PMI U.S. PRESIDENT'S MALARIA INITIATIVE
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Role of Digital Tools in Fighting Malaria at the Community Level

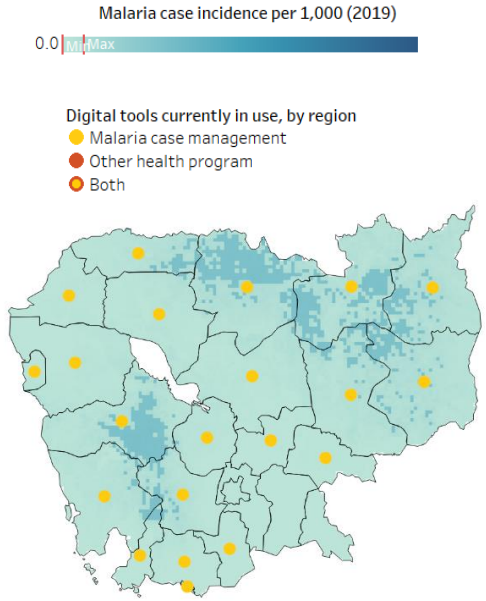
CAMBODIA

Executive Summary

Malaria is declining, with most cases occurring in forest goer communities, migrant mobile populations, and along the border. No deaths due to malaria were reported in the past three years, but 9,944 cases were reported in 2020, of which 8,990 were *P. vivax*. The annual malaria incidence rate fell from 2.1 per 1,000 in 2019 to 0.6 in 2020.[1–4] Achieving Cambodia's elimination target by 2025 requires increasing coverage of forest goer communities and addressing the relatively high *P. vivax* caseload.

Cambodia's malaria information system (MIS) is a comprehensive digital surveillance system that includes case management, vector control, and stock management. With additional support from Global Fund and U.S. President's Malaria Initiative (PMI), civil society organizations strengthen capacity for routine, real-time reporting at the community level. The surveillance guidelines were updated recently to incorporate "Aggressive Intervention" steps including integration of case investigation and notification in the Cambodia Malaria App, designed to streamline use by community-level malaria workers and upload data directly to the MIS.

Ensuring a functional digital health technical working group is a cross-cutting opportunity with the potential to facilitate recommendations outlined in this report. The priorities identified by Digital Square are consistent with the 2021 Malaria Elimination Action Framework, and Ministry of Health recommends improving visualization, interpretation, and usage of data at all levels and improve processes, tools, and training to enable timely reporting.



MALARIA

Incidence per 1,000 people in 2020

0.6[1]

PEOPLE

Village Malaria Worker (VMW) and Mobile Malaria Worker (MMW)[5]

6,172 VMW/MMWs are equipped with mobile phones to report real-time MIS data from 55 priority operational districts in 21 provinces[2]

3 per 10,000 people

GOVERNANCE

National Digital Health Strategy

NO

SYSTEMS

Digital Health Index

Not applicable, as Cambodia has not participated in the assessment.[6]

digital square

Recommended Actions

PEOPLE

Community health workers and other decision-makers

Strengthen targeted training and quality assurance to optimize use of digital tools at the community level

Further training of VMWs and MMWs as well as other community-level actors, complemented by practical job aids such as digitized supervision checklists, post-training monitoring, and routine data quality assessments, is needed to promote consistent, correct, and real-time use of MIS at the community level. This is particularly important for recently activated components such as malaria product stock management.

GOVERNANCE

Strategies and policies

Promote Cambodia's policy support for community-level use of digital surveillance tools as good practice in similar elimination settings across Asia Pacific.

National guidelines endorse community-level case management and reporting through the Cambodia Malaria App. Analysis and documentation of results associated with Cambodia's policy support for community-level rapid diagnosis and treatment aided by digital tools is recommended, given the potential for learnings from Cambodia to inspire good practices in other Asian Pacific countries.

Develop eHealth strategy to guide the integration of MIS with HIS 3.0

While a national HMIS enterprise architecture document exists, Cambodia does not yet have an eHealth strategy to guide integration across vertical digital systems in future. CNM's digital expertise and experience could be leveraged to help the MOH Surveillance Department develop an eHealth strategy to promote interoperability between (currently) vertical data systems, data security, and other objectives to be identified by national stakeholders.

SYSTEMS

Processes and digital tools

Plan interoperability of MIS with broader health information systems

Efforts are needed to plan interoperability layers between malaria and national notifiable disease reporting. A limited number of malaria indicators are reported by health facilities through the HMIS. As Cambodia enters pre-elimination phase, it is essential to ensure the country is prepared to meet WHO's comprehensive data requirements across all provinces. This will require interoperability between existing systems to ensure integrated data capture and validation.

Target application adaptation to support elimination and broader primary health care goals

CNM is working to integrate fingerprint patient identification and image-based analysis of rapid diagnostic test results in the Cambodia Malaria App. Pharmacovigilance components may be helpful additions in the future—for example to monitor radical cure outcomes. Using the app or another tool to strengthen active foci management should also be considered. As malaria programming is integrated with other primary health care programming in Cambodia, opportunities to extend use of the app to integrated Village Health Support Groups should also be considered.

Use digital tools to assess compliance with private-sector policy

Even if private provider involvement in case management continues to be limited in Cambodia, CNM and partners should consider using digital tools to track pharmacy and private clinic practices. For example, digital surveys or mystery client studies can be used to assess availability of substandard diagnostics or medicine in the private sector. Data could be used to update the policy as needed.

Review MIS data access criteria to promote data use at subnational as well as national levels

Access to disaggregated national data is centrally managed but not fully transparent, according to stakeholders. Additional clarity regarding data access criteria is needed to facilitate stakeholder access to and use of MIS data. Enabling stakeholders who have experience analyzing geospatial and malaria data as well as implementers with community-level experience can facilitate the identification and use of operational solutions. In addition, systems are needed to ensure that the analysis of data collected at community level is shared back with community stakeholders and used to enable VMWs and MMWs to contribute to and understand decisions informed by data they collect and report. This will also help develop capacity for data analysis and use at both operational district and community levels.

Methodology

A desk review, key informant interviews, and a consultative workshop were conducted to develop the content and recommendations in this document. The survey was not completed in the standard format due to availability of ample documentation of tools and existing programs.

DESK REVIEW	SURVEY	INTERVIEWS	WORKSHOP	ANALYSIS
In **JANUARY 2021**, **22** documents were reviewed to establish a foundation of knowledge on the malaria strategy, community health program(s), governance, data systems and architecture, role of data in decision-making, and infrastructure. See Appendix A.	A survey was not conducted as documentation was sufficient to understand tools being used at the community level.	Interviews were conducted with **17** individuals from organizations such as **National Center for Parasitology, Entomology and Malaria Control (CNM), World Health Organization (WHO), Clinton Health Alliance Initiative (CHAI)**, between **MARCH 2021** and **JUNE 2021.**	A workshop was conducted with 7 participants in **JUNE 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 **PMI Cambodia** and **CNM.** Data were last collected in **JULY 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 other decision-makers that 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

Village malaria workers (VMWs) and mobile malaria workers (MMWs) are essential to Cambodia's national malaria strategy. The VMW program, under the National Center for Parasitology, Entomology and Malaria Control (CNM), was initiated in 2004 in targeted zones. The VMW's primary mandate to provide malaria diagnosis and treatment has been expanded to include treatment adherence support as well as surveillance, vector control, and stock management components and related reporting through the Cambodia Malaria App. VMWs may cover other primary health areas currently being considered by CNM.

6,172[2] **Malaria workers in the country**	**Compensation Policy:** **PAID** **Payment varies by cadre**
6,172[2] **Providing malaria community case management**	**Compensation Policy:** **PAID** **Payment varies by cadre**

Mobile malaria workers were developed as a cadre of community-based outreach workers focused on reaching mobile, forest goer communities at risk. Whereas VMWs may cover other health areas (and some are being permanently transitioned to support multiple, integrated community health needs in low malaria burden areas), the MMWs are focused exclusively on malaria.

Both the Malaria Case Management Guidelines and the most recent Malaria Elimination Action Framework highlight the important role of VMWs and MMWs in Cambodia's elimination program. VMW and MMW activity has facilitated significant gains in Cambodia's testing rate. According to CNM and World Health Organization (WHO) data, in 2020 the total testing rate increased by 60% from 212,221 malaria tests conducted in 2019 to 341,139. VMW and MMWs were responsible for 84% of the total tests conducted in 2020. As malaria burden declines, CNM is collaborating with the ministry of health (MOH) to convert some VMWs into multipurpose outreach health workers. The longer-term plan is for all VMWs to be absorbed into a national network of community-based health workers.

Per government policy, VMWs and MMWs receive a $20 USD monthly stipend and travel allowance. The costs related to building their capacity to use mobile/digital tools—have been supported by additional funds from the Global Fund, PMI, and the Bill & Melinda Gates Foundation, with additional technical and operational support from various civil society organizations (CSO) partners including University Research Company (URC), Catholic Relief Services (CRS), CARE, Malaria Consortium, Population Services International, and as of 2021, as well as the Cambodia Malaria Elimination Project (CMEP). Although significant investments have been made to date and continue (including multiple trainings for VMWs and MMWs), stakeholders interviewed for the Digital Community Health Initiative review explained that additional support is needed to ensure community-level *use* of the MIS and related tools especially during the COVID-19 pandemic in the country. In addition to continuous supervision and monitoring, stakeholders identify a need for practical job aides, including a digital supervision checklist, as well as regular hardware upgrades to ensure community-level workers are equipped and committed to real-time reporting. Improving and familiarizing use of current sharing MIS data access to partners working with VMWs and MMWs also has potential to facilitate data use at subnational levels. CNM has taken steps to address this by sharing disaggregated data.

Community health worker digital readiness

While the quality of community-level data generated by Cambodia's system has improved significantly over the past three years according to MoH, WHO and other stakeholders, there is a need for further capacity-building and quality assurance to complete the transition from paper-based to digital systems in the context of low literacy levels among VMWs and MMWs as well as insufficient mentoring.

Data-driven decisions at each level of health system

Cambodia's MIS is a centralized system for malaria data generated from community to health facility to operational district to hospital (provincial) and national levels. VMWs and MMWs report community-level case management and other data directly using real-time reports through the Cambodia Malaria App. During monthly meetings at their affiliated community health center, facility-based staff help cross-check paper-based reports and ensure mobile uploads are accurate and complete. According to the most recent Malaria Elimination Action Framework, Cambodia has a 99% reporting rate, which speaks to the adoption of the MIS, although stakeholders interviewed for the review highlight a need to improve both quality and timeliness. Additional technical assistance from WHO and CSOs implementing elimination activities with support from Global Fund and PMI has been one of the keys to facilitating community-level reporting into the national MIS as well as promoting the use of data to inform elimination program and policy decisions. For example, surveillance data highlighting incidence among mobile forest goer communities was key to Cambodia's decision to develop the MMW cadre and more specific placement of MMWs in areas with the highest incidence. Several challenges associated with data-driven decisions have already been overcome, according to stakeholders. Data access issues are being discussed through monthly surveillance and the National Malaria Program convened data review meetings. Although the supply management component of the Cambodia Malaria App is being used at community and other levels, there are initial signs that this component of the application needs more troubleshooting and support. In addition, partners recommend clarifying and extending data access to partners with capacity to help the national program analyze and use data has potential to increase data use. Some stakeholders report accessing disaggregated data from provincial authorities, but national disaggregated data is less accessible. No partners interviewed have access to national aggregated data or the ability to run disaggregated analysis to assess or inform community-level program decisions. More discussion regarding the data access issues may help CNM to help partners find solutions as CNM explains that disaggregated national data is available via a CNM weblink, while raw data will continue to be only available at the national level.

NATIONAL LEVEL	Through the malaria surveillance system, CNM receives real-time reports from the community networks (VMWs/MMWs) and all levels of health facilities. Data access by each level of the health system, cleaning, and decision-making is centralized within CNM. Most of the functions to facilitate review of malaria data are automated, consistent with Cambodia's elimination phase. Following case reporting, case investigation and classification happens. Foci investigations are linked with the Cambodia Malaria App. WHO and other stakeholders describe Cambodia's surveillance system as highly sophisticated. Challenges include the system's vertical nature and limited integration. While stakeholders have free access to subnational level disaggregated data and national aggregated but additional raw data may help to improve elimination programming. CNM is planning steps to improve access to raw data in future. A digital health technical working group (TWG) does not yet exist, although the Department of Planning and Health Information (DPHI) previously established a DHIS2 TWG. This forum has not met for more than a year according to stakeholders interviewed. A key challenge for this TWG is the multiple digital health systems used across the MOH, including CNM's MIS. This forum may become more effective if DPHI adapts the mandate to support coordination and interoperability across currently used systems. A DHIS2 pilot was conducted by CNM but was not contextualized to the Cambodia experience and thus resulted in a decision to move away from externally supported systems. CNM reports high satisfaction with the current MIS, and participates in MOH integration discussions. CNM currently serves as a role model for MOH and other health sectors as the MIS is very advanced and comprehensive compared to other health data systems in use.
PROVINCIAL LEVEL	At provincial level, electronic reports are generated from MIS across hospitals and ODs for their catchment coverage. Provincial hospitals and health facilities also report real-time case management and other activities through the application. Provincial-level authorities can grant stakeholder access to provincial data, although in some cases provincial-level requests for data are influenced by central leadership if there are concerns about unnecessary data access. Challenges include limited feedback loops to ensure ODs and community-based workers are included in data use decisions.
OPERATIONAL DISTRICT LEVEL	Operational districts (ODs) pull data from the MIS for all referral hospitals, health centers, and VMW/MMWs under their catchment. VMWs and MMWs report case management, vector control, and malaria product supply management data through both the Cambodia Malaria App and paper-based reports. Their mobile and paper-based reports are reconciled during monthly meetings organized at the nearest health center. At the OD level, there are also Village Health Support Group members who provide broad health education. At district level, there are functional working groups that meet quarterly to review the situation for their community level, often with support from donor funds (GF, PMI, ADB) operated by respected partners. Key challenges at operational district level include tool and data interpretation, consistent data quality collection as well as difficulties related to broken/lost mobile devices.

Governance

	DIGITAL	COMMUNITY HEALTH	MALARIA
Name	Health Information System Master Plan	Third Health Strategic Plan (HSP3)	Malaria Elimination Action Framework 2 (MEAF2)
Current strategy dates	2016–2020	2016–2020	2021–2025
Coordinating body	Department of Planning and Health Information, MOH	Department of Planning and Health Information, MOH	National Center for Parasitology, Entomology & Malaria Control (CNM), MOH
Funding strategy	No	Yes	Yes

Cambodia has been working on an eHealth strategy for several years, but, as of June 2021, it has not yet been approved. The strategy is currently under review by the Department of Planning and Health Information within the MOH.

The *Health Information System Master Plan* (Master Plan) and third *Health Strategic Plan* (HSP3) are the two leading guidelines for digital health in Cambodia. Presently, there is no approved digital health framework. The Master Plan is a three-phase plan to digitalize health in Cambodia. The first phase (2016–2020) focused on coverage, quality, management, and use of current systems will be prioritized, establishing a Health Interoperability Standards Committee (HISC) and developing, testing, and implementing a client registry, facility registry, and interoperability layer. According to the HSP3, health-sector-specific unique identifiers will be used across all health information systems and deployment of telemedicine systems will be piloted in select hospitals in Phnom Penh. The second phase (2021–2025) will include deployment of a nationwide HMIS/electronic medical record (EMR) in the public health sector, including reporting by private-sector health facilities that have not previously participated in the HMIS. Cambodian National ID is used across all HIS and medical platforms and telemedicine platforms established in select provinces and municipalities. Phase 3 (2026–2030) is designed to include nationwide deployment of MIS/EMR in both public and private sectors, nationwide implementation of health strategy, and establishment of national health service and national telemedicine platforms. *The Health Strategic Plan* (2016–2020) sets forth actions to expand information communication technology (ICT) infrastructure and build up a central health repository by integrating existing data bases. The ultimate goal of this work is to ensure availability of high-quality data to support evidence-based policies, decisions, surveillance, and response systems as well as monitoring and evaluation to improve health service delivery and improve health outcomes. This goal would be supported by fostering a better digitally enabling environment by increasing human resource capacity and having digital governance structures in place. The DCHI review was unable to access information regarding the extent to which HSP3 milestones were met, or whether the priorities for 2020 onward have been updated as the fourth *Health Strategic Plan* (HSP4) has not yet been finalized as of June 2021.

Under the RAI 2 and 3 grants, Cambodia, along with all other Southeast Asian countries, participates in the Regional Data Sharing Platform established in 2014. This platform is designed to monitor regional artemisinin resistance and progress toward elimination.

The MIS Surveillance Task Force under CNM includes WHO, CNM, and implementation partners. This task force oversees MIS management and day-to-day surveillance issues. They meet as needed and are guided by the following key documents: *Cambodia's Malaria Elimination Action Framework* (MEAF), the *Malaria M&E Framework,* and the *MIS Surveillance Manual* (many international partners provided input to design this, including WHO).

GOVERNANCE Policies define digital health and health data governance roles, responsibilities, and structures.	In principle, digital health is governed by DPHI and the HIS TWG, which was responsible for developing the *HIS Master Plan* that guides digital health transformations in Cambodia. In practice, TWG functionality could be improved by more regular meetings with participation from all stakeholders, including vertical health program teams managing health area–specific MIS. According to the Health GeoLab report, DPHI's authority to enforce geospatial data standards can be further clarified. In addition, guidelines and protocols are needed to support consistent mapping and geospatial data management across vertical health programs.
DATA MANAGEMENT Policies provide specifications for data access, privacy, security, and confidentiality and outline stipulations for data sharing.	MIS data are managed by CNM at the national level. Partners, including CHAI and WHO, are able to attend monthly data review meetings chaired by CNM to promote the review and use of data collected through MIS and other mechanisms. The Surveillance TWG meetings (held quarterly or more often as needed) are also an opportunity to discuss data. Stakeholders interviewed identified the need to clarify access requirements and facilitate access as a strategy of improving data use.
STANDARDS AND INTEROPERABILITY Policies describe an enterprise architecture, normative standards—such as health information standards—and digital identity.	*The HIS Master Plan* expired in 2020, without the health enterprise architecture established (originally targeted for 2018). Stakeholders interviewed identify a need for detailed guidelines and tools to facilitate interoperability between malaria and other health area data within HIS.
INFRASTRUCTURE Policies define data hosting and storage (e.g., local or cloud), mobile device management, and telecommunications access.	The MIS is partially hosted on a physical server at CNM and stored as a cloud database. The *HIS Master Plan* describes the need to develop regulations, policies, and guidelines on storage, privacy, confidentiality, security, retrievals, and use of patient records. CNM has documented guidelines/standard operating procedures for the MIS, although some components are still being developed in 2021 (i.e., documented criteria for MIS raw data access by partners).
WORKFORCE Policies describe workforce job structures and descriptions, plans for training, digital literacy expectations, and incentives for digital adoption.	The *HIS Master Plan* outlines specific workforce planning steps including developing an HIS capacity-building plan, defining categories of staff needing training, creating jobs and training/refresher courses, and organizing training and other support. DCHI was unable to collect information to assess the extent to which these steps have been started or completed.

Systems

Data flow

The Cambodia Malaria App is used differently at different levels. At OD level, health centers use the stock management module to track malaria commodity disbursement and stock levels as a real-time inventory management function. Also at OD level, health centers record case investigation data to classify all cases and track investigation efforts in real time. Another module is used for foci investigation at health center level and a new module is being developed to track foci-clearing interventions at OD/health center level. Community-level data are linked via weblink and reported through app-equipped smartphones in real time. Following community or other level reporting of confirmed cases, automated notifications of confirmed cases are sent to MIS which real time viewing capacity by health facilities at OD/provincial and national levels. As mentioned elsewhere in the document, the main challenges to community-OD-provincial level data flow include varying VMW/MMW capacity and digital literacy as well as damaged or lost smartphones or slight delays due to temporary connectivity gaps. At national, provincial, district, and community (inclusive of CSOs) levels, there are different dashboards created with MIS data and designed for use at various levels. These help with visualization and are designed to facilitate data-informed decisions for the malaria program.

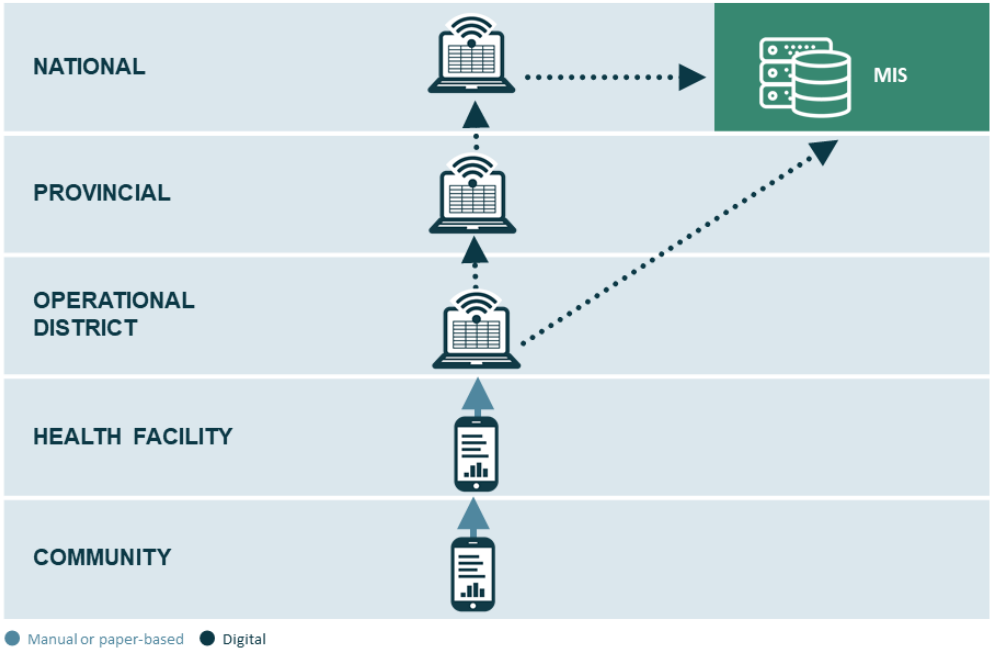
Despite several signs of routine data flow, and fairly strong national-level data use, there are opportunities for improvement. Stock and case investigation data and related flows indicate gaps in coordination and data use across levels according to some stakeholders. For example, health facility stock levels may be fine while OD stock levels could be low, indicating a delayed data flow and varying quality of data collected regarding stock levels at facility level (i.e., expiration dates etc.) and that levels within the system may not be optimally coordinated. In addition, special approvals are currently required from MOH to collect or disseminate all health data outside of the standard, approved systems. Security standards may be clarified in the eHealth strategy currently under review by MOH.

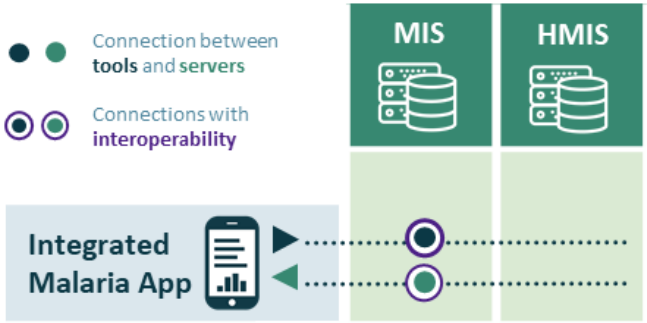
Compared to the health information system, the malaria MIS focuses on a single health area. MIS includes geospatial data as well as a broader range of indicators tracked, whereas HMIS covers topline indicators related to a few diseases including diarrhea, respiratory diseases, and malaria (microscopy, rapid diagnostics test covering Pf only, new RDT capable of distinguishing Pf and Pv—the evolution of malaria diagnostic methods makes it difficult to analyze malaria HMIS data over time.) While HIS 3.0 is also a digital system, it covers data reported from the health center only whereas MIS includes community-level and geo-spatial reporting. Options for integration include developing the HMIS to align with MIS components/capacities deemed necessary across multiple diseases or integrating malaria into the system hosted by the MOH's Communicable Disease Control Department (Cambodia CDC) that currently tracks all notifiable diseases with a single, electronic system designed to record symptoms. One of the challenges of this vision is the work that remains to ensure all diseases covered by an integrated system are uniformly well diagnosed. Without consistent diagnosis, the quality of the data will not be reliable. Dengue is cited as an example, whereby even hospital-level diagnosis is not currently reliable. HMIS is managed by Department of Planning and Health Information (covering immunization, maternal newborn child health, and HIV as well as TB and malaria) whereas MIS is malaria elimination-focused and run by CNM. The Cambodian CDC runs a system that tracks all notifiable diseases and provides weekly notification. CNM accesses the Department of Drugs and Food (DDF)-managed logistics management information system quarterly, which is not frequent enough in the opinion of key stakeholders. Because LMIS managed by DDF (mSupply) was not scaled by the MOH, it is unclear whether mSupply will be part of the digital landscape in future.

In 2018, the MIS was fully operational in Cambodia to track malaria case testing and diagnosis. Capture surveillance for elimination data, real-time reporting, and commodity stock management reporting features are being implemented; however, there are more modules that are not yet functional as of September 2021. Data are stored at CNM and on cloud servers. There is a need to plan resources to maintain the system—as is, or as an evolved version of the system, i.e., cloud-based—in future. CNM indicates that the reporting rate is 99% as of 2019.

Some stakeholders recommend opportunities to reduce both the HIS and MIS reporting fields/formats to reduce overlap and reduce unnecessary work at health center and community levels.

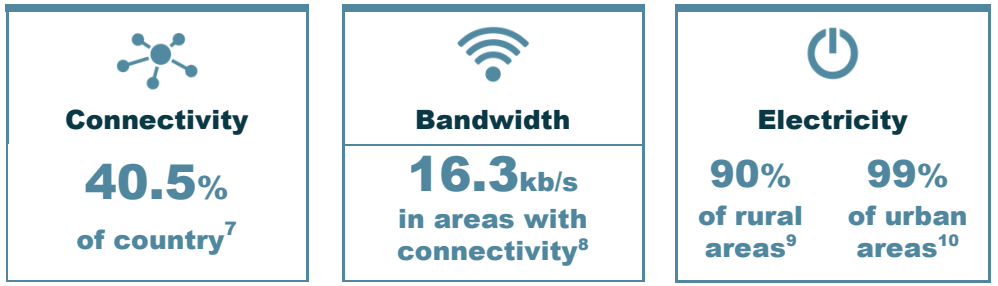
At present, the Cambodian MIS is a stand-alone system for malaria elimination surveillance. The MIS system incorporates data from all levels (community, district, provincial, national) and displays data for dashboards and decision-making. Data connectivity between the Cambodia Malaria App and HIS 3.0 exists, although interoperability connections are not yet in place. Aggregated MIS data is shared with HIS monthly, but integration currently happens manually. The Cambodian MOH has a long-term goal of combining all health data systems into a single platform. CNM and other stakeholders are concerned about how to minimize the loss of important malaria data during the integration phase. HIS currently collects data linked to a shorter list of indicators than the MIS. In addition to avoiding loss of important malaria data—given that MIS includes a much broader range of data reported at community level—stakeholders also raise questions about how to ensure quality in the context of system integration.





Digitally enabling infrastructure

Cambodia's centrally managed malaria digital surveillance system includes great potential to inform community-level decisions, particularly if data access is expanded as mentioned earlier. Data is currently recorded by VMWs and MMWs on paper-based reporting forms, as well as reported through the Cambodia Malaria App, to facilitate validation and cross-checking for data quality.



Cambodia's use of mobile phones and internet has increased rapidly in the last decade. About 19.5 million Cambodians are mobile phone users and an estimated 40% of the population uses the internet. Despite these statistics, there are still disparities between urban and rural internet access—particularly in the north and northeastern provinces where malaria burden is greatest. Given 70% of Cambodia's population lives in rural locations and high malaria transmission is found in some of the more remote areas of the country, in provinces along borders with Vietnam, Laos, and Thailand, access to stable internet services remain a significant challenge.

Cambodia's power coverage has become more stable in recent years; however, in some northern and northeastern provinces, limited power and/or connectivity means MIS data may not be reported as soon as it is entered into the application. In these cases—which stakeholders estimate occur in roughly 25% of community reported cases.[11]

Data is uploaded automatically when app users reconnect. Multiple cellular carriers are functioning in Cambodia, with Cellcard and Smart predominant in the high burden areas. CNM conducted a needs assessment to inform the selection of networks/credit providers to facilitate community-level access to and use of the app. Offline functionality has been created and deployed which will allow Cambodia Malaria App users to enter data into the app while offline and be automatically transmitted once internet is available.

Digital health tools in use and functionality

Cambodia's Malaria App is a highly sophisticated, vertical surveillance system currently covering 55 ODs in 21 provinces. The Cambodia Malaria App is a strong example of bringing surveillance as close to communities at risk of malaria as possible, by equipping VMWs and MMWs to report real-time case management data through an application on their mobile phone. In addition, the application represents a relatively comprehensive tool, covering case management, vector control, and product supply management components as well as linkage to treatment adherence messaging for confirmed *P. vivax* cases. WHO, PMI, United Nations Office for Project Services, and other stakeholders interviewed describe Cambodia Malaria App as one of the strongest digital surveillance systems for malaria in the region, while also recognizing the potential to strengthen the recently introduced stock monitoring module for greater consistency across case management and product distribution data. The app was designed by CNM in 2016, after considering DHIS2 and other systems, and following initial investments and technical assistance through government, Global Fund and PMI-supported projects.

VMWs and MMWs receive regular training—which includes MIS and mobile reporting components at least once a year. However, some stakeholders explain that hardware management, mobile data, and other logistical issues related to maintaining equipment (i.e., lost or damaged phones) and capacity to use digital health tools are limiting community-level use of the application. The Surveillance Technical Working Group identified opportunities to further improve the user interface for optimal use at community level. The updated version of the application will improve the user interface including additional required functionality for real time program reporting on Pv elimination.

The DHIS2 Android Capture App was previously piloted as a surveillance pilot to support malaria patient enrollment, case notification, case investigation, and reactive case detection. The case notification application was designed for health centers to report malaria cases to ODs and CNM in real time. The application also had functionality to report stockouts but was not assessed at that time. Key attributes included offline abilities, SMS alert for notifying cases, International Mobile Equipment Identity login, language selection (English or Khmer), use images as data elements and option sets, clean UI and navigation, relationships, and configurable search fields. The application can feed into several web-based platforms for surveillance, procurement of supplies (Artemisinin-based combination therapies, RDTs, etc.), and monitoring and evaluation. This tool was supported by the Gates Foundation and PMI (for one year) projects. Another tool that has been developed is the Malaria Case Surveillance (MCS) mHealth tool, which was introduced by PSI in 2016 to collect private case management results. The tool was used through PSI malaria programming supported by Gates Foundation–funded Greater Mekong Subregion Elimination of Malaria through Surveillance (GEMS) and RAI 2. DHIS2 was briefly piloted by CNM, however, the platform did not have the required functionalities for malaria elimination in Cambodia.

In addition to the national surveillance system, various research projects have used digital tools to facilitate data collection. For example, Institut Pasteur of Cambodia (IPC) utilized GPS-equipped mobile phones to implement a forest-goer intermittent presumptive treatment research project. Their research led to scaled intermittent preventive therapy (IPT) through the CNM and WHO “Intensified Response Plan” (also known as “aggressive interventions”) in six provinces. Whereas GPS-equipped mobile phones to detect and respond to real-time hot zones in forest goer communities may not be cost-effective in the current deceleration phase, IPC recommends revisiting if caseloads rise in future. Malaria Consortium has also used ODK tools to facilitate community-level data collection for surveys.

USE CASE(S)	Cambodia Malaria App
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	Cambodia Malaria App
Aggregate case reporting and analytics Tool collects aggregate case data and has data analytic functions in tool or online	■

CASE MANAGEMENT FUNCTIONALITIES	Cambodia Malaria App
Individual case entry and 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 HMIS Tool sends information to the official national health information system	□
Offline capability Tool functions, at least partially, offline	■

MANAGEMENT & SUPERVISION FUNCTIONALITIES	Cambodia Malaria App
VMW/MMW identification Tool uniquely identifies VMWs/MMWs	■
VMW catchment location Tool identifies VMW associated position in org unit hierarchy/link to health facility/system	□
VMW 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

Digital Square is a PATH-led initiative funded and designed by the United States Agency for International Development (USAID), the Bill & Melinda Gates Foundation, and a consortium of other donors. This country brief was made possible by the generous support of the American people through USAID. The contents are the responsibility of PATH and do not necessarily reflect the views of USAID or the United States Government.

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APPENDIX A

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APPENDIX B

Abbreviations

ACT	artemisinin-based combination therapy
ANC	Antenatal Care
CNM	National Center for Parasitology, Entomology and Malaria Control
CDC	Communicable Disease Control Department (Cambodia CDC)
CHAI	Clinton Health Alliance Initiative
CMEP	Cambodia Malaria Elimination Project
CRS	Catholic Relief Services
CSO	civil society organizations
DCHI	PMI Digital Community Health Initiative
DPHI	Department of Planning and Health Information
EMR	electronic medical record
GEMS	Greater Mekong Subregion Elimination of Malaria through Surveillance
HIS	health information system
HISC	Health Interoperability Standards Committee
HMIS	health management information system
MOH	Ministry of Health
HSP3	Health Strategic Plan 3
ICT	information communication technology
IPT	intermittent preventive therapy
LLIN	Long lasting insecticidal net
MCS	malaria case surveillance
MEAF	Malaria Elimination Action Framework
MIS	malaria information system
MMW	mobile malaria worker
MOH	Ministry of Health
NMCP	National Malaria Control Program
OD	operational district
ODK	Open Data Kit
PSI	Population Services International
RDT	rapid diagnostic test
TWG	technical working group
UNOPS	United Nations Office for Project Services
URC	University Research Company
USAID	United States Agency for International Development
VMW	village malaria worker
WHO	World Health Organization

APPENDIX C

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APPENDIX D

Next-generation digital health tool functionalities for malaria case management

CASE MANAGEMENT FUNCTIONALITIES	Cambodia Malaria App
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 (HIS 3.0, etc.)	■
Referral coordination Tool allows VMW to notify local health facility of referrals and track them	■
Scheduling & work planning Tool allows VMW to plan and schedule key activities in the community	□

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

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