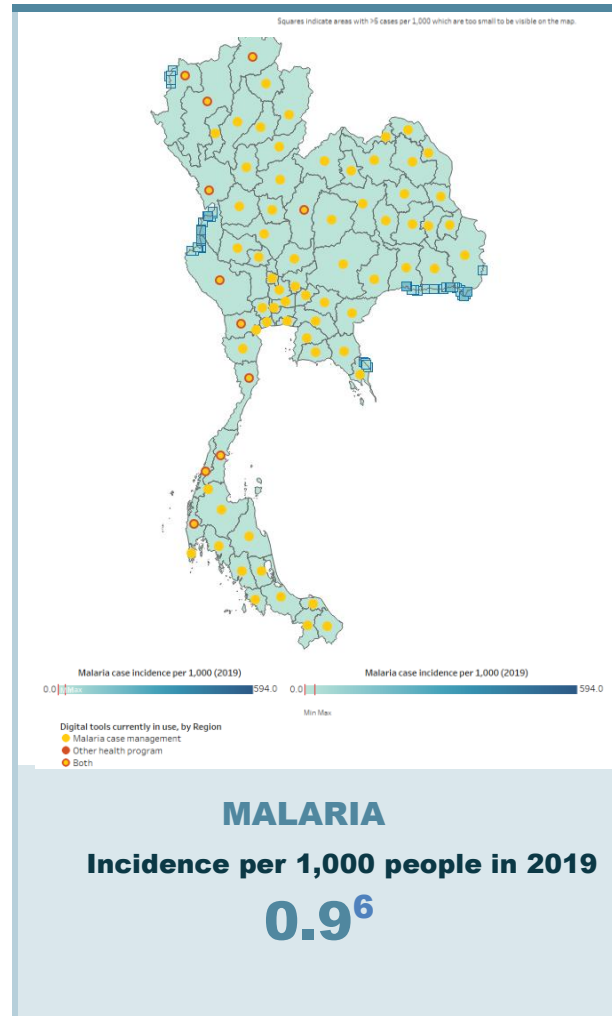# THAILAND

Executive Summary

In the last decade, Thailand has achieved a 91 percent decrease in malaria incidence through efforts led by the Ministry of Public Health's (MOPH) Division of Vector Borne Diseases (DVBD), in coordination with and civil society organizations (CSOs).[1] In this epidemiological context, Thailand's *National Malaria Elimination Strategy* (2017–2026) includes a commitment to "develop technologies, innovations, measures, and models" to achieve malaria elimination by 2024.[2]

DVBD has used "Malaria Online," a web-based Tableau business intelligence platform, as its malaria information system (MIS) since 2009. Malaria Online is one of the most comprehensive digital surveillance systems in the region. It tracks near real-time, geo-referenced, case-based entomological, epidemiological, and laboratory surveillance data, and generates automated aggregated and graphical reports. Efforts are underway to expand the use of mobile technology at the community level, including for foci management.

Malaria case detection and reporting may become more challenging as remaining cases are concentrated at borders and in geographically remote areas. Investments in strengthening Thailand's MIS and complementary digital health tools need to be planned in the context of Thailand transitioning from a vertical malaria program to integrated management of malaria with other community health priorities within the MOPH.

Squares indicate areas with >5 cases per 1,000 which are too small to be visible on the map.

Malaria case incidence per 1,000 (2019)
0.0 — 594.0   Malaria case incidence per 1,000 (2019)
0.0 — 594.0
Min Max

Digital tools currently in use, by Region
○ Malaria case management
○ Other health program
○ Both

MALARIA
Incidence per 1,000 people in 2019
0.9[6]

PEOPLE
Community Health Worker (CHW)

1,002,450 CHWs[3]
143 per 10,000 people

GOVERNANCE
National Digital Health Strategy
YES[4]

SYSTEMS
Digital Health Index[5]
SCORE: 4

Recommended Actions

The United States President's Malaria Initiative (PMI) and DVBD discussed the following recommendations during a May 2021 workshop, following review of the key findings from in-depth interviews and the desk review. The following recommendations are designed to build on Thailand's strengths and opportunities for improvement related to digital health excellence for malaria and other community health priorities.

PEOPLE

Community health workers and other decision-makers

Expand capacity to use Malaria Online at subnational levels.
Technical expertise is concentrated within the Ministry of Public Health's (MOPH's) Division of Vector Borne Diseases (DVBD) and their technical partners. Considering the pending integration of the malaria program with the broader health system, subnational level capacity building efforts should extend beyond the current malaria workforce.

Create a culture of data appreciation and use at both national and subnational levels.
To improve the data use culture, capacity building is needed in the areas of information and communications technology, subnational use of dashboards, as well as greater collaboration between DVBD and other malaria stakeholders and the existing Surveillance Rapid Response Team and Emergency Operations Center.

Build DVBD and MOPH capacity to oversee maintenance of digital tools.
Investing in building the DVBD's capacity to tailor, update, or troubleshoot the surveillance

GOVERNANCE

Strategies and policies

Develop a strategy for community adoption of digital health.
Given the limited use of digital health tools at the community level in Thailand, there is a need to review the current policy that governs community-level contributions to malaria case management and surveillance. This should be followed by development of a strategy that is appropriate for Thailand's context—preparing for malaria elimination and prevention of malaria reintroduction in future.

Hold collaborative discussions with the Information and Communications Technology unit of the MOPH to discuss process and responsibilities.
To support integration of the malaria information system into the 43 Folders data platform, there is a need to develop specific guidelines on key procedural steps and responsibilities and a more detailed plan for executing the standards outlined in the *Concept of Thailand's Health Information Standards and Interoperability*.

SYSTEMS

Processes and digital tools

Conduct an independent review of Reveal to guide optimal use at the community level.
This would entail obtaining user feedback, assessing the extent to which Reveal is being integrated into Malaria Online, and assessing the need for additional functionalities to optimize use at community level and in the context of the integration of malaria programming and surveillance into Thailand's broader health system. To contribute to this assessment, DVBD should identify the exact specifications, user-friendly qualities, and feasible maintenance requirements needed for community-level use of digital tools, including but not limited to Reveal, to support elimination goals.

Expand data access for subnational partners working in malaria.
Access to data—including disaggregated data—at the subnational level will facilitate data-informed decisions at provincial and lower levels.

Strengthen data exchange between vertical programmatic systems and the national health management information system.

system and digital tools for use at the community level will reduce technical dependence on Mahidol University and global mechanisms, as well as reliance on external funding.

Refresh standard operating procedures on community health workers.

There is a need to clarify the standard operating procedures on outreach workers' roles, responsibilities, and tools that were approved as part of the national malaria elimination strategy.

Ensuring interoperability of the malaria information system and the health management information system is a priority as Thailand integrates its malaria services into the general health system.

Develop an action plan to support integration of Malaria Online with either the R506 or 43 Folders platform.
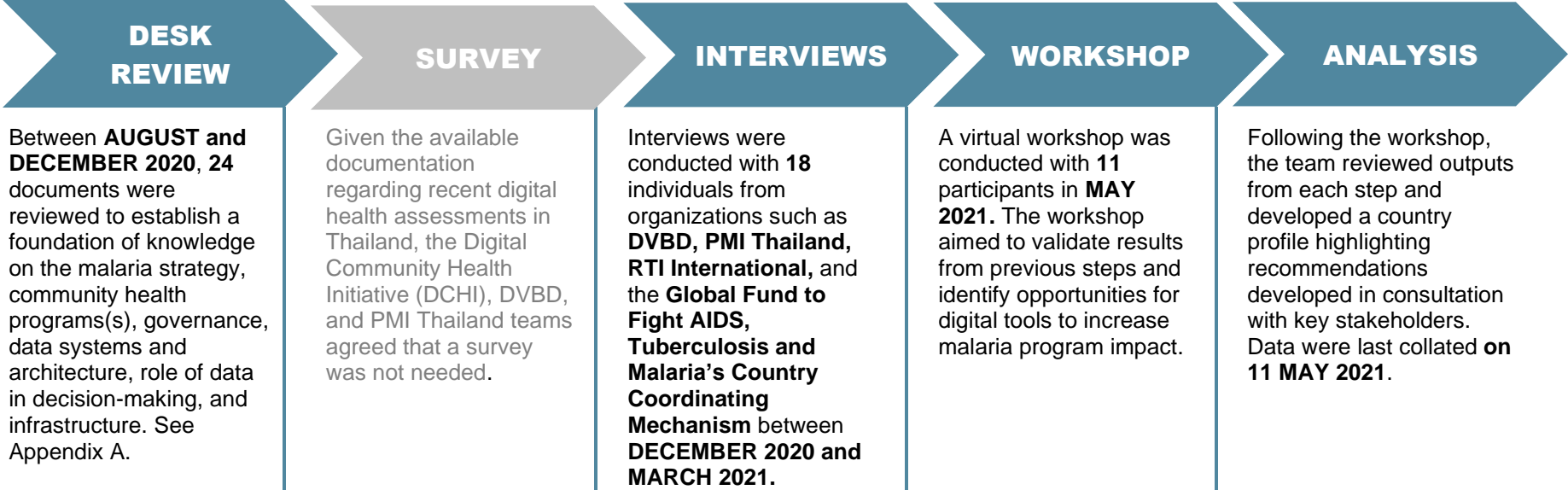
Thailand has two digital health platforms—R506 for notifiable diseases and 43 Folders for all health issues. It is a priority to clarify specific steps to integrate malaria data management systems following the shift from a vertical to an integrated malaria program.

Assess potential for user-friendly, integrated mobile/digital tools to increase community worker effectiveness.

Any digital health tool should be designed for simplicity, practical use, and compatibility with broader health systems. The Clinton Health Access Initiative and Mahidol Oxford Tropical Medicine Research Unit's use of digital tools at the community-level in research activities and the recently expanded use of Reveal at household level for foci management—specifically case detection, case investigation, net distribution and related communication--may yield learnings that can be leveraged to inform expanded application of user-friendly digital tools at the community level in Thailand.

Methodology

To develop this document, PATH incorporated key findings collected from a desk review and key informant interviews. Key findings were validated during a May 2021 virtual workshop with key stakeholders, PMI Thailand, and DVBD. Documentation and revision of the document with input from both DVBD and PMI Thailand was completed during the 6 weeks following the workshop. The entire process took place between August 2020 and July 2021.

DESK REVIEW	SURVEY	INTERVIEWS	WORKSHOP	ANALYSIS
Between **AUGUST and DECEMBER 2020**, **24** documents were reviewed to establish a foundation of knowledge on the malaria strategy, community health programs(s), governance, data systems and architecture, role of data in decision-making, and infrastructure. See Appendix A.	Given the available documentation regarding recent digital health assessments in Thailand, the Digital Community Health Initiative (DCHI), DVBD, and PMI Thailand teams agreed that a survey was not needed.	Interviews were conducted with **18** individuals from organizations such as **DVBD, PMI Thailand, RTI International,** and the **Global Fund to Fight AIDS, Tuberculosis and Malaria's Country Coordinating Mechanism** between **DECEMBER 2020 and MARCH 2021.**	A virtual workshop was conducted with **11** participants in **MAY 2021.** The workshop aimed to validate results from previous steps and identify opportunities for digital tools to increase malaria program impact.	Following the workshop, the team reviewed outputs from each step and developed a country profile highlighting recommendations developed in consultation with key stakeholders. Data were last collated **on 11 MAY 2021**.

Information collected through the methods described above was categorized according to key components within three domains: people, governance, and systems. These domains and their underlying components were informed by an existing maturity model and adapted to incorporate malaria-specific content. The components include personnel, training, and technical support ("People"); policies, strategies and governance structures, and their implementation ("Governance"); and data flow, digital tool structures, functionalities, and use ("Systems"). Together, these components describe the *desired state* for CHW use of digital tools for malaria case management, a state in which community health programs can leverage digital tools to generate and use data that improve malaria programming with the ultimate aim to decrease the local malaria burden.

PEOPLE

People highlights the community health workers, supervisors, information technology support staff, and decision-makers who contribute to effective use of digital tools and data in malaria community health programs.

GOVERNANCE

Governance describes the national strategies and policies that provide the framework for community health programs' use of digital tools for malaria and their implementation.

SYSTEMS

Systems describes the processes and digital tools that enable community health platforms to effectively use digital technology and data to strengthen malaria and other health programs.

People

Thailand's community health worker (CHW) model has significant reach through an estimated 1 million outreach workers nationwide; however only 2,450 of them focus on malaria. These CHWs are located predominantly in rural provinces. Currently, CHWs focus on noncommunicable diseases, but they are transitioning to an integrated model known as the "family health volunteer model", which will be under the purview of the MOPH. Generally, the Government of Thailand, with funding support from the Global Fund, organizes five days of training per year for the CHWs, with additional malaria-specific or refresher trainings organized as needed. Per government policy, CHWs are paid (payment varies by cadre) roughly $93 USD per 1 month (~10 days' level of effort).

In addition to the CHWs managed through the MOPH, an estimated 450 malaria post workers provide malaria services at the community level in 41 endemic provinces. Malaria post workers provide screening with rapid malaria tests; however, they are not involved in dispensing malaria treatment. Malaria post workers, in collaboration with malaria clinics, organize proactive case detection, including use of rapid diagnostic tests at community level. Additionally, an estimated 2,000 outreach communicators who are affiliated with CSOs promote testing and treatment adherence behaviors among communities at risk. DVBD has recently altered policies related to CSOs to clarify that medically trained outreach workers can provide rapid tests for malaria and referrals for treatment; however, most communicators are not medically trained. Certification by the National Malaria Control Programme of Thailand is required for individual communicators to gain this additional responsibility.[7]

The Shoklo Malaria Research Unit and malaria clinics support malaria post workers with the ability to both test and treat. The International Rescue Committee is also conducting malaria testing and treatment in refugee camps and distributing long-lasting insecticidal nets along the Thai-Burmese border. Malaria post worker activities are reported through the MIS; CSO-affiliated communicators report through CSO reports shared with DVBD and other central stakeholders (with the exception of International Rescue Committee refugee data, which are reported through the MIS). DVBD has a long-term vision of integrating all CSO reporting and training into one platform. The Global Fund's RAI3-Elimination (RAI3E, the third phase of the Regional Artemisinin-resistance Initiative) grant includes support for community outreach costs. In addition, the General Health Service Division within the National Health Security Office provides complementary support through the Prevention & Promotion budget. Health-promoting hospitals can plan projects and request funding for initiatives as well as CHW/malaria post worker support through this mechanism.

~1 million[3] Community health workers in country	Compensation Policy: PAID Payment varies by cadre
450 Providing malaria community case management	Compensation Policy: PAID Payment varies by cadre

Community health worker digital readiness

There has been limited use of digital tools at the community level to address malaria or other public health priorities in Thailand. Despite this, CHWs (known as village health volunteers in Thailand) are typically equipped with elimination project-funded mobile and smart devices. In the last decade, Thailand has seen rapid growth in cell phone usage, connectivity, and digital readiness. The barriers to expanded CHW use of digital tools are largely related to Thailand policy and program context. Mobile technology has been used only recently at community level in Thailand through the Reveal tool, which is supported by the Clinton Health Access Initiative. Most malaria-focused community outreach workers in Thailand (~2,000 out of ~2,450 total) are affiliated with civil society partners. CHWs are not allowed to provide community-level test or treatment services; instead they focus on raising awareness about malaria symptoms and encouraging testing (for symptomatic cases) and treatment adherence (for confirmed cases.) In select cases, CSO communicators use the LINE mobile application to communicate regarding screening and referral activities at the community level.

Data-driven decisions at each level of the health system: People and capacity to use data

Thailand's Malaria Online system has proven to be a critical resource for DVBD and other national-level decision-making on the national malaria program. In several interviews, key informants highlighted DVBD's frequent review of data and use of the Malaria Online system for decision-making. While most of the decision-making currently occurs at the national level, during interviews as well as the workshop, DVBD and other stakeholders acknowledged that there is need to extend data use for decision-making at the health facility and community levels. Currently, CHWs use paper-based tools to report their community outreach (including distribution of long-lasting insecticidal nets) and client follow-up activities. This has led to challenges in data consistency and timeliness. Increased use of digital tools at the community level may allow provincial and district health offices, malaria clinics, and CHWs to become more involved in reviewing data and thus adjusting outreach methods based on need. The nationwide deployment of Reveal and its community-level piloting in 2021 by DVBD, Clinton Health Access Initiative, and the World Health Organization will include use of mobile technology for foci management, one of the key priorities in Thailand's malaria elimination strategy. The piloting of Reveal at the community level will be the national malaria program's first use of a digital health tool outside of health facilities in Thailand.

NATIONAL LEVEL	Data use at the national level is strong. The malaria dashboard serves as a key national-level resource for reports to the Division of Vector Borne Diseases (DVBD) leadership as well as to DVBD partners. Key informants recognized DVBD's active efforts to review and use data; they describe Thailand as leading in this area relative to other countries. Currently, the DVBD regularly reviews a single integrated dashboard with 12 different tabs. Several CSOs are working with DVBD to strengthen the malaria information system, including RTI International, which is working on data analytics, and the Clinton Health Access Initiative, which is expanding the dashboard to enhance the foci investigation section and to integrate Reveal data.
PROVINCIAL / SUB-NATIONAL LEVEL	When the malaria program is integrated with the Ministry of Public Health, malaria data will be compiled with other community health data at the provincial level—similar to the two national data systems—through the Health Data Center (HDC). The HDC leads reporting of integrated data using a digital system. Workshop participants noted the specific process and timeline for integrating Malaria Online into HDC is somewhat unclear at this time, as the malaria team has not been able to facilitate an in-depth discussion with information and communications technology units within the MOPH. Decision-making processes will likely need to be adjusted under the HDC platform. In the meantime, use of malaria data at the provincial level is limited by factors outlined elsewhere in this profile, including perceived user interface challenges and limited bandwidth and capacity.
DISTRICT / SUB-REGIONAL / SUB-NATIONAL LEVEL	DVBD aims to strengthen monitoring of every foci response according to 1:3:7 surveillance guidelines,[2] which require malaria cases to be reported within one day and investigated within three days, and foci to be investigated and addressed accordingly within seven days. Access to and use of Malaria Online varies at this level, and decision-making remains within the national level.
HEALTH FACILITY LEVEL	At the health facility level, aggregated data reports are developed using paper-based forms from malaria posts and health facilities. These forms are submitted to the national level. Anecdotal feedback from stakeholders, field visit findings, and an RTI International user assessment indicated that data are not systematically assessed and used by facilities unless feedback is shared from the national level. At the health facility level, currently, the focus is on collecting, digitally transcribing, and sharing data up to the national level. Efforts to encourage data use at health facility and lower levels have been limited to date.
COMMUNITY LEVEL	Data use is limited to paper-based forms, which are digitalized and shared through Malaria Online. Some uses of simple mobile-based reporting channels were noted during in-depth interviews and the desk review, but these examples are rare. DVBD expressed interest in assessing opportunities to use Reveal to enable CHWs to collect and share data in real time in the future. However, given the end of CHAI's support for Reveal, DVBD explained that future roll-out and strengthening of this tool was pending technical and financial support beyond 2021.

Governance

	DIGITAL	COMMUNITY HEALTH	MALARIA
Name	*eHealth Strategy*	*Primary Health Care in Thailand*	*National Malaria Elimination Strategy*
Current strategy dates	2017–2026	1978–2014	2017–2026
Coordinating body	Ministry of Public Health	Department of Health Services Support, Ministry of Public Health	Division of Vector Borne Diseases, Ministry of Public Health
Funding strategy	Investment plan	None, expired	Investment plan

Thailand developed its national eHealth strategy in 2015; the strategy includes an enterprise architecture and recommends improving connectivity and setting standards for interoperability, data management, and use so that all health data systems can be integrated across the country. The digital transformation strategy is designed to consolidate vertical health data and surveillance work into an integrated cloud space managed by MOPH. Domestic financing is currently supporting the development of integrated infrastructure, including the creation of an integrated cloud space.

The Information and Communications Technology (ICT) unit of the MOPH plays a prominent role in Thailand's overall digitalization. Specifically, the ICT unit is leading efforts to integrate all health systems into the Health Data Center (HDC) platform 43 Folders. To aid in the digital transition, the MOPH's ICT unit developed *Concept of Thailand's Health Information Standards and Interoperability.* This report details Thailand's health data systems and the steps needed to establish information standards and interoperability for sustainable content and syntactic, semantic, and security concerns. In addition, the Department of Disease Control released a roadmap for the transition to a national health information system architecture, titled *Thailand Government Enterprise Architecture Framework*. This document puts forth specific requirements pertaining to technology and data exchange formats for interoperability. Both documents address interoperability to some extent, but information yielded in interviews suggested that additional tools and practical guidance are needed to bolster interoperability in Thailand. Specific to planning integration of Malaria Online with one of the national data systems, DVBD and other stakeholders identified the need for closer consultation between the MOPH's ICT unit and DVBD, a detailed plan that maps steps and responsibilities to achieve integration, and guidelines to support appropriate use of the integrated system in the malaria program at national and subnational levels.

Interoperability was identified as a challenge in Thailand—both during key informant interviews and the literature review phases of the project-- due to fragmented health data systems as well as a lack of clarity about the specific, operational plans and timelines to transition from an independent Malaria Online system outside of the national data system to interoperability between Malaria Online and one of the national data systems. The government is taking active steps to address interoperability concerns. The National Science and Technology Development Agency has funding from the Government of Thailand to build and use the Health Level 7 (HL7) platform to facilitate data sharing across hospitals only (not other facility types) so that hospitals can access patient records through a single, integrated system. This is currently being piloted in 30 hospitals, with strong potential to be rolled out further, according to the World Health Organization office in Thailand. The governance of the HL7 platform is unknown, but it presents another viable platform for other data exchange use cases.

GOVERNANCE policies define digital health and health data governance roles, responsibilities, and structures.	The Ministry of Digital Economy and Society issues policy decisions for all ministries involved in the governance of the malaria information system, including MOPH. Currently, the Division of Vector Borne Diseases (DVBD) oversees the Malaria Online information system. In the large-scale integration efforts underway, the Malaria Online server will be transitioned to and thereafter maintained by the Department of Disease Control. Additionally, Malaria Online roles, responsibilities, and structures are likely to evolve. Thailand has an eHealth strategy, but enforcement has varied.
DATA MANAGEMENT policies provide specifications for data access, privacy, security, and confidentiality and outline stipulations for data sharing.	Authorized individuals with a username and password can access Malaria Online. Stakeholders interviewed for this profile indicated that many individuals have access to the data; however, multiple levels of security and DVBD approvals govern access. Memorandums of understanding are required between organizations and the MOPH to exchange health data and ensure security. The MOPH developed a standard data security protocol, but a security breach in 2019 led to increased oversight of data security. Aggregate information on the dashboard is available to the public.
STANDARDS AND INTEROPERABILITY policies describe an enterprise architecture, normative standards—such as health information standards—and digital identity.	There are separate standard guidelines for the R506, 43 Folders, and Malaria Online systems. There is currently very limited interoperability between Malaria Online and the two national systems. While the *Concept of Thailand's Health Information Standards and Interoperability* documentation exists, these standards have not yet been operationalized.
INFRASTRUCTURE policies define data hosting and storage (e.g., local or cloud), mobile device management, and telecommunications access.	In 2019, the Department of Disease Control developed the *Thailand Government Enterprise Architecture Framework*, a roadmap for the transition to a national health information system architecture, which includes technology requirements and data exchange formats for interoperability. The National Science and Technology Development Agency has received funding from the Government of Thailand to build and use the HL7 platform to facilitate data sharing through a single integrated system across hospitals only. The malaria information system has not yet been incorporated into the national data infrastructure, so this is a critical interoperability priority.
WORKFORCE policies describe workforce job structures and responsibilities, plans for training, digital literacy expectations, and incentives for digital adoption.	Standard operating procedures for all community health workers (CHWs) have not been developed. The roles of CHWs affiliated with malaria clinics (i.e., malaria post workers) differ from those of CHWs affiliated with CSOs (communicators), which influences digital health practices. Roles and responsibilities of some malaria post workers and communicators have been outlined under RAI2-Elimination (RAI2E) and RAI3E; however, these have not yet been reconciled with national standard operating procedures for all types of CHWs in the country.

Systems

Data flow

Malaria case data are collected through two channels in Thailand: health facilities and CHWs. CHWs primarily share data with malaria clinics via paper-based or verbal reporting processes.[8] All community-level data are reported to health facilities, then digitally transcribed and fed into DVBD's MIS. Aggregated malaria data are available to all through the Malaria Online dashboard. Informal communication between program managers, health facilities, and CHWs or CSO-affiliated communicators occurs through SMS, LINE, phone, and social media channels depending on the project and location.

There are two national data platforms in Thailand—the R506 system for all notifiable diseases, which is coordinated by the Bureau of Epidemiology, and the 43 Folders system for all health issues, which is coordinated by HDC. In addition to these two central systems, there are multiple, health-area-specific, vertical data systems, including Malaria Online (the MIS). A third platform, HL7, is being trialed for the health-promotion hospitals. This platform is designed to create a single integrated system for all hospitals in Thailand. Due to the fragmented nature and the plethora of siloed systems, streamlining health data into one system has been difficult.

DVBD has initiated planning for the interoperability of Malaria Online and R506, with reporting of some Malaria Online data into the HDC as an intermediate step in this direction. The timeline and detailed plan to improve interoperability are not yet finalized due to COVID-19 and other priorities of MOPH's ICT unit. In the short term, DVBD has plans to coordinate with the MOPH ICT unit to integrate MIS data into the Department of Disease Control's HDC system. Once interoperability is achieved, MIS data will be available in the MOPH's R506. Of the large datasets in the MIS, only malaria testing and treatment data will be reported through HDC. In the long-term, DVBD plans to integrate data for malaria and other vector-borne diseases into a single system.

Thailand has abundant options for health data systems, but challenges remain in interoperability. Thailand's MIS is more sophisticated and thus more difficult to integrate into a central system. DVBD is learning from other health areas and their respective transitions into HDC. Some progress has been made to consolidate Malaria Online and R506 data through the Bureau of Epidemiology, using an algorithm to check figures before finalizing data. However, procedures for this consolidation are not finalized or documented. Additionally, the Inform Asia Project, which is funded by PMI, is working on improving consistency of malaria data reported through multiple systems. A cloud system has been proposed by MOPH. Documentation is scarce but could be an indication of where the eHealth strategy is moving.

Figure 1 (left). Data flow into the malaria information system.
Figure 2 (right). Current tools in use and interoperability with national platforms.
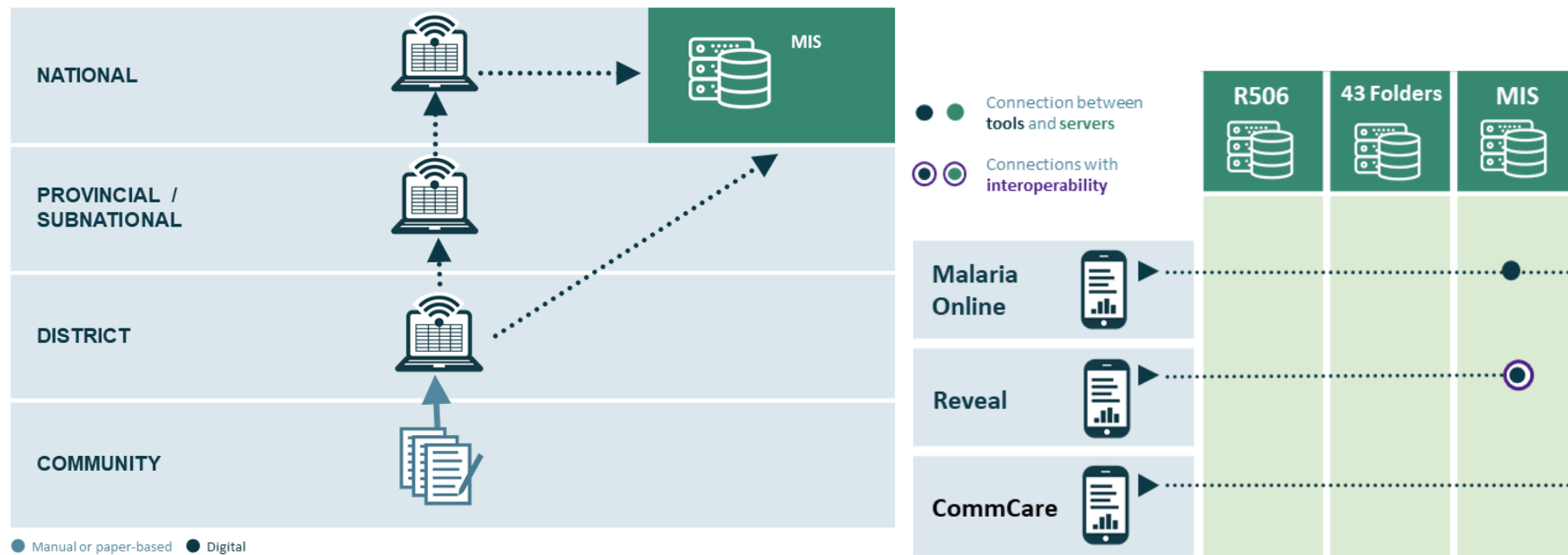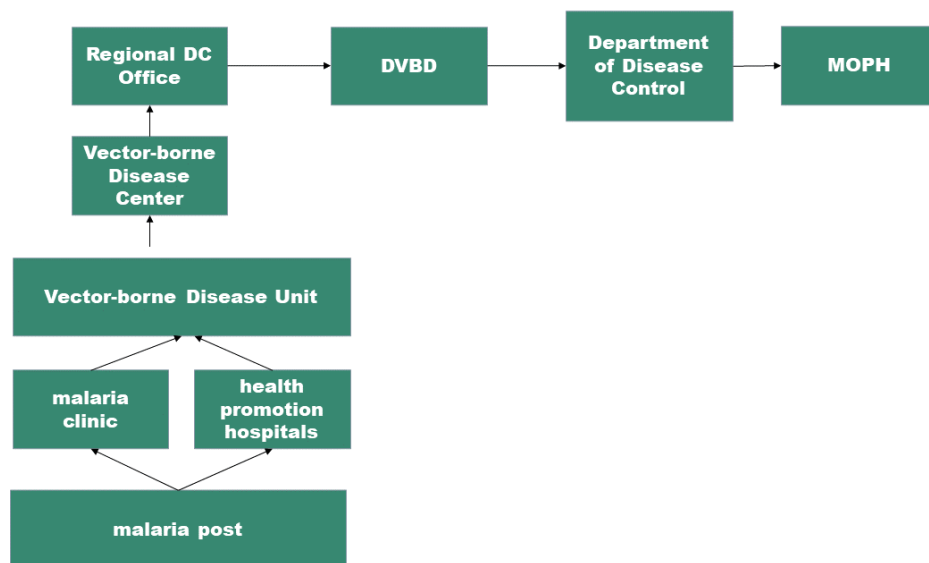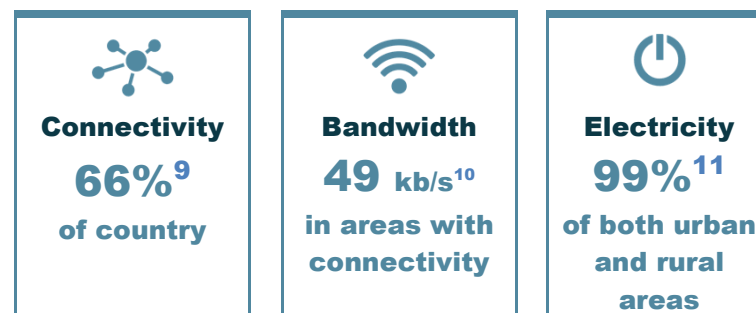

Figure 3. Chain of review for malaria data.

Digitally enabling infrastructure

More than 75% of Thailand's adult population are internet users. Additionally, about 72 percent of Thailand's population uses smartphones with internet connectivity. Connectivity varies by location and season, with stronger connectivity in cities and limited access in rural and border areas. Power interruptions are common during the rainy season, particularly in more remote areas. The geographic disparities in internet access and usage will be important to consider when expanding digital health tools to the community level. Addressing connectivity also will be critical for malaria case management, as malaria transmission is higher in border and rural regions. Three main cellular providers cover most of the country: True, Advanced Info Service Plc. (AIS), and dtac.

Connectivity
66%[9]
of country

Bandwidth
49 kb/s[10]
in areas with connectivity

Electricity
99%[11]
of both urban and rural areas

The MOPH has set forth the vision of "strengthening [the] health system to make Thailand a stable, prosperous, and sustainable nation." This vision is guiding Thailand to Health 4.0. Based on the literature reviewed for this profile, this remains a priority for the MOPH; it has been integrated into the 20-year national digital economy strategy. Recognizing that technology changes daily, the MOPH has indicated it will share more details as policy and guidelines are instituted. Stakeholders indicated that the MOPH may be developing an integrated system for enterprise resource planning, including digital systems and tools to support multiple administrative, financial, and operational functions.

Digital health tools in use and functionality

There is limited use of digital health tools at the community level in Thailand. In some instances, a tool has been introduced by a donor agency but not widely adopted by DVBD. In addition to Malaria Online, two tools currently are being used in select high-burden areas: Reveal and CommCare. DVBD piloted Reveal for CHW use in three provinces in October 2020 and has plans to scale up use in 2021. The Reveal tool was developed by Ona with support from Akros. The application, which can be used online or offline, is built to report on case detection, case investigation, foci response, distribution of long-lasting insecticidal nets, and larval site marking and clearance at the district and provincial levels in all 41 endemic provinces. The data are then uploaded into the web user interface, whereby malaria program staff can analyze case details at the sub-village level and determine if specific foci responses are necessary. Depending on foci management needed, a mobile data collection tool is used to facilitate an interview and collect data. These data are then uploaded to the website and dashboard where DVBD can review case management data. Reveal uses a separate digital architecture to interface with the MIS. In principle, Reveal data are reported in real time, depending on when the team can upload data—ideally the same day they are collected. There are plans to train CHWs to use Reveal to register families before reactive case detection efforts in 2021. The DVBD and other stakeholders recommend monitoring the pilot and conducting an additional assessment, including an independent review, to inform further planning for expanded use by CHWs.

CommCare is an open-source platform with mobile tool functionalities. Researchers can collect data through their phone and transmit to a local server (both online and offline functionalities). Dimagi previously worked with Thailand's anti-dengue program to develop a CommCare tool to facilitate community level research regarding dengue fever at the community level. This body of work was supported by the United States Agency for International Development's (USAID's) Regional Development Mission for Asia and Mobile Solutions Technical Assistance and Research (mStar) project.[12] Press releases also indicate that CommCare is working with the International Rice Research Institute[13] in bolstering agriculture and Save the Children's education unit along the Thai-Burmese border.[14]

With support from USAID's Global Health Supply Chain Program-Procurement and Supply Management project led by Chemonics, DVBD is developing a digital stock-reporting tool that is linked with Malaria Online. This application includes a dashboard and standardized report templates to facilitate data-informed decision-making around malaria commodity stock levels. Trainings for DVBD on this tool began in December 2020.

For *Plasmodium vivax* malaria, the Shoklo Malaria Research Unit employs an innovative method of digital fingerprinting to determine new or recurring infections in symptomatic patients along the Thai-Burmese border near Mae Sot area, through clinics they support in Tak Province. The Shoklo Malaria Research Unit has a two-pronged program of research and humanitarian services, with an emphasis on maternal and child health and infectious diseases, including malaria. The integration of malaria with maternal and child health services allows their staff to remain relevant in an elimination environment and provides an entry point for malaria testing and treatment for vulnerable populations, including migrants, pregnant women, and children under five years of age. In the last ten years, these clinics have seen the significant impact of their work. They used to see up to 100 *P. falciparum cases* per day in 2008; in 2019, they saw less than 1 per month. For dengue, a computer algorithm is being used to identify and assess the risk of open water vessels in Bangkok. Using Google Street View images, open water-holding containers are mapped, and container data are assessed and integrated into a decision support dashboard. Neither of these innovations are integrated into Malaria Online or health management information systems.[15]

USE CASE(S)	CommCare	Reveal
Providing malaria community case management	▪	▪
Tracking malaria proactive and reactive case detection	▪	■
Tracking malaria screening with referral	▪	▪
Transmitting messages to community on malaria	▪	☐
Training health workers	☐	☐
Tracking routine LLIN distribution during ANC or EPI visits	▪	▪

■ = Current use   ▪ = Possible, but not currently in use   ☐ = Does not meet use case

CASE MANAGEMENT FUNCTIONALITIES	CommCare	Reveal
Aggregate case reporting & analytics Tool collects aggregate case data and has data analytic functions in tool or online	▪	■
Individual case entry & analytics (*important in low-burden or elimination settings*) Tool collects individual case data and has data analytic functions in tool or online	▪	■
Case geolocation (*important in low-burden or elimination settings*) Tool allows collection or use of geospatial data for individual cases	■	■
Interoperability with health management information system Tool sends information to the official national health information system	☐	▪

Offline capability

Tool functions, at least partially, offline

	CommCare	Reveal
	◻ (light)	◼ (dark)

◼ = Current use   ◻ (light) = Possible, but not currently in use   ☐ = Does not meet use case

MANAGEMENT & SUPERVISION FUNCTIONALITIES	CommCare	Reveal
CHW identification Tool uniquely identifies CHWs	◻	◻
CHW facility catchment location Tool identifies CHWs' associated position in org unit hierarchy/link to health facility/system	◻	◻
CHW performance analytics Tool has analytic functions (data validation, graphs, charts) that support data quality, quality of care, or other performance issues	◻	◼
Communication Tool allows two-way communication between peer groups, associated health facilities, or supervisors	◻	◻

◼ = Current functionality   ◻ = Possible, but functionality not currently in use   ☐ = Does not have functionality

Appendices

References

1. PMI. PMI Digital Community Health - Key Informant Interview. (2021).

2. Ministry of Public Health (MOPH), Thailand. *National Malaria Elimination Strategy Thailand 2017-2026*. Nonthaburi, Thailand: MOPH; 2016.

3. Narkvichien M. Thailand's 1 million village health volunteers - "unsung heroes" - are helping guard communities nationwide from COVID-19. World Health Organization website. August 28, 2020. https://www.who.int/thailand/news/feature-stories/detail/thailands-1-million-village-health-volunteers-unsung-heroes-are-helping-guard-communities-nationwide-from-covid-19.

4. Information and Communication Technology Center, Ministry of Public Health (MOPH), Thailand. *eHealth strategy, Ministry of Public Health (2017 - 2026)*. Nonthaburi, Thailand: MOPH; 2017. https://ehealth.moph.go.th/index.php/resources/draft-ehealth-strategy-ministry-of-public-health-2016-2021.

5. Herrick T, Gannon S, Gilbert S. How digital health maturity can inform global goods design [blog post]. *Stories From Digital Square and Our Partners* [Digital Square blog]. December 9, 2019. https://digitalsquare.org/blog/2019/12/6/how-digital-health-maturity-can-inform-global-goods-design.

6. U.S. President's Malaria Initiative (PMI). *Thailand, Lao PDR, and Regional Malaria Operational Plan FY 2020*. Washington, DC / Atlanta, GA: US Agency for International Development / US Centers for Disease Control and Prevention; 2020. https://d1u4sg1s9ptc4z.cloudfront.net/uploads/2021/03/fy-2020-thailand-malaria-operational-plan.pdf.

7. World Health Organization - Regional Office for South-East Asia. *Report of the Programmatic Review of the National Malaria Control Program in Thailand*. India: World Health Organization; 2012. apps.who.int/iris/bitstream/handle/10665/206269/B4926.pdf?sequence=1&isAllowed=y.

8. Division of Vector Borne Diseases, Department of Disease Control, Ministry of Public Health (MOPH), Thailand. *Malaria Online: The Digital Surveillance System for Thailand Malaria Elimination*. Nonthaburi, Thailand: MOPH; 2019. https://publicadministration.un.org/unpsa/Portals/0/UNPSA_Submitted_Docs/2019/3fe4c1ba-e00b-4250-8816-f513c3b209c6/2020%20UNPSA_Malaria%20online_full%20report_27112019_111848_f62725d9-bd75-4846-a44c-8524838f4e87.pdf?ver=1441-03-30-111848-927.

9. The World Bank website. Individuals using the Internet (% of population) - Thailand page.
   https://data.worldbank.org/indicator/IT.NET.USER.ZS?locations=TH. Accessed August 14, 2021.

10. The World Bank website. GovData360: Internet bandwidth page.
    https://govdata360.worldbank.org/indicators/hc7f28901?country=THA&indicator=593&countries=BRA&viz=line_chart&years=2011,2017. Accessed
    August 14, 2021.

11. The World Bank website. Access to electricity, urban (% of urban population) - Thailand page.
    https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS?locations=TH. Accessed August 14, 2021.

12. Saijai Liangpunsakul wins People's Choice Award for mHealth work [blog post]. *The Dimagi Blog*. January 27, 2014.
    https://www.dimagi.com/blog/saijai-liangpunsakul-awarded-for-mhealth-work/.

13. International Rice Research Institute website. CommCare page. https://www.irri.org/commcare. August 14, 2021.

14. Dimagi website. Mobile data collection: Education programs page. https://www.dimagi.com/sectors/education/. August 14, 2021.

15. Mahidol Bremen Medical Informatics Research Unit. MIRU's projects LARGE-SCALE detailed mapping of dengue vector breeding sites from geo-
    tagged images and understanding the role of human mobility in malaria transmission on mahidol world. https://miru.ict.mahidol.ac.th/8-news/44-miru-
    on-mahidol-channel.

Additional references

Shah J. *User Assessment of the Malaria Information System (MIS)*. Washington, DC: United States Agency for International Development; 2020.

Shaw A. *CSO and Community Contribution to Malaria Elimination in Thailand*. Bangkok: Malaria Free Mekong; 2019.
https://www.malariafreemekong.org/wp-content/uploads/2019/10/Thailand_CSO_Consultations_October2019.pdf.

Ba I. *Digital Solutions for Malaria Elimination*. Phnom Penh: Clinton Health Access Initiative; 2019.

Division of Vector Borne Diseases, Department of Disease Control, Ministry of Public Health (MOPH), Thailand. *Malaria Elimination Operational Plan 2021–2025*. Nonthaburi: MOPH; 2020.

Division of Vector Borne Diseases, Department of Disease Control, Ministry of Public Health (MOPH), Thailand. *Malaria Online: The Digital Surveillance System for Thailand Malaria Elimination*. Nonthaburi: MOPH; 2020. https://publicadministration.un.org/unpsa/Portals/0/UNPSA_Submitted_Docs/2019/3fe4c1ba-e00b-4250-8816-f513c3b209c6/2020%20UNPSA_Malaria%20online_full%20report_27112019_111848_f62725d9-bd75-4846-a44c-8524838f4e87.pdf?ver=1441-03-30-111848-927.

Division of Vector Borne Diseases, Department of Disease Control, Ministry of Public Health (MOPH), Thailand. *Thailand Transition Readiness Assessment for Malaria Report*. Nonthaburi: MOPH; 2019.

Jones T, Drury P, Zuniga P, Roth S. *Digital Health Impact Framework User Manual*. Metro Manila, Philippines: Asian Development Bank; 2018. https://www.adb.org/sites/default/files/publication/465611/sdwp-057-digital-health-impact-framework-manual.pdf.

Kijsanayotin B, Thit WM, Thanapak W, et al. *EHealth in Thailand: Interoperability and Health Information Standards*. Nonthaburi: Thai Health Information Standards Development Center, Health System Research Institution; 2016. https://www.hsri.or.th/en/researcher/media/printed-matter/detail/7040.

Malaria Free Mekong. Malaria CSO platform Thailand. Presented at: 13th Meeting of the RAI Regional Steering Committee, March 26–27, 2019; Phnom Penh, Cambodia. https://raifund.org/sites/raifund.org/files/rsc_documents/final_minutes_13th_rsc_final_0.pdf.

Malaria Free Mekong and World Health Organization. *Impact of the Covid-19 Pandemic on Malaria Activities in GMS Countries*. Thailand: Malaria Free Mekong; 2020.

Mekong Malaria Elimination Program and World Health Organization. Regional data sharing platform (RDSP) to facilitate malaria surveillance data sharing in Greater Mekong Subregion (GMS). Presented at: 13th Meeting of the RAI Regional Steering Committee, March 26, 2019; Phnom Penh, Cambodia. https://raifund.org/sites/raifund.org/files/rsc_documents/final_minutes_13th_rsc_final_0.pdf.

Ministry of Public Health (MOPH), Thailand. *National Malaria Elimination Strategy Thailand 2017-2026*. Nonthaburi, Thailand: MOPH; 2016.

Olivares PP. Digital solutions for malaria elimination. Presented at: Global Digital Health Forum 2020, December 7–9, 2020; virtual event.

Thailand National Malaria Control Program. *Logistics Management Information Systems Roadmap*. Thailand: Cooper Smith; 2019. https://static1.squarespace.com/static/548487dce4b08bf981fe60d5/t/60c9050069e17d72deb73a0a/1623786764664/CooperSmith_PSM_Thailand_LMIS_Roadmap.pdf.

United Nations Office for Project Services (UNOPS). Update on RAI2E opening session. Presented at: 13th Meeting of the RAI Regional Steering Committee, March 26, 2019; Phnom Penh, Cambodia.

United Nations Office for Project Services (UNOPS). Updates on RAI2E grant implementation. Presented at: 13th Meeting of the RAI Regional Steering Committee, March 26, 2019; Phnom Penh, Cambodia.

U.S. President's Malaria Initiative (PMI). *Thailand, Lao PDR, and Regional Malaria Operational Plan FY 2018*. Washington, DC: PMI; 2018. https://reliefweb.int/sites/reliefweb.int/files/resources/fy-2018-thailand-regional-malaria-operational-plan.pdf.

U.S. President's Malaria Initiative (PMI). *Thailand, Lao PDR, and Regional Abbreviated Malaria Operational Plan FY 2019*. Washington, DC / Atlanta, GA: US Agency for International Development / US Centers for Disease Control and Prevention; 2019. https://d1u4sg1s9ptc4z.cloudfront.net/uploads/2021/03/fy-2019-thailand-abbreviated-malaria-operational-plan.pdf.

U.S. President's Malaria Initiative and RTI International. *Inform Asia: USAID's Health Research Program. User Assessment of the Malaria Information System (MIS)*. Chapel Hill, NC: RTI International; 2020.

United Nations (UN). *E-Government Survey 2018: Gearing E-Government to Support Transformation towards Sustainable and Resilient Societies*. New York: UN; 2018. https://www.unescap.org/sites/default/d8files/knowledge-products/E-Government%20Survey%202018_FINAL.pdf.

Abbreviations

1:3:7 surveillance guidelines	Malaria cases to be reported within one day and investigated within three days, and foci to be investigated and addressed accordingly within seven days
43 Folders	Data platform for all health issues
ANC	antenatal care
CHW	community health worker (known as village health worker in Thailand)
COVID-19	coronavirus disease 2019
CSO	civil service organization
CSO-affiliated communicators	Health workers outside of the Ministry of Public Health and financed by nongovernmental and other organizations
DVBD	Division of Vector Borne Diseases
EPI	Expanded Programme on Immunization
HDC	Health Data Center
HL7	Health Level Seven Digital platform for select hospitals
ICT	information and communications technology
LINE	Mobile communication application
LLIN	long-lasting insecticidal nets.
LMIS	logistics management information system
MIS	malaria information system
MOPH	Ministry of Public Health
mStar	Mobile Solutions Technical Assistance and Research
PMI	United States President's Malaria Initiative
R506	Data platform for notifiable diseases
RAI2E	RAI2-Elimination, the expansion of the Regional Artemisinin-resistance Initiative
RAI3E	RAI3-Elimination, the third phase of the Regional Artemisinin-resistance Initiative and Global Fund award mechanism
Reveal	Mobile application in use across Thailand and supported by the Clinton Health Access Initiative
SMS	short message service

APPENDIX C

Contributors

Informant Name	Organization
Maria Lorela Averilla	Chemonics International
Inessa Ba	Clinton Health Access Initiative
Sara Fewer	University California San Francisco
Elijah Filip	Clinton Health Access Initiative
Dr. Deyer Gopinath	World Health Organization
Pedro Pagalday Olivares	Clinton Health Access Initiative
Dr. Amnat Khamsiriwatchara	BIOPHICS
Suravadee Kitchakarn	Division of Vector Borne Diseases, Ministry of Public Health
Jean Miller	Chemonics International
Sathapana Naowarat	RTI International
Sara Rossi	UCSF
Jui Shah	RTI International
Alister Shaw	Raks Thai
Dr. Prayuth Sudathip	Division of Vector Borne Diseases, Ministry of Public Health
Dr. Krongthong Thimasarn	Country Coordinating Mechanism for the Global Fund
Dr. Suriya Wongkongkathep	Country Coordinating Mechanism for the Global Fund

Next-generation digital health tool functionalities for malaria case management

CASE MANAGEMENT FUNCTIONALITIES	CommCare	Reveal
Notifications Tool sends and receives notifications	▣	☐
Stock reporting & analytics Tool collects stock data and has analytic functions to support stock and logistics data analysis and decision-making	▣	■
Interoperability with other national health systems Tool sends information to other national systems (iHRIS, LMIS, etc.)	▣	☐
Referral coordination Tool allows CHW to notify local health facility of referrals and track them	▣	☐
Scheduling & work planning Tool allows CHW to plan and schedule key activities in the community	▣	■

MANAGEMENT & SUPERVISION FUNCTIONALITIES	CommCare	Reveal
Decision support Tool provides algorithms or checklists to guide CHW service provision	▣	■
Training materials & resources Tool provides access to training materials, policies, or other useful reference documents	▣	■
CHW geolocation Tool allows collection or use of CHW geolocation data for monitoring and planning distribution	▣	■
Supervision Tool can be used by supervisors to assess CHW skills and capacity	▣	☐

■ = Current functionality   ▣ = Possible, but functionality currently not in use ☐ = Does not have functionality