Learnings from Thailand in building strong surveillance for malaria elimination

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On the cusp of *Plasmodium falciparum* (*Pf*) elimination, Thailand is accelerating towards zero malaria by 2024. This commentary reviews the heart of its success—effective surveillance—and what else may be needed to reach zero on time.

Thailand aims to eliminate malaria by 2024, following China’s malaria elimination certification in 2021 and Sri Lanka’s in 2016. The country reported just 2893 malaria cases last year, down from 24,332 in 2015, mirroring broader progress across the Greater Mekong Subregion (GMS). Regional collaboration has supported Thailand’s success, as malaria epidemiology is heavily influenced by population mobility across forested areas along international borders. Thailand has joined a cohort of 25 countries (dubbed E-2025) with the potential to halt malaria transmission by 2025. To do so, it plans to build on longstanding success factors—robust case-based surveillance informing decentralized action—complemented by new approaches.

Designing surveillance for elimination

A functional surveillance system is crucial for improving malaria services and for measuring progress toward elimination goals, as affirmed in the World Health Organization’s Global Technical Strategy for malaria, which named surveillance as a core intervention. Malaria free status is only bestowed upon countries that can affirm, beyond reasonable doubt, the absence of local transmission for three years. These criteria necessitate a surveillance system that generates complete, reliable, and timely data suitable for action.

Thailand’s National Malaria Elimination Strategy 2017–2026 (NMES) reoriented the malaria control program into an elimination program centered on upgraded surveillance. Thus, in 2017, Thailand adapted the 1-3-7 strategy from China to prioritize timely, evidence-based action. For each confirmed malaria case, notification occurs within 1 day, case classification within 3 days, and local response within 7 days. The resulting data guide district teams to conduct reactive case detection, coordinate across sites for patients with travel history, and identify vector control targets to further inhibit transmission. Adherence to 1-3-7 protocols exceeded 80% within the first few years, and preliminary results suggest the strategy is effectively driving elimination by encouraging rapid response.

The NMES also introduced subvillage-level stratification of “foci” based on past or current malaria transmission. Stratification is an essential tool for considering heterogeneity in epidemiology, geography, and health systems to optimize malaria interventions and the use of resources. Utilizing foci as the unit of measurement results in remarkably detailed information for Thailand’s interventions and analyses. This granularity, a hallmark of malaria elimination
to its efforts, resulting in a proportional rise in Reaching and maintaining zero malaria potential causes, and development of symbiotic countries’ interventions that enabled this success may not suf 18. This door biting, limiting the effectiveness of interventions like shorter course tafenoquine to improve treatment adherence17. prevent relapse and is exploring the feasibility to safely introduce transmission is insuf fi cacy monitoring fol- rm parasite clearance and rm information relevant and actionable for local jurisdictions. a malaria vector that for some countries challenges is exacerbated by long hours spent outdoors playing, and seasonal workers. Promising research that could support Thailand’s elimination goals includes chemoprophylaxis for forest goers19, topical microbial repellants20, and mass drug administration with endectocides like ivermectin21, 22.

Prevention of re-establishment (POR) planning is a require- ment for malaria elimination and a key component of Thailand’s strategy to sustain fragile gains. Provincial POR plans will utilize an expanded stratification, comprising epidemiological and environmental receptivity and vulnerability, to outline actions that prevent local transmission if cases are identified. These actions will rely on a broad workforce as part of Thailand’s gradual integration of its vertical malaria program into the general health system.

Vital to the success of both POR and elimination will be the retention of high-quality surveillance, despite an inevitably reduced central malaria team. In addition to building technical capacity, investing in data quality and interoperability can simplify fundamental analyses for a general health staff with competing priorities. The comprehensiveness of Thailand’s surveillance approaches is admirable; however, in a future scenario of very few, dispersed malaria cases, nimble strategies that balance risk of transmission with available resources could be beneficial.

There is a reciprocal relationship between malaria burden and surveillance needs, resulting in increasing costs per case as countries approach elimination. Unfortunately, where malaria decreases, risk perception may follow, and it may become harder to rally political, financial, and popular support for malaria programming. To fully fund the NMES, Thailand advocated for domestic resources to complement external funds. Since then, funding partners are increasingly harmonizing their resources. In tandem, Thailand is encouraging subnational units to prioritize malaria in their local budgets and engage in malaria programming.

Finally, a crucial factor for success will be continued leadership that prioritizes compassion and equity. Malaria patients may live on the fringes of society or geography, and elimination will require flexible and safe ways to reach the displaced, under-employed, and unreached. Policy and resilience are strengthened by a plurality of perspectives, so engaging women, youth, and minority communities in decision-making may spark the creativity needed in last-mile endeavors. Thailand is setting a notable example, with women at the helm of the Division of Vector Borne Diseases and several of its subunits.

Although at the global level, momentum against malaria has slowed, Thailand exemplifies that for some countries—including several in the GMS—crossing the malaria elimination finish line is a reality within view.

Cross-continental trends in surveillance
Like Thailand, a growing number of national malaria programs across sub-Saharan Africa (SSA) are facing multiple transmission settings within country boundaries. To remain relevant, the surveil- lance system and in-country expertise must evolve to meet changing data needs. For many countries in SSA, this will begin with a transition from aggregate to case-based reporting. But Thailand’s experience shows that continual subsequent system refinements are needed. Additional tools, such as interactive dashboards and mobile applications, can promote appropriately decentralized data review and decision-making in a heteroge- neous context but may also require revisions. There is limited understanding about the cost of maintaining these iterations of effective malaria surveillance from control to elimination11.

There is newfound demand for drug efficacy monitoring follow- ing the emergence of partial artemisinin resistance in P f parasites in Uganda12 and Rwanda13. As similar trends may have put pressure on partner drugs such as piperaquine in the GMS14, these findings may threaten a range of antimalarial formulations in SSA. GMS countries have substantial experience to share, developed through regional collaboration. Active participation in regional networks on drug efficacy surveillance, which is inher- ently a cross-border issue, will support data sharing, research on potential causes, and development of symbiotic countries’ strategies, as well as maximize available resources in SSA.

Reaching and maintaining zero malaria
The legacy of Thailand’s success is a complex map of remaining cases clustered in hard-to-reach areas and populations. As the interventions that enabled this success may not suffice to reach zero malaria, the country is always considering new approaches.

As in many elimination settings, Thailand has seen P f succumb to its efforts, resulting in a proportional rise in Plasmodium vivax (P v), which was responsible for 94% of cases last year. Since P v can relapse, causing iterant episodes of malaria16, interrupting transmission is insufficient for elimination. Thailand has been successfully using 14-day primaquine for radical treatment to prevent relapse and is exploring the feasibility to safely introduce shorter course tafenoquine to improve treatment adherence17.

Thailand’s primary malaria vectors show preference for outdoor biting, limiting the effectiveness of interventions like insecticide-treated nets and indoor residual spraying. This challenge is exacerbated by long hours spent outdoors playing, traveling, or working by populations like school-aged children, forest goers, and seasonal workers. Promising research that could support Thailand’s elimination goals includes chemoprophylaxis

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**References**

1. Zeroin, J. Zeroing in on malaria elimination. Final report of the E-2020 initiative. (World Health Organization, Geneva, 2021).
2. Global technical strategy for malaria 2016–2030, 2021 update. (World Health Organization, Geneva, 2021).
3. Cao, J. et al. Communicating and monitoring surveillance and response activities for malaria elimination: China’s “1-3-7” strategy. PLoS Med. 11, e1001642 (2014).
4. Lertpiriyasuwat, C. et al. Implementation and success factors from Thailand’s 1-3-7 surveillance strategy for malaria elimination. Malar. J. 20, 201 (2021).
5. Dondorp, A. M. et al. Artemisinin resistance in Plasmodium falciparum malaria. N. Engl. J. Med. 361, 455–467 (2009).

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1. Zeroin, J. Zeroing in on malaria elimination. Final report of the E-2020 initiative. (World Health Organization, Geneva, 2021).
2. Global technical strategy for malaria 2016–2030, 2021 update. (World Health Organization, Geneva, 2021).
3. Cao, J. et al. Communicating and monitoring surveillance and response activities for malaria elimination: China’s “1-3-7” strategy. PLoS Med. 11, e1001642 (2014).
4. Lertpiriyasuwat, C. et al. Implementation and success factors from Thailand’s 1-3-7 surveillance strategy for malaria elimination. Malar. J. 20, 201 (2021).
5. Dondorp, A. M. et al. Artemisinin resistance in Plasmodium falciparum malaria. N. Engl. J. Med. 361, 455–467 (2009).
6. Ashley, E. A. et al. Spread of artemisinin resistance in *Plasmodium falciparum* malaria. *N. Engl. J. Med.* 371, 411–423 (2014).

7. Imwong, M. et al. The spread of artemisinin-resistant *Plasmodium falciparum* in the Greater Mekong subregion: a molecular epidemiology observational study. *Lancet Infect. Dis.* 17, 491–497 (2017).

8. Sudathip, P. et al. Progress and challenges of integrated drug efficacy surveillance for uncomplicated malaria in Thailand. *Malar. J.* 20, 261 (2021).

9. Boonyalai, N. et al. *Plasmodium falciparum* phenotypic and genotypic resistance profile during the emergence of Piperazine resistance in Northeastern Thailand. *Sci. Rep.* 11, 13419 (2021).

10. Ma, S. et al. Effectiveness of implementation of electronic malaria information system as the national malaria surveillance system in Thailand. *JMIR Public Health Surveill.* 2, e20 (2016).

11. Shah, J. A. & Ye, Y. Strengthening malaria surveillance systems: do we have a good understanding of the level of investment needed? Symposium at 69th American Society of Tropical Medicine and Hygiene Annual Meeting, virtual (2020).

12. Asua, V. et al. Changing prevalence of potential mediators of aminoquinoline, antifolate, and artemisinin resistance across Uganda. *J. Infect. Dis.* 223, 985–994 (2021).

13. Uwimana, A. et al. Emergence and clonal expansion of in vitro artemisinin-resistant *Plasmodium falciparum kelch13 R561H* mutant parasites in Rwanda. *Nat. Med.* 26, 1602–1608 (2020).

14. Amaratunga, C. et al. Dihydroartemisinin-piperaquine resistance in *Plasmodium falciparum* malaria in Cambodia: a multisite prospective cohort study. *Lancet Infect. Dis.* 16, 357–365 (2016).

15. Price, R. N., Commons, R. J., Battle, K. E., Thriemer, K. & Mendis, K. *Plasmodium vivax* in the era of the shrinking *P. falciparum* map. *Trends Parasitol.* 36, 560–570 (2020).

16. Chu, C. S. & White, N. J. Management of relapsing *Plasmodium vivax* malaria. *Expert Rev. Anti Infect. Ther.* 14, 885–900 (2016).

17. Llanos-Cuentas, A. et al. Tafenoquine versus primaquine to prevent relapse of *Plasmodium vivax* malaria. *N. Engl. J. Med.* 380, 229–241 (2019).

18. Trung, H. D. et al. Behavioural heterogeneity of anopheline species in ecologically different localities in Southeast Asia: a challenge for vector control. *Trop. Med Int Health* 10, 251–262 (2005).

19. Jongdeepaisal, M. et al. Acceptability and feasibility of malaria prophylaxis for forest goers: findings from a qualitative study in Cambodia. *Malar. J.* 20, 446 (2021).

20. Lucas-Barbosa, D., DeGennaro, M., Mathis, A. & Verhulst, N. O. Skin bacterial volatiles: propelling the future of vector control. *Trends Parasitol.* 38, 15–22 (2022).

21. Kobylinski, K. C. et al. Safety, pharmacokinetics, and mosquito-lethal effects of ivermectin in combination with dihydroartemisinin-piperaquine and primaquine in healthy adult Thai subjects. *Clin. Pharm. Ther.* 107, 1221–1230 (2020).

22. Wamaket, N. et al. Anopheles bionomics in a malaria endemic area of southern Thailand. *Parasit. Vectors* 14, 378 (2021).

23. Sudathip, P. et al. The investment case for malaria elimination in Thailand: a cost-benefit analysis. *Am. J. Tropical Med. Hyg.* 100, 1445–1453 (2019).

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J.A.S. wrote this commentary.

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