ECONOMIST IMPACT

Dengue defence:

prioritising actionable strategies for prevention

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Contents

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About this report

Dengue defence: prioritising actionable prevention strategies is an Economist Impact report supported by Takeda. This report provides a toolkit viewed through two lenses: six domains and five target areas (referred to hereafter as the "6 strategic domains" and "5-S target areas") to guide policymakers in creating and strengthening long-term policies and programmes for dengue prevention.

While the toolkit is designed to apply across countries at different stages of dengue prevention, its development focused on seven dengue-endemic countries: Argentina, Brazil, Colombia, Indonesia, Malaysia, Thailand and Vietnam. The findings were informed by a literature review of global studies, country-specific evidence, and two regional expert workshops attended by public health leaders, clinicians and community advocates.

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Executive summary

Dengue is no longer a seasonal nuisance. It is now a year-round, region-spanning threat driven by climate change, rapid urbanisation and increased human mobility. In 2024 alone, over 14m people were infected and nearly 11,000 died. As outbreaks intensify and borders blur, countries need to move beyond reactive crisis response, towards long-term strategies that are integrated, data-driven and grounded in local realities.

To support this shift, Economist Impact developed the SHIELD Toolkit for Dengue Defence. Drawing on literature review, World Health Organisation (WHO) frameworks and consultations across seven priority countries—Argentina, Brazil, Colombia, Indonesia, Malaysia, Thailand and Vietnam—the toolkit provides practical, action-oriented guidance to help all countries strengthen dengue prevention systems at national and subnational levels.

It is structured around 6 strategic domains:

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Secure political will to put dengue on the national agenda

- Treat dengue as a year-round public health priority integrated into national health plans.
- Ensure long-term financing tied to shared targets, to encourage cross-ministerial action and accountability.
- Invest in proactive measures such as surveillance innovation and technical capacity, not just outbreak response.

Harmonise and build integrated prevention systems

- Combine traditional control methods with innovations such as wolbachia, vaccines.
- Ground systems in local insights and community feedback to shape effective interventions.
- Train and mobilise health workers to maintain vigilance and integrate efforts with climate and sanitation agendas.

Inform actions with data and digital tools

- Shift from reactive to predictive approaches by integrating clinical, entomological, climate and behavioural data into surveillance to trigger early action.
- Use tools like early warning models and unified surveillance to guide timely, targeted actions.
- Design analytical systems to generate actionable insights and support data-based investment decisions.

Expand sustainable and diversified financing

- Secure long-term, predictable funding through a mix of domestic budgets, aid and private investment.
- Explore innovative financing tools like social impact bonds and performance-based transfers.
- Align dengue prevention with wider development goals to access larger financing platforms.

Leverage community power for resilient dengue prevention

- Promote behaviour change with context-specific, credible messaging delivered through trusted networks.
- Counter misinformation using digital tools and real-time communication.
- Support local champions to build ownership and strengthen community-led prevention efforts.

Drive impact through partnerships across sectors

- Develop national frameworks to guide strategies tailored to local context.
- Establish institutionalised task-forces that co-ordinate efforts across health, environment, education and local authorities.
- Engage private-sector partners to enhance delivery through tools like AI and joint countermeasure initiatives.

This toolkit is intended for policymakers, public health authorities and multi-sectoral partners. It offers a flexible, evidence-informed resource to guide both system-wide reform and more targeted improvements.

As the burden of dengue grows, so must our ambition to control it. We must act—early, together and for the long term.

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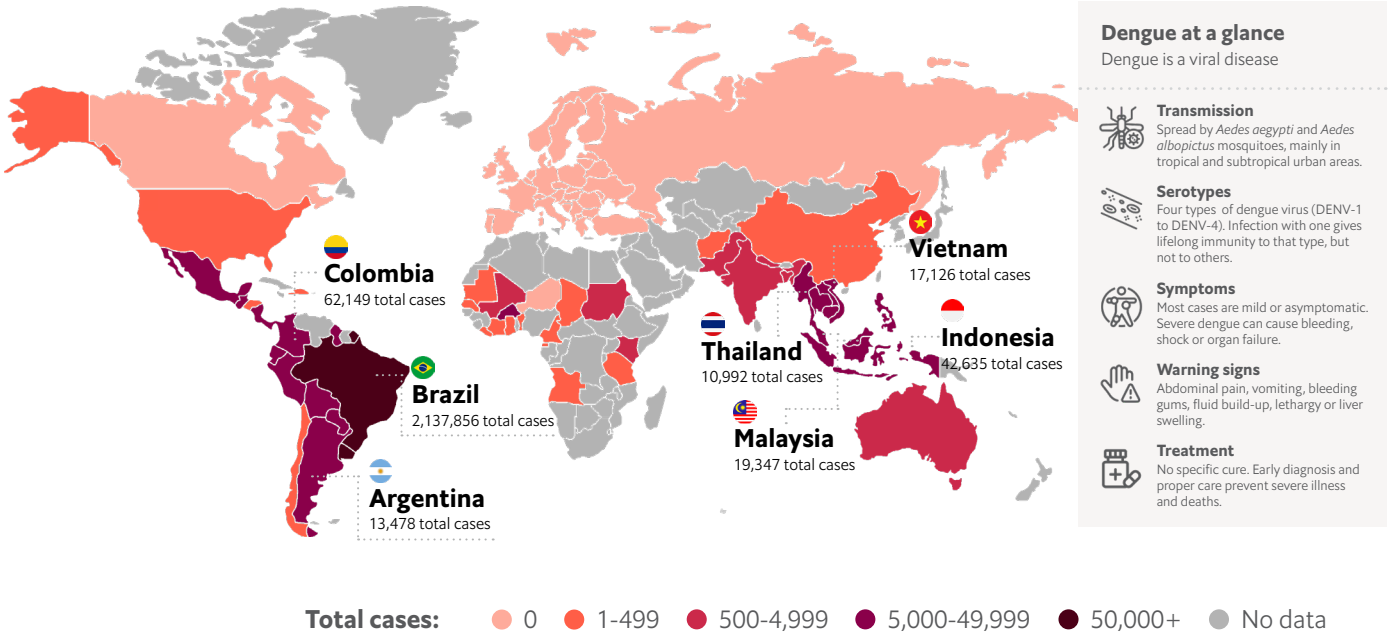
Dengue at a crossroads: why must we act?

The rising burden of dengue

Dengue, one of the fastest growing mosquito-borne diseases, threatens about half the global population.[1] Once confined to the tropical and subtropical zones, it is now endemic in more than 100 high- and low-income countries.[2] In 2019, the WHO listed dengue among the top ten threats to global health.[3]

As of March 2025, 97.3% of total dengue cases were concentrated in the Americas; the South-East Asian and Western Pacific regions account for 2.1%.[4] In Latin America, cases surged more than 600% between 2023 and 2024.[5] Globally, reported infections rose nearly thirtyfold since 2000—from just over 500,000 to more than 14m in 2024, when close to 11,000 people died.[2,6]

Figure 1: Global dengue situation, 2025



Source: WHO. Global dengue surveillance. Data reported as of April 29th 2025[6]

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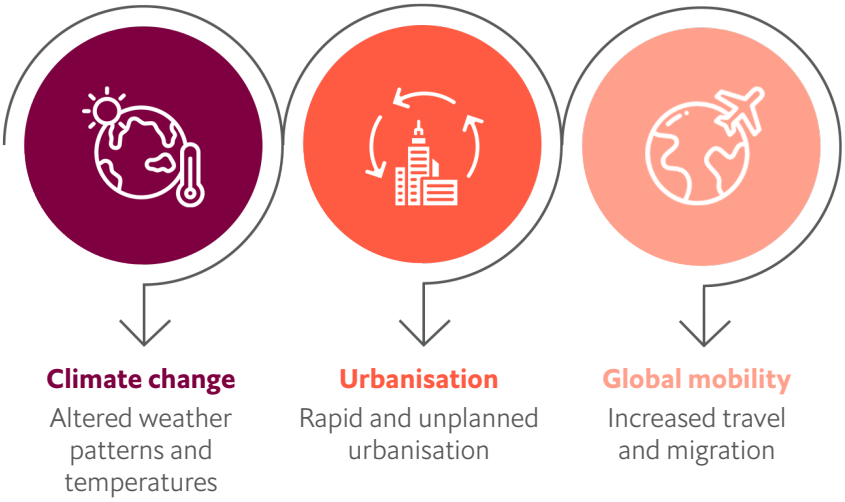
The rise of dengue is driven by more than short-term weather patterns. Climate change plays a part: higher rainfall, rising temperatures and humidity allow mosquitoes to thrive and move into new areas.[7] Previously subtropical and temperate zones, such as in central Argentina and northeastern Brazil, as well as high-altitude areas in Indonesia and northern Vietnam, are becoming new hotspots for transmission.[8–11] But the surge in cases is also driven by the movement of people. Rapid—often unplanned—urbanisation creates crowded areas with poor sanitation and standing water, ideal for *Aedes* mosquito breeding.[2] Global travel and migration spread the virus quickly across borders, helping dengue reach new regions and re-emerge in old ones.[12] Such is the case in metropolises like Rio de Janeiro, Jakarta and Bangkok.[13,14] Tackling the disease means addressing these root causes together, with co-ordinated efforts that go beyond the health sector.

Figure 2: Factors increasing dengue spread



Source: Economist Impact analysis

Impact on health systems and economies

If not addressed, dengue will have consequences. Outbreaks strain healthcare systems. In Vietnam, at the Hospital for Tropical Diseases in Ho Chi Minh City, dengue admissions surged by 150-200% in 2022 compared to 2021. By mid-June 2022, more than 300 dengue patients were hospitalised there—nearly 60% of the hospital's 550-bed capacity—with some treated in makeshift beds in hallways.[15] Indonesia has faced similar pressures. At Kendari City Hospital, bed occupancy during dengue outbreaks has exceeded 85%, breaching the Ministry of Health's recommended maximum. The strain disrupted care and stretched nursing staff to their limits.[16] The situation in Brazil has been more alarming: in just the first half of 2024, the country reported more than 6.3m dengue cases and more than 129,000 hospitalisations—equivalent to 70% of all dengue-related hospitalisations in the previous five years.[17]

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During dengue outbreaks with high inpatient volumes, 42% of healthcare workers in Malaysia experienced high levels of emotional burnout from anxiety, stress and working an average of 72.5 hours per week.[18,19]

The economic impact is also significant. A 2013 estimate put the global cost of dengue illness at $8.9bn, with South-East Asia, East Asia and Oceania bearing the heaviest burden, followed by Latin America and South Asia (Table 1).[20] Figure 3 shows the cost of dengue in selected countries, broken down into direct and indirect expenses, and as a share of GDP.

Table 1: Overall costs of dengue by region (2013 dollars)

REGION	COST ($m)*
South-East Asia, East Asia, Oceania	4,804.5
Latin America and Caribbean	1,734.1
South Asia	1,698.6
Sub-Saharan Africa	255.1
North Africa and the Middle East	77.9
Central and Eastern Europe, Central Asia	8.4

* All dollar figures given in this report are in United States dollars unless otherwise specified.

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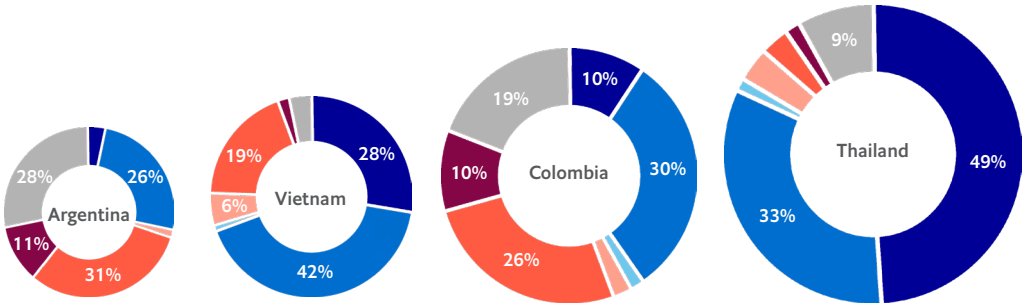
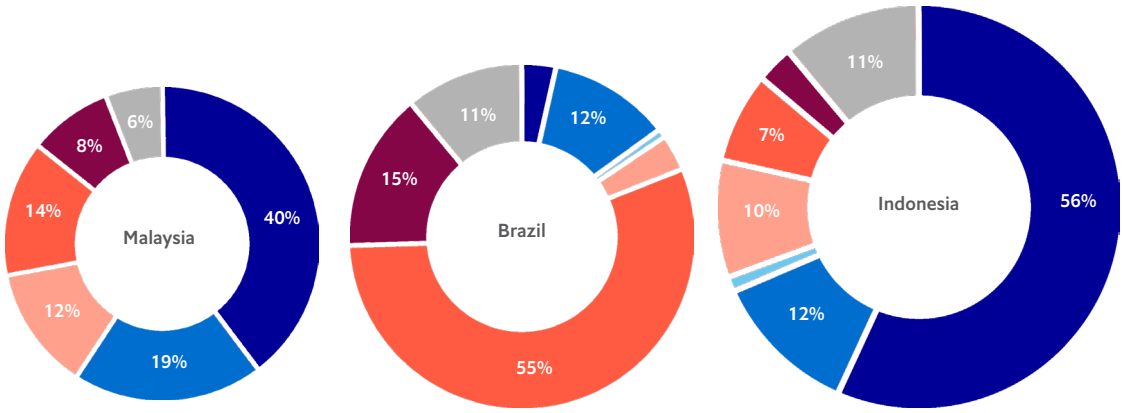
Figure 3: Dengue's economic burden and potential workforce gains, selected countries



	Argentina	Vietnam	Colombia	Thailand
Total cost of Dengue*	US$72m	US$94m	US$120m	US$425m
Cost of Dengue as % GDP*	0.01%	0.04%	0.03%	0.10%
Doctors that could be hired by reallocating 30% of dengue-related costs**	1,500	900	1,500	3,200



	Malaysia	Brazil	Indonesia
Total cost of Dengue*	US$608m	US$728m	US$2195m
Cost of Dengue as % GDP*	0.19%	0.03%	0.24%
Doctors that could be hired by reallocating 30% of dengue-related costs**	3,700	6,200	16,700

- Direct costs of ambulatory cases
- Direct costs of hospitalised cases
- Direct costs of non-medical cases
- Cost of fatal cases
- Indirect costs of ambulatory cases
- Indirect costs of hospitalised cases
- Indirect costs of non-medical cases
- = ~1,000 doctors

Note: Chart sizes reflect total dengue-related costs.
*Figures are based on 2013 data.
**Doctor estimates assume 30% of dengue spending is saved and redirected to public-sector salaries. Estimates are based on 2025 CPI-adjusted costs and 2025 average annual doctor salary data.[21] See Appendix II for details.

Source: Shepard et al. (2016). Global Economic Burden of Dengue. Supplementary material and Economist Intelligence Unit dataset

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To present the scale of dengue costs in more tangible terms, we adjusted these country-level findings for inflation, using the United States consumer price index (CPI).[22] The resulting 2025-equivalent costs are about 38% higher. We then modelled a scenario in which 30% of dengue-related spending is saved and reallocated to hiring doctors in the public sector—a hypothetical that illustrates what prevention could enable (see Appendix II for methodology and assumptions).

The results are expressed in practical terms: the number of doctors whose salaries could be covered with a 30% saving (see Figure 3). In Indonesia, that would fund 16,700 doctors. Brazil could hire 6,200, Malaysia 3,700, Argentina and Colombia 1,500 each, and Vietnam 900.

These estimates are deliberately conservative. They account only for inflation, not for population growth, urbanisation or the increasing spread of the virus. The true costs—and potential savings—are almost certainly higher.

More broadly, recent estimates put the global cost at $306bn in international dollars between 2020 and 2050.[23] In Brazil, lost workdays due to dengue reduced GDP by $876m, while in Thailand, outbreaks have severely impacted tourism revenues.[24] The true economic costs extend well beyond direct medical expenses, affecting productivity, workforce participation and national GDP, especially in countries with large informal sectors.

Despite the growing toll of dengue, investment in prevention remains low. Between 1975 and 2020, the diseases spread by *Aedes* mosquitoes, such as dengue, Zika and chikungunya, cost an estimated $94.7bn. Of that, just $7.6bn—around one-tenth—was spent on management and prevention; the rest was economic damage. Dengue alone accounted for $76.5bn of the total cost, almost entirely driven by damage rather than management and prevention.[25] The disparity between damage and management costs highlights the missed opportunity for savings through more active control.

WHO strategies: setting the direction

Amid rising dengue cases and their impacts, the WHO has called for countries to review their dengue preparedness and response plans. Recently published documents such as *Global Strategic Preparedness and Response Plan for Dengue 2022-2030 (SPRP), Global Vector Control Response 2017-2030, and Global Arbovirus Initiative 2022* provide frameworks to guide this process.[12, 26, 27] Together, these call for co-ordinated outbreak response, integrated mosquito control, improvements on real-time surveillance and equitable access to diagnostics and vaccines. The most ambitious target is set in the WHO's neglected tropical disease roadmap: *Ending the Neglect to Attain the Sustainable Development Goals: a road map for neglected tropical diseases 2021-2030*. The target is to have zero dengue-related deaths by 2030.[28]

What the global plans miss

While WHO frameworks set a strong foundation, several emerging challenges warrant greater focus:

- **Fighting falsehoods and disinformation in an overloaded information landscape**: strategies and tools to detect and counter false narratives remain limited.

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- **Modernising detection in a tech-driven world:** novel diagnostics, quicker reporting and AI-driven forecasting are underused in routine systems.
- **Securing funding in an era of geopolitical flux:** sustained investment is fragile, with few safeguards against shifting priorities.

Tackling these frontiers—while building on established foundations—is key to resilient, future-ready dengue prevention and control.

Closing the gaps: why do we need the toolkit?

Countries with endemic dengue face rising caseloads, recurrent outbreaks and the growing strain of year-round transmission. Their health systems must not only respond to emergencies but also sustain long-term prevention and control efforts in off-peak periods—all in an evolving, resource-constrained environment.

Simultaneously, as climates warm and urban centres expand, arboviruses such as dengue are likely to spread into new geographies. Increased global travel and migration will hasten this shift. Changes in information flows, technological capability and geopolitical priorities will reshape the context in which public health systems operate. The pace of this change will require systems to adapt quickly.

This toolkit tackles the dual challenges of rising endemicity and a rapidly shifting global context. It consolidates best practices from the broader literature, country experience and WHO guidance into a single, practical resource that complements, rather than replaces existing strategic documents. Designed for decision-makers and health practitioners, it translates established principles into practical actions suited for today's challenges. It supports countries where dengue is already endemic, as well as those at risk of future outbreaks.

As dengue threats rise, systems must be ready to act. This toolkit is a call to action: to prepare, adapt and respond to mitigate the impact of dengue.

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How to use the toolkit?

From national policymakers and local governments to healthcare providers, community leaders and the private sector, each of a broad range of stakeholders has a role in leading the frontline effort. The toolkit guides decision-makers in strengthening dengue prevention, providing a roadmap for turning strategy into impact on the ground. Lasting progress will depend on co-ordinated action across these key actors, in the health sector and beyond.

To support this, we have created the SHIELD toolkit for dengue defence. The toolkit collates evidence from a literature review and WHO guidance, and translates them into 6 goals or strategic domains of dengue prevention and control (see Table 2):

Table 2: 6 strategic domains of the SHIELD toolkit for dengue defence

THE 6 STRATEGIC DOMAINS	
Strategic Domain I	Secure political will to put dengue on the national agenda
Strategic Domain II	Harmonise and build integrated prevention systems
Strategic Domain III	Inform actions with data and digital tools
Strategic Domain IV	Expand sustainable and diversified financing
Strategic Domain V	Leverage community power for resilient dengue prevention
Strategic Domain VI	Drive impact through partnerships across sectors

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Each strategic domain is anchored by **action objectives**–broad goals indicating must be achieved. These are broken down into specific **key action points**, which detail how the objectives can be implemented.

Each key action point is focused on a **target area**, highlighting where efforts need to be strengthened (see Table 3).

Table 3: 5-S target areas of the SHIELD toolkit for dengue defence

TARGET AREA	ACTIONS INVOLVED
Stewardship	Setting national or subnational priorities; establishing policies or laws; aligning national and local strategies; co-ordinating across sectors
Surveillance	Collecting real-time data , predicting outbreaks; new diagnostics; creating digital platforms; integrating surveillance systems; assessing community knowledge
Science	Developing or implementing new tools, technologies, or interventions through research (including user nudges or novel reporting systems); adapting programmes based on evidence (and evaluation)
Skills	Strengthening the synergies between the health system and other systems; training formal health-sector workers; delivering health-care services; strengthening or creating laboratory capacity; improving clinical outbreak response
Support	Engaging and empowering communities by running awareness campaigns; establishing and training volunteer networks; creating supportive local infrastructure

Underpinning these action items are two enabling elements: capacity requirements and stakeholders.

1. **Capacity requirements** are the specific institutional, technical, financial or human-resource capabilities needed to effectively implement a key action.
2. **Stakeholders** are the organisations, institutions or groups that have a direct role in designing, financing, implementing or supporting a key action. These are divided into primary stakeholders, who lead or are chiefly responsible for the action, and secondary stakeholders, who provide support or complementary contributions.

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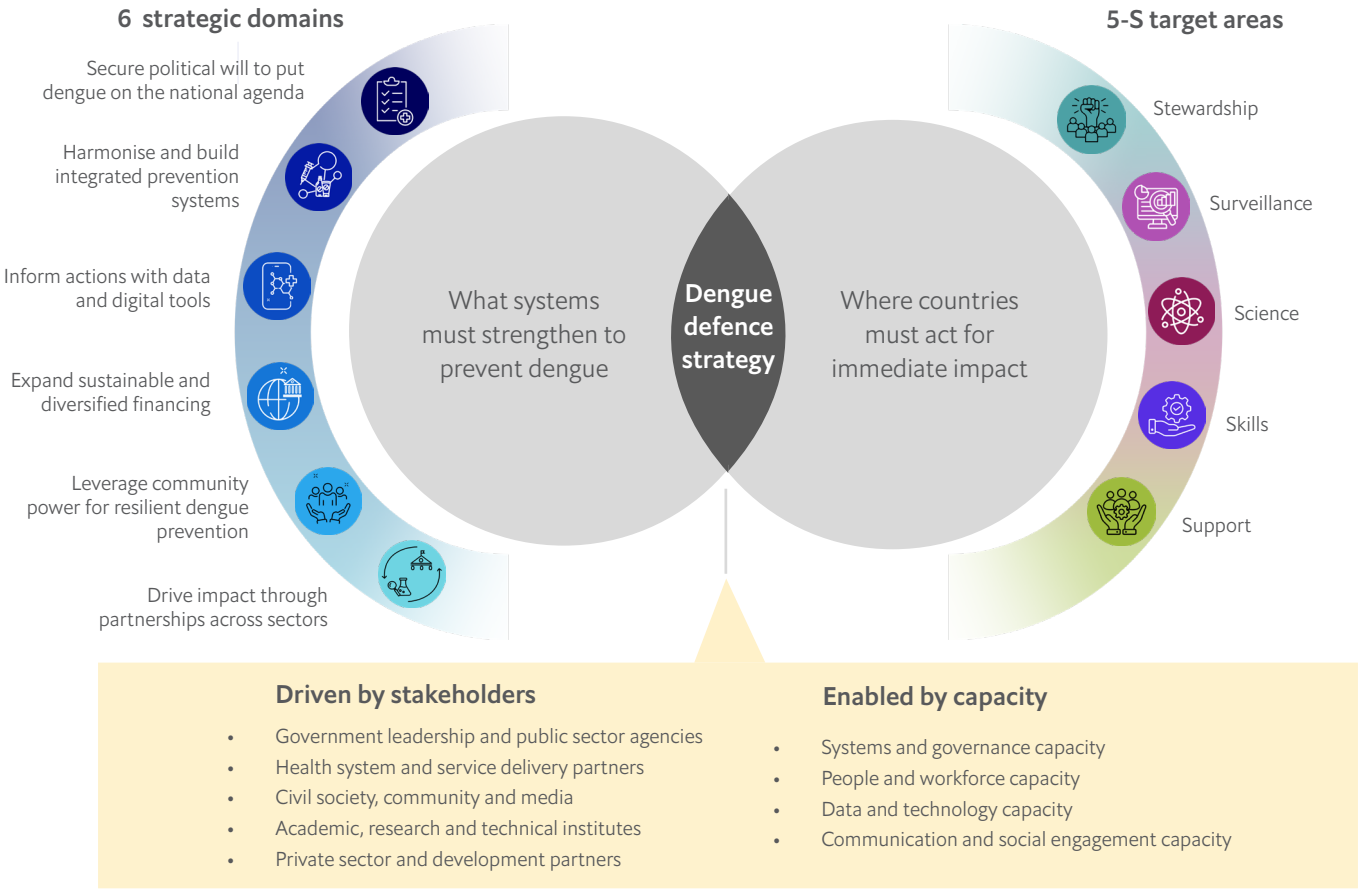
These components all synergise to constitute the SHIELD toolkit for dengue defence, structured around 6 strategic domains and delivered through a 5-S target area approach. It has one overarching goal: strengthening dengue prevention and control (Figure 4).

Figure 4: SHIELD toolkit structure: strategic domains, target areas, stakeholders and capacity requirements



Source: Economist Impact analysis

There are two ways to use this toolkit, depending on need:

1. **By strategic domain:** This approach is for decision-makers aiming to prioritise broad, systemic change. Each strategic domain defines a critical goal for strengthening dengue prevention and control. Users can work through the objectives and action points in each domain to launch large-scale initiatives, build long-term capacity, and align efforts across sectors.

2. **By target area:** This approach is for users who need to prioritise specific gaps or weaknesses in current plans. Target areas identify the essential components of dengue prevention and management where gaps are most pressing. By prioritising key action points within one or more target areas, users can channel resources and efforts where they are needed most—delivering targeted improvements while advancing progress in the broader strategic domains.

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Strategic Domain I: Secure political will to put dengue on the national agenda

Dengue is often treated as a seasonal nuisance—urgent only during outbreaks, quickly forgotten once case numbers fall. But this short-term view lets the disease rebound, undermining progress and exhausting health systems. Elevating dengue to a permanent place on the national health agenda is not just about securing attention—it is about embedding accountability, ensuring investment, sustaining momentum between crises and strengthening long-term control and resilience.

The WHO reinforces this perspective, calling for "safe and effective arbovirus preparedness, prevention and control measures with a whole-of-society and regional approach through sustained collaboration and partnerships among countries, communities, and financial and technical partners." Dengue prevention and control, it notes, is a shared responsibility that requires everyone to act.[12]

What gets in the way:

- **Competing health priorities** dilute political attention, political will and subsequent funding.
- **Dengue transmission cycles (every 4-5 years)** make sustaining political commitment and funding difficult, leading to waning attention and underinvestment between outbreaks.
- **Research and workforce planning remain reactive**, limiting the integration of new tools and sustained prevention capacity.
- **Weak mandates and a lack of enforcement mechanisms** limit evaluation against key performance indicators (KPIs) and undermine accountability for sustained

Making dengue everyone's business

Dengue's cyclical nature poses a unique political challenge. Lokman Hakim Bin Sulaiman, professor and deputy vice-chancellor (research) at IMU University in Kuala Lumpur observes, "Every four to five years you'll have a dengue epidemic without fail. No matter what you do, it just comes back." These recurring outbreaks trigger equally cyclical waves of political attention. Once the immediate threat fades, so does the urgency to act. "This cyclic nature of the disease outbreak makes it hard to sustain political and financial priority in the years between," Professor Sulaiman adds. Silvia Gold, president of the Mundo Sano Foundation, agrees: "While dengue is recognised as a public health priority, consistent year-round prevention efforts are lacking."

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"This cyclic nature of the disease outbreak makes it hard to sustain political and financial priority in the years between."

Lokman Hakim Bin Sulaiman, professor, deputy vice-chancellor (research), IMU University, Kuala Lumpur

Strong political will and leadership are needed to sustain action beyond crisis periods. Tikki Pang, a visiting professor at Yong Loo Lin School of Medicine of the National University of Singapore, affirms, "Unless you have political will and commitment, which is backed by adequate resources and a multi-sectoral and multi-stakeholder coalition behind it, nothing's going to move."

Malaysia's National Dengue Strategic Plan (2015-2020), aligned with the WHO's global dengue strategy to strengthen surveillance, case management and rapid response, was one effort to institutionalise long-term action. A high-level dengue national committee and task-force, led by the deputy prime minister, co-ordinated seven ministries—including housing, education and local government—to enforce integrated vector management and nationwide cleanliness policies.[29] In 2017, Malaysia allocated $48.36 million to vector control and prevention activities. In 2018, $6.75m—equivalent to just 1.04% of the Ministry of Health's national budget—was spent on dengue prevention and treatment. While the government has made regular investments in dengue control, this remains a small share of health spending, even as healthcare accounts for around 5% of GDP. Sustained funding is needed to keep pace with the growing threat.[30]

Indonesia's "3M Plus" programme also integrates dengue prevention into national health planning, supported by dedicated funding ($712,531 annually) and partnerships with institutions such as the Research Center for Climate Change at Universitas Indonesia, to incorporate climate data into prevention strategies. This is strengthened by high-level advocacy campaigns like Dengue Day to increase public awareness, while collaborations with the World Mosquito Programme reinforce long-term commitment to innovation.[31]

Colombia has taken a similarly structured approach. Its national dengue strategy, grounded in the 2024 surveillance protocol and Basic Attention Plan, integrates prevention into national health planning through six pillars—surveillance, care, diagnosis, vector control, communication, and environment. Defined roles span all levels of government: the Ministry of Health sets priorities and the National Institute of Health oversees surveillance, while insurers and local health departments co-ordinate care and lead community response.[32]

Argentina offers another example. Its 2024 Comprehensive Preparedness and Response Plan adopts a four-phase framework recommended by the Pan American Health Organisation (PAHO) to enhance surveillance, strengthen healthcare response capacity and ensures timely treatment to reduce severe dengue cases.[33] While not a guaranteed safeguard, these whole-of-government, long-term planning frameworks and financial commitments help keep up momentum and reduce the risk of political will fading between outbreaks.

Yet strong national leadership alone is not enough. International recognition of dengue as a global health priority is needed to reinforce domestic commitment. Support from multilateral institutions, global advocacy and high-level champions help maintain visibility and unlock resources. Eduardo Quevedo, regional advocacy and government relations manager for Latin America at the World Mosquito Programme, notes, "A global champion is needed to move the global agenda towards making dengue a priority and advocating for changes in dengue prevention."

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Global visibility not only galvanises increased funding but also creates a vision for long-term planning, helping to maintain attention outside peak transmission periods.

"A global champion is needed to move the global agenda towards making dengue a priority and advocating for changes in dengue prevention."

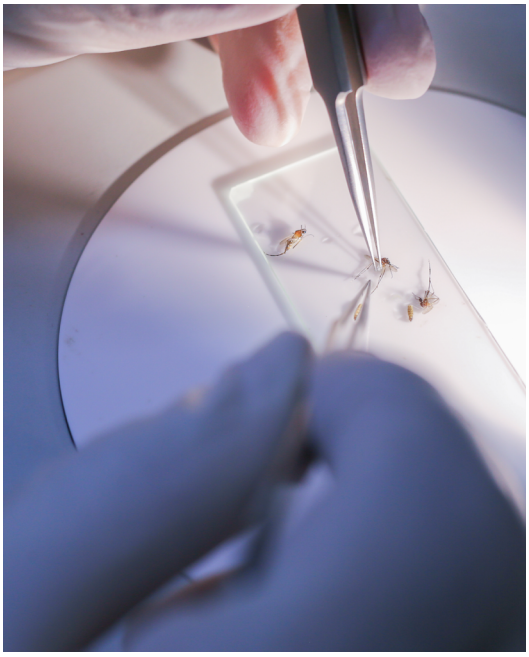
Eduardo Quevedo, regional advocacy and government relations manager for Latin America, World Mosquito Programme

Moving from reaction to readiness

Too often, research and implementation efforts respond to dengue outbreaks rather than anticipate them. But forward-looking research must be a part of national dengue strategies to move from a reactive to a proactive response.

Since 2004, Brazil has invested more than $28.6m (166m reais) in dengue research, supporting 232 projects focused on vector control and diagnostics.[34] One innovation has been vigi@dengue, a real-time surveillance system adopted by the Natal municipal health department in partnership with the Federal University of Rio Grande do Norte.[35] The system identifies high-risk areas earlier by weekly risk mapping based on epidemiological and entomological data, enabling targeted interventions. This approach proved effective in the city of Natal during the 2015 epidemic, where case numbers dropped compared to previous outbreaks.[36] However, it was not scaled nationally due to resource constraints and integration challenges. Brazil has also taken a leading role in integrating dengue vaccination into its national prevention strategy. The Ministry of Health is marking an important step toward layered, sustainable control by collaborating with private pharmaceuticals and national research centres.[37, 38]

Argentina has also advanced its dengue prevention capacity by strengthening the role of science in local surveillance. The National Scientific and Technical Research Council (CONICET) supports research across universities and institutes, which results in close collaboration with administrative health departments at different government levels to support daily case monitoring, hotspot identification and targeted control efforts. According to Aníbal Carbajo, principal investigator at the Universidad Nacional de San Martín, Argentina "There is collaboration between researchers and several health departments at the national, provincial and municipal level—in some cases, to the point of helping with daily analysis of the number of dengue cases, identification of hot spots and direction of control efforts." One notable initiative, developed in partnership with the Buenos Aires provincial Ministry of Health, uses an artificial intelligence (AI) model to analyse historical dengue data. The system forecasts potential outbreaks and supports more targeted, data-driven prevention strategies.



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Thailand's Vector-Borne Disease Management Strategy 2023-2032 underscores the need to move from reaction to readiness by investing in operational research and field-based implementation. It recognises the importance of specialist roles, such as in entomology, not only in monitoring and controlling vector populations but also in informing adaptive, evidence-based strategies.[39] The strategy includes concrete plans to strengthen entomological surveillance networks, expand laboratory and field infrastructure, and establish training pipelines to address chronic workforce shortages. Eggi Arguni, a professor in pediatrics at the Faculty of Medicine, Public Health and Nursing of Universitas Gadjah Mada, Indonesia, echoes a similar issue for Indonesia, saying, "Human-resource development is critical—not only for community volunteers but especially for entomologists, who remain scarce."

Targeted capacity-building, from operational teams to technical specialists, demonstrates planning for long-term commitment to dengue prevention, grounded in evidence and designed to translate into effective local action.

Accountability that drives action

Sustained action cannot be achieved without robust accountability measures. These hinge on legal frameworks, active community participation and transparent reporting. Professor Sulaiman says, "Public health challenges like dengue are a shared responsibility. Every ministry should take ownership of dengue problem, have a budget, and share accountability through joint key performance indicators." Professor Pang adds, "The regulations are there, but if they're not enforced, that's going to impact long-term prevention."

Thailand provides a model for decentralised accountability. Its Subdistrict Administrative Organisation Act (2009) empowers 76 provinces to enact local dengue vector control 2023-2032, which sets measurable targets in areas including health literacy and vector-control metrics, with progress reviewed in two phases (2023-2027 and 2028-2032).[39]

Indonesia fosters grassroots action through "*jumantik* cadres"—community volunteers, mobilised to conduct household larvae inspections and report data to puskesmas (local health centres). This network supports the national 3M Plus programme and routine monthly surveillance reporting.[41]

For accountability to translate into results, enforcement mechanisms and data use are critical. Brazil's Notifiable Disease Information System (SINAN) mandates dengue reporting across all 5,570 municipalities, integrating epidemiological, entomological, and environmental data for year-round monitoring.[42] Colombia has a similar dengue-tracking system without the other integrated components.[43] More importantly, SINAN links funding directly to reporting compliance. Municipalities that fail to submit reports from public and private healthcare facilities for more than two months face automatic cancellation of allocated financial resources, creating a powerful incentive for sustained local-level political commitment.[44] In Colombia, the National Institute of Health transforms real-time data from the National Surveillance System (SIVIGILA) into actionable insights. It publishes weekly epidemiological reports and annually updates prevention protocols to sharpen national surveillance and control goals.[45]

The table below lists the key action items under Strategic Domain I. Each specifies where capacity needs to be built or strengthened, who leads the effort and who supports it for effective implementation. Each action item also corresponds to a core target area, offering a reference point for countries seeking to assess or focus efforts in specific areas of dengue prevention.

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Strategic Domain I: Secure political will to put dengue on the national agenda

Target areas:
Stewardship · Surveillance · Science · Skills · Support

Target areas	Key action items	What is needed?	Who leads it?	Who supports it?
Making dengue everyone's business				
	Integrate dengue into health plans	Capacity to revise policies and laws	Heath ministry, parliament	Public health agency, regional agencies
	Create dengue unit with ring-fenced funds	Budget lines for dengue	Health ministry, public health agency	Finance ministry, development partners
	Align ministry budgets and shared KPIs	Joint planning and budgeting platforms	Finance ministry, planning ministry	Health ministry, line ministries
	Launch political advocacy and communication strategy	Communications expertise for government engagement	Health ministry, planning ministry	Line ministries*, development partners
Moving from reaction to readiness				
	Invest in research and development	Research funding and innovation links	Science ministry, health ministry	Universities, biotech firms
	Evaluate existing prevention efforts and update national strategy	Monitoring and evaluation systems for strategy updates	Health ministry, public health agency	Universities, development partners
	Build field research and entomology skills	Training in operational research	Health ministry, public health agency	Universities, education ministry
Accountability that drives action				
	Use data for decisions and evaluations	Analytics and independent reviews	Heath ministry, public health agency	Parliament, regional agencies, local health authorities, hospitals
	Maintain year-round surveillance	Surveillance systems and legal support	Health ministry, public health agency	Parliament, local health authorities, hospitals
	Use surveillance data to review progress and publish performance reviews	Tools for transparency and reporting	Health ministry, public health agency	Civil society, development partners

Abbreviations: KPIs = key performance indicators; biotechs = biotechnology firms
*Line ministries include: Environment, Education, Urban Development, Tourism, Finance etc.

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Strategic Domain II: Harmonise and build integrated prevention systems

Sustainable dengue control depends on systems that are integrated, adaptable and able to operate beyond crisis periods. No single intervention suffices—traditional methods must blend with emerging tools and be tailored to local conditions. Long-term effectiveness also requires embedding institutional roles and a skilled workforce that can respond quickly and keep up momentum beyond outbreaks. The WHO notes that success hinges on "tailoring vector-control initiatives to local contexts, employing traditional methods and innovative technologies," and "adapting strategies based on lessons learned and changes in the epidemiological landscape."[12]

What gets in the way:

- **Fragmented use of countermeasures** reduces their overall effectiveness; interventions must be integrated and used in combination.
- **Inconsistent enforcement and implementation of local interventions** weakens programme impact over time.
- **Gaps in maintaining a trained local workforce**—both volunteer and formal healthcare workers—hinder continuous, community-based surveillance, prevention and outbreak response.
- **Limited planning around sustained, multi-source financing** hampers long-term planning and reduces flexibility to adapt to local priorities.

Integrate and sustain: layered prevention strategies that work

Dengue control efforts are more effective and enduring when multiple prevention tools are integrated into existing health and environmental systems. Professor Arguni says, "Everybody agrees that for dengue, we don't have a single silver bullet. We have to integrate all of the prevention measures—not only vector control, but also case management, diagnostics and vaccination—because each one targets a different part of the problem."

> **" Everybody agrees that for dengue, we don't have a single silver bullet. We have to integrate all of the prevention measures—not only vector control, but also case management, diagnostics and vaccination—because each one targets a different part of the problem."**
>
> **Eggi Arguni**, professor in paediatrics, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Indonesia

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Thailand-based studies have shown the value of combining prevention strategies through modelling. One national modelling study estimated that integrating vaccination, insecticides targeting adult mosquitoes and community engagement could reduce the dengue burden by up to 79%.[46]

Complementing this, a modelling study of Indonesia's wolbachia deployments combined with vaccination strategies estimates that these interventions may be highly cost-effective in high-density urban areas, potentially saving up to US$27.1m annually in Jakarta alone, with a benefit-cost ratio of 3.4.[47]

In Argentina, a dengue-control programme in Clorinda offers important lessons in integrated, sustained delivery. Over five years, citywide initiatives reduced dengue risk through a combination of larvicide application, breeding-site elimination and intensive community outreach. The programme showcased close co-ordination between the municipal government, national health agencies and local women as vector-control workers—resulting in high household compliance and creating a foundation for institutionalising control routines in the public health system.[48]

Integration can also extend to other disease areas. Many countries still operate disease-specific surveillance systems in isolation, missing opportunities to streamline data and improve the response. "Each infectious disease, including HIV, malaria, tuberculosis, and dengue, operates within its own distinct surveillance system," says Tham Chi Dung, Vaccine and Immunisation Team Lead at PATH, Vietnam. "But the systems don't talk to each other. That remains a big issue for mobilising resources for disease control and prevention." Disease surveillance, he adds, is often fragmented, with epidemiological, laboratory, and environmental data managed separately across different diseases. Integrating these data streams could enhance early-warning systems and improve the efficacy of long-term dengue control strategies. "In Vietnam, surveillance is done for dengue, but not yet for Zika and chikungunya—even though it's the same vector," he notes. "Why not integrate them into a single surveillance programme? How to do that remains a difficult question for the health system."

"In Vietnam, surveillance is done for dengue, but not yet for Zika and chikungunya—even though it's the same vector. Why not integrate them into a single programme? How to do that is a difficult question for the health system."

Tham Chi Dung, vaccine and immunisation team lead at PATH, Vietnam

Power the frontline workforce

Well-trained and motivated local health workers are critical to early detection, public engagement, and rapid response. In Vietnam, event-based surveillance broadened the outbreak detection network by training more than 1,300 local actors—including money lenders and factory managers—to report unusual health events, enhancing early-response capacity.[49] In Thailand, village health volunteers trained in larval surveillance reduced dengue morbidity from 175.6 to 64.7 cases per 100,000 within 12 months in high-risk districts.[50] Orawan Tawaytibhongs, director of Khaoyoi Hospital, which is operated by Thailand's Ministry of Public Health, explains, "Village health volunteers are our frontline informal health workforce. Emphasising this is very important. We also give them a small monetary incentive, but really, they do this out of pride to help the community." Together, these workforce strategies can improve community awareness, prevention behaviours and local outbreak response.

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Orawan Tawaytibhongs, director, Khaoyoi Hospital, Thailand

In Colombia, the Red Cross trained more than 150 community volunteers to form dengue brigades in response to severe outbreaks. These teams took the lead on early detection, referral and vector-control efforts in high-risk households, schools and health centres. With technical support from the International Federation of Red Cross and Red Crescent Societies (IFRC), volunteers were equipped with skills in community-based health, vector-control, and risk communication.[51] Targeted, community-led models can build local response capacity quickly and where it is needed most.

Regional efforts are also strengthening national frontline capacity. In response to the global dengue emergency declared in December 2023, PAHO activated its incident-management system, co-ordinating surveillance and training across the region. By mid-2024, more than 120,000 health professionals had received training in clinical management, with technical missions deployed to ten countries and virtual sessions covering topics from vector control to laboratory strengthening.[52] In Argentina, this translated into a national training programme delivered in collaboration with PAHO. "In 2024, Argentina's Ministry of Health worked on a comprehensive human-resource training programme based on PAHO courses," explains Tomás Orduna, tropical infectious disease specialist and former head, Department of Tropical and Travel Medicine (CEMPRA-MT) at F.J. Muñiz Infectious Diseases Hospital, Argentina. "It recruited students from across the country, and through webinars, they accessed PAHO's course on comprehensive dengue management—which was very important." This model of technical co-operation shows how international support can help scale frontline capacity and embed prevention into national systems.

Alongside training volunteers and expanding community-based efforts, many countries still face workforce gaps in their formal health systems. Jarir At Thobari, professor of pharmacology in the Faculty of Medicine, Public Health and Nursing at Universitas Gadjah Mada, Indonesia, notes, "Indonesia still needs to improve the number and distribution of healthcare professionals—doctors, nurses, and specialists like internists, microbiologists and paediatricians—especially across the many islands where infrastructure and diagnostic capacity are still lacking." Addressing these shortages is essential to ensure equitable access to diagnosis and treatment in addition to dengue prevention—especially in underserved and remote regions.

Build resilience into routine prevention

Embedding dengue prevention into the everyday routines of health systems and communities strengthens long-term resilience.

In Indonesia, dengue surveillance workers in Semarang boosted community participation, with 80% of surveyed residents perceiving a drop in local cases.[53] A regional technical meeting on arbovirus control echoed this experience, stressing that sustained behaviour change requires structured engagement and long-term investment, especially in high-risk settings like schools and workplaces.[54] For example, in Indonesia, efforts could be further strengthened by shifting from short-term grants and fragmented engagement towards more integrated, climate-responsive programmes to ensure continuity across planning cycles or other shocks to the healthcare system.[55]

Malaysia has shown how flexible delivery can sustain progress during disruption. During the covid-19 pandemic, vector-control trials continued despite major operational constraints. Authorities adapted by reducing intervention cycles from six to four and overlapping activities to maintain coverage while cutting costs.[56]

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Brazil is reinforcing resilience through national systems. In 2024, its Ministry of Health transferred $45m (256m reais) to support state and municipal disease-control efforts. This included training disease-control agents and regularising insecticide stockpile distribution nationwide. The creation of a National Arbovirus Room added real-time monitoring capacity, operating 24/7 to detect early warning signs. The use of the wolbachia method, targeting mosquito transmission, was also intensified, reflecting Brazil's move toward layered prevention.[57]

These experiences highlight the value of flexible delivery mechanisms supported by stable financing.

Bring external partners on board for long-term impact

In many countries, dengue prevention is largely funded through national budgets, with limited support from international donors or agencies. "In Colombia, we haven't had significant external funding for dengue—it's mostly public funding," says Zulma Cucunubá, director of the Institute of Public Health and professor of infectious disease epidemiology at Pontificia Javeriana University. In Thailand, the picture is similar. "For dengue, we mostly use the national budget—unlike malaria, which benefits from international support. That makes scaling harder," explains Darin Areechokchai, acting medical officer, advisory level at the Department of Disease Control of the Ministry of Public Health, Thailand.

"For dengue, we mostly use the national budget—unlike malaria, which benefits from international support. That makes scaling harder."

Darin Areechokchai, acting medical officer, Department of Disease Control, Thailand

Aligning national strategies with donor priorities has helped countries mobilise support for integrated dengue control. Brazil and Colombia continue to partner with global funders to expand access to wolbachia mosquito releases, combining local implementation with international backing to scale prevention efforts.

In Brazil, a new partnership between the Oswaldo Cruz Foundation (also known as Fiocruz) and the World Mosquito Programme (WMP) aims to accelerate access to low-cost, long-term protection against dengue, chikungunya and Zika. The WMP is investing $10m to support the construction and operation of a new biofactory in Rio de Janeiro, which will house automated production equipment and provide expanded staff training to meet growing demand across municipalities. To scale deployment nationally, WMP has also committed up to US$10m to establish a matching fund, designed to attract co-investment from Brazilian companies, philanthropic organisations, and high-net-worth individuals. This co-funding model reflects an emerging best practice: using public-private finance mechanisms to speed up adoption of proven tools, increase domestic ownership and extend the reach of national prevention strategies.[58]

Shifts in global health funding require a turn from dependency to sustainability. Mr Patil explains, "Countries cannot rely on donor- or grant-funding in perpetuity. This is an opportunity to embed sustainability into policy—whether through sin taxes or other domestic revenue sources. Pilots can start with donor support, but they should gradually transition into sustainably funded government programmes."

The table below lists the key action items under Strategic Domain II. Each specifies where capacity needs to be built or strengthened, who leads the effort, and who supports it for effective implementation. Each action item also corresponds to a core target area, offering a reference point for countries seeking to assess or focus efforts in specific areas of dengue prevention.

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Strategic Domain II: Harmonise and build integrated prevention systems

Target areas:
Stewardship · Surveillance · Science · Skills · Support

Target areas	Key action items	What is needed?	Who leads it?	Who supports it?
Integrate and sustain: layered prevention strategies that work				
	Combine traditional and innovative tools	Capacity to scale tools; Reliable supply chains	Health ministry, public health agency	Local government, universities, biotech firms
	Embed dengue into climate and sanitation efforts	Cross-sector co-ordination frameworks	Local government, environment ministry	Health ministry
	Plan long-term adoption into local systems	Strategic budget planning and national guidelines	Health ministry, local health authority	Finance ministry, planning ministry, environment ministry
Power the frontline workforce				
	Train and mobilise local health workers and health volunteers	Co-ordinated training platforms	Health ministry, local government	Training institutes, civil society
	Build local workforce capacity for surveillance and outbreak response	Field epidemiology and outbreak training	Public health agency, health ministry	Universities, local health authorities, regional partners
	Develop targeted strategies and career pathways to retain skilled health workers	HR systems and career pathways	Ministry of Health, local government, HR authority	Training institutes, donors
Build resilience into routine				
	Institutionalise local dengue roles in existing public health structures	HR policy and planning	Health ministry, local government	Health authorities, HR authority
	Develop long-term implementation plans with multi-year budgets for continuity	Strategic planning and policy continuity systems	Health ministry, local government	Finance ministry

Abbreviations: HR = human resources

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Strategic Domain II: Harmonise and build integrated prevention systems

Target areas:
Stewardship · Surveillance · Science · Skills · Support

Target areas	Key action items	What is needed?	Who leads it?	Who supports it?
Bring external partners on board for long-term impact				
	Pursue global and philanthropic funding aligned with national dengue goals	Grant writing and donor co-ordination	Health ministry, donor unit	Finance ministry, donors
	Align national strategies with donor priorities and reporting requirements	Funding tracking and reporting systems	Health ministry, donor unit	Planning ministry, donors

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Strategic Domain III: Inform actions with data and digital tools

To remain effective, dengue responses must adapt to changing transmission patterns and evolving community priorities. Data-driven intervention is important in this effort. Accurate real-time data is essential for estimating the true burden of dengue and enabling effective prevention. When clinical, laboratory, climate, and community data are integrated, outbreaks can be anticipated and contained before they escalate. Technology plays a key role by speeding data collection and analysis, while community reporting—through tools like hotlines or mobile apps—extends surveillance to hard-to-reach areas and encourages public involvement in early detection.

As the WHO SPRP highlights, "Collaborative and integrated surveillance systems contribute to the early detection and control of dengue...A rapid response is critical to reduce the spread of disease and its impact on communities."[12]

What gets in the way:

- **Limited integration of diverse data streams**—including climate, entomological, clinical, and environmental inputs—hampers a comprehensive, One Health view of dengue risk.
- **Low integration of social and behavioural data into surveillance systems** misses early-warning signs related to community risk factors and intervention uptake.
- **Weak mechanisms to evaluate, scale and finance technologies**—such as health technology assessments or cost-effectiveness studies—slow the adoption of promising new countermeasures.
- **A lack of tools that enable community reporting and participation** limits grassroots engagement and ownership in early detection and response.

Let local data shape the response

Local data is most powerful when it drives programme design—helping governments target high-risk groups, tailor outreach, and adjust delivery strategies in real time.

Brazil offers a strong example of how data can guide large-scale prevention efforts. In 2023, the Ministry of Health launched a nationwide immunisation campaign, prioritising more than 500 municipalities with a high dengue burden and focusing on children aged 10-14, who face higher hospitalisation rates.[59, 60] The roll-out was fully subsidised and guided by geographic and demographic risk data to maximise impact. Early implementation revealed challenges, particularly with second-dose adherence and reaching adolescents who do not routinely access health services. In response, local authorities launched school-based catch-up campaigns and introduced active tracking to improve

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completion. This approach reflects a broader equity-driven model that combines free public access, adaptive delivery mechanisms and data-informed targeting of vaccination.

Thailand's national strategy embeds data-informed protocols in frontline operations, setting strict timelines for response. "Thailand's 3-3-1 strategy remains a cornerstone of dengue response," says Dr Areechokchai. "We report suspected cases within the first three hours, conduct larval surveys in the next three and implement community mosquito control within one day." To strengthen implementation, Yasothon province piloted a mobile-enabled version of the system. The results were promising: case reporting within the first three hours rose from 36% to 48%, larval surveys within three hours improved from 58% to 72% and fogging within one day increased from 64% to 94%.[61]

Detect faster, act smarter

Early-warning systems enable faster outbreak detection and more targeted responses—crucial for staying ahead of transmission in increasingly unpredictable environments. But to be effective, these tools must draw on real-time surveillance systems that link local reporting with national platforms. These systems must also incorporate other relevant data streams, such as climate and environmental information, to enable predictive analytics. Professor Cucunubá agrees, saying, "I truly believe integrating health and climate is critically important."

Thailand provides a strong example of how real-time surveillance data can guide localised interventions. Region-specific larval indices and serotype monitoring help tailor interventions to seasonal patterns, particularly around the monsoon period.[62] Dr Areechokchai explains, "We look at surveillance data, not only the number of cases but also the mosquito larva index. We analyse this on the dashboard to identify high-risk areas in Thailand before outbreaks occur."

In Vietnam, the Model Satellite-based System (D-MOSS) combines satellite data, weather forecasts, and water-availability models to predict dengue outbreaks up to eight months in advance across 13 high-risk provinces.[63] While such forecasting tools are valuable, their impact is limited without strong surveillance systems on the ground. Mr Dung explains, "Surveillance [in Vietnam] still faces major challenges. reporting is mostly paper-based at the district and community levels, often delayed by a week or more. The systems don't talk to each other, which makes early detection difficult." Although digital platforms exist at the national level, gaps in local integration continue to hinder timely response.

Malaysia's DenMap and eDengue systems enable real-time mapping of dengue cases, helping health authorities quickly identify hotspots. Forecasting models in Selangor using climate variables and machine learning now predict outbreaks 20-60 weeks ahead, supporting longer-term planning. Such models also support the testing of mitigation strategies through adjusting mosquito/human bite rate conditions.[64]

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In Brazil, AI-driven tools like Mapzer use street imagery to detect over 1m potential mosquito breeding sites across 23 municipalities, helping local governments act quickly.[65] At the national level, the Ministry of Health and research institutions are developing the Alert-Early System for Outbreaks with Pandemic Potential (AESOP), a new early-warning system that combines health, environmental and sociodemographic data from Brazil's Unified Health System. Using machine learning, the platform aims to predict where outbreaks are likely to spread and guide targeted interventions.[66,67] Ms Boaventura notes, "The implementation of digital health interventions is one of the most effective strategies to improve epidemiological surveillance and early detection of outbreaks. To maximise their impact and ensure equitable adoption across regions these initiatives must be coordinated by the Ministry of Health, as many municipalities lack the technical infrastructure or expertise required to lead them independently."

In Argentina, the use of AI is also being piloted to support day-by-day forecasting of dengue outbreak. In the province of Buenos Aires, AI models are being trained to predict where future outbreaks may occur based on historical case data.[68] "The AI model is already working," says Mr Carbajo, "though the model is still learning and needs more historical data to be trained."

Together, these examples point to a growing shift—from static reporting to adaptive, predictive systems. When national plans prioritise digital integration and local authorities are empowered to act on the data, dengue responses can be faster, smarter and far more effective.

Build the backbone of detection

Strengthening early detection requires integrating clinical, lab, and epidemiological data into a single system, supported by validated diagnostics that work in real-world settings.

Scaling these tools demands investment in infrastructure, diagnostics, quality assurance and skilled personnel. Professor Cucunubá notes, "Getting data faster while maintaining quality means investing in connectivity, cleaning, and people."

Argentina has consolidated its clinical, epidemiological, and laboratory data through the National Health Surveillance System, linking public and private facilities and employing a nationwide network of diagnostic labs capable of serological and molecular testing.[8] Mr Carbajo explains, "There is good monitoring. It is national and mandatory. When a province isn't reporting, it's immediately noticeable. These monitoring processes have been in place since 2009 and were well established by the 2016 dengue epidemic." This level of visibility and enforcement helps sustain national co-ordination and data quality.

Thailand's "Lansaka Model" introduced an online larval index surveillance system with training for village health volunteers, resulting in a decline in dengue incidence and improved local response.[50]

In Indonesia, simplified diagnostics such as the NS1 antigen test, a rapid tool for detecting dengue, are being scaled up to improve dengue detection in resource-limited settings.[69] Yet much more infrastructure is needed to achieve national coverage. Professor Thobari states, "Not all hospitals or health centres have the infrastructure for even basic diagnostics like NS1. We also need stronger labs, and more trained doctors, nurses and specialists, especially in remote areas."

> **" Not all hospitals or health centres have the infrastructure for even basic diagnostics like NS1. We also need stronger labs, and more trained doctors, nurses and specialists, especially in remote areas."**
>
> **Jarir At Thobari**, professor of pharmacology at Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Indonesia

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Improving diagnostic infrastructure and clinical capacity is vital not only to reduce deaths but to ensure that care is accessible beyond urban centres. Bridging these gaps will be key to delivering equitable dengue management.

These examples highlight the importance of ensuring that diagnostics are not only developed and approved, but also supported by the laboratories, clinical networks and health professionals required to use them effectively. For countries to reach the goal of zero dengue deaths, better detection must go hand in hand with stronger clinical management at all levels of the health system.

Put communities in control

Community-based reporting closes critical gaps in formal surveillance systems, enabling quicker local action and fostering stronger public ownership in dengue prevention. "Real-time data is crucial—and communities must be part of the surveillance system," says Professor Pang. "You're not just relying on doctors or physicians, but on trained community members who can provide early warning. Ownership matters. When the community is part of the system, you get faster detection and stronger response."

In Colombia, the Ibagué Saludable platform includes two mobile apps: one for inspectors and the other for the public. Residents can report mosquito breeding sites, while health workers upload inspection data using geolocation tools, enabling two-way communication and a targeted response.[70]

In Thailand, village health volunteers use mobile apps to report mosquito breeding sites. "This mobile app data goes to the district team, and action happens within 24 hours," explains Ms Tawaytibhongs. Malaysia's experience shows that digital tools alone are not enough—engagement must be sustained. A national survey found more than 90% of respondents supported receiving dengue alerts and 88% were ready to act if dengue risk increased in their area. But only 64% reported actively checking local updates—highlighting a critical gap in the feedback loop.[71] These tools must be paired with ongoing outreach and communication to remain effective.

These examples highlight the value of accessible tools that not only empower communities to drive local response, but also reinforce accountability and encourage consistent, preventive behaviours.

> **"Real-time data is crucial—and communities must be part of the surveillance system."**
>
> **Tikki Pang**, visiting professor, Yong Loo Lin School of Medicine, National University of Singapore

Show the value of prevention

As outlined in relation to Strategic Domain II, modelling studies from Thailand and Indonesia have shown how combining tools like wolbachia, vaccination and community engagement can significantly reduce the dengue burden. These results highlight the potential of innovation—but health impact alone is not enough.

Demonstrating the economic returns of innovation in a country context is equally vital to sustain political commitment and secure long-term financing. Cost-effectiveness data helps decision-makers justify new investments and avoid spending on interventions that are ineffective or poorly adapted to local needs. Dr Areechokchai explains, "We need cost-effectiveness studies for new interventions like wolbachia and dengue vaccination. Innovation must be proven to be both effective and affordable in each country context." Professor Cucunubá notes that evidence alone is not enough: "Someone in the ministry of economics will have to provide the economic or fiscal impact of the new interventions to make the decision of whether or not to implement."

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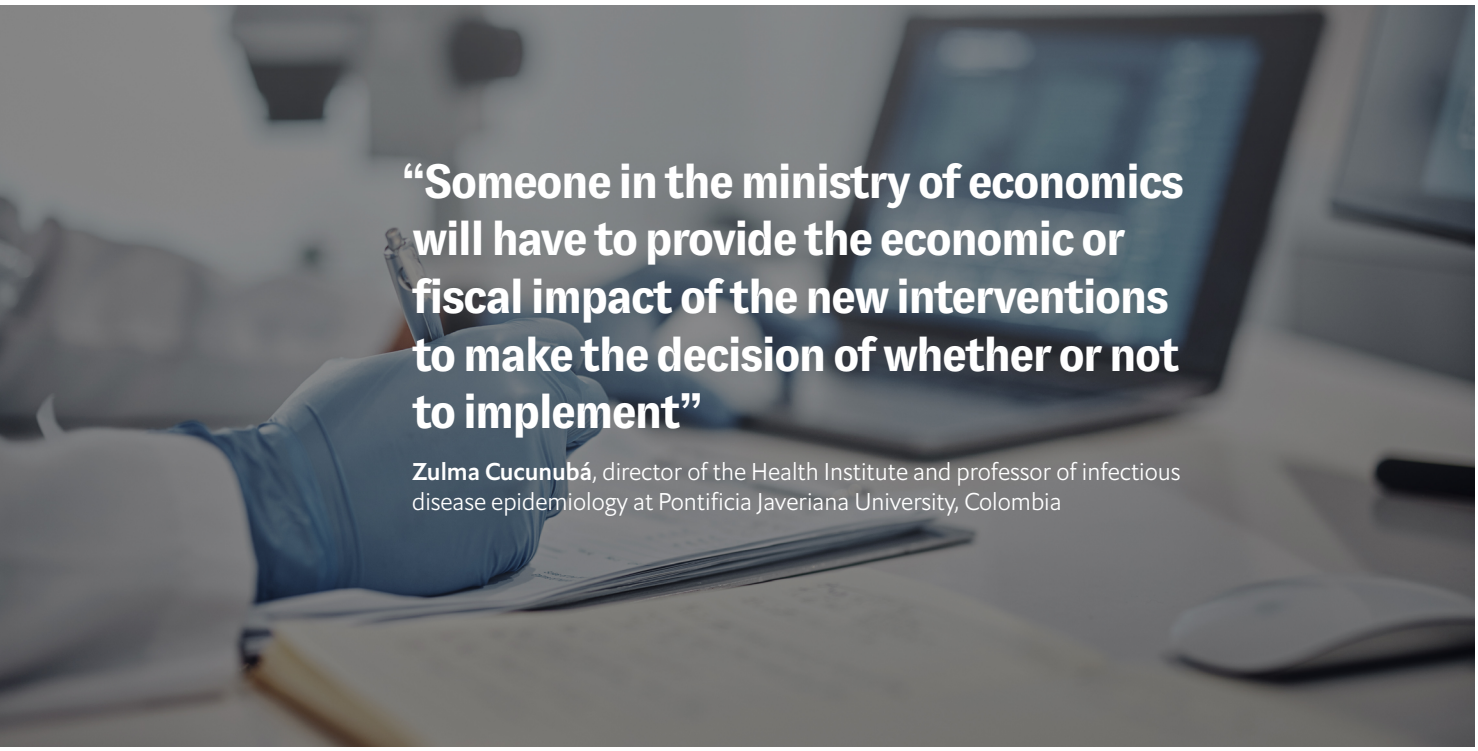

> **"Someone in the ministry of economics will have to provide the economic or fiscal impact of the new interventions to make the decision of whether or not to implement"**
>
> **Zulma Cucunubá**, director of the Health Institute and professor of infectious disease epidemiology at Pontificia Javeriana University, Colombia

A national, model-based evaluation of wolbachia mosquito deployments in Vietnam projected the intervention to be cost-effective over a ten-year horizon. The analysis estimated a benefit-cost ratio of 1.75 and a cost of around $420 per disability-adjusted life year (DALY) averted. It also suggested that the strategy could prevent 6.2m symptomatic cases and save around $300m in economic losses.[72]

The example highlights the power of economic evidence, from national modelling to intervention assessments, in making the case for investing in prevention systems.

There is growing scope for governments to partner with international organisations and academic institutions to strengthen the local evidence base. Learning from successful models elsewhere—and adapting them to national and subnational contexts—can guide better decisions. Regional platforms and global agencies have a role to play in supporting this exchange and ensuring innovation is both affordable and effective.

The table below lists the key action items under Strategic Domain III. Each specifies where capacity needs to be built or strengthened, who leads the effort and who supports it for effective implementation. Each action item also corresponds to a core target area, offering a reference point for countries seeking to assess or focus efforts in specific areas of dengue prevention.

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Strategic Domain III: Inform actions with data and digital tools

Target areas: Stewardship, Surveillance, Science, Skills, Support

Target areas	Key action items	What is needed?	Who leads it?	Who supports it?
Let local data shape the response				
	Update actions using data and feedback	Real-time systems and adaptive tools	Local government, health authorities	Universities, civil society, biotech firms
	Deploy tailored packages in hotspots	Operational planning and logistics	Local government, health authorities	Public health agency
Detect faster, act smarter				
	Deploy integrated data platforms and mobile tools to monitor risks and predict outbreaks	Digital platforms, infrastructure and modelling expertise	Health ministry, public health agency	Meteorology agencies, universities, tech firms, development partners
	Establish co-ordination mechanisms for timely data sharing to support outbreak forecasting and response	Reporting tools, co-ordination structures, data governance	Public health agency, local health authorities, hospitals	Digital health units, health informatics teams
Build the backbone of detection				
	Unify clinical, epidemiological, and lab data for surveillance	Integrated databases and skilled IT staff	Health ministry, public health agency	Local health authorities, hospitals, digital health units
	Scale up reliable rapid diagnostics	Field trials and validation studies	Health ministry, public health agency	Universities, diagnostic firms
	Set national diagnostic validation process	Regulatory and evaluation systems	Health ministry, regulatory authority	Universities, diagnostic firms

Abbreviations: biotech = biotechnology, IT = information technology

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Strategic Domain III: Inform actions with data and digital tools

Target areas:
Stewardship · Surveillance · Science · Skills · Support

Target areas	Key action items	What is needed?	Who leads it?	Who supports it?
Put communities in control				
	Launch apps or hotlines to enable public reporting	Real-time systems and adaptive tools	Local government, health authorities	Universities, civil society, biotech firms
	Establish feedback systems to alert communities and frontline responders	Operational planning and logistics	Local government, health authorities	Public health agency
Show the value of prevention				
	Build investment case for innovative dengue tools using cost and impact data	Health economics and policy analysis capacity	Health ministry, health economics units	Finance ministry, planning ministry, universities, regional partners

Abbreviations: apps = applications; biotech = biotechnology

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Strategic Domain IV: Expand sustainable and diversified financing

Sustainable financing is the critical link between strategy and delivery. Without predictable, long-term and diversified funding, countries cannot sustain the systems needed to reduce the dengue burden at scale.

The WHO notes, "Predictable and long-term financing will be required to support vector control programming," and "robust and predictable financing is essential to consolidate vector control successes and sustain strong returns on investment."[26] New funding models must be mobilised to maintain momentum, close resource gaps and drive long-term implementation.

What gets in the way:

- **Over-reliance on fragmented, short-term funding streams** limits the ability to scale and sustain prevention programmes.
- **Limited private-sector engagement frameworks** constrain opportunities for co-financing, innovation and incentivising shared value.
- **Lack of planning on designing and managing innovative financing mechanisms**, such as social-impact bonds or pooled procurement, delays uptake of alternative funding models.
- **Failure to position dengue within broader climate, health security, and resilience agendas** restricts access to large-scale, multi-sectoral funding platforms.

Attract private capital and funding

Closing funding gaps in dengue prevention requires greater private-sector engagement, but this is not yet adequately mobilised in most settings. In Brazil, the national development bank—the National Brazilian Bank for Social and Economic Development—committed $88m (500m reais) to *Aedes*-related disease control, including $61.7m (350m reais) in credit to support private sector research and development and commercialisation, and $17.6m (100m reais) for dengue vaccine development.[73] National development banks, including regional institutions such as the Asian Infrastructure Investment Bank, could become important vehicles for mobilising long-term investment in dengue prevention.

In Indonesia, community willingness to vaccinate is high, but ability to pay is low. A 2023 survey found more than 90% of parents were willing to vaccinate their children—yet most could not afford market prices.[74] This highlights the need to expand vaccine access through domestic production, insurance coverage, employer

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benefits and stronger links between immunisation targets and health budgets.[75] Professor Sulaiman notes, "Employers could support dengue prevention, as they did during covid-19, by educating employees and expanding benefits to include preventive measures."

"Employers could support prevention for dengue like they did for covid-19 by educating employees and expanding benefits to include preventive measures."

Lokman Hakim Bin Sulaiman, professor, deputy vice-chancellor (research), IMU University, Kuala Lumpur

Scale what works with innovative financing models

Many of the most promising dengue solutions, such as vaccination and wolbachia, need upfront investment that may exceed routine health budgets, and so require financing strategies that go beyond annual public budgets. Dr Quevedo observes, "It's about having all technologies available for the population, but the main issue is funding. How can a health system manage to procure all these technologies?"

In Indonesia, multiple modelling studies have examined the cost-effectiveness of dengue vaccination and wolbachia over a ten-year horizon.[76-78] One study noted that full-scale implementation could strain routine immunisation budgets.[77] A stepwise rollout, prioritising high-burden areas, was proposed alongside measures to expand fiscal space by mobilising domestic revenue through tax reform and economic growth. Exploring blended finance, which combines public and private capital, or insurance-linked models could be alternative approaches to address the fiscal constraints.

In Indonesia several options are under consideration for funding this roll-out. These include a "vaccine *sukuk*" (sharia-compliant bond) budget-tagging mechanisms adapted from climate finance ("green *sukuk* bonds"), and a national trust fund for vaccine procurement and delivery. These proposals draw inspiration from Indonesia's experience managing climate-related financing and reflect a growing effort to adapt alternative global financing tools for health.[79]

New revenue links may also help. "In transport, road taxes can be earmarked for road safety programmes. In health, sugar, alcohol and tobacco taxes can be channeled to address non-communicable diseases. But for infectious diseases, and dengue in particular, we haven't built that linkage," says Mr Patil. "We need to think more creatively." Taiwan has successfully implemented a tobacco and alcohol tax that is earmarked for health, and specifically for immunisation. Around 35% of the total National Vaccine Fund budget is supplied by the tobacco surcharge.[80] In the Philippines, taxes on tobacco, alcohol, and sugar-sweetened beverages are earmarked under Universal Health Care reforms, helping to expand and stabilise funding for the health sector.[81] These examples show how sin taxes can be used to fund prevention and immunisation—offering a template that could be adapted to support dengue control.

"In health, sugar, alcohol and tobacco taxes can be channeled to address non-communicable diseases. But for infectious diseases, and dengue in particular, we haven't built that linkage. We need to think more creatively."

Aniruddha Patil, united head—health and education investments, private sector operations, Asian Development Bank

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Position dengue within broader development agendas

As dengue outbreaks become increasingly shaped by broader environmental, technological and geopolitical forces, new opportunities are emerging to reframe and finance prevention. The growing recognition of climate-sensitive diseases allows countries to tap into funding streams for climate adaptation and resilience. Misinformation challenges—amplified through social media—can be addressed through digital health and behavioural research grants. Meanwhile, shifting donor priorities and geopolitical dynamics may require countries to strengthen regional partnerships and diversify funding sources. These contextual shifts create momentum to reposition dengue prevention as part of a broader investment in development, stability and public health security.

Dengue prevention must thus be positioned within broader resilience and development agendas to unlock more sustainable funding. Thailand's ten-year Vector-Borne Disease Management Strategy is explicitly aligned with the Sustainable Development Goals (SDGs) and Universal Health Coverage, and calls for integration with global partners such as the Global Fund, USAID, and GAVI.[39] But the global funding landscape is shifting. Donor support for dengue may become less predictable over time, requiring countries to diversify funding sources. Regional cooperation platforms like the Association of South-East Asian Nations (ASEAN) could play a greater role by recognising dengue as a regional priority and mobilising collective resources for surveillance, vector control, and vaccine access. Other philanthropic organisations can play a catalytic role by supporting pilot programmes, funding new research and championing dengue as a global health priority within broader development conversations.

National cost data can help build this case. In Malaysia, the total annual cost of dengue is estimated at $68.9 million, with 67% of the burden coming from indirect costs, such as lost productivity. This burden is spread across ministries of health, labour, education and housing—highlighting how dengue is a cross-cutting economic and social issue. Climate-sensitive urban planning, workplace health policies, and social protection systems all have a role to play. By framing dengue prevention as an investment in economic resilience and workforce stability, countries can access a broader set of funding streams, including those focused on climate adaptation, health security, and sustainable development.[82] Mr Patil notes, "Getting a dedicated, multi-year budget for dengue is a challenge. It's hard to quantify the economic impact—and that's what finance ministries need to justify the investment." Studies assessing the economic toll of dengue, as is the case above, are therefore crucial to securing long-term political and financial commitment.

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> **"Getting a dedicated, multi-year budget for dengue is a challenge. It's hard to quantify the economic impact—and that's what finance ministries need to justify the investment."**
>
> **Aniruddha Patil**, unit head–health and education investments, private-sector operations, Asian Development Bank

The table below lists the key action items under Strategic Domain IV. Each specifies where capacity needs to be built or strengthened, who leads the effort and who supports it for effective implementation. Each action item also corresponds to a core target area, offering a reference point for countries seeking to assess or focus efforts in specific areas of dengue prevention.

Strategic Domain IV: Expand sustainable and diversified financing

Target areas: Stewardship, Surveillance, Science, Skills, Support

Target areas	Key action items	What is needed?	Who leads it?	Who supports it?
Attract private capital and funding				
	Create co-financing partnerships with private sector	Public-private partnership (PPP) legal, technical and engagement capacity	Health ministry, finance ministry	Private companies, insurers, employers, universities, development partners
	Design value propositions to attract private investment	Market analysis and incentive design	Health ministry, industry or trade ministry	Finance ministry, business associations

Abbreviations: PPP = public-private partnership

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Strategic Domain IV: Expand sustainable and diversified financing

Target areas:
Stewardship · Surveillance · Science · Skills · Support

Target areas	Key action items	What is needed?	Who leads it?	Who supports it?
Scale what works with innovative financing models				
	Pilot innovative financing models (eg, social-impact bonds*)	Expertise in impact investing and pooled procurement	Health ministry, finance ministry	Development partners, investors, insurers, universities
Position dengue within broader development agendas				
	Include dengue in cross-sector funding proposals (climate, health security, GAVI, etc)	Proposal development and cross-sector co-ordination	Health ministry, finance ministry	Environment and urban ministries, UN agencies, donors
	Align financing with SDG and UHC goals	Health finance strategy and co-budgeting capacity	Health ministry, planning ministry	Education, urban and local government ministries, donors
	Leverage existing funds for messaging and mobilisation	Budget tracking and risk communication capacity	Health ministry, finance ministry	NGOs, community health groups, development partners

Abbreviations: GAVI = Global Alliance for Vaccines and Immunisation; UN = United Nations; SDG = Sustainable Development Goals; UHC = Universal Health Coverage; NGOs = non-governmental organisation
* Social-impact bonds = An outcome-based financing mechanism in which private investors fund social programmes upfront. If the programmes meet or exceed agreed-upon targets, the investors are repaid (often with a return) by the commissioning body. If the programmes fail to achieve sufficient results, investors bear some or all of the financial loss.
Source: Social Impact Bonds. OECD report.

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Strategic Domain V: Leverage community power for resilient dengue prevention

Public participation is critical to dengue control: without community trust, knowledge and action, even the best interventions will fall short. Tailored communication, sustained engagement and locally adapted incentives empower people to adopt protective behaviours, dispel misinformation, and sustain preventive action over time. Empowering communities also builds resilience, fostering a sense of shared responsibility for health outcomes.

The WHO notes, "Community engagement is central to our strategy...only this approach is likely to lead to sustained behavioural impact."[12]

What gets in the way:

- **One-size-fits-all communication strategies** fail to resonate across diverse cultural, linguistic, and socio-economic groups.
- **Gaps in monitoring public attitudes, misinformation, and behavioural drivers** hinder early and effective engagement.
- **A lack of sustained, locally meaningful incentives** limits community motivation to maintain preventive behaviours and take ownership of dengue prevention.
- **Insufficient emphasis on finding, empowering, and showcasing** trusted local leaders diminishes the reach and credibility of public health messaging.

Teach it, track it, turn the tide

Engagement begins with education and is sustained through behaviour change and strengthened by real-time feedback. Long-term awareness and action depend on credible messaging, context-specific outreach and clear public feedback loops that build trust and drive change.

In Brazil, gaps in communication continue to limit the impact of dengue-prevention efforts. A recent national study concluded that there is a need to decentralise communication, investing in interpersonal and community strategies that reflect local contexts.[83] Maria Aparecida de Oliveira, a researcher at the Global Public Health Observatory postdoctoral fellow at Johns Hopkins Bloomberg School of Public Health and senior consultant at UNESCO in Brazil, reinforces this point: "The main issue in Brazil is clear communication with the public. We keep having outbreaks because recommendations are not implemented—and health education is still missing." Yet local successes suggest what is possible. In Fortaleza, a year-long, community-led intervention significantly reduced mosquito densities by combining school mobilisation, clean-up drives and targeted messaging.[84] Still, such efforts remain the exception rather than the norm.

In Argentina, the Ministry of Health's 2024 communication strategy reframed dengue prevention as a year-round responsibility. Campaigns targeted schools, households and community spaces, moving away from a focus

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on fogging and towards daily practices like source reduction.[33] In Córdoba, student-led science programmes turned schoolchildren into household health educators. Following the intervention, 65% of students reported their families had become more proactive in removing containers where mosquitoes could breed.[85] Ms Boaventura affirms that starting behaviours young is key. "Investments in health education, starting at schools, can be a game changer in improving dengue prevention—both for vector control and vaccine uptake," she says.

"Investments in health education, starting at schools, can be a game changer in improving dengue prevention—both for vector control and vaccine uptake."

Viviane Boaventura, researcher at Oswaldo Cruz Foundation, and associate professor and co-ordinator of the immunopathology programme, School of Medicine, Federal University of Bahia, Brazil

Across the Asia-Pacific region, sustained community engagement efforts have highlighted the importance of locally tailored approaches. In Malaysia and Indonesia, faith leaders have played a central role in promoting vaccine acceptance and dispelling misinformation, especially in conservative or hesitant communities.[13] Meanwhile in Thailand and Vietnam, knowledge, attitudes and practice surveys on preventive behaviours have been used to refine outreach strategies, revealing persistent gaps between moderate awareness and low adoption of preventive practices.[86, 87]

People today are no longer passive recipients of information. They choose what to watch, read and share—often turning to social media instead of official sources. As a result, national TV campaigns often fail to give people the guidance they want.[84] This reflects a growing need to invest in trusted local voices and digital influencers who shape community narratives—particularly as social media plays a growing role in both disseminating and countering misinformation. Professor Pang explains, "Health care professionals who are active on social media can be highly influential in raising awareness about dengue among patients and their families."

As social media platforms increasingly shape public opinion, more emphasis is needed on real-time tracking of public sentiment—monitoring beliefs, behaviours and misinformation trends before they gain traction. This is where proactive "pre-bunking" becomes essential: equipping communities with clear, trusted information before disinformation takes hold. "After covid-19, the heightened stigma around vaccines has made it even more important to strengthen communication strategies to effectively counter misinformation and boost vaccine uptake," says Ms Boaventura.

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Design for trust, deliver through local channels

Reaching the right people with timely, tailored messages is essential to building trust and encouraging dengue prevention. Dr Quevedo explains, "Campaigns must be rooted in local communities—because trust isn't built with one-size-fits-all messages, but through voices that speak to people's realities. Clarity and cultural relevance are our best antidotes against misinformation and disinformation."

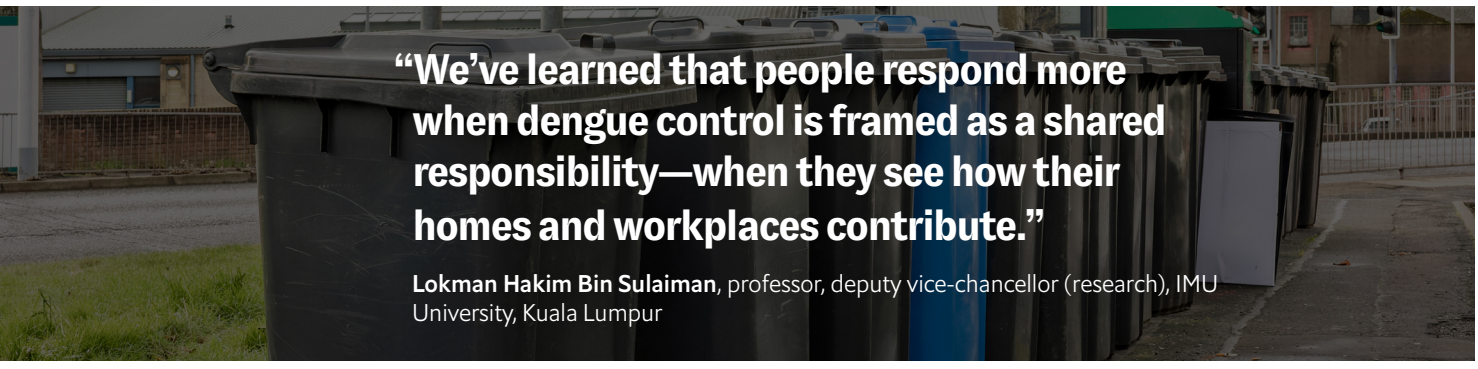
A review of arbovirus surveillance found that mobile apps and platforms like X, formerly called Twitter, were useful for sending real-time alerts, tracking rumours and nudging users towards safer behaviours. In some cases, online searches about dengue helped predict outbreaks up to eight weeks in advance. But digital tools come with risks—such as information overload, poor data quality, and the exclusion of people without internet access.[88] Technical safeguards are needed.

So is thoughtful messaging—an observation reinforced by findings from a 2024 cross-regional study of youth in Latin America and the Asia-Pacific. While general awareness of dengue was moderate, only 33.5% of young people in the Asia-Pacific and 50.6% in Latin America had heard of dengue vaccines. Willingness to be vaccinated was even lower—just 40.1% in the Asia-Pacific and 48.2% in Latin America. The study also found that knowledge alone did not lead to behaviour change; gaps in trust, lingering vaccine concerns, and lack of localised messaging remained key barriers.[13]

Make communities part of the solution

When governments co-ordinate effectively with communities, responsibility for dengue prevention becomes shared. The Brazilian city of Fortaleza provides a notable example. As part of a WHO-led initiative, "disease agents" partnered with schools, religious groups, and municipal agencies to replace chemical fogging with mechanical control methods such as container removal. Community members were informed before waste collection days and given guidance on prevention techniques. The initiative reduced vector indices and shifted dengue prevention from a government-driven activity to a co-produced public good.[89]

Malaysia has embedded this idea into its national strategy through the *gotong royong* model, rooted in the cultural value of mutual aid. Informal neighbourhood leaders mobilise residents for regular clean-up drives, supported by clear messaging and shared norms. These community figures act as local champions, reinforcing expectations and creating peer pressure to maintain dengue-free environments. In this way, communities take an active, visible role in sustaining vector control.[90] Professor Lokman explains, "We've learned that people respond more when dengue control is framed as a shared responsibility—when they see how their homes and workplaces contribute."



"We've learned that people respond more when dengue control is framed as a shared responsibility—when they see how their homes and workplaces contribute."

Lokman Hakim Bin Sulaiman, professor, deputy vice-chancellor (research), IMU University, Kuala Lumpur

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The table below lists the key action items under Strategic Domain V. Each specifies where capacity needs to be built or strengthened, who leads the effort and who supports it for effective implementation. Each action item also corresponds to a core target area, offering a reference point for countries seeking to assess or focus efforts in specific areas of dengue prevention.

Strategic Domain V: Leverage community power for resilient dengue prevention

Target areas:

Stewardship · Surveillance · Science · Skills · Support

Target areas	Key action items	What is needed?	Who leads it?	Who supports it?
Teach it, track it, turn the tide				
	Run targeted awareness campaigns in schools and communities	Public campaign design, school health education	Health ministry, local government, local health authorities	Education ministry, schools, community groups, media, employers
	Assess community knowledge, attitudes, and behaviours through surveys and feedback tools	Behavioural research and feedback tools	Health ministry, local government, public health agency, local health authorities	Universities, NGOs, civil society, development partners
	Train community leaders to promote dengue prevention	Community training and standard messaging	Health ministry, local government, public health agency, local health authorities	Universities, NGOs, civil society
	Counter misinformation with trusted channels	Crisis communication and media engagement	Technology ministry, tech and media companies	Local health authorities, community groups, influencers, health ministry
	Engage trusted public figures to amplify dengue prevention messages and promote positive behaviours	Strategic communication partnerships	Health ministry, local government, local health authorities	Media, community groups
Design for trust, deliver through local channels				
	Adapt messages to local culture and context	Culturally sensitive communication capacity	Health ministry, local health authorities	Universities, behavioural scientists, community and civil society

Abbreviations: NGOs = non-government organisations

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Strategic Domain V: Leverage community power for resilient dengue prevention

Target areas:
Stewardship · Surveillance · Science · Skills · Support

Target areas	Key action items	What is needed?	Who leads it?	Who supports it?
	Deploy digital tools and apps for behaviour change	Digital tools and user-centred design	Health ministry, digital health units, tech partners	Health workers, civil society groups
	Use schools and workplaces as training hubs	Community-based education systems	Public health agency, local government, local health authorities, schools, community groups, employers	Universities, NGOs, civil society, development partners
Make communities are part of the solution				
	Co-ordinate top-down and community efforts	Local co-ordination and monitoring systems	Local government, local health authorities, health ministry	Health workers, civil society groups
	Promote local champions and success stories	Recognition and social mobilisation strategies	Local government, local health authorities, health ministry	Media, civil society, schools, religious institutions

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Strategic Domain VI: Drive impact through partnerships across sectors

While strong national leadership and political will are essential foundations for dengue prevention—as outlined in the section on Strategic Domain I—they are not enough on their own. Effective dengue prevention also depends on empowered local action and active co-ordination across sectors. Strategies must be coherent nationally but responsive to local contexts. Equally important are formal partnerships with public, private and civil-society actors, which help align priorities, share data and pool resources. Together, these vertical and horizontal links reduce fragmentation and support a more unified, agile response.

As the WHO notes, "Building partnerships across government, academia, NGOs, and the private sector enables countries to align efforts, anticipate challenges, share resources, and adapt swiftly to emerging risks, ensuring interventions are both coherent nationally and effective at the community level."[12]

What gets in the way:

- **Siloed governance structures** weaken co-ordination across ministries, sectors and administrative levels.
- **Limited platforms and incentives** for data-sharing across borders and between sectors hinder joint planning and action.
- **Poor alignment between national strategies and local implementation** reduces the coherence and effectiveness of the dengue response.
- **Underdeveloped public-private partnerships** limit access to partnerships for innovation, financing and delivery.

Making decentralisation work

Effective dengue control relies on strong national leadership working in tandem with empowered local implementation. Thailand demonstrates this balance well: subdistrict governments are legally authorised to enforce vector control through local ordinances, while the national public health system leads surveillance, ensuring national coherence with local responsiveness.[40] In general, roles are clearly defined across government levels—from national strategy-setting to municipality-led outbreak investigations—ensuring a co-ordinated and timely response.[32] Yet clear roles alone are not enough; gaps in capacity and financing can hinder effective local execution. Dr Quevedo observes, "Most countries in the Latam region follow the same model: a centralised leadership with local implementation. However, a disconnection is observed in what central government wants to achieve and what states

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and cities can achieve, considering their available capacities."

"A disconnection is observed in what central government wants to achieve and what states and cities can achieve, considering their available capacities."

Eduardo Quevedo, regional advocacy and government relations manager for Latin America, World Mosquito Programme

Argentina illustrates the challenge of balancing national co-ordination with provincial autonomy in a federal system. Each province has its own health ministry, and the National Health Council (COFESA) meets monthly to align policies across the 24 jurisdictions. Tomás Orduna, a tropical infectious disease specialist and former head of Department of Tropical and Travel Medicine (CEMPRA-MT) at the F. J. Muñiz Infectious Disease Hospital, Argentina explains, "COFESA convenes all 24 provincial ministries of health monthly, aiming to provide homogeneity in execution of policies across [the] country. In practice, each province adapts the policies to their local resources and past outbreak experience." While the structure encourages policy alignment, implementation still depends on local capacity and experience.

Indonesia offers a promising example of local adaptation. In Sleman, risk mapping using a geographic information system has helped guide targeted interventions.[91] Meanwhile, improved co-ordination between hospitals, health centres, and local authorities to ensure dengue prevention efforts are consistent and aligned with national goals is becoming a priority. A recent review of dengue programme implementation in Bandung pointed to the importance of streamlining roles and communication between levels of government to support more effective and coherent delivery.[92] National plans must still leave room for local autonomy and respond to on-the-ground realities in this process. Professor Arguni explains, "Programmes are always top-down from the central government, but we also have local autonomy. So even if the central government says to do a certain kind of programme, if the provincial government doesn't budget for it, it is not in their work—and that affects the evidence base and how we assess impact."

In Malaysia, district health departments lead vector-control activities and incur the majority of costs, reflecting strong local engagement. There is now an opportunity to strengthen fiscal flexibility through mechanisms like performance-based transfers to better support frontline teams.[93]

These examples suggest that countries are moving towards more adaptive and aligned models, with further scope to enhance co-ordination and funding flow across levels.

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Breaking silos: working across sectors

Dengue prevention is a shared responsibility across sectors—but fragmented governance can lead to duplication and missed opportunities. Promising models of cross-cutting co-ordination are emerging and offer lessons for broader system change.

The citywide dengue programme in Clorinda Argentina highlighted earlier for its integrated delivery, is also an example of effective intersectoral collaboration, involving municipal authorities, research institutions, and women-led community groups in sustained vector control. Over five years, it conducted 120,000 house inspections and 37,000 larvicide applications, sharply reducing larval indices and likely preventing outbreaks. During the 2007 regional surge, Clorinda's dengue incidence was 30 times lower than that of neighbouring Paraguay.[48] These local models are powerful, but need to be replicated and embedded at scale. Dr Orduna explains, "Dengue continues to have an overly centralised role in health and is not supported in the same way by other ministries or areas such as education or the environment. Intersectoral co-ordination needs improvement at the national level in Argentina."

Colombia offers an example of co-ordination at the national level. Through its Puesto de Mando Unificado (PMU), a centralised command centre, the government brings together multiple industries, along with the education and environmental sectors, during declared emergencies, such as a dengue outbreak.[94] "When a situation is declared a priority, all sectors are co-ordinated," explains Professor Cucunubá. The next challenge is to apply this kind of whole-of-government response not only during crises, but as part of everyday prevention.

Collaboration between sectors is not only about alignment, but also learning. Viviane Boaventura, a researcher at the Oswaldo Cruz Foundation and an associate professor at the Federal University of Bahia, explains, "Collaboration between government and academia is essential to generate evidence on what's working—whether strategies are being properly implemented, whether campaigns are influencing behaviour, and what can be improved by comparing outcomes across different regions or cities."

Indonesia's national dengue taskforce brings together health ministries, researchers, local officials and civil society to co-ordinate response and prevention—ensuring dengue remains a shared responsibility across institutions.[31] In Thailand, a multi-sector vector-borne disease strategy aligns health, education and defence agencies under a common plan, supported by digital platforms and donor investment.[39]

"Dengue continues to have an overly centralised role in health and is not supported in the same way by other ministries or areas such as education or the environment. Intersectoral co-ordination needs improvement at the national level in Argentina."

Tomás Orduna, a tropical infectious disease specialist and former head of Department of Tropical and Travel Medicine (CEMPRA-MT) at the F. J. uñiz Infectious Disease Hospital, Argentina

The untapped potential of regional co-operation

Regional co-operation is also gaining traction. UNITEDengue enables real-time data-sharing across borders, while regional initiatives such as the ASEAN Member States Dengue Vaccination

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Advocacy Steering Committee and ASEAN Network for Drugs, Diagnostics, Vaccines, and Traditional Medicines Innovation support vaccine policy harmonisation and research co-ordination.[95] Aniruddha Patil, unit head for health and education investments in private-sector operations at the Asian Development Bank, reflects on this evolving regional agenda: "Collaboration needs to happen at two levels. Within countries, it starts with identifying who is truly responsible—it's not always the health ministry as Singapore shows, where the National Environment Agency leads dengue prevention. Regionally, ASEAN is a strong forum, but it has multiple priorities and needs to be coaxed to bolster its dengue response, perhaps by an honest broker with the power to bring everyone to the table"

However, more can be done to strengthen cross-border reporting and expand lab capacity in under-resourced areas. "ASEAN provides a platform to discuss and share information among countries along the border. But we still lack cross-border field investigation or cross-border dengue control that is actually implemented." adds Dr Areechokchai.

"ASEAN provides a platform to discuss and share information among countries along the border. But we still lack cross-border field investigation or cross-border dengue control that is actually implemented."

Darin Areechokchai, acting medical officer, Department of Disease Control, Thailand Thailand

These experiences reflect growing momentum towards more unified, cross-cutting strategies. When governments move beyond institutional silos and align strategies across sectors and borders, they can respond to dengue more quickly, effectively and sustainably.

Private sector partnerships for reach and results

Structured engagement with the private sector may expand dengue prevention capacity. Brazil has pioneered several innovative tools through such collaboration. Platforms like AESOP—developed with academic, public health, and tech sector partners—combine AI and real-time data to identify emerging dengue hotspots and support a faster response.[96]

Indonesia is exploring ways to involve the private sector more systematically. In Bali, hotels have begun introducing mosquito-control measures, with growing recognition of the role that tourism-linked businesses can play in guest education and local vector reduction.[97]

In Thailand, public-private partnerships support fogging operations, community education, and sanitation improvements, particularly at the subdistrict level. Some local governments have partnered with private pest-control firms to conduct fogging in high-risk zones, while businesses have contributed through clean-up campaigns and waste management as part of corporate social responsibility programmes.[40] This approach potentially allows the government to test implementation strategies without immediate public spending, helping to build evidence that supports national adoption.

The next step is to deepen these partnerships by formalising channels for innovation-sharing, financing, and implementation. Where these relationships are structured and sustained, the private sector can amplify reach and drive long-term gains.

The table below lists the key action items under Strategic Domain VI. Each specifies where capacity needs to be built or strengthened, who leads the effort and who supports it for effective implementation. Each action item also corresponds to a core target area, offering a reference point for countries seeking to assess or focus efforts in specific areas of dengue prevention.

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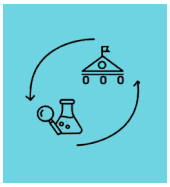

Strategic Domain VI: Drive impact through partnerships across sectors

Target areas: Stewardship, Surveillance, Science, Skills, Support

Target areas	Key action items	What is needed?	Who leads it?	Who supports it?
Making dengue everyone's business				
	Set direction and align local with national goals	Co-ordination tools (frameworks, memorandums of understanding, guidelines)	Health ministry, cabinet secretariat	Local government, local public health authorities
	Tailor local actions to epidemiological trends	Local data use and implementation capacity	Local government	Health ministry, national public health agency, academia
	Support local implementation with funding aligned to national goals	Capacity for performance-based financing	Finance ministry, health ministry	Cabinet secretariat, local government
Moving from reaction to readiness				
	Engage all sectors for strategic alignment	Leadership and co-ordination across sectors	Health ministry, cabinet secretariat	Line ministries*, planning ministry, local government
	Establish cross-sector dengue task-force	Cross-sector training and communication systems	Health ministry, cabinet secretariat	Line ministries*, local government
	Hold regular task force meetings	Data-sharing and reporting systems	Health ministry, national public health agency	Line ministries*, local government
	Establish partnerships for implementation of community-fit solutions	Local partnership management	Local government, health authorities	Community groups
The untapped potential of regional co-operation				
	Facilitate regional dengue collaboration	Capacity for cross-border data and surveillance	Health ministry, national public health agency	Regional agencies, foreign ministry
Private-sector partnerships for reach and results				
	Foster structured collaboration with private sector for research and implementation	Partnership frameworks for joint delivery	Health ministry, local government	Academia, WHO, pharma and tech, construction, insurers, philanthropies

Abbreviations: WHO = World Health Organisation; pharma = pharmaceutical; tech = technology
*Line ministries include: Environment, Education, Urban Development, Tourism, Finance etc.

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What next?

The report highlights 6 strategic domains where countries should focus to make meaningful, long-term progress on dengue prevention. These include:

1. **S**ecuring political will to put dengue on the national agenda
2. **H**armonising and building integrated prevention systems
3. **I**nforming actions with data and digital tools
4. **E**xpanding sustainable and diversified financing
5. **L**everaging community power for resilient dengue prevention; and
6. **D**riving impact through partnerships across sectors

As dengue becomes more frequent, severe and widespread, there is no time for delay. Governments must act before seasonal outbreaks tip into regional crises. But action must also be smarter. Efforts must be designed to last—capable of adapting to shifting climates, the emergence of new technologies and a changing global health landscape.

Crucially, dengue cannot be addressed in isolation. It shares vectors, risk drivers and response systems with other arboviruses. Integrating dengue prevention into broader public health and climate resilience strategies offers an opportunity to amplify impact and future-proof national systems against a growing spectrum of mosquito-borne disease threats.

This is not just a toolkit for dengue. It is a call to rethink how countries plan, partner and invest in epidemic prevention for the future. The priorities are clear and the path is defined. What matters now is action.

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Appendix I: Methodology

This report was developed through a multi-phase research process combining a structured literature review, expert consultation and iterative drafting to develop a practical and evidence-based dengue prevention toolkit.

Laying the groundwork: literature review

We began with a structured review of global and regional literature to understand what works, and what gaps exist in dengue prevention and control. Separate reviews were conducted for Latin America and the Asia-Pacific to capture differences in approach, health systems and disease dynamics. Both reviews followed a systematic search covering peer-reviewed research, grey literature and policy documents from the past decade. This was complemented by a small number of current government policy documents shared by Takeda's country research teams.

A full description of the review process, along with two PRISMA diagram—for Latin America (Figure A1) and the Asia-Pacific (Figure A2)—is provided in the following figures below:

Figure A1: Latin America literature review PRISMA diagram

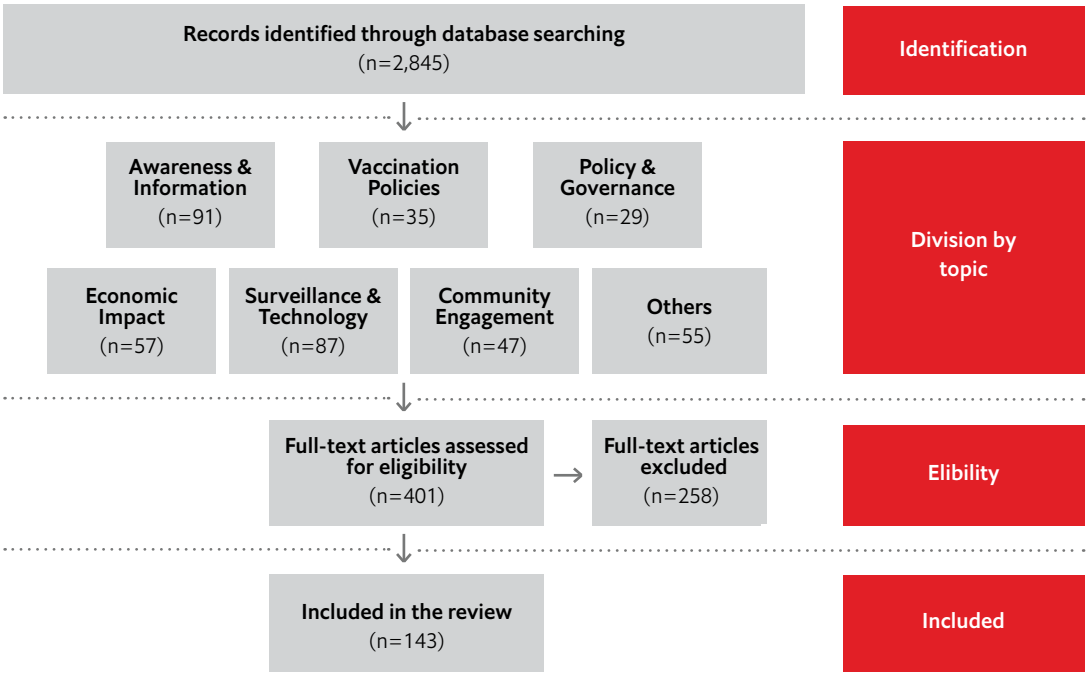

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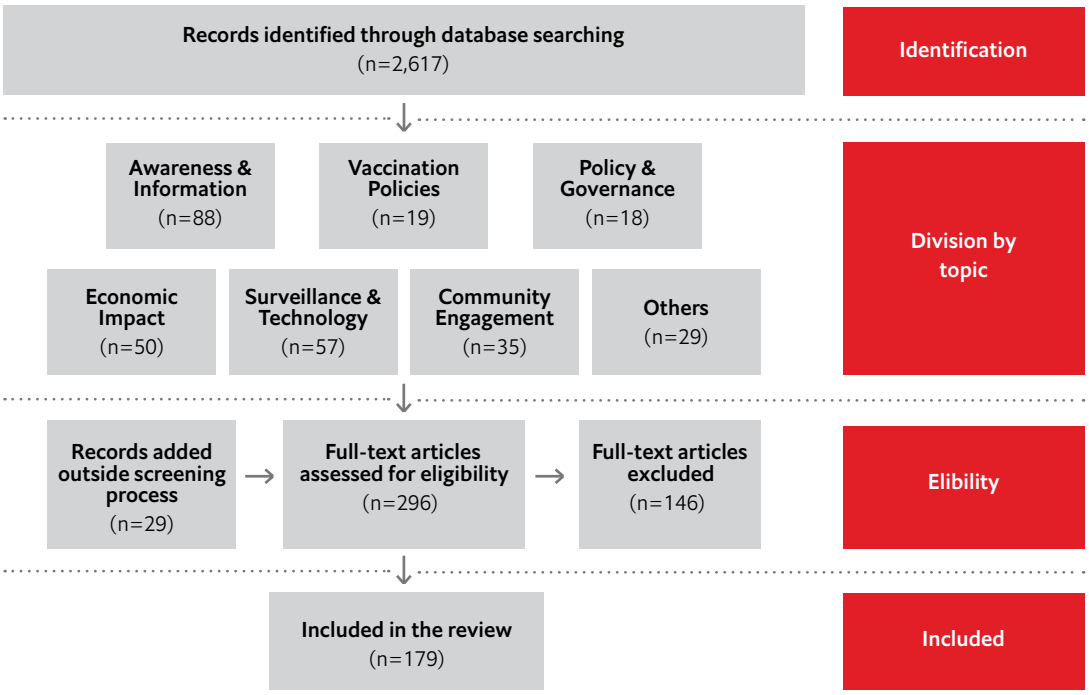
Figure A2: Asia Pacific literature review PRISMA diagram



In parallel, we reviewed key guidance from the WHO, including *Global Strategic Preparedness and Response Plan for Dengue (2022-2030)*, *Global Vector Control Response (2017-2030)*, *Global Arbovirus Initiative (2022)* and the *Roadmap for Neglected Tropical Diseases (2021-2030)*.[12, 26, 27] These materials helped shape the structure of the toolkit and ensured alignment with international strategy.

Building the framework: strategic domains and target areas

The framework is organised around 6 strategic domains—core pillars of dengue prevention. In each strategic domain, there are several key action points organised by their action objectives.

Each key action point in the toolkit maps to one target area and includes the relevant stakeholders and capacity needs. This structure reflects the intersectoral nature of dengue prevention, with each domain covering different target areas and involving a range of stakeholders.

Testing and refining: expert consultation

To validate the toolkit, we held two regional workshops with experts from across the seven focus countries: Argentina, Brazil, Colombia, Indonesia, Malaysia, Thailand and Vietnam. These included leading voices in dengue research, policy and practice, from national disease-control officials and hospital directors to academic researchers, regional advocates and development finance specialists.

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Experts were asked to review domain-specific actions and comment on the relevance of each proposed action item within their national and subnational contexts. These discussions were important in identifying barriers to practical implementation, unearthing new practices and clarifying the roles of stakeholders across a variety of sectors. Country examples provided by experts were incorporated throughout the report to illustrate implementation in practice.

From research to report

Following the consultations, we wrote this narrative report, which combines findings from the literature with country examples and expert quotes. The toolkit was finalised alongside the report and shared in full in two versions (see Toolkit by strategic domain and Toolkit by target area).

Several rounds of internal review were done to sharpen the language and check for gaps, ensuring the content was practical for policy audiences. The result is a flexible toolkit that all countries can adapt and apply to strengthen dengue prevention across sectors.

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Appendix II: Analysis on potential reallocation of dengue cost

Table A1: Potential reallocation of dengue costs (2025 dollars, 30% savings scenario)

Country	Dengue cost 2013 ($m)*	2025 CPI-adjusted cost ($m)	Avg annual doctor salary 2025	Doctors funded (30% cost saved)
Indonesia	$2,195	$3,022	$54,321	16,690
Brazil	$728	$1,003	$48,750	6,170
Malaysia	$608	$837	$67,044	3,747
Thailand	$425	$585	$54,675	3,210
Colombia	$120	$166	$33,120	1,499
Argentina	$72	$99	$19,983	1,485
Vietnam	$94	$129	$42,705	908

*All figures are in US dollars unless stated otherwise.

Methodology

To estimate the number of doctors who could be financed by reducing dengue-related spending, we first adjusted 2013 cost figures for inflation. Using the United States CPI-U (all-items), the 2013 annual average index of 232.957 was compared to the April 2025 index of 320.795, yielding an inflation factor of 1.377.[1]

We applied this factor to each country's 2013 dengue cost to calculate 2025 price-equivalent totals. These adjusted costs were then divided by the average annual doctor salary in 2025, sourced from World Population Review, to estimate the number of doctors that could be funded if all dengue-related costs were avoided.[2] The table presents a 30% savings scenario to reflect a plausible level of cost reduction through improved dengue prevention.

1. US Bureau of Labour statistics [Accessed on 28 May 2025] Available at: https://data.bls.gov/pdq/SurveyOutputServlet

2. World Population Review [Accessed on 28 May 2025]. Available at: https://worldpopulationreview.com/country-rankings/doctor-pay-by-country#doctor-pay-by-country

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Assumptions

- **Inflation-only adjustment**: Figures are adjusted solely for United States inflation. They do not account for epidemiological change, population growth or increasing urbanisation. As such, actual costs in 2025 may be higher, making these estimates conservative.
- **Public-sector equivalence**: Salaries are based on 2025 national average doctor earnings, which may include private sector pay. For this analysis, these are assumed to approximate public-sector compensation.
- **Uniform salaries**: Country-level averages are used. Variation by seniority, specialisation or region is not reflected.
- **Currency neutrality**: All figures are in United States dollars. Exchange-rate movements since 2013 are not considered.
- **Feasibility framing**: A 30% savings rate was selected to reflect plausible reductions through integrated prevention rather than full cost elimination.

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