue vaccine should have...



Seizing opportunity: a comprehensive approach to dengue prevention

Effective, long-term dengue control in Thailand requires greater investment of resources, improved vector control and dedicated efforts to address the gaps in current prevention strategies highlighted in the previous section.⁴⁴ This could best be achieved through a coherent national strategy that incorporates evidence-based vector control measures and vaccines, multi-sectoral collaboration, and sustained funding.²

Local governments lead the charge

The MoPH plays a key role in developing evidence-based national strategies for dengue prevention and control, but these are implemented by local governments.³⁰ Thailand's decentralised healthcare system, therefore, requires improved coordination between central and local governments. Manit Teerantikanont, chair of the National Vaccine Institute Executive Board and the Vaccine for People Foundation says, "While the local governments [district-level] have the necessary budget, healthcare personnel, VHVs, and are able to influence the community, the disease

[dengue] control committee operates at the provincial level and the responsibility to raise awareness and conduct disease surveillance, [both] important aspects of dengue prevention, resides with MoPH. We need to strengthen district-level governments to independently handle dengue prevention and not look to the provincial government or the MoPH."

As part of this, equipping local governors with management and leadership skills can significantly strengthen dengue prevention. "[Governors must] be able to prioritise [prevention] work not only during a dengue outbreak but also during routine work to prevent future outbreaks," says Adisak Bhumiratana, head of Thammasat University's Research Unit in One Health and EcoHealth. Furthermore, local efforts go beyond just the government. "The [MoPH] recognises six key settings—schools, religious sites, factories, hotels and resorts, government offices, and hospitals—that are prone to dengue outbreaks and urges these institutions to take responsibility for their own environments," says Dr Areechokchai. "However, there is often a noticeable lack of ownership and implementation of effective larvae control measures in these settings."

"We need to strengthen district-level governments to independently handle dengue prevention and not look to the provincial government or the MoPH."

Manit Teerantikanont, chair of the National Vaccine Institute Executive Board and the Vaccine for People Foundation

Although legal tools such as the Communicable Diseases Act empower local authorities to some extent, the successful enforcement of such legislation depends on providing flexibility to adapt laws to local contexts, as well as offering support for their implementation effectively.^{44, 45} “The problem at the local level is not how to formulate policy and promulgate the law,” says Dr Bhumiratana. “Currently, law enforcement is not aligned with the local environment and the local governance structure, which leads to compliance issues.”

It is also crucial for provinces to coordinate their prevention efforts to prevent the spread of dengue. Dengue does not respect provincial borders, so success in one province is contingent upon the efforts of others.⁴⁶ This calls for horizontal coordination. “It is important to integrate vector-related information between health offices at the district and provincial level [so that it can be] leveraged in mapping and stratifying different risk areas around the country,” says Dr Bhumiratana.



“Most people feel that vector control is the job of government or public health personnel, but the public have to recognise their responsibility to control the larvae breeding site and get rid of water container[s].”

Darin Areechokchai, deputy director of the Bureau of Vector-Borne Diseases at the MoPH’s Department of Disease Control

Dengue control starts with community engagement

There is relatively high awareness of dengue in Thailand, but a greater focus is needed on the role of individuals when it comes to prevention. “Most people feel that vector control is the job of government or public health personnel,” says Dr Areechokchai. “But the public have to recognise their responsibility to control the larvae breeding site and get rid of water container[s].”

Although VHVs already play a key role in raising awareness, their efforts could be enhanced through a top-down, standardised approach to skills training, which includes increasing awareness, motivation and community involvement, as well as monitoring community health status.

Public education approaches vary between rural and urban areas. “Efforts to raise dengue awareness in rural areas are visible through information dissemination by way of paper and online trails, along with engaging social workers to teach mosquito prevention to women, students and the elderly,” says Nattinee Isarankura, director of the Division of Communicable Disease Control in the Bangkok Metropolitan Administration’s Health Department. “This is different from cities like Bangkok, where raising dengue awareness is an intermittent task that happens more aggressively when there is a fatality or severe dengue fever outbreak.”

Another crucial factor is individual risk perception, which refers to one’s perceived susceptibility to threats like dengue.⁴⁷ “Risk perception is more important than knowledge and awareness,” says Dr Bhumiratna. “Everybody knows about dengue, everybody has awareness, but when we check households for *Aedes* vector infestation, there are high levels of larval productivity [owing to] household activity, because people do not think they contribute to the problem. If we do a dengue awareness campaign without raising the risk perception, it jeopardises the effectiveness of other campaigns.” This is especially important when designing health education programmes and it impacts important outcomes such as vaccine uptake.

“ Risk perception is more important than knowledge and awareness. Everybody knows about dengue, everybody has awareness, but when we check households for *Aedes* vector infestation, there are high levels of larval productivity [owing to] household activity, because people do not think they contribute to the problem. If we do a dengue awareness campaign without raising the risk perception, it jeopardises the effectiveness of other campaigns.”

Adisak Bhumiratana, head of Thammasat University’s Research Unit in One Health and EcoHealth

“Dengue control requires the co-operation of multiple sectors, ranging from health to family, home, social, education and environmental sectors; support from the private sector is also important.”

Nattinee Isarankura, director of the Division of Communicable Disease Control in the Bangkok Metropolitan Administration's Health Department

Collaboration is key

Dengue prevention is not just the responsibility of the health sector. “Dengue control requires the co-operation of multiple sectors, ranging from health to family, home, social, education and environmental sectors; support from the private sector is also important,” says Dr Isarankura.

As local health systems assume greater responsibility in dengue prevention, a participatory approach at the community level is imperative. Policymakers must work with community and religious leaders, local non-profit organisations, and educational institutions to improve the effectiveness of prevention strategies.⁴⁸ There are initiatives in Thailand that provide a platform for such collaborations, such as the Provincial Committee for Disease Control, a body bringing together public- and private-sector representatives and community leaders. “A challenge is how to maximise the benefit of such mechanisms for dengue prevention and drive them effectively,” says Dr Chunsuttiwat.

In 2022 the launch of the Dengue Zero Memorandum of Understanding brought together eleven private and public entities to strengthen private-sector support in tackling Thailand's dengue burden through community-level awareness.⁴⁹ It has since yielded a schools-focused pilot project and an event designed to coordinate responses to the 2023 outbreak.^{50,51}

Despite the key role of LAOs in dengue prevention, they often lack resources.⁴⁹ Greater public-private collaboration could bridge the gap. “At all levels, the significance of private sector participation is highly recognised,” says Dr Chunsuttiwat. “In particular we need to accelerate the involvement of the private sector at the local level.”

Beyond public-private partnerships, collaboration between a range of stakeholders can push dengue prevention forward. “From a national standpoint, we need strong collaboration between the public and the private [sectors],” says Prof Pitisuttithum. “But it is equally important to look at other collaborators, like medical societies, to play a part in engagement and education.” Coordination must also be fostered between researchers and policymakers to help yield innovative and workable solutions.

“At all levels, the significance of private sector participation is highly recognised. In particular we need to accelerate the involvement of the private sector at the local level.”

Supamit Chunsuttiwat, advisor at the MoPH's Department of Disease Control

“We are exploring the application of meteorological data, such as rainfall and humidity patterns, to estimate the likelihood of a dengue outbreak.”

Apinya Niramitsantipong, deputy director of the Bureau of Vector-Borne Diseases at the MoPH’s Department of Disease Control

Build robust foundations on data, analysis and active surveillance

Surveillance is vital for dengue prevention because it allows for risk assessment and programme evaluation.⁴⁹ There are clear gaps in data collection and governance. Under-reporting of case numbers is common, owing to regional and socioeconomic disparities, the difficulty in identifying mild dengue cases, and a lack of continuous reporting from private clinics and hospitals.^{7,8}

“There is often a lack of detailed data at the local level,” says Dr Areechokchai. “For instance, most provinces and districts might be aware of the number of cases or deaths due to dengue, but they may not have specific information about the type of dengue infection or the circulating serotype in their area.” And although both vector and disease surveillance data are collected, health services are not integrated to utilise this information effectively.

Thailand would also benefit from active surveillance, based on wider community testing, to bolster every aspect of dengue prevention: case reporting, vector control, vaccine introduction, community education and community engagement. “We need to know more about the vector and, for example, the larvae survey, insecticide resistance, etcetera,” says Dr Areechokchai. Active surveillance of vector and disease spread should be maintained consistently.⁴⁹

Understanding the link between weather and climate and the incidence of vector-borne diseases like dengue through data analysis is also crucial.

“We are exploring the application of meteorological data, such as rainfall and humidity patterns, to estimate the likelihood of a dengue outbreak,” says Apinya Niramitsantipong, deputy director of the Bureau of Vector-Borne Diseases at the MoPH’s Department of Disease Control.

Such efforts could empower public health experts and LAOs to take proactive measures against potential dengue outbreaks. Epidemiologists and health authorities should also utilise local data on the movement of people, especially between urban and rural communities.^{2,52}

Dengue prevalence and transmission are influenced by socioeconomic, infrastructural and environmental parameters.⁵³ Data on high dengue transmission areas are needed to optimise resources and tailor preventive measures. “Identifying areas with high transmission rates within a province or country allows us to focus our vaccination efforts where they are most needed,” says Prof Pitisuttithum.

“Identifying areas with high transmission rates within a province or country allows us to focus our vaccination efforts where they are most needed.”

Punnee Pitisuttithum, professor emeritus in Mahidol University’s Department of Clinical Tropical Medicine

Harness innovation to supercharge dengue prevention

Technology must be used to support dengue prevention initiatives in Thailand. An existing example of such technology use is TanRabad, an online platform designed to establish a national dengue surveillance system (see Box 4). Despite negatively impacting dengue prevention during its peak, the covid-19 pandemic ushered in medical innovations that could prove useful against dengue. For example, implementing covid-style rapid and real-time diagnostic tests could significantly improve the speed and accuracy of dengue detection. This would facilitate quick and targeted prevention strategies to control the spread of the disease.

By leveraging technology such as AI and predictive analytics, administrators can more effectively plan for dengue prevention. AI can also assist in enhancing previously overlooked areas like insecticide fogging, a method of dispersing insecticides into the air to kill mosquitoes and other flying insects. “Currently, to estimate the effectiveness of spraying mosquito control chemicals, sampling droplets were analysed for the volume median diameter (VMD) by visual microscopy. However, we are exploring ways to enhance [the fogging] process by leveraging technology and implementing AI algorithms to automate and determine the VMD,” says Dr Niramitsantipong. Such innovations will ensure more efficient and targeted control efforts. They should be supported by policymakers.

Box 4: TanRabad: innovating to improve dengue surveillance

A government-led online platform, TanRabad plays a pivotal role in fortifying dengue control in Thailand. It consists of five digital apps:

1. **TanRabad SURVEY** enables the real-time collection of larval survey data.
2. **TanRabad WATCH** provides visualisations of epidemics and consolidates vector indices for easy analysis.
3. **TanRabad REPORT** supports the production of routine reports on epidemics and vector indices.
4. **TanRabad BI** generates comprehensive reports on epidemics and vector indices based on users’ perspectives.
5. **TanRabad QUALITY** supports the management of larval data from TanRabad SURVEY.

In 2018, 95% of users utilised TanRabad for dengue surveillance and control, and 92.5% were satisfied with its support for policy planning. Additionally, 91.4% used it for larvae breeding site control, and 88.9% used it during outbreaks.⁵³ It helped to reduce government medical costs and lost income for 44,151 dengue patients, saving 330m Thai Bhat (US\$9m).⁵⁴

Conclusion : coherent, coordinated action is needed

The most effective way to tackle dengue in Thailand is through a single, cohesive national strategy. This must incorporate the input and coordinated efforts of national and subnational authorities, local communities, key institutions (schools, employers, hospitals, temples and tourist sites, among others), and the private sector. With this in mind, our research has drawn us to arrive at the following urgent calls to action for progress in dengue prevention in Thailand and beyond.

1. Implement a national strategy to increase awareness of dengue risks, transmission and prevention measures.

Dengue awareness varies by geography and demographics. Policymakers should aim to increase risk perception of dengue and educate people on transmission, prevention measures and the importance of personal responsibility. **It is crucial for the government to develop a national strategy that is informed by best practices drawn from across the country.**

2. Empower local governments, foster community engagement and promote inter-sectoral collaboration.

Local governments are at the forefront of dengue control efforts. They also have significant community influence. Empowering local governors would enable them to implement measures such as vector control, awareness campaigns and procurement of supplies more effectively. **Policymakers must work to improve coordination between local authorities and the health ministry,** especially in terms of monitoring vector and disease spread.

Prevention also requires empowering and engaging with community and business leaders. **Policymakers should implement strategies designed to motivate individuals and communities to take ownership of dengue management,** with a focus on six key settings: schools, religious buildings, workplaces, hotels and resorts, public-sector offices, and hospitals. Again, coordination is key to prevent the fragmentation of efforts.

Public-private partnerships at the district and subdistrict level would mobilise resources, expertise and innovation beyond the limits of local and national government. **Equally, policymakers must improve coordination and cooperation with the scientific community** to ensure that promising innovations can be scaled-up effectively.

3. Leverage technology and data to improve surveillance and planning.

Policymakers should seek to implement active surveillance and improve coordination and knowledge-sharing among local and national authorities.

Data and technology such as AI should be harnessed to create predictive models, plan ahead, implement effective countermeasures and monitor impact.

4. Learn from best practices and scale-up initiatives to improve vector control measures.

Thailand's success stories in dengue prevention are often limited to local initiatives or pilot studies—they need to be scaled-up. Political will and sustained funding are essential to scale-up effective prevention initiatives, such as the use of *Wolbachia* mosquitoes or the Lansaka Model.

Policymakers must focus on improving coordination among stakeholders at all levels to ensure integrated efforts to improve vector control and develop new approaches.

5. Vaccines are key—ensure optimal use as part of a national dengue prevention strategy.

The government must dedicate resources towards the research and development of safe, effective and cost-effective vaccines. As the search for safer and more effective vaccines continues, **policymakers must collaborate with relevant stakeholders to promote awareness about existing vaccines and ensure their optimal use.** This includes ensuring that vaccination is available and accessible to all via public health programmes.

Going global

Although these calls to action were devised for Thailand's context, the insights and recommendations are applicable to all countries facing the challenge of fighting dengue. The following points should be priorities for policymakers in any country facing a rising dengue burden:



Awareness about disease and prevention
Prioritise the development of a single, coordinated national strategy to tackle dengue, incorporating the full gamut of resources from the national to the local level.



Coordinated national strategy
Prioritise the development of a single, coordinated national strategy to tackle dengue, incorporating the full gamut of resources from the national to the local level.



Optimal use of available resources
Make the most of available resources, such as vector control efforts and existing vaccines, to effectively work towards the goal of dengue prevention.



Investment in technology and innovation
Prioritise investments in technology and innovation, ranging from the expansion of community-level strategies to the development of improved vaccines.

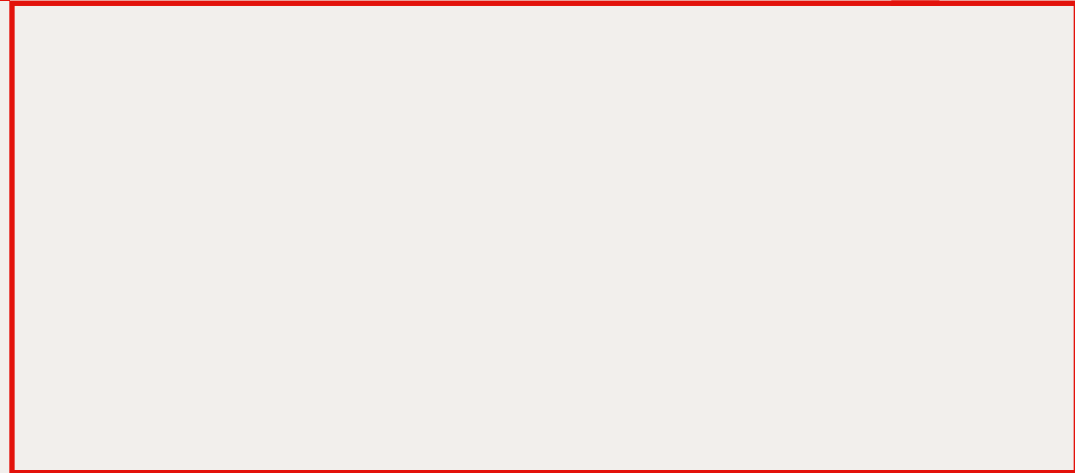
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