Guidance on establishing a national malaria data repository

Version 1.0, July 2025

World Health Organization

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Contents

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Acronyms and abbreviations

API	application programming interface
BI	business intelligence
CHAI	Clinton Health Access Initiative
D2A	Data-to-Action
DHIS2	District Health Information Software, version 2
HBHI	High burden to high impact
HMIS	Health Management Information System
HR	human resources
iMISS	Integrated Malaria Information Storage System
IPTp	intermittent preventive treatment of malaria in pregnancy
IRS	indoor residual spraying
ITN	insecticide-treated net
LMIS	Logistics Management Information System
MD Sync	Metadata Synchronization application
M&E	monitoring and evaluation
NGO	nongovernmental organization
NMP	national malaria programme
NMDR	National Malaria Data Repository
PMI	U.S. President's Malaria Initiative
SOP	standard operating procedure
SMC	seasonal malaria chemoprevention
PMC	perennial malaria chemoprevention
WHO	World Health Organization

Glossary

Application programming interface (API)

An API provides a set of rules and instructions that lets different software programs talk to each other. It tells developers what they can ask for, how to ask for it and the format of the results. The technical details of how things are done behind the scenes to deliver the “what” in the “format” are hidden.

Dashboard

A customizable visual interface within the District Health Information System, version 2 (or other platforms) that displays data visualizations such as charts, tables and maps to support monitoring, decision-making and reporting.

Data dictionary

A structured collection of names, definitions, formats and attributes of data elements, indicators and disaggregations used in a system. It ensures consistency across data collection, reporting and analysis by standardizing how data are defined and used.

Importation (data)

The one-time or periodic transfer of data from one system or source into another. Unlike a system integration, importation is often manual or only semi-automated, typically involves static data snapshots, and may not involve a live or ongoing relationship between systems. It is particularly common for initial set-up or ad hoc data uploads (e.g. uploading an Excel file into a database).

Interoperability

The standards, protocols, technologies and mechanisms that enable data to flow and be understood between diverse systems. This includes technical interoperability (the basic ability of systems to connect and exchange data using APIs and middleware), semantic interoperability (data standards and mapping), and organizational interoperability (aligned and understood business processes and workflows).

Metadata

Descriptive information about data that defines how they should be structured, entered, stored and interpreted. Examples include data element names, codes, categories and indicator names, codes and formulas.

Modules

A module is a set of different data collection and collation tools within a specific thematic or programmatic area; for example, entomology or epidemiology forms, indicators and dashboards make up an “entomology module” and “epidemiology module”, respectively. Modules contain the metadata that are required to incorporate data into an information system, typically including standard data elements, indicators, forms, validation rules, visualizations and analysis outputs. Because modules are made up of metadata that can be imported/exported easily, module-specific metadata packages can save a lot of time when developing a particular module, as system developers do not need to start from scratch.

Non-routine data

Data not collected through standard Health Management Information System (HMIS) mechanisms, such as entomological surveys, climate data, research studies or partner-led interventions.

Routine data

Data collected regularly through established systems, such as HMIS, typically on a weekly or monthly basis, and used for day-to-day programme monitoring and decision-making.

Surveillance

The continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation and evaluation of public health practices.

System integration

The process of enabling different data systems (e.g. HMIS, Logistics Management Information System, or survey databases) to exchange data with each other or with the National Malaria Data Repository using APIs or middleware platforms. Integrations enable ongoing, automated and often bidirectional connection between systems to enable real-time or near-real-time data exchange and synchronization.

Introduction

1. Context and background

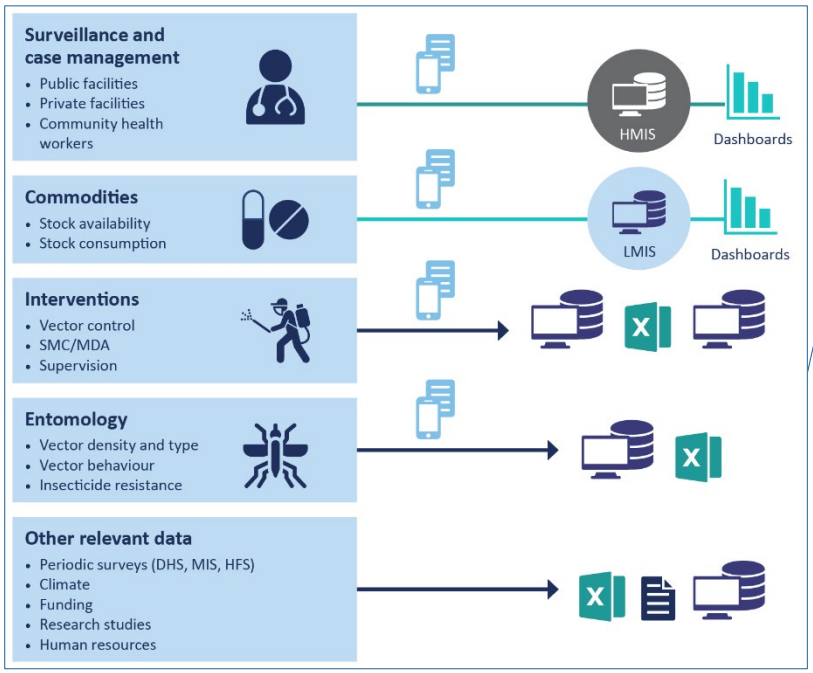
To control and ultimately eliminate malaria, countries need to regularly carry out surveillance and have an up-to-date system to collect, review and analyse their data. National malaria control and elimination programmes (NMPs) in endemic countries generally rely on epidemiological data routinely collected through their Health Management Information System (HMIS). These core data help to monitor malaria incidence and assess interventions. However, valuable complementary data – such as data related to interventions, laboratories, commodities, vector control, entomology, climate, population, finance, therapeutic efficacy studies and biological threats – often remain fragmented across ad hoc spreadsheets, pilot systems and siloed partner-implemented platforms due to the limitations of current information systems.

Since 2016, countries have recognized the need for a consolidated malaria data repository, but funding has not been available to support implementation. Building on WHO's training and capacity-building efforts in surveillance, the creation of a unified platform was proposed to connect these disparate data sources. By integrating routine health system data with critical supplementary information that often remains isolated, a repository managed by NMPs enables programmes to move beyond fragmented analyses and achieve a comprehensive, evidence-based understanding of the malaria landscape and a more informed response.

A National Malaria Data Repository (NMDR) serves as a centralized location to store, manage and easily access all available malaria-related data – covering areas such as epidemiology, entomology, vector control, chemoprevention and finance – along with contextual information (e.g. population denominators). Often structured as a data warehouse or integrated information system, the NMDR supports NMPs by organizing and visualizing this information through indicators and dashboards. This enables a holistic understanding of disease trends and intervention effectiveness. Beyond data consolidation, the NMDR should aim to optimize data systems, digitize spreadsheet-based processes and replace siloed systems – ultimately strengthening the broader data and surveillance ecosystem, as illustrated in Figs. 1 and 2.

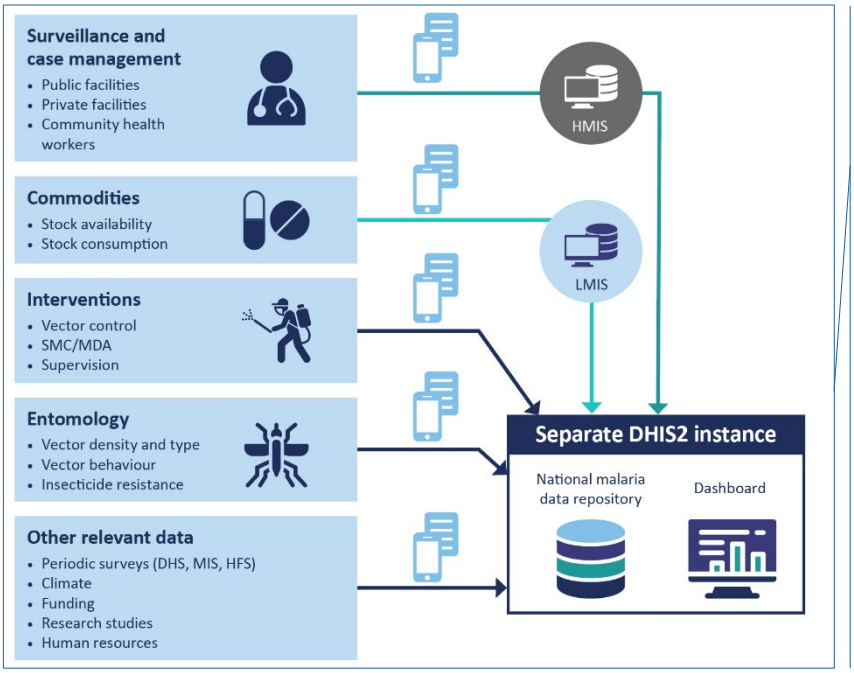
An NMDR is a strategic tool that strengthens malaria surveillance, planning and decision-making. By integrating data from multiple sources such as health facilities, laboratory systems, surveys and partner databases, the NMDR provides a centralized view of malaria trends, intervention outcomes and operational needs, enabling evidence-based decision-making. The NMDR ensures standardization across data sets, improving data quality, comparability and alignment with national and global reporting standards. It incorporates tools for analysis, visualization and mapping, enabling timely insights and evidence-based decision-making. With built-in interoperability, the NMDR connects seamlessly with existing systems such as the District Health Information System, version 2 (DHIS2) and Logistics Management Information System (LMIS), while maintaining strong data governance through security and access controls. These combined features make the NMDR an essential component of modern malaria surveillance architecture.

Fig. 1. Example data audit showing how a country's data are often collected and stored before implementing an NMDR



In this example, surveillance/ case management data are reported into the HMIS, while commodities data are reported into the LMIS. Intervention data, entomology data and other relevant data are collected and stored in multiple siloed spreadsheets and activity-specific databases. This presents challenges around standardization, access, and joint analysis across different thematic areas.

Fig. 2. Example data audit showing how a country's data would be collected and stored after implementing an NMDR



In this example, surveillance/ case management data continue to be reported into the HMIS, and commodities data continue to be reported into the LMIS. A new NMDR DHIS2 instance retrieves malaria data from both the HMIS and LMIS. Intervention data, entomology data and other relevant data are now reported into the NMDR DHIS2 instance, replacing the various siloed spreadsheets and activity-specific databases shown in Figure 1a. In such an integrated NMDR, the information system is optimized by incorporating data into the NMDR in a systematic way.

SMC: seasonal malaria chemoprevention, MDA: mass drug administration, LMIS: Logistics Management Information System, DHS: Demographic and Health Survey, MIS: malaria indicator survey, HFS: health facility survey

This guidance document was developed with attention to cross-cutting principles of gender, equity, ethics and human rights. It promotes inclusive stakeholder engagement by ensuring that diverse voices, including those from marginalized and underserved populations, are considered in the design and implementation of malaria data systems. Ethical data governance is emphasized through domains such as governance and access as well as data quality and standards, which support transparency, accountability and equitable access to data.

2. The need for an NMDR

Despite significant investments in malaria control, the disease remains a major public health threat, particularly in areas with high transmission and limited resources. Many countries continue to face systemic data challenges that undermine the effectiveness of their programmes. Weak surveillance systems, fragmented data streams and poor access to reliable information hinder timely, evidence-based responses.

The establishment of an NMDR addresses these core weaknesses. An NMDR serves as a centralized platform that brings together malaria-related data from multiple sources, including data on epidemiological surveillance, laboratory results, interventions, commodities and contextual factors such as climate and population. By consolidating this information, the NMDR enables stronger decision-making, better coordination among stakeholders and more efficient allocation of resources.

By offering a clear, integrated view of malaria trends and intervention outcomes, the NMDR not only supports the effectiveness of national programmes but also strengthens health systems and aligns with global malaria elimination goals.

The rationale for establishing an NMDR is rooted in the need to address the following key data system weaknesses:

2.1. Fragmented and poorly managed data streams

Malaria-related data are often scattered across multiple uncoordinated systems, ranging from HMIS platforms to partner-run databases and Excel spreadsheets. These fragmented data environments result in inconsistencies, duplication and lack of interoperability. An NMDR serves as a centralized platform for collecting, storing and managing malaria data from various sources. Consolidating these data in one repository ensures consistency, reduces duplication and enhances accessibility for analysis, saving time and effort through automation and improving data quality and integrity.

2.2. Inadequate surveillance and delayed monitoring

Many existing systems are not equipped to support timely and comprehensive surveillance of malaria cases and interventions. This limits the ability of programmes to monitor trends, evaluate the performance of routine services, and detect outbreaks and emerging resistance early enough to respond effectively. By consolidating and organizing data from multiple sources, an NMDR enables more robust and continuous tracking of key malaria indicators, intervention outcomes and service delivery performance. Strengthened surveillance through the NMDR is essential for timely strategy adjustments and rapid response to changing transmission patterns.

2.3. Weak data integration and limited use for decision-making

Even when data are available, they are rarely analysed holistically. The lack of tools and platforms that integrate diverse data streams limits the ability to triangulate and use information for planning

and decision-making. An NMDR enables NMPs and decision-makers to access accurate and comprehensive data sets that support decisions on resource allocation, supportive supervision, intervention design and policy formulation, ensuring that efforts are targeted where they are needed the most, based on evidence.

2.4. Poor coordination across stakeholders

Malaria control involves diverse actors, including government ministries, partners, nongovernmental organizations (NGOs), donors and the private sector. Yet, without a shared data platform, coordination is often disjointed and reporting is burdensome. An NMDR enables collaboration by serving as a shared platform for data sharing and communication, aligning efforts across stakeholders and ensuring that everyone works from the same evidence base.

2.5. Inefficient resource allocation

Without clear, up-to-date information on coverage and impact, interventions may be poorly targeted or misaligned with actual needs. An NMDR provides granular data to guide the strategic deployment of resources – for example, to address gaps identified in the coverage of insecticide-treated nets (ITNs) or indoor residual spraying (IRS), or to prioritize chemoprevention efforts – thereby improving the efficiency and equity of resource distribution.

2.6. Strengthening health systems

The process of establishing and maintaining an NMDR contributes to the overall strengthening of health systems. It promotes the development of data management capacities, enhances the skills of health workers, and fosters a culture of data use and evidence-based practice. It also reinforces and strengthens integrated and government-owned health information systems by bridging gaps created by system siloes; reduces costs associated with managing multiple fragmented platforms; and makes malaria data more interoperable with broader health sector-wide data warehouses, observatories and emergency operation centres. These improvements have broader benefits for the health system beyond malaria control.

3. What constitutes an NMDR?

The World Health Organization (WHO) recommends that countries view the NMDR as a strategic investment that addresses these persistent challenges. By consolidating data, improving surveillance, supporting data-driven decision-making, fostering collaboration and reinforcing national systems, the NMDR becomes a foundational tool in the fight against malaria. As countries move towards elimination, such platforms will be essential for timely, effective and sustained action.

While an NMDR can include a wide variety of malaria-related data, it is recommended that five key areas be targeted when establishing such a repository: routine epidemiological trends, vector control interventions, chemoprevention interventions, stock, and data quality. These areas establish a strong foundation for a comprehensive NMDR, but they are not strict prerequisites. While combining two or more areas may be sufficient for an NMDR to be considered as such, particularly in the early stages, the goal should be to progressively include at least these five areas over time. It is understood that not all countries implement all areas of work and that NMDR contents do not need to be exhaustive. The configuration may vary based on local needs and capabilities, and countries may also opt to prioritize additional components.

To establish an NMDR with a minimum recommended configuration, the following key areas should be included as relevant (see Annex 1. List of NMDR modules for a full list of modules):

1. Reporting on trends in cases and deaths (epidemiological module):
    - **Epidemiological** data: Collect and analyse data on malaria cases, deaths and trends over time (modules 1 and 2).
    - **Laboratory** data: Include data from rapid diagnostic tests and laboratory confirmations (module 1).
    - **Treatment** data**:** Track the number of cases treated (module 1).
2. Targeting of vector control interventions:
    - **ITNs**: Track the distribution and usage of ITNs (module 9).
    - **IRS**: Monitor the implementation and effectiveness of IRS (module 8).
3. Targeting of chemoprevention interventions:
    - **Intermittent preventive treatment of malaria in pregnancy (IPTp**): Track coverage and uptake of IPTp doses among eligible pregnant women to assess coverage gaps (module 1).
    - **Seasonal malaria chemoprevention (SMC)**: Where implemented, track the administration and impact of SMC (module 10).
    - **Perennial malaria chemoprevention (PMC)**: Where implemented, monitor the use and outcomes of PMC (PMC module).
    - **Malaria vaccine**: Where implemented, monitor the coverage and effectiveness of the malaria vaccine (module 11).
4. **Stock management:** Provide information on the availability of malaria control inputs: orders, deliveries, shortages, losses and expiries (module 3).
5. **Data quality:** Provide information on data quality, which can include data quality indicators calculated from inputs from other modules (such as routine epidemiological reporting forms) or newly collected data based on audit activities (module 16).

Modules should, where appropriate, support data disaggregation by gender, age and pregnancy status. This enables malaria surveillance systems to identify and respond to disparities in disease burden and service access, particularly among vulnerable populations.

These modules form the core components of an NMDR and should be considered the baseline to strive for, as relevant to the interventions and areas of work in a country. This configuration aims to provide comprehensive data collection and analysis to support effective malaria control and prevention efforts. While these are the recommended core modules, the decision on which ones to integrate should ultimately be guided by the programme's priorities and tailored to the specific strategies and interventions being implemented in each context. NMPs can prioritize additional modules (e.g. entomological surveillance, supervision and survey data, among others) according to their data management and decision-making needs, maturity of the modules, and ease of installation and customization (see a complete list of modules in Annex 1. List of NMDR modules).

Geographical and organizational reference data

A fundamental requirement for any information system, such as DHIS2, is the availability of standardized geographical and organizational reference data. These data are essential for enabling the accurate representation and visualization of geospatial data, which is important for effective health system planning, monitoring and decision-making.

It is necessary to work with the national agency responsible for this information to gather the following elements:

- **organizational units** and **codes** (down to the lowest administrative or facility level);
- **health facility** coordinates (latitude and longitude);
- administrative boundary shapefiles; and
- population estimates and catchment populations for each level.

These foundational data sets must be integrated into the system from the outset to ensure consistency, interoperability and the ability to generate geographically disaggregated outputs across all modules.

4. Use cases for the NMDR

Following the rationale and recommended minimum requirements for establishing an NMDR, it is essential to understand the practical applications and benefits of such a repository. The following use cases illustrate how an NMDR can be effectively used to address technical and data gaps, improve the overall efficiency of malaria programmes and ultimately enhance malaria control efforts.

Key use cases

- Improved data management:
    - **Data integration**: Consolidate routine epidemiological data, laboratory results and stock data (typically from systems such as the HMIS and LMIS), interventions, and non-routine data sources such as entomological surveillance, drug resistance surveillance, partner databases and climate data into a common platform.
    - **Automated reports and dashboards**: Automatically convert stored data into calculated indicators, dynamic dashboards, reports and bulletins, saving significant time and effort that would otherwise be required to repeatedly compile, map, transform, analyse and visualize data.
    - **Readiness for advanced analytics:** Have data that are already fully primed and ready to be input into advanced analytics (such as mathematical models).
- Routine data use:
    - **Data quality assurance** across all modules**:** Monitor and ensure data quality as information is generated and reported, providing timely feedback to lower levels to optimize data use for decision-making. Data quality underpins all modules, ensuring reliable analysis and effective programme management.
    - **Monitoring and evaluation (M&E)**: Use data to monitor the implementation of malaria control activities and interventions, such as case management, ITNs, IRS, and chemoprevention measures (IPTp, SMC, PMC, etc.).

    - **Early warning, outbreak detection and response**: Monitor retrospective data, climate patterns and mosquito surveillance to detect malaria outbreaks and coordinate timely, evidence-based responses.
    - **Supply chain management**: Manage supply chain and stock data considering epidemiological indicators to ensure timely availability of malaria commodities.

- Strategic and operational planning:
    - **Epidemiological and intervention stratification**: Analyse data for subnational stratification, identifying the strata with the highest malaria burden and prioritizing interventions accordingly.
    - **Forecasting and resource allocation**: Use predictive measures along with relevant case, consumption, climate, environment and human resources data to forecast demands for malaria commodities and allocate resources effectively, thereby avoiding stockouts and service interruptions.
    - **Programme reviews**: Conduct mid-term or annual programme reviews to assess the impact of interventions, track implementation of recommendations from previous reviews, and adjust strategies as needed. The data required for these reviews, including historical recommendations and follow-up actions, should be loaded and readily available in the system.

- Regional and global reporting:
    - **Standardized reporting**: Enable faster and easier reporting of case, laboratory, intervention and commodity data to regional and global entities, such as WHO, RBM Partnership to End Malaria, and donors, using standardized indicators and automated formats.
    - **Cross-border collaboration**: Facilitate data sharing and collaboration across borders to address regional malaria challenges and coordinate interventions.

5. The NMDR within the broader surveillance context

For an NMDR to fulfil the use cases described in the previous section, its development must take into consideration the broader context, infrastructure, technical and operational processes, and behavioural factors that influence how and where data are collected, reported, shared and used. Below are some common challenges within the broader surveillance context and solutions to employ when planning for and developing an NMDR.

Facilitators of a functional and sustainable NMDR

- Data quality and completeness:
    - **Standardization**: Implement standardized data collection and reporting protocols to ensure adherence to established data dictionaries for newly generated data. For historical data, conduct one-time mapping and conversion to established standards for NMDR importation.
    - **User-centred design:** Revise data collection and reporting tools to be more intuitive, clear and user-friendly to minimize unnecessary human error.
    - **Quality assurance**: Employ dashboards and other specific DHIS2 tools to equip users with easy-to-access data quality monitoring outputs and mechanisms. Ensure clear standard operating procedures (SOPs) for data quality assurance.

    - **Capacity-building**: Plan for and provide training and support to health workers and data managers to improve data collection, quality assurance and management practices. This should include building their capacity to readily use the system to access data, perform basic analyses, and generate maps, charts and other visualizations to support decision-making at all levels.

- Data integration and interoperability:
    - **Health information system interoperability**: Ensure interoperability between core established ministry of health systems, such as the routine HMIS, LMIS, geo-registries and other health-related information systems, to facilitate seamless data integration.
    - **Siloed systems:** Revisit the role of and need for siloed activity-specific information systems and spreadsheets, identifying opportunities to retire these tools by migrating or consolidating reporting in another system.
    - **Data exchange mechanisms**: Invite key stakeholders to participate in workshops to prepare the protocols and data standards required for interoperability.
- Data governance and sharing:
    - **Privacy and security**: Establish data governance policies to ensure privacy and security of data access and use.
    - **Data-sharing agreements**: Establish data-sharing agreements with other departments and/or partners to ensure timely access to existing or foreseeable data.
    - **Data use policies**: Develop and enforce data use policies to facilitate data sharing and collaboration across departments and stakeholders.
- Sustainability:
    - **Funding**: Secure funding for the initial set-up, maintenance, operation, training and supervision of the NMDR, including server costs, hosting, backups and external support.
    - **Systems strengthening**: Ensure that the NMDR fits into the broader ministry of health digital ecosystem and architecture by co-planning and co-designing with the HMIS unit or other relevant digital health/information systems department.
    - **Capacity-building**: Develop a path to sustainability through continuous training, capacity-building, knowledge transfer and stakeholder engagement.
    - **Government commitment**: Commit to developing and implementing policies to secure future support, encourage use and develop a data-driven culture.

6. The role of the WHO, countries and partners

WHO leads efforts to improve malaria surveillance through the development of standard modules for the NMDR. WHO emphasizes continuous improvement, documentation, training and sustainable data management to enhance malaria interventions. WHO regional and country offices (e.g. the WHO Regional Office for Africa and country offices in the African Region) provide tailored technical support to help countries implement an NMDR effectively, establish strong governance frameworks, and secure funding. Partners contribute by sharing resources, expertise and structured feedback, which strengthens the adaptability and effectiveness of the NMDR. They also assist in setting up repositories and developing standard modules.

While the initial focus of the NMDR initiative was on "High burden to high impact" (HBHI) countries, this guidance is intended for all malaria-endemic countries. Drawing on the early implementation experiences of HBHI countries, this document compiles lessons learned and practical insights to support broader adoption and adaptation of the NMDR approach. Every country is encouraged to establish an NMDR as a strategic step towards strengthening malaria surveillance and advancing data-driven control and elimination efforts.

7. Objectives of this document

This document is intended to provide NMPs, HMIS units and implementing partners with practical guidance on how to establish a functional NMDR, drawing on best practices for governance, planning, development, implementation, roll-out, training and sustainability.

This document is based on experiences from countries that have created their own NMDRs or are in the process of doing so. It guides users through a series of steps – from the initial planning stage through to developing the repository, incorporating all available malaria-related data, developing visualizations and dashboards, and training personnel on the use of these tools.

This document is accompanied by a set of Excel templates that can be downloaded and adapted by countries (see Annex 2. Establishing an NMDR: example templates).

NMDR phases

Developing and institutionalizing an NMDR realistically takes several years from inception to maturity, involving multiple iterations and module additions. However, an NMDR can begin adding immediate value within the first year after completing the first module. Broadly, NMDR development follows the following four phases (see Table 1):

1. Planning the NMDR
2. Initial NMDR set-up and data integration
3. **Intermediate NMDR development**: iterative integration of additional modules, roll-out and training
4. **Advanced NMDR development**: governance, sustainability, and continued improvement and supervision.

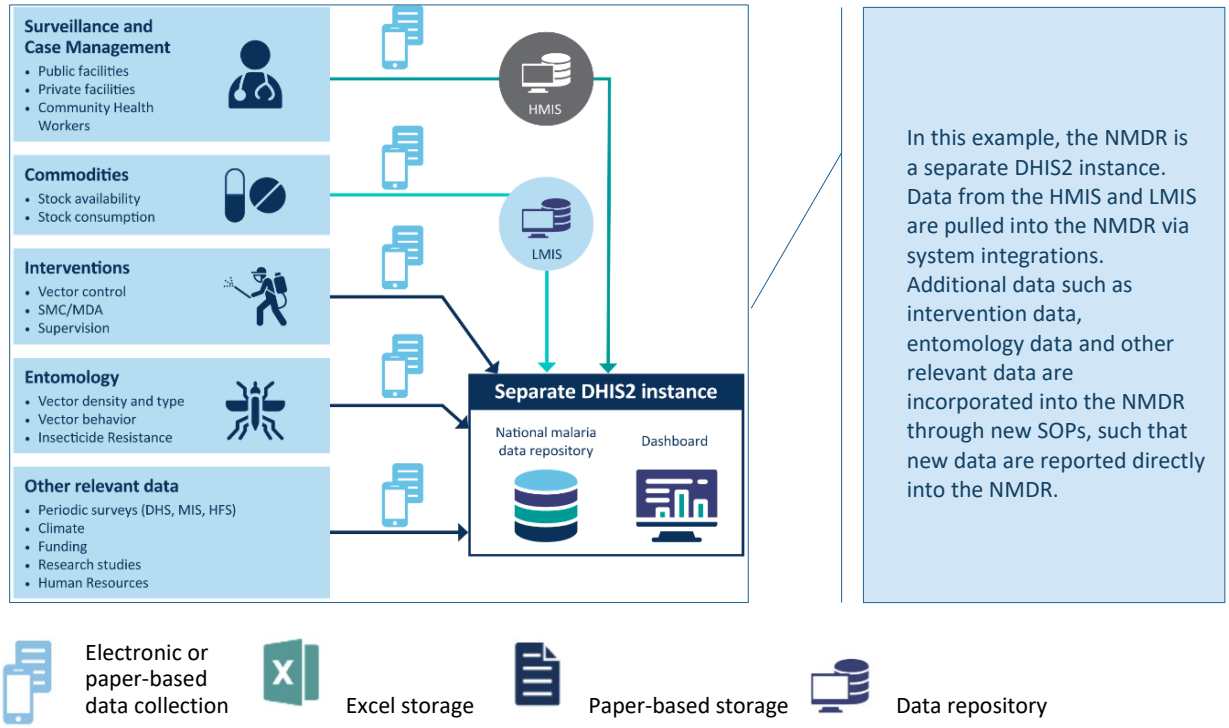
Phases 3–4 repeat as modules are progressively prioritized, installed, customized, rolled out and institutionalized.

Table 1. Phases of NMDR development

Phase overview	Phase outcomes
1. Planning the NMDR	
The planning phase sets the foundation, vision and scope of the NMDR, and establishes the governance and stakeholders that will form a working group for the NMDR initiative. This includes an on-the-ground champion to drive implementation and coordinate the technical working group.	The planning phase establishes the components of the NMDR initiative and includes the following activities: - **Convene stakeholders**: Gather representatives from various organizations to create a shared vision and collaborative network. - Create a **shared vision**: Define the overarching goal and challenges the NMDR aims to address. - Establish a **working group**: Form a group of experts to guide and support the project. - Designate a national champion and focal point. - Create **a partner activity map**: Map out partner activities for collaboration and data sharing. - Define the data scope of the NMDR via a **data audit and mapping** (high-level) and develop a prioritized list of thematic areas to include. - Develop a costed workplan. - Decide on whether to fully embed the NMDR within the routine HMIS/DHIS2 instance or develop a separate malaria-specific instance (Figs. 3 and 4).
2. Initial NMDR set-up and data integration	
Initial development of the NMDR, set-up and data integration During the initial phase, the NMDR is created for a single thematic area, or "module", such as epidemiology or entomology. Programmes should choose the thematic area to start with based on the programmatic needs and the area of expertise of the national champion.	Initial set-up of the NMDR platform that will host all modules (a link to the routine HMIS can be established for data synchronization, e.g. administrative hierarchy, if a separate stand-alone instance/platform is used). See Fig. 4. Configure/develop a single thematic area (e.g. epidemiology or entomology) based on local expertise, with SOPs in place for data collection, management and visualization. An illustrative list of possible NMDR modules is provided in Annex 1. List of NMDR modules. Lessons learned and gathered in this stage are expected to inform future modules and strengthen project management processes around design, development, testing, and so on. In some cases, modules can also be developed concurrently if there is sufficient project management capacity to coordinate across different working groups.

3. Intermediate NMDR development: integrating additional modules	
Once the NMDR has been established for the first thematic area, additional thematic areas can be itemized and prioritized. These are then incorporated into the NMDR one thematic area at a time, although there can be some overlap with modules being worked on concurrently. Developments follow the same path as the initial phase.	Integrate additional thematic areas into the NMDR, following the same activities as in Phase 2. Additional data outputs and SOPs should be put in place for managing and analysing data at different levels (e.g. national, district), including dashboards, reports and bulletins based on real-world data use needs.
Implementation and roll-out	
This is an iterative phase involving capacitating users, monitoring module usage, and resolving any technical, operational and organizational barriers to full module usage and institutionalization.	Once a thematic module has been developed, it is then tested and piloted. Roll-out should include any necessary communication, training and follow-up activities. It should also include refinements and iterations to both the system design and SOPs based on user feedback and observed gaps and challenges. It should also include refinements and iterations to both the system design and SOPs and dashboards based on user feedback and observed gaps and challenges. While it is possible to pilot multiple modules concurrently if resources allow, piloting one module first will generate critical lessons that can be applied to all further modules, thereby enhancing quality and efficiency.
4. Advanced NMDR development: governance and sustainability	
Advanced NMDR development: governance and sustainability	Advanced NMDR development should be guided by a governance mechanism. During this stage, the steering committee remains active, providing oversight and guidance to drive and follow-up on the development, implementation, data use, analytics and roll-out of new thematic areas. The committee ensures quality and adherence to SOPs and NMP guidance. This phase will also include plans for continued improvement and supervision of the development and maintenance of the repository. Training at all levels will continue to be carried out as new data and functionality are incorporated into the NMDR, or when changes or updates happen as part of continued system maintenance.

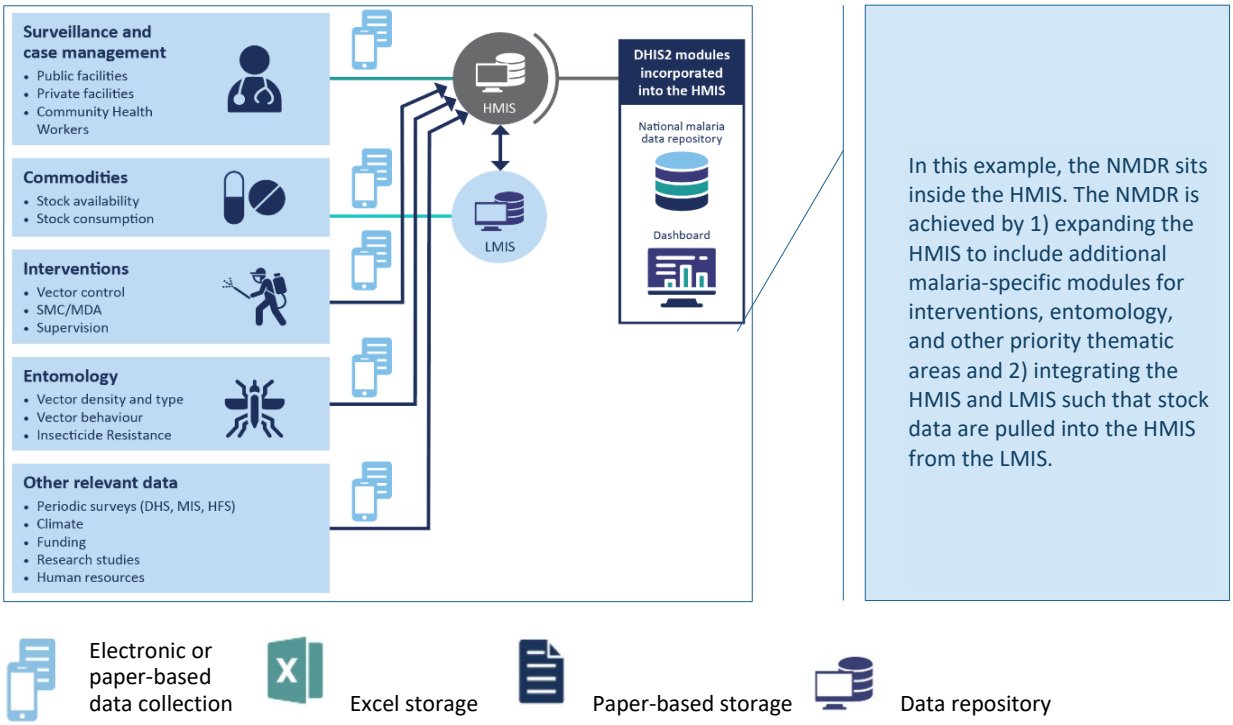
Fig. 3. Configuring a separate DHIS2 instance



MDA: mass drug administration, DHS: Demographic and Health Survey, MIS: malaria indicator survey, HFS: health facility survey

Note: Fig.2 and 3 are identical. the repetition is intentional for clarity.

Fig. 4. Incorporating modules into the HMIS/DHIS2 instance



MDA: mass drug administration, DHS: Demographic and Health Survey, MIS: malaria indicator survey, HFS: health facility survey

8. NMDR readiness assessment

Establishing an NMDR is a critical step towards strengthening malaria surveillance, improving data-driven decision-making and enhancing national health information systems. However, successful implementation requires a clear understanding of a country's current capabilities, infrastructure and strategic alignment (see Fig. 5a and 5b).

Generalized assessment tools have been developed to support countries in evaluating their preparedness to design, implement or enhance national data repositories or warehouses, and these tools can be leveraged when planning for malaria-specific repository needs.

Readiness assessments are a critical first step in implementing an NMDR, as they lay the groundwork for effective planning, development and sustainability. These assessments are recommended in both pre- and post-NMDR contexts and should ideally be completed in consultation with the appropriate HMIS unit or digital health/information systems department.

- In **pre-NMDR** settings, the **National Data Storage Assessment Tool,** see Annex 3. Readiness assessments, helps to define the scope and assess the feasibility of integrating fragmented data sources. This tool is particularly useful for countries embarking on NMDR design where no repository currently exists. The assessment ensures that the most appropriate repository or variant is selected based on technical realities. It includes tools such as the **decision checklist** for repository selection, a **sustainability assessment**, and a **data source mapping tool** to support implementation planning.
- In contexts where an **NMDR already exists**, the **National Data Repository Self-Assessment Tool,** see Annex 3. Readiness assessments, is more appropriate. This tool provides a comprehensive evaluation of current performance by identifying gaps and opportunities for improvement. It is structured around four key areas: Governance and Access, Data Quality and Standards, Sustainability and Scalability, and Infrastructure and Technology. Rather than producing an aggregate score, the assessment supports targeted gap identification and improvement planning in areas such as security, interoperability and usability.

The assessment process also helps to align stakeholder expectations and supports the development of costed work plans (see Phase 1: Develop a costed work plan). It lays the foundation for scalability, long-term sustainability (see Phase 4: Advanced NMDR development: governance and sustainability), and effective data use.

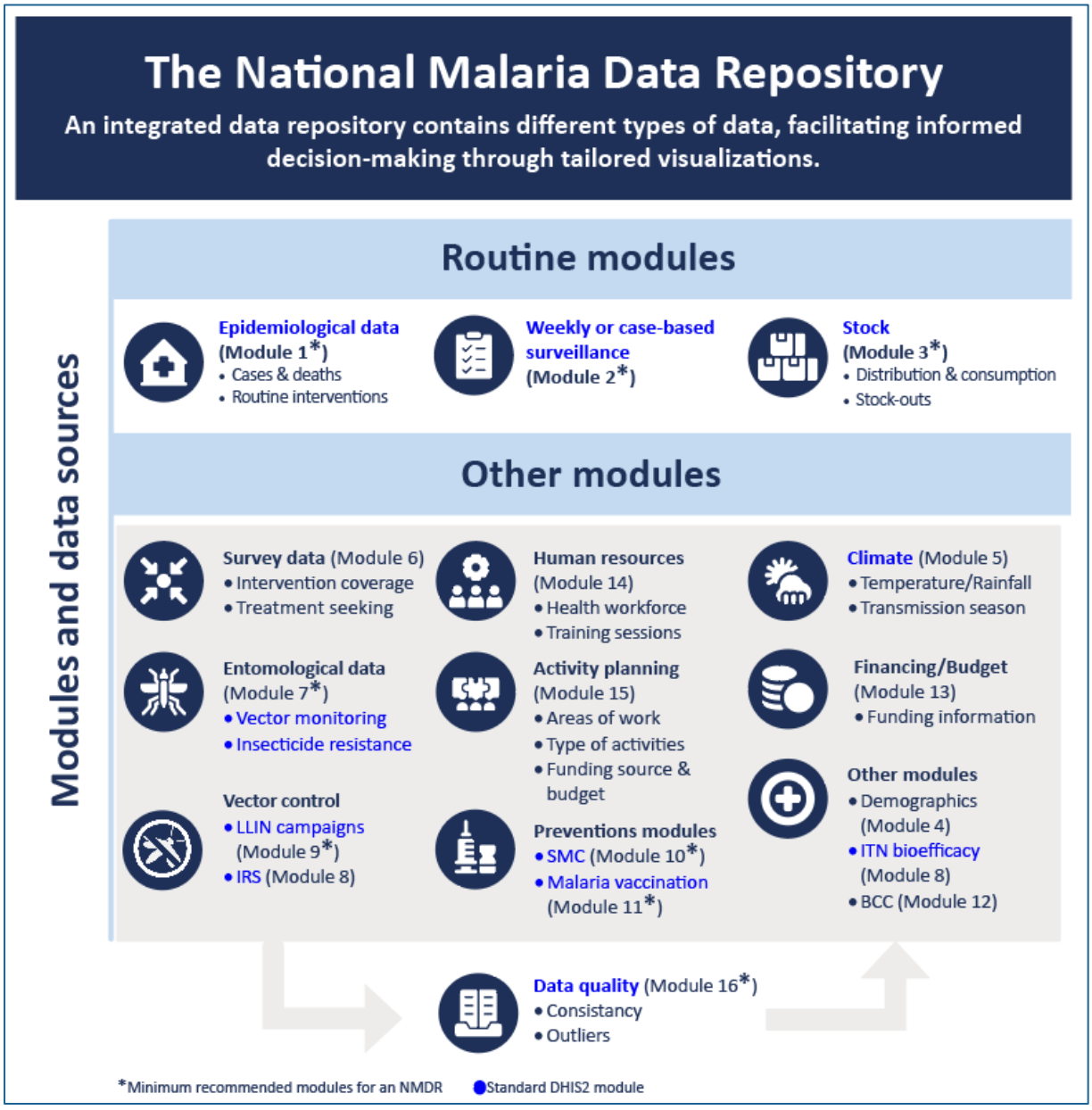
The assessment tools can be customized to align with a country's specific context, strategies and technical capacity. As more countries begin implementing NMDRs and sharing feedback, the tools will continue to be refined and improved to better support planning, evaluation and long-term sustainability.

9. Audience

The primary audience is NMPs, ministry of health personnel, routine health information systems staff and local partners. While the primary audience is at the national level, the NMDR will also address the needs of subnational users, particularly those at the operational level. The specific focus on subnational needs will vary across modules, depending on the type of analysis and actions required.

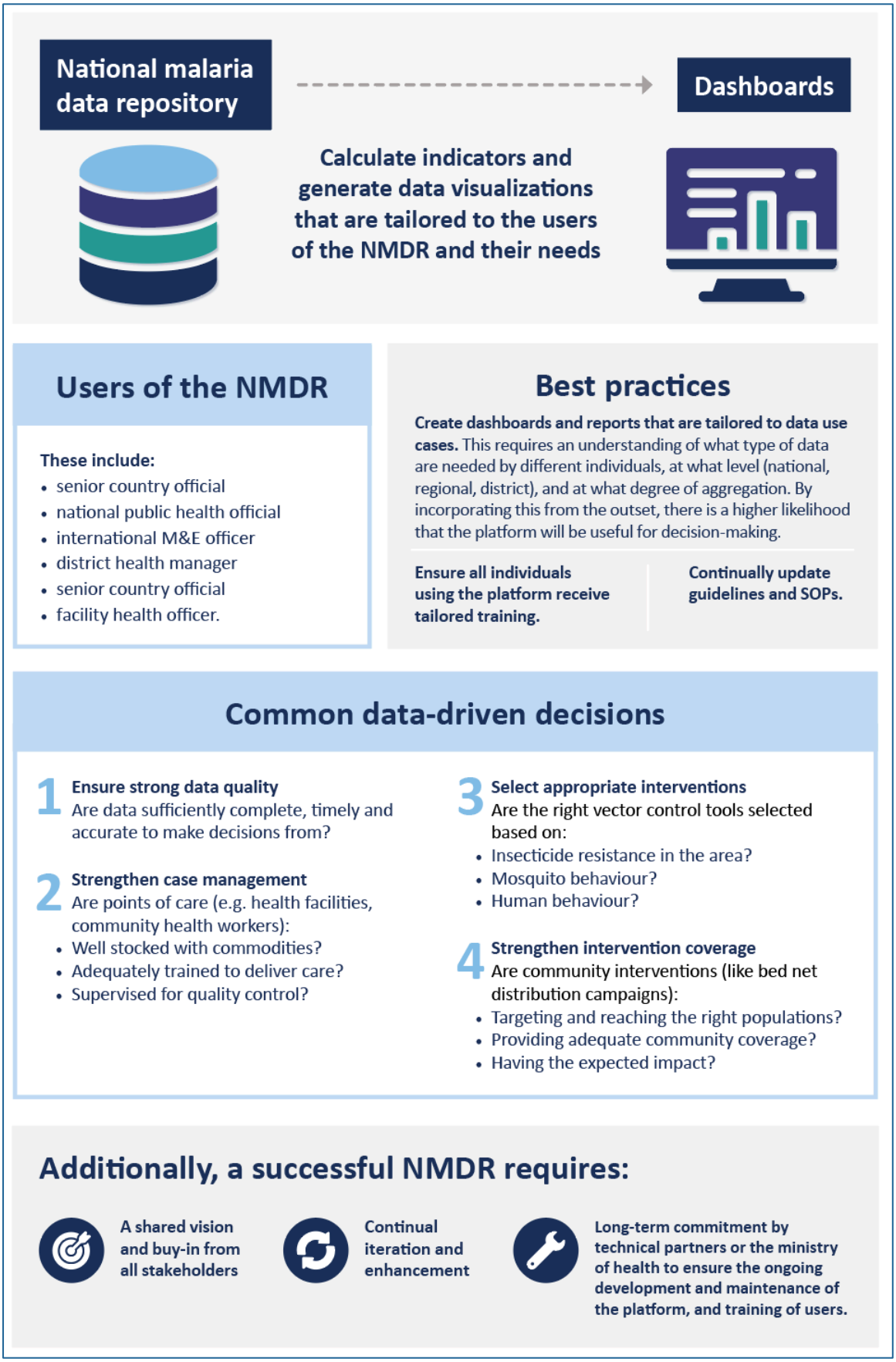
The broader NMDR audience also includes international organizations and funding agencies (such as the WHO Global Malaria Programme, the Global Fund to Fight AIDS, Tuberculosis and Malaria, Gavi, the Vaccine Alliance, and the U.S. President's Malaria Initiative [PMI]), NGOs and other technical implementing partners, academia, and other relevant stakeholders.

Fig. 5a. A successful NMDR – modules and data sources



BCC: behaviour change communication

Fig. 5b. A successful NMDR – users, best practices and decision-making



Phase 1. Planning the NMDR

Overview	The planning phase sets the foundation, vision and scope of the NMDR, and establishes the governance and stakeholders that will form a working group for the NMDR initiative. This includes a national champion to drive implementation and coordinate the technical working group.
Outputs	This phase establishes the thematic data components of the NMDR initiative and includes the following activities: - Convene stakeholders. - Create a shared vision of the NMDR and its intended users. - Establish a governance mechanism. - Establish a steering committee and working group(s); designate a national champion. - Create a partner activity map. - Define the data scope of the NMDR via a data audit and mapping (high-level) and develop a prioritized list of thematic areas to include. - Develop a costed work plan.
Helpful resources	Establishing an NMDR: example templates

1. Convene stakeholders

Bring together a diverse group of stakeholders who will play crucial roles in establishing the NMDR. The stakeholders typically include representatives from the NMP, government health ministries and digital health units, international organizations, NGOs, technical experts, information technology specialists, data specialists, data generators and users. The goal of convening this group is to create a shared vision, build a collaborative network and garner collective support for the NMDR initiative.

2. Create a shared vision for the NMDR

An important component of this initial stage is the creation of a shared vision that encompasses the overarching goal and the challenges the NMDR seeks to address. Although the shared vision will be specific to each country, in general an NMDR should seek to create a single, integrated data repository that improves data quality, data accessibility and data use in the country and supports evidence-based decision-making in malaria interventions.

Commonly, the NMDR will aim to solve the core challenges of:

- fragmented data from multiple sources;
- lack of standardization in reporting, tools and indicators; and
- lack of standardized data outputs/visualizations.

Identifying the vision of the NMDR will also require an understanding of the key users and the data-driven decisions they need to make. These aspects are described in Define key users and data use cases.

3. Establish a governance mechanism

A critical step in ensuring the efficacy, transparency and sustainability of the NMDR is the establishment of clear mechanisms governing decision-making and how the system will be used. This may include establishing policy documents, guidelines, procedures and best practices, as well as a strategy to ensure that the NMDR integrates effectively with existing systems and practices.

Important considerations during this stage include which stakeholders should be involved in specific aspects of governance and in what capacity. This includes decision-making around the best custodians for technical functions and maintenance, financial considerations and strategies for how changes to data collection and display will be made.

It may be worth conducting a stakeholder analysis when deciding on governance mechanisms and the roles and responsibilities associated with the long-term maintenance and governance of the NMDR.

4. Establish a steering committee and working group(s)

After convening stakeholders and establishing a governance mechanism, the next step is to form a project steering committee and dedicated working group(s). The steering committee will oversee the NMDR initiative. It is essential to identify a national champion, as this person will play a critical role in supporting the overall vision, development and implementation of the NMDR. It is also critical to include representation from the ministry of health's relevant HMIS unit, digital health and/or information systems department to ensure that all NMDR decisions are aligned with the country's broader digital health ecosystem, capacity and priorities. Some countries choose to divide the steering committee into a technical committee and a coordination committee, with the former focused on database implementation and the latter focused on stakeholder management and collaboration

The working group(s) should consist of individuals with expertise in various relevant fields, including data managers, technical experts and health professionals. Each working group is responsible for providing guidance, expertise and technical support throughout the NMDR initiative's life cycle, and should be highly involved and consulted throughout the design, development, testing, training, implementation, and M&E of each module.

Some countries leverage existing steering committees and working groups that are already in place, for example:

- an existing surveillance technical working group to serve as the steering committee;
- other technical working groups to drive individual module development – e.g. an entomology technical working group to lead the design, development and implementation of an entomology module.

In any scenario, the early planning, development and piloting phases of the NMDR will require many touchpoints to ensure adequate stakeholder involvement, decision-making and consensus. Realistic timelines and expectations should be set accordingly.

Lesson learned: the importance of a national champion

Experience has shown that successful NMDR implementation is highly dependent on effective coordination and oversight. A key step is therefore designating an on-the-ground national champion. This individual is usually someone from the NMP who brings valuable experience from surveillance and M&E activities and can effectively coordinate a strong local stakeholder network covering a range of competencies. The champion serves as the NMDR's point person, coordinating activities, managing communications, problem solving and providing feedback to the different stakeholders. The champion's role is instrumental in driving the project forward and ensuring that it aligns with the country's specific needs and goals.

5. Create a partner activity map

Mapping out the activities of partner organizations is vital for collaboration and data sharing. The partner activity map should be kept up to date to reflect the landscape of external support. Involving partners at each step helps countries to:

- **cultivate** partner buy-in and ensure that partners are not developing and implementing parallel tools;
- **establish** alignment on common data dictionaries and indicator definitions so that partners can contribute their relevant data to the NMDR in a standardized manner;
- **establish** protocols and data-sharing agreements governing exactly how partners will submit their relevant data to the NMDR (e.g. monthly data entry exercise, quarterly data import exercise);
- **ensure** that partner activities involving data collection, data quality assurance and data use are aligned with the NMDR road map.
    - Example 1: If insecticide resistance monitoring activities are planned in 6–12 months, stakeholders could prioritize having the insecticide resistance component of the entomology module developed, tested and ready for use in time for this activity.
    - Example 2: If a partner is supporting data review meetings in specific districts, this partner could be more involved in subnational dashboard design, piloting and the consolidation of end-user feedback.

6. Define the NMDR scope

As part of the planning phase, the NMDR scope should be defined by the working group(s), ensuring adequate stakeholder consultation across all thematic areas. First, target indicators to include in the NMDR should be selected. WHO has created a list of over 200 indicators across numerous themes that countries can consider incorporating into their NMDR (see Annex 4 NMDR indicator list). Start by reviewing the indicators that stakeholders feel should be included in the NMDR and cross-reference these with national strategic plans and key partners in order to jointly establish a broad vision of components across different thematic areas. When selecting indicators, the working group should consider data use needs across all target end users, spanning routine data use as well as broader strategic planning and programme evaluation needs. See Phase 2: Define key users and data use cases for further guidance on selecting decision-relevant indicators.

At minimum, countries should consider indicators from the five thematic modules recommended as the baseline NMDR in section 3 of the Introduction (What constitutes an NMDR?). These five modules are routine epidemiology, vector control interventions, chemoprevention interventions, stock, and data quality. Many more indicators from other modules can also be selected (see Annex 1. List of NMDR modules).

7. Conduct a high-level data audit and prioritization

From the selected indictors, a high-level data audit and mapping exercise should be conducted to rapidly identify the volume of data that is targeted for integration into the NMDR and the degree of data fragmentation. This data mapping is essential for accurate work planning and for setting clear expectations with stakeholders. For example, an NMDR initiative that only requires data integration from 2–3 mature information systems will look very different from an NMDR that requires data integration from 2–3 mature information systems, 8–10 pilot or project-specific partner systems, and 15–20 spreadsheets – in terms of not only technical development, but also data dictionary development, data process flow harmonization and stakeholder alignment. When selecting indicators, working groups should ensure that disaggregations by gender, age and pregnancy status are included where relevant. This supports equity-focused analysis and enables targeted interventions for vulnerable populations, including pregnant women and children.

Once the indicators and data sources have been mapped out and aligned to their respective modules, the NMDR steering committee and working group(s) can assign relative priority levels and target timelines to the different modules.

During this process, it is important to capture not only what data are currently available, but also what priority data could be available in the near future. For example, if an intervention such as an ITN distribution campaign is scheduled, including the relevant module earlier in the NMDR road map can ensure that it is ready in time for the campaign.

A more detailed and in-depth data audit (building off this initial Planning Phase data audit) will later be conducted as part of the development phase for each module. This is described in Phase 2: Audit and map data.

8. Develop a costed work plan

Finally, the working group(s) should establish a work plan for the project. The work plan should outline the project's scope, objectives, timeline and key milestones. It also assigns specific roles and responsibilities to team members and stakeholders. The work plan should be country-specific, addressing the unique challenges and requirements of each location.

Some key information to consider when creating a work plan includes the following:

Roles: Each stakeholder's role should be precisely defined. For instance, the ministry of health or the NMP may be responsible for overseeing the entire project. They may be tasked with making high-level decisions and providing the necessary funding. Meanwhile, epidemiologists and data experts may be tasked with handling data collection, validation and analysis. IT specialists within the ministry of health HMIS unit or department of information systems may be responsible for setting up the technical infrastructure.

Activities: Along with roles, specific activities are assigned to individuals or teams. For example, epidemiologists may be responsible for collecting and cleaning malaria-related data from health care facilities. IT specialists might set up the data repository's technical infrastructure, including servers and data storage. Project managers may ensure that all stakeholders are coordinating effectively and that the project stays on schedule.

Timelines: It is essential to establish timelines for each activity. This helps to track progress and ensure that the project is moving forward as planned. Country examples have shown that it is helpful to organize timelines against thematic components, e.g. routine epidemiology, vector control, chemoprevention. Within each component, different steps can then be specified for (i) scoping, (ii) design, (iii) configuration, (iv) data cleaning/mapping/importation, (v) dashboard/report development, (vi) testing, and (vii) refinement, and expectations around the involvement of different stakeholders and working groups can be clearly established.

Costs: There will be costs associated with the different activities. It is important to consider the budget associated with both development and non-development costs, such as server capacity and targeted training sessions for different users (see Table 2). The high-level data audit in the previous step will allow for technical specialists to provide estimates regarding the level of technical effort for each module.

Table 2. Typical NMDR cost categories

Component	Description of need
Technical developer support	Technical support to develop the NMDR. NMPs may be able to leverage internal ministry of health developer support without cost, while others may need to hire developer consultants or vendors.
Meetings and workshops	Convening of select stakeholders for scoping and design > development > testing cycles of different NMDR modules. Informal meetings at ministry of health offices or held virtually can minimize/eliminate the potential costs required here.
Servers and hosting	Upgrade to existing servers or procurement of new ones, whether cloud or local
Hardware	Procurement of devices as needed (typically only required when new digital reporting processes are established as part of NMDR development)
Connectivity	Internet, sim cards, monthly/annual data plans to cover devices in the field
Licenses	Can include licensed software for data collection, management, visualization, help desk, project management, financial systems, mobile device management, and so on, as well as costs for domain names, SSL certificates

Training	For central, regional, district and health facility users on use of digital tools. Consider e-learning options for refreshers to minimize training costs.
Supervision	Supportive supervision visits to support system usage and user performance. Consider remote supervision or bundling with other activities to minimize costs.

Sources of finance: Each budget line should have a funder or funders associated with it.

> **Lesson learned: plan early for sustainability**
>
> Plans for resource mobilization and sustainability discussions should take place in the early stages of the initial phase. A malaria programme may not necessarily be able to maintain the technical skills needed to support ongoing system maintenance. Such programmes should therefore receive technical support from sustained technical partners or the ministry of health (e.g. HMIS unit, department of information systems, or equivalent digital health units). Financing needs for NMDR development and sustainability should be included in broader planning exercises, such as the national strategic plan and associated costed operational plans.

Table 3 includes a summarized version of the timeline for Phases 1–2. Please see the sample work plan in Establishing an NMDR: example templates for the complete timeline for Phases 1–4.

Table 3. Sample work plan

Phases and activities	Parties responsible	Collaborators	Q1	Q2	Q3	…	Q5	Q6	Q6 +	Costs	Sources of finance
Phase 1. Planning the NMDR											
1. Identify and convene stakeholders											
2. Create a shared vision for the NMDR and its intended users											
3. Establish a governance mechanism											
4. Establish a steering committee, working groups, national champion											
5. Create a partner activity map											
6. Define the NMDR scope											
7. Conduct a high-level data audit and prioritization											
8. Develop a costed work plan											
Phases 2. Initial NMDR set-up and data integration											
1. Select and set up the platform for the NMDR											
2. Confirm selection of initial thematic area(s) (module) and convene subgroup											
3. In-depth module-specific data audit and mapping											

4. Elaborate key users and data use cases within module		
5. Configure/develop the module into the NMDR		
5.1 Module set-up (defining data dictionary and indicators)		
5.2 Consolidate, clean and map historical data		
5.3 Historical data importation		
5.4 Define future state data flow (periodic imports, continuous integration with a source system, direct data entry); design and implement future data flow processes		
5.5 Develop, refine and extend dashboards to specific needs; iterate		
6. Test and iterate on module with stakeholders and end users		
7. Roll-out and training		

An alternative work plan template is provided in Annex 2. Establishing an NMDR: example templates, which can be used to identify the human resources, workshops and timelines required for essential activities in the NMDR development journey. It also provides a list of illustrative deliverables that can be used as milestones to track progress throughout the implementation phase.

Please note, the sample budget sheet in Table 4 includes only Phase 1. For the full template, please see the sample budget sheet in Annex 2. Establishing an NMDR: example templates.

Table 4. Sample budget sheet

	Costs (external staff responsible for setting up and managing the NMDR)		Additional experts required		
Role	**IT expert responsible for the DHIS2 system**	**M&E expert familiar with the DHIS2 system**	**Person 3 e.g. LMIS expert**	**Person 4 e.g. server admin**	**Person 5**
Phases and activities	**Days**	**Days**	**Days**	**Days**	**Days**
Phase 1. Planning the NMDR					
1. Identify and convene stakeholders					
2. Create a shared vision for the NMDR and its intended users					
3. Establish a governance mechanism					
4. Establish a steering committee, working group, national champion					
5. Create a partner activity map					
6. Define the NMDR scope					
7. Conduct a high-level data audit and prioritization					
8. Develop a costed work plan					

Phase 2. Initial NMDR set-up and data integration

Overview	During the initial phase, the NMDR is created for a single thematic area, or "module", such as epidemiology or entomology. The thematic area chosen to start with should be based on the national champion's area of expertise.
Outputs	An NMDR platform with SOPs in place for data collection, data management and data visualization within one selected thematic area
Helpful resources	DHIS2 resources, including DHIS2 implementation guide, modules for epidemiology and vector control and entomology, metadata assessment and maintenance, MetaData Synchronization (MD Sync), and configuring new dashboards For the full list of DHIS2 resources, go to https://dhis2.org/resources/.

1. Set up the platform for the NMDR

Countries have set up their NMDR in different ways involving either a DHIS2 or a non-DHIS2 implementation. Some countries familiar with DHIS2 have opted for the DHIS2 route, which involves either (i) configuring a separate malaria DHIS2 instance or (ii) incorporating the modules into the routine HMIS/DHIS2 instance. Countries in the African Region that have opted for hybrid or non-DHIS2 implementations include Cameroon and South Africa. Cameroon uses the open-source "OpenHEXA" as its data integration platform in combination with DHIS2 as the actual data warehouse, while South Africa uses the "Harmony" platform.

The exact platform a country chooses to adopt as its repository depends on a number of factors – primarily the existing technical capacity and software familiarity within the ministry of health's HMIS unit (or equivalent digital health/information systems department) when the repository will be managed in-house, or the availability of diversified vendors to set up and manage systems. When considering outsourcing, countries will also need to consider the capacity to manage vendors effectively. It is important to consider the long-term sustainability of the system, understanding that it will require continuous maintenance and improvements. This maintenance should ideally take place without complete reliance on a single third-party organization (i.e. without vendor lock-in). As DHIS2 is already used by the ministry of health in the majority of countries, it may be the more sustainable option. This document focuses on DHIS2, but a comparison between DHIS2 and non-DHIS2 implementations can be found in Annex 5. Additional information on DHIS2.

When electing to use DHIS2 for the NMDR, a primary consideration is whether to configure a separate malaria DHIS2 instance (meaning a malaria-specific set-up including its own URL, set of data entry forms, users and dashboards), or whether to incorporate additional modules into the existing HMIS/DHIS2 instance (Figs. 3 and 4). This choice should be based on the advantages and disadvantages of each approach and consultations with relevant information system stakeholders.

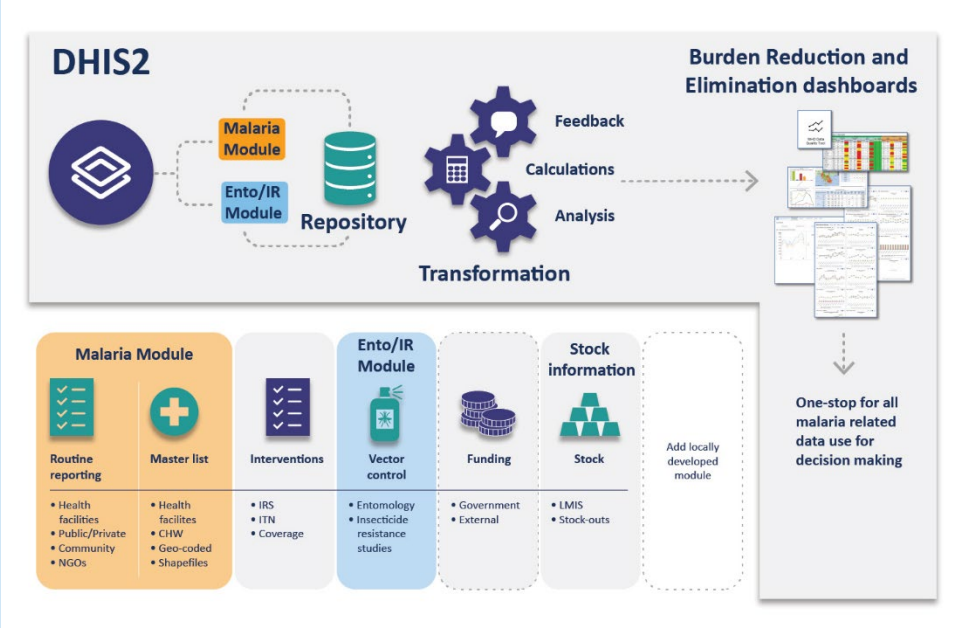
Box 1. DHIS2 modules for epidemiology and for entomology and vector control: pre-built packages to streamline data collection, cleaning and analysis

WHO, in conjunction with collaborating partners including the University of Oslo, and with Member States, has developed standard DHIS2 modules for malaria epidemiology and for entomology and vector control. The modules contain a packaged metadata set of standard data collection forms, automatically calculated indicators, data visualizations and thematic dashboards that allow for the collection, visualization and interpretation of data in line with WHO recommendations for some specific thematic areas (see Fig. 6). While these standard packages ensure alignment with WHO guidelines and can significantly fast-track development, countries should carefully adapt the out-of-box designs to suit the individual in-country workflows and data needs of the programme. These tools include:

- aggregate module and case-based module for burden reduction and elimination settings; and
- modules for entomological surveillance and vector control interventions.

The modules are being continuously expanded to meet country-specific needs and to include new procedures and methods for entomological surveillance and vector control intervention monitoring. Note that while these modules map to many of the recommended NMDR indicators listed in Annex 2. Establishing an NMDR: example templates, they will not necessarily cover all NMDR needs. Therefore, countries may need to design some modules from scratch.

Fig. 6. DHIS2 malaria modules



CHW: community health worker

1.1. Option A: configure a separate DHIS2 instance

The first option (Fig. 3) described here is to create a separate DHIS2 instance to house the repository that is linked to the routine HMIS. This involves establishing a distinct DHIS2 environment dedicated to hosting the NMDR, while ensuring seamless integration with the existing HMIS by synchronizing metadata (e.g. data elements) across the two systems and scheduling regular data exchange mechanisms between the two DHIS2 instances. The synchronization between the two DHIS2 instances ensures that routine epidemiological indicators are standardized and shared across systems, while the additional NMDR-specific DHIS2 instance can be further built out to accommodate other modules such as entomological and vector control data (see Annex 1. List of NMDR modules).

When configuring the set-up of two interoperable DHIS2 instances, two primary approaches can be considered. The first is to leverage standard DHIS2 out-of-the-box functionality, which involves configuring data elements, indicators and other settings within the new DHIS2 instance from the ground up. Alternatively, a more advanced method is recommended, which is to configure the synchronization and data update processes using the MD Sync tool; this can streamline the transfer of relevant information between the HMIS and the repository.

A step-by-step guide to setting up the repository in a separate instance can be reviewed in Annex 5. Additional information on DHIS2.

The advantages of having a separate DHIS2 instance are as follows:

- Greater control over content: Creating a separate DHIS2 instance provides greater autonomy and control over the content and data specific to the NMDR. This ensures that the repository can be tailored to meet the unique requirements of malaria data management.
- Less “data overhead”: With this approach, there is reduced data overhead in terms of developing data elements, indicators and other system configurations. This streamlining reduces the complexity of managing the repository, making it more efficient and user-friendly.
- Faster system on equivalent hardware: Separating the repository from the routine HMIS can lead to improved system performance, even when using equivalent hardware. This enhanced speed and responsiveness can contribute to a more efficient data management process.

The disadvantages of having a separate DHIS2 instance are as follows:

- Maintenance resources: Creating a separate DHIS2 instance means that there will be an additional system to maintain and manage. This entails regular updates, backups and monitoring, which often requires additional resources. NMPs should understand whether such maintenance resources are realistically available in the long term, or whether it is more realistic to leverage and share resources with the HMIS.
- Potential redundancy: Some countries have progressively expanded their HMIS in recent years to incorporate data beyond routine epidemiology, including other minimum recommended NMDR modules such as chemoprevention, vector control and stock management. In this case, creating a separate NMDR instance to accommodate minor additional malaria-specific modules may have limited utility and applicability if most data are already in the HMIS.

- Clarity among end users: End users may require additional support to understand when to use different DHIS2 instances for different activities and responsibilities. They may also require support to transition seamlessly between, and work within, multiple DHIS2 instances.

1.2. Option B: incorporate NMDR modules into the HMIS

Another option is to incorporate the NMDR modules directly into the HMIS (Fig. 4). This approach offers the advantage of integrating the NMDR seamlessly with the existing health data infrastructure. However, it is important to note that any modification to the HMIS may entail a lengthy approval process, which is typically conducted on an annual basis. This process is characterized by its rigidity, although this rigidity is justified by the fact that the HMIS serves as the fundamental backbone of the routine surveillance system and is used by all other health programmes.

The advantages of incorporating the modules into the routine HMIS are as follows:

- Simplified system maintenance: One notable advantage is that with the repository integrated into the HMIS, there is only one system to manage and maintain. This unified approach can reduce the administrative burden associated with operating multiple systems. This can be particularly important when technical maintenance funding and resources are limited, as each system requires individual maintenance.
- Broader health data integration: Integrating the NMDR with the HMIS enables management of a broader spectrum of health data. This is particularly advantageous because other diseases and health indicators can coexist within the same framework. This also streamlines data collection and reporting processes, as health workers can use a single platform to manage a variety of health-related information.

The disadvantages of incorporating the modules into the routine HMIS are as follows:

- Increased “data overhead”: A drawback of this integration is the potential for increased data overhead. As more data elements and indicators are added to the system to accommodate various health topics, data management may become more complex. This can lead to a larger data set to manage, potentially requiring more storage and computational resources, as well as data management resources to keep data organized and usable.
- Reduced control by the NMP: Another trade-off is that integrating with the HMIS may result in less direct control for the NMP. This is because the HMIS typically operates under a broader scope that encompasses various health issues, not just malaria. Decisions related to HMIS management, system updates and data collection priorities may be influenced by a larger group of stakeholders, which could impact the autonomy of the NMP in managing the malaria-specific repository.

Importantly, a separate NMDR instance should not be used as a workaround to address inherent HMIS design limitations or deficiencies, given the importance of strong HMIS data quality and use. Rather, NMPs should work with the HMIS unit to address any HMIS design limitations for modules already in the HMIS (such as missing indicator calculations or fit-for-purpose dashboards for routine epidemiology) while building towards the broader NMDR through whichever option is selected.

2. Decide which thematic area to use as the starting point

The first set of data transferred into the NMDR is typically referred to as a country's "entry point". Different countries have used different entry points when setting up their NMDR. For example, Burkina Faso, Mozambique and the Niger started by transferring routine epidemiological data into a separate DHIS2 instance.[1] Ghana, however, first focused on entomology and will concentrate on bringing in routine epidemiological data and other prioritized data after the initial entomology module implementation.

Experience has shown that it is beneficial if the designated on-the-ground champion is in the same field as the starting thematic area. For example, if a country has highly active entomologists who are able to take on the responsibility of being the on-the-ground champion, it would make sense for entomological data to be the entry point. Starting with readily available standard WHO DHIS2 modules can also help get the project running. The clear established guidelines and out-of-the-box templates of these modules can be reviewed and revised, instead of starting from scratch.

By selecting an initial module as the entry point and running through the NMDR platform set-up and module configuration process, countries can develop procedures for adding data to the repository, see results quickly, and iron out any project coordination issues. This process provides a valuable mini NMDR piloting experience. After the first thematic area has been successfully incorporated into the NMDR, tested, validated and used, this process can be more efficiently repeated for additional thematic areas.

3. Audit and map data

Countries should start by reviewing the selected NMDR indicators pertaining to the thematic module selected as the entry point, and the high-level data audit conducted during the Planning Phase (see Phase 1: Define the NMDR scope and Conduct a high-level data audit and prioritization). Expand on this data audit by further identifying and elaborating what data sources are available to calculate these selected indicators, and how the data are currently collected, reported and stored. This includes mapping out all distinct electronic systems and databases that currently store these indicators and their inputs. It is also possible that multiple systems will store similar indicators, e.g. both an HMIS and Integrated Disease Surveillance and Response system can provide "total confirmed malaria cases". In these scenarios, both systems can be targeted when defining the NMDR scope and conducting the data audit. (Distinct prefixes or other tags can be used to differentiate these sources for end users.)

For each data source, the following information should be recorded, as shown in the example data audit in Table 5:

- **Module:** This is the thematic area of the data source, e.g. entomology or epidemiology.
- **Form name:** This is the name of the specific data source, e.g. malaria monthly report.

[1] Transferring routine epidemiological data into the NMDR would only be required if developing a separate NMDR-specific DHIS2 instance. For countries that have opted to build the NMDR into the HMIS DHIS2 instance, routine epidemiological data would most likely already be in the HMIS. However, countries would still need to dedicate time and effort to review and revise the routine epidemiological forms, validation rules, indicators, dashboards and other outputs in order to ensure that the module is relevant for real-world decision-making needs.

- **Description:** This is a brief description of the type of data collected and the data source, e.g. inpatient cases at hospital level.
- **Data reporting frequency:** The frequency is monthly, weekly, daily, event or case-based, etc., based on the lowest temporal granularity of the data in the current electronic storage format.
- **Availability of historical data:** Are there historical data that can be imported into the NMDR and how complex will that process be? Cleaning and compiling messy historical data can be a lengthy process and may add to the cost and complexity of the project, especially where developers or third-party technicians must be paid to incorporate these data. Leveraging data experts in working groups can help to minimize costs in this area.
- **Spatial granularity:** This could be health facility, household, village, district, sentinel site, etc., based on the lowest level of spatial granularity of the data in the current electronic storage format.
- **Proposed NMDR granularity:** What level of granularity is required in the NMDR? In some cases, the data used in the NMDR might be at the same level of granularity as the source, although this is not always necessary or optimal. For example, surveys may have been conducted at the household level; however, the most pertinent information to include in the NMDR may be indicators at an appropriate administrative unit level (province, district), and individual household data would bloat the database without purpose.
- **Current electronic storage method:** Reviewing where and how data are currently stored can help to inform decisions about how those data will be added to the NMDR. For example, in cases where data are currently stored in robust systems (e.g. CommCare, OpenLMIS or another DHIS2 instance), developing a direct integration may be an appropriate (and operationally sound) solution. In other cases (e.g. where data are being recorded using spreadsheet software such as Excel or in a partner system), it may be best to develop a reporting form in the NMDR so that data can be directly reported into the NMDR, or periodically imported into the NMDR using an import template.
- **NMDR data flow:** This is the proposed route through which data will be added to the NMDR. Data can be added in one of three ways, with considerations to weigh noted below:

    1. Data can be pushed through an integration with a source system (e.g. MD Sync app for DHIS2–DHIS2 integrations between the HMIS and NMDR, or an OpenLMIS–DHIS2 integration between the HMIS and LMIS, or NMDR and LMIS).
        - Consider whether the system is mature and scaled, as system integrations require dedicated technical maintenance to keep the two systems connected and actively exchanging data.
        - Additional data integration platforms can be used as ETL (extract, transform, load) middleware to set up manageable pipelines and allow for automated synchronization between source systems and the NMDR.
    2. Data can be periodically imported using an import template (e.g. using the Bulk Load app for a user-friendly process) or via the application programming interface (API), which is more technical.
        - This approach requires clear SOPs for when the data will be imported, by whom and how. This can be a good option for incorporating periodic survey data from

the Demographic and Health Survey and malaria indicator survey, or for partner-generated data that are shared monthly or quarterly.

3. Data can be directly entered via an electronic data entry form embedded in the NMDR (DHIS2 allows for both web-based entry on a computer and offline entry on an Android mobile device).
    - This approach requires clear SOPs for when the data will be reported, by whom and how. This can be a good option for data streams that are routine or semi-routine, such as insecticide resistance monitoring or supervision.

In some cases, it may make the most sense to digitize new reporting forms in other information systems that will be integrated with the NMDR, such as the HMIS or LMIS, especially if the users are similar. For example, it may be optimal to digitally report the tracking of SMC commodities across warehouses into the LMIS instead of into the NMDR if warehouses are using the LMIS.

- **NMDR technical consultant effort:** The expected system implementer and technical workload (e.g. from developing system integrations or new reporting forms) should be itemized to arrive at a total level of effort. This informs the development effort and budget needed for each individual data source and ultimately the overall development budget.

Table 5. Example data audit for epidemiology and entomology

Module	Form/data set name	Description	Data collection frequency	Are historical data available?	Source granularity	Proposed NMDR granularity	Current electronic reporting/ storage method	NMDR data flow	NMDR technical consultant effort
Case surveillance (HMIS)	Malaria monthly report	Aggregated malaria case data compiled from facility register and community health worker forms	Monthly	Yes	Facility	Same as source	HMIS (DHIS2)	HMIS DHIS2 → NMDR DHIS2	System integration (with HMIS)
	Health centre admission form	Inpatient cases at health facility level	Monthly	Yes	Facility	Same as source, malaria data only	HMIS (DHIS2)	HMIS DHIS2 → NMDR DHIS2	
	Hospital admission form	Inpatient cases at hospital level	Monthly	Yes	Facility	Same as source, malaria data only	HMIS (DHIS2)	HMIS DHIS2 → NMDR DHIS2	
	Antenatal care	Pregnant cases from antenatal care visits	Monthly	Yes	Facility	Same as source, malaria data only	HMIS (DHIS2)	HMIS DHIS2 → NMDR DHIS2	
	Weekly surveillance form	Suspected cases, confirmed cases, and deaths for children under 5 and over 5	Weekly	Yes	Facility	Same as source, malaria data only	HMIS (DHIS2)	HMIS DHIS2 → NMDR DHIS2	

Entomological	Larval collection	Larval collection, classification and density	Ad hoc	Yes	Sentinel site	Same as source	Excel	Direct entry into NMDR DHIS2 (via web capture, Excel import, or DHIS2 Capture mobile app)	Digitize new form
	Adult collection	Adult collection, classification and density	Ad hoc	Yes	Sentinel site	Same as source	Excel	Direct entry into NMDR DHIS2 (via web capture, Excel import, or DHIS2 Capture mobile app)	Digitize new form
	Insecticide resistance	Insecticide resistance by insecticide	Ad hoc	Yes	Sentinel site	Same as source	Excel	Direct entry into NMDR DHIS2 (via web capture, Excel import, or DHIS2 Capture mobile app)	Digitize new form
	Insecticide resistance – intensity concentration	Insecticide resistance by insecticide and concentration	Ad hoc	Yes	Sentinel site	Same as source	Excel	Direct entry into NMDR DHIS2 (via web capture, Excel import, or DHIS2 Capture mobile app)	Digitize new form

	Insecticide resistance – molecular and biochemical mechanism	Molecular mechanism of resistance	Ad hoc	Yes	Sentinel site	Same as source	Excel	Direct entry into NMDR DHIS2 (via web capture, Excel import, or DHIS2 Capture mobile app)	Digitize new form
	Insecticide resistance – synergist-insecticide bioassay	Insecticide resistance synergy between compounds	Ad hoc	Yes	Sentinel site	Same as source	Excel	Direct entry into NMDR DHIS2 (via web capture, Excel import, or DHIS2 Capture mobile app)	Digitize new form

4. Define key users and data use cases

Next, review and update any initial high-level end-user mapping developed during the Planning Phase, diving into the specific roles and data use needs of each user expected to interact with the selected module. Mapping out the target users and the data they require to make key decisions will help to refine the selected indicators and the level of spatial and temporal data granularity that is needed in the NMDR for timely and effective decision-making (see Table 6 for an example). This step will also guide dashboard design and ensure that dashboards are developed based on real-world decision-making needs and scenarios. Countries should carefully consider both routine data use needs and those for strategic planning and programme evaluation, and how data use needs may vary across user profiles and levels. Designing each NMDR module with these anchoring points in mind will mean that the NMDR has a greater chance of providing utility for end users (see Phase 2: Develop, refine and extend dashboards to specific needs). In many cases, mapping target end users also helps with planning for training, equipment and other deployment needs. For example, if entomologists are to play a role in submitting data to the NMDR from sentinel sites and monitoring results in dashboards, they will need to be equipped with tablets to access the NMDR and included in training activities.

Table 6. Example key user and their needs

Name	Angela Mensah
Organization	National Malaria Elimination Programme, Ghana
Position	Head of the Vector Surveillance Unit
Level/functional area	National, district level 1, district level 2
Use case and programmatic needs	Angela works in the vector control team of Ghana's NMP. She is responsible for overseeing the following: • Vector surveillance: Which mosquito species are present and are these species resistant to any insecticides? • Vector control and elimination interventions: Where should vector control interventions such as IRS or ITNs be carried out and are they successful in reducing the malaria incidence?
Understanding Data-to-Action (D2A) needs	D2A use case: where IRS should be targeted **Where** the decision takes place: In this use case, the decision on where IRS should occur will take place at the national level. **Who** makes the decision: The vector control technical working group makes the decision at the country level. Note that the final decision to implement IRS depends on the availability of funding once a full subnational tailoring process has been conducted.

	What data are needed to make the decision: Entomological data on the insecticide resistance status of vectors and their biting behaviour are needed. **When** is the decision needed: Targeting of interventions is done every 3–5 years, aligned to the national strategic plan.
Data visualization needs	Angela (and other key decision-makers) will need to see graphs of vector surveillance data disaggregated by district level. Vector surveillance charts: • Which sentinel sites have submitted vector surveillance data? This will indicate the degree to which routine entomological data are available. • Which species are being detected? This will indicate which interventions would be the most suitable. • Are the mosquito populations resistant to any insecticides? This will show which insecticides can be used and which should be avoided during interventions. • Have any new invasive species (such as *Anopheles stephensi*) been detected? This should be reported to WHO. Vector control intervention charts: • What is the coverage of vector control interventions conducted? This will ensure that observed impact is properly linked to the degree to which the intervention was successfully deployed in the community. • What are mosquito population numbers before and after interventions are carried out? This will help to understand whether interventions have been successful in reducing the number of mosquitoes. • What are the malaria case numbers before and after interventions? This will help to determine whether the interventions have affected the presence of malaria in the local population. Note: Some programmatic questions cannot be easily visualized because the underlying data are either not collected routinely or annually, or they require specific analytical techniques.
What equipment does the user require?	Laptops are suitable for the office and travel, whereas tablets and telephones are more suitable for mobile field work, offering superior portability, built-in GPS, touchscreen interface, and multimedia capabilities. These devices facilitate real-time data capture and transmission, even in offline environments.

What training does the user require?	Angela will require training to gain a deeper understanding of the following: • DHIS2: How to use DHIS2. • Data collection: In what format are data being collected and which modules should be used (mosquito surveillance data, IRS implementation data, ITN distribution data) from the field, sentinel sites and laboratories? • Data input: How are data added to the system? Who enters data into the system and at what frequency? • Data quality assurance: Who is responsible for monitoring and validating incoming data? • Data cleaning: Who is responsible for data cleaning, and what is the process? • Dashboard visualization: How can data outputs be accessed and newly created in the DHIS2 dashboards and visualization apps? How can visuals be filtered and modified? How can data be extracted?

D2A framework

What is a D2A framework?

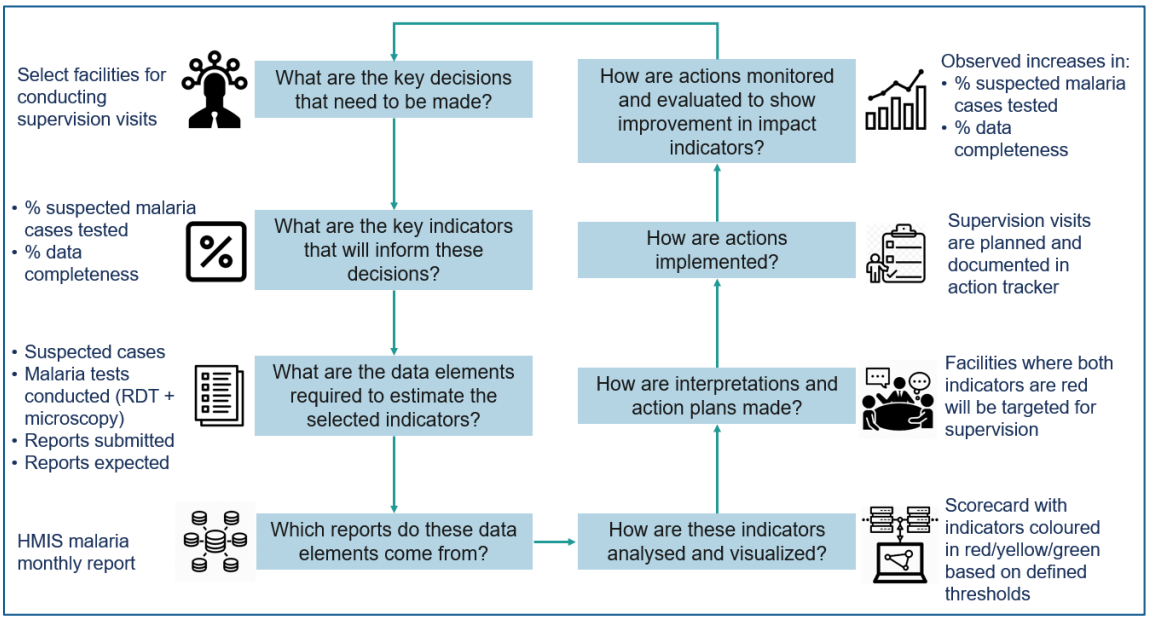
The D2A framework provides guiding principles for improving data-driven decision-making in malaria surveillance and health care interventions. Specifically, a D2A framework helps to identify **who** (at which level of any given system) should do **what** (e.g. identify a situation/problem, make a decision, implement an action, etc.), **when** (what timelines are required), and **how** (what resources are required and how should they be mobilized). As malaria-endemic regions intensify efforts towards elimination, designing NMDRs with an embedded D2A approach ensures that such repositories can be easily leveraged to provide actionable insights and optimize programme implementation.

Key components of the framework

Countries embarking on developing NMDRs would benefit from embedding D2A components into the design phase, whether adapting and optimizing existing WHO standard packages or designing new custom modules for specific country needs.

The components of the D2A framework should be led by NMPs and can be informed by the recommendations of surveillance assessments. Although countries should tailor their D2A framework to respond to their specific needs, many of its components can be easily applied in a wide variety of country contexts. These include: (i) identifying key programmatic decisions based on data; (ii) establishing corresponding key indicators for surveillance and action planning; (iii) defining data elements necessary for accurate indicator estimation; (iv) determining data sources (e.g. malaria surveillance systems, reports); (v) ensuring proper analysis, visualization and interpretation of data; and (vi) formulating and implementing action plans based on insights (see Fig. 7 illustrating the interaction between data collection, decision-making, action implementation and impact evaluation).

Fig. 7. Key dimensions of a D2A framework alongside an example use case for supervision targeting



Mapping "personas" (or archetypes of data users and decision-makers) to their decision-making and data needs and corresponding NMDR modules is good practice for facilitating the development of the NMDR across each of the selected modules and ensuring that the repository is fit for purpose for real-world decision-making needs.

Conclusion

A well integrated D2A framework enhances decision-making by providing a structured approach to analysing and acting upon data insights and helps to anticipate any potential bottlenecks that might impede effective decision-making. The D2A framework complements this by offering systematic tracking of key indicators and ensuring accountability through well defined action plans. Together, these frameworks drive more effective malaria surveillance and broader health care improvements.

Lesson learned: identify key users and their data needs early on

Failing to identify key users and their needs early on in the project can result in a number of project failures, outlined below, that hinder effective use of the NMDR.

- An NMDR can be created that merely brings different types of data into a central database but does not make it easy to use those data (e.g. indicators are disorganized and hard to find).
- End users are not engaged during module design processes and are not given any opportunity to provide input or feedback, leading to disengagement with the NMDR.
- Dashboards reflect the data being added to the repository, but are difficult to interpret, do not have the right spatial or temporal disaggregation, and are disconnected from any real-world decision-making needs.

The use of D2A frameworks can help to minimize these risks.

5. Configure the module in the NMDR

This section provides a high-level overview of the initial set-up procedure and data integration when using DHIS2.

5.1. Module set-up (defining data dictionary and indicators)

Data can only be entered or imported into the system once a data dictionary has been defined and configured in the system using DHIS2's native data model and schema. To make this process easier, WHO has created several standard module packages in DHIS2 for some thematic areas. These modules provide preconfigured data collection forms, data visualizations and dashboards, with automatically calculated indicators relevant to malaria monitoring and the creation of an NMDR. These include modules on entomology and vector control. Note that these modules require careful adaptation and tailoring to country-specific workflows, processes and needs in order to be relevant; however, they can help fast-track the configuration process considerably, while providing built-in adherence to WHO standards and coding conventions. Additional information on modules and their functions is available in Annex 1. List of NMDR modules.

While the WHO DHIS2 modules encompass many NMDR indicators, they do not cover all NMDR indicators suggested by WHO (see indicator list in Annex 4. NMDR indicator list). Therefore, there may still be data streams that require the design and implementation of new data collection tools and associated reporting processes, such as a supervision programme. In some cases, it may make the most sense to digitize these new electronic reporting forms in an existing system, such as the HMIS or LMIS, and use system integrations to ensure that the data are pushed to the NMDR as is relevant. In other cases, embedding these forms in the NMDR (if it is a separate instance) may be the best option. These reporting systems should then be tested to ensure that they are functioning as planned and refined based on testing/piloting results and feedback. More information on creating custom data entry forms in DHIS2 can be found at docs.dhis2.org: Manage data sets and data entry forms.

5.2. Consolidate, clean and map data

Historical programmatic data that fall under the scope of the module should be compiled, cleaned and mapped to prepare it for importation into the NMDR. This may require significant effort if the data are stored in many different files, formats and systems, and if different geospatial reference lists are being used (e.g. different health facility lists). In addition, a key step in the initial set-up of the DHIS2 instance is to ensure data quality and integrity. This includes ensuring that raw data have been appropriately cleaned before importation (e.g. removing duplicate data or resolving missing data points) and performing metadata assessment and maintenance. Data cleaning might be an iterative process, however, as the NMDR may reveal additional data quality gaps that should be addressed.

5.3. Data importation

After historical data are compiled, a technical system implementer can import the data into the NMDR against the data dictionary that has been defined and configured in the system. Generally, it is recommended that data imported into the NMDR be aggregated (i.e. weekly or monthly data points) rather than imported as individual line listings (i.e. all individual data points from mosquito

sampling efforts or patient-level data). This ensures that the repository contains only the information that is most pertinent to end users, personally identifiable data remain protected, and database performance is not slowed down by unnecessarily large data tables. Any patient- or household-level data should typically be aggregated to the lowest possible level within the administrative or health divisions (e.g. health facility for case-based surveillance data, ward or commune for campaign data, sentinel sites for vector monitoring); however, it may be necessary to keep some granular data in order to preserve GPS coordinates for geospatial analysis, depending on decision-making needs.

5.4. Future state data flow implementation

Future and incoming data can continue to be integrated with DHIS2 in one of three ways:

- Established system integrations (e.g. with the LMIS): This can be done via a point-to-point integration between two systems or via a middle layer data exchange mechanism.
- Leveraging periodic imports: The Bulk Load app allows for end users to download ready-to-fill Excel templates that enable user-friendly uploading of programmatic data into a DHIS2 instance. Alternatively, the API can be used for more technical users.
- Directly entering new data into an electronic reporting form embedded in the NMDR: This can be done via web-based entry or via the offline-capable mobile DHIS2 Capture Android app.

Box 2. Country example: Nigeria's integration of data from its HMIS

After initial efforts to identify relevant variables that should be included in the NMDR, Nigeria's team chose to set up a separate DHIS2 instance and import variables from the national HMIS. The team was careful to use the same variable IDs between systems to ensure that it would be easy to import data into the NMDR from the HMIS in the future.

Ongoing data exchange was facilitated using middleware that could pull data from the HMIS into the repository periodically. The team also ensured alignment with existing data collection sites and practices, maintaining a single point of data entry in the HMIS.

This prevented duplication of effort and ensured that busy health care workers could continue to enter data as normal, while still making those data available in the repository.

5.5. Develop, refine and extend dashboards to specific needs

After configuring the DHIS2 instance and integrating the necessary data sources, the next step involves developing and refining how dashboards display data to end users. When using WHO DHIS2 standard modules, some preconfigured dashboards will be available automatically and may just require some simple tailoring. For other thematic areas, or for other data use needs, this will require configuring new dashboards. Dashboards should be intentionally designed and tailored to meet the specific needs and objectives of their end users, taking each individual user profile and level into consideration.

Data visualization: A critical aspect of dashboard refinement is data visualization. This includes creating charts and tables that present the data in a more understandable and actionable format. Charts can visually represent trends, comparisons and correlations, making it easier for users to interpret and derive insights from the data.

Partner-specific reports: In many cases, partner organizations, such as funding organizations, require specific reports. Partner-specific reports can be created within the DHIS2 system to automate this for the NMP.

Data availability and completeness: To support the creation of dashboards and partner-specific reports, it is crucial for all relevant data points to be available in the system. This involves ensuring that data from various sources have been successfully integrated into the DHIS2 instance. The completeness and timeliness of data are essential to provide accurate and up-to-date information on the malaria situation.

Geographical hierarchies (administrative levels and health divisions): DHIS2 allows for data aggregation and analysis at different administrative levels, such as national, regional and district levels. The refinement of dashboards should consider the hierarchical structure of data. This means that users can view and analyse data not only at the national level but also at subnational levels, which is particularly valuable for localized malaria control efforts. Dashboards can be dynamically configured to present data at different default levels depending on the user profile.

5.6. Technical challenges during DHIS2 set-up

A number of technical issues may be encountered during the set-up of a DHIS2 instance. Some common problems and their solutions are addressed in Annex 5. Additional information on DHIS2. Additional technical details are addressed in the DHIS2 implementation guide available at docs.dhis2.org: Implementation guide¶.

Box 3. Country example: Ghana's experience of incorporating standard modules into its DHIS2 NMDR

Ghana, in its aim to enhance malaria surveillance and control efforts, established a second DHIS2 instance dedicated to entomology. The NMP is currently planning to integrate this module into the HMIS. The aim of this integration is to create a seamless flow of data between the entomological module and routine health data, providing a more holistic perspective on malaria-related information.

Ghana has had great success by holding workshops to install, configure and tailor modules in the country's NMDR. These workshops have served as a collaborative platform, bringing together key stakeholders, including representatives from the NMP, HMIS experts with DHIS2 experience, and partner organizations such as Clinton Health Access Initiative (CHAI). As an experienced partner, CHAI played a crucial role in guiding the integration process and sharing insights on effective data manipulation techniques.

An initial workshop focused on the installation of the entomology module. Following the success of that initial workshop, subsequent workshops were held that focused on installing non-routine modules such as climate data. This involved not only the integration of the data but also the development of applications and dashboards tailored to visualize and analyse climate-related information.

These workshops each spanned a week, giving sufficient time for comprehensive discussion, hands-on training and collaborative problem-solving. This extended duration facilitated in-depth exploration of the technical aspects of module installation and data manipulation.

The success of integrating climate data serves as a blueprint for future efforts to bring on board additional non-routine data. Ghana envisions conducting similar week-long workshops, thereby maintaining a consistent and collaborative approach to module expansion.

Box 4. Country example: hybrid DHIS2 solutions

Several countries, including Côte d'Ivoire, Cameroon, Democratic Republic of the Congo, Mali and the Niger, chose to adopt a hybrid solution, combining OpenHEXA for managing integration pipelines and DHIS2 as the NMDR. OpenHEXA acts as the ETL platform used to retrieve and process information from diverse sources, particularly those that are not stored in DHIS2. Data extraction pipelines are implemented as direct connections through APIs or as semi-automated scheduled import jobs that retrieve data from their original sources, such as Excel, ODK, Access, SQL or other databases and source files. The OpenHEXA platform can be hosted either in the cloud or locally and acts as a central ETL aggregator, pulling, transforming and depositing dispersed pieces of information into the NMDR DHIS2 instance. Additional comprehensive analysis and data products are developed in OpenHEXA and can be either re-injected into the NMDR or visualized through more advanced business intelligence (BI) tools such as Tableau, Power BI or Superset.

Box 5. Country example: Côte d'Ivoire's approach to NMDR implementation

The NMP of Côte d'Ivoire embarked on its NMDR implementation journey in early 2024, as part of a broader project designed to enhance malaria surveillance data use, funded by the Gates Foundation. The national programme adopted an approach whereby the NMDR was to be configured through a series of dedicated technical workshops, proceeding module by module.

The first step in the process was to convene a launch meeting with the NMP and partners to present the NMDR concept and establish a rough implementation plan. A dedicated focal point was named, and steps were taken to formally establish a steering committee and technical working group to guide the design and implementation of the repository.

An initial technical workshop took place in early March 2024 to map relevant data sources, information systems and malaria stakeholders. Workshop participants also identified and reviewed options around the NMDR platform solution, hosting and general architecture, and developed a prioritized list of NMDR modules. Technical specifications were recommended to the steering committee, while available infrastructure and resources for local hosting were assessed. As a result, a dedicated DHIS2 instance was created, replicating the HMIS organization unit structure and other key metadata, to be hosted locally by the NMP.

Subsequently, several configuration workshops were organized under the leadership of the NMP, each attended by technical staff from the national programme and other Ministry of Health departments, as well as by key technical partners relevant to the modules being configured. Each workshop typically lasted for 7–10 days and was conducted off-site to ensure that technical staff could efficiently advance the specific objectives for configuring the NMDR modules, with 3–5 modules covered in each workshop. These objectives included: (i) identifying the source data to be included; (ii) configuring the metadata (data elements, indicators, forms); (iii) importing source data through one-off imports or establishing a direct API connection to the source systems; (iv) identifying relevant data visualizations and outputs; and (v) configuring the corresponding dashboard for each module. In between configuration workshops, the NMP and Bluesquare worked further on the platform configuration, including by fine-tuning modules and importing additional legacy data.

While this approach may be comparatively resource-intensive and requires considerable time to implement, it has resulted in strong ownership and progressive, ongoing capacity strengthening of the NMP, HMIS and other teams involved in the NMDR development process.

Phase 3. Intermediate NMDR development: integrating additional modules

Overview	Once the NMDR has been established for the first thematic area, additional thematic areas can be itemized and prioritized. These are then incorporated into the NMDR one thematic area at a time, although there can be some overlap, with modules being worked on concurrently. Developments follow the same path as the initial phase.
Outputs	Integrate additional thematic areas into the NMDR, following the same activities as in Phase 2. Additional dashboards and SOPs should be put in place for managing and analysing data at different levels (e.g. national, operational), including advanced analytics based on data use needs and real-world bulletins and reports.
Helpful resources	See Annex 2. Establishing an NMDR: example templates (NMDR data itemization and planning table template) and Annex 4. NMDR indicator list.

1. Decide which additional thematic areas and indicators to include

Phase 1 involves high-level indicator selection and data auditing and mapping to identify the overall target NMDR modules. Phase 2 then involves elaborating on the initial auditing and mapping data for the first selected module to incorporate into the NMDR, arriving at a detailed list and approach for exactly what data will be included and how, before initiating platform configuration.

During Phase 3, this process will be continued to incorporate the remaining modules into the NMDR. After selecting the next module to work on, the indicators originally selected in Phase 1 should be reviewed and updated as needed.

Lesson learned: ensure that the NMDR remains adaptable to emerging insights and changing needs

The process of loading a module's metadata is dynamic and involves continuous enhancement and iteration. As the understanding of malaria dynamics evolves, new data points, indicators and data collection forms may need to be added to the modules. Countries should adopt an iterative approach, ensuring that the NMDR remains adaptable to emerging insights and changing needs in malaria control and elimination efforts. This includes finding and embracing opportunities to improve data collection systems and reporting processes. Incorporating review of existing data flow processes within existing stakeholder forums (e.g. thematic technical working groups) can help ensure that emerging needs and desired changes are routinely evaluated, discussed and prioritized for incorporation into the NMDR.

2. Audit and map data, and prioritize modules for inclusion in the NMDR

The final output of the data mapping and itemization step should be a complete overview of the data to be included in the NMDR, grouped into modules. The modules should be prioritized based on the vision of the NMDR and its key users, and data accessibility. The factors to consider are described below in more detail.

Data accessibility: It is important to consider the source and format of the data and how accessible they are. Understanding the level of difficulty in digitizing and incorporating these data into the NMDR will help to determine which data sets to incorporate into the repository first, and which will require more time to access and convert into the required format.

Human capital: When prioritizing data, it is important to consider the human and technical capacity, and the appetite that stakeholders have for incorporating the different modules. To assess the human capital, profiles should be created for each position, detailing the number of individuals available and the level at which they are operating (national, regional, district). Positions to consider include computer scientists in the front-/back-end, web developers, statisticians, epidemiologists, biostatisticians, data managers, doctors and entomologists. Profiles should also be created for the programme manager, different implementers and the personnel that will train users on the selected platform.

Technical capital and access to infrastructure: When considering the technical aspects, it is essential to evaluate the infrastructure required to host the NMDR platform effectively. This includes understanding computer requirements, such as storage capacity and processing power. It is crucial to understand how well the existing technical resources can sustain the repository. This assessment ensures that the chosen hardware and infrastructure can handle the load and provide a responsive system, which is vital for efficient data management.

Access: Identifying who has access to the required infrastructure is essential. The ownership of the infrastructure – whether it lies with the ministry of health, the NMP or a partner organization – should be clarified. It is also important to specify which partner organizations are involved and the form of any infrastructure support they provide. In addition, programmes should consider the feasibility of establishing data transfer mechanisms between the selected NMDR platform and other systems, using APIs. If direct API integration is challenging, alternatives such as Excel-based two-step integration can be explored to ensure smooth data flow between systems.

3. Define key users and data use cases

For each of the audited and prioritized modules, the key users and data use cases should be identified, as described in Phase 2: Define key users and data use cases.

4. Integrate the modules into the NMDR in a phased approach

The same process for integrating each of the prioritized modules into the NMDR should be followed as described in Phase 2: 5.1 Module setup (defining data dictionary and indicators). 5.2 Consolidate, clean and map data, 5.3 Data importation, and 5.5 Refine and extend dashboards to specific needs.

Box 6. Country example: Burkina Faso's experience bringing together stakeholders in week-long workshops

Burkina Faso has found it useful to bring together stakeholders in week-long joint design and development workshops. The team uses this time to review progress to date, decide on additional data to incorporate into the NMDR, add data to the repository and test the linkage so that future data can be easily incorporated. Table 7 gives an overview of a workshop held in Burkina Faso, summarizing the key activities over the week.

Table 7. Activities carried out by Burkina Faso during a data integration workshop (for HMIS component of epidemiology module)

Activities	Day								
	1	2	3	4	5	6	7	8	9
Provide an overview of the process of setting up an NMDR.									
Explain the current malaria data repository in the country and the configuration of the DHIS2 instance that has been created.									
Review the existing data and data gaps.									
Identify additional data that the team would like to transfer to the national malaria data repository.									
Add the data from the HMIS to the DHIS2 NMDR by matching indicators and data elements, creating data elements and input forms.									
Test the data flow between the HMIS and the DHIS2 NMDR.									
Achieve interoperability between the HMIS and the DHIS2 NMDR.									
Test the interoperability between the HMIS and the DHIS2 NMDR.									

Develop dashboards, for example, on morbidity, mortality and intervention coverage.	
Continue developing the dashboards.	
Decide on data validation rules.	
Review the work carried out during the workshop.	
Decide on the next steps to take.	

5. Continuously optimize data repositories and information systems

It is likely that countries will have a mixture of data sources, including information systems (e.g. DHIS2) for the HMIS and LMIS, siloed partner-owned information systems (e.g. PMI VectorLink), and ad hoc solutions (e.g. Microsoft Access or Excel). Special attention should be given to semi-routine data managed in ad hoc tools such as Access and Excel, as this indicates that information systems could be more robust. The goal should be to improve the collection and reporting of these data. When assessing data that lack an information system, it is helpful to explore where it makes most sense for those data to be collected/reported into, in consultation with the ministry of health informatics/digital health unit.

Regardless of the information system approach for routinely collected data, there will always be additional data generated by surveys, academic studies, and so on. These emerging data will require ongoing governance and alignment on the best approaches to incorporating this data (i.e. processes for importation or manual entry), as well as clear roles and responsibilities.

Lessons learned

1. The use of paper-based reporting is often revealed during the data audit and mapping process; these forms should be digitized as part of the NMDR process. Very often, non-HMIS and non-LMIS programmatic data are either paper-based and stored in Excel, or collected and stored in partner-owned systems. Integrating Excel data as-is without defining new electronic reporting processes can create challenges, as there will always be more Excel-based data to incorporate, along with the access delays, mismatches in administrative units, inconsistent data dictionaries and other persistent challenges. Migrating to standardized electronic reporting forms, whether in an existing information system or the NMDR itself, can mitigate some of these issues.
2. Programmes should be strategic about automated integrations. Trying to integrate multiple pilot systems will overwhelm digital health/informatics units. It is not reasonable or sustainable for a government to ingest data from every system or source. Instead, malaria programmes and digital health/informatics units should be prepared to prioritize, consolidate and retire tools, while establishing clear pathways and guidelines for partners to ensure that their data are submitted to the NMDR.

3. Change management is the most difficult aspect of introducing any new system and should be initiated early. This includes revising guidelines, SOPs, supervision structures, and job descriptions. Operational changes can also be piloted through an incremental roll-out of the new system, which may reveal critical challenges with stakeholder buy-in.
4. Importantly, systems do not need to be "finished" before they can be used and tested. A phased approach catches design and workflow issues early on and provides the opportunity for "quick wins".

Phase 4. Advanced NMDR development: governance and sustainability

Overview	The advanced stage involves ensuring the long-term sustainability of the NMDR and ongoing maintenance. Training at all levels will continue to be carried out as new data are incorporated into the NMDR or when changes or updates happen as part of continued system maintenance.
Outputs	Advanced NMDR development: guided by a governance mechanism During this stage the steering committee remains active, providing oversight and guidance to drive and follow up on development, implementation, data use, analytics and roll-out of new thematic areas. The committee ensures quality and adherence to SOPs and NMP guidance. This phase will also include plans for continued improvement and supervision of the development and maintenance of the repository. Training at all levels will continue to be carried out as new data and functionalities are incorporated into the NMDR or when changes or updates happen as part of continued system maintenance.
Helpful resources	• Establishing an NMDR: working document • User training best practices (Digital solutions for malaria elimination community of practice, 2019)

1. Establishing the steering committee and governance framework

The establishment of a steering committee at the onset of the NMDR planning phase is a foundational step that anchors the entire development process. Composed of representatives from the NMP, other ministry of health departments (such as the HMIS unit) and key partners, the committee provides essential strategic direction from the beginning. Its role does not end with initial set-up; instead, it remains a vital governance mechanism throughout implementation, scale-up and routine use of the NMDR.

By including high-level internal and external stakeholders and establishing a consistent rhythm of meetings and decision-making, the committee creates a platform for addressing emerging challenges, guiding technical evolution and ensuring alignment with national priorities. Most importantly, it plays a critical role in securing long-term sustainability by maintaining oversight, mobilizing resources and fostering ongoing stakeholder commitment. As the NMDR moves from development into routine operation, this initial foundation must evolve into a sustained governance process.

Box 7. Country example: Nigeria's approach to establishing governance mechanisms

Nigeria's NMDR was launched in 2020 as a web-based, integrated platform to consolidate malaria data from both routine and non-routine sources. Governance is anchored in the NMDR project charter, which outlines the platform's purpose, scope, governance arrangements, user access levels and risk mitigation strategies. This framework provides long-term direction and ensures alignment with the National Malaria Strategic Plan. Oversight is provided by the Surveillance, Monitoring, Evaluation, and Operational Research branch of the National Malaria Elimination Programme, with support from WHO, the Global Fund, PMI and other partners. The development of the Nigerian NMDR has relied on different governance mechanisms.

- An initial concept note described how the NMDR could be developed in the country. Nigeria initially conducted meetings with a broad range of stakeholders, including external experts such as the team involved in the development of Ghana's NMDR, as well as donors and other partners in Nigeria. They then held meetings to discuss funding sources, long-term expense management, maintenance and other factors relevant to the long-term success of the NMDR.
- From these initial meetings, a project charter was developed that included guidelines for how the NMDR would be implemented and managed, as well as a deployment strategy and considerations around personnel training and system maintenance.
- The Nigerian team noted the importance of including all relevant stakeholders and high-level groups, as well as clearly defining roles and responsibilities, to ensure the smooth functioning of the system over the long term.

Note: All funding for the NMDR in Nigeria has come from external sources, notably PMI and the Global Fund. While this external support has been critical to the launch and development of the system, it also highlights a key vulnerability in that long-term sustainability cannot rely solely on external funding. It is therefore essential that internal, sustainable financing be identified and secured to ensure the NMDR's ongoing maintenance, operation and development.

2. Ongoing governance and oversight

Building on this foundation, the steering committee and governance framework continue to provide crucial ongoing oversight, decision-making and communication. They ensure that the NMDR remains on track, addresses end-user needs and challenges, and delivers the desired data use outcomes. The committee remains the key decision-making authority, ensuring that the NMDR is appropriately budgeted for, resources are secured, system maintenance is conducted and users are capacitated.

In addition, the committee monitors and periodically evaluates NMDR usage, performance, management and governance, and identifies areas for improvement. This sustained oversight is what transforms the steering committee from a planning body into a long-term guardian of the NMDR's relevance, effectiveness and sustainability.

Box 8. Country example: Nigeria

Nigeria's project steering committee typically meets biannually, or quarterly if there are any issues related to the functioning of the NMDR. This includes dealing with bottlenecks affecting the functioning of the project, as well as high-level issues such as where and how project components (e.g. infrastructure and support functions) are hosted.

Stakeholders involved in these meetings include internal members of the Nigerian team as well as high-level external stakeholders such as WHO and the Global Fund.

3. Continue to develop and maintain the NMDR

A key step in ensuring the long-term success of the NMDR is a clear strategy for reviewing, managing and maintaining system performance. Clear procedures, roles and responsibilities should be established with respect to the following points:

- ongoing M&E of system performance through periodic assessments, aligned with a broader programmatic M&E framework;
- continuous user support and helpdesk mechanisms to ensure that all actors have access to a system support mechanism and all feedback/challenges are logged and resolved;
- infrastructure and device set-up and maintenance, including device management policies/protocols, long-term Internet/data plans, clear processes for device distribution and replacement, server and data centre maintenance, and scale-up/growth plans;
- ongoing system administration capacity to manage daily system use needs: e.g. user accounts and system access, dashboard administration and maintenance, and data clean-up; and
- long-term technical system maintenance to manage ongoing fixes, enhancements and upgrades, following proper groundwork and development processes.

4. Training and deployment

To ensure that the NMDR continues to be used and to evolve, all contributors to and users of the system need to be trained on its usage and kept abreast of any developments. This requires creating clear training guides, SOPs, and roles and responsibilities, all made accessible through a knowledge repository that outlines expectations around how each actor should be using the system to report, review, update, manage and use the data. Key points to consider include the following:

- Develop adequate product documentation (e.g. tutorials, SOPs, a governance framework and other materials that detail how the system should be managed and used across multiple levels).
- Conduct training of trainers workshop(s) at the central level. Topics covered in these workshops may include training on the use of DHIS2 in general and specific training on modules that have been added to the repository (e.g. epidemiology or entomology).
- Conduct training workshops at a subnational level.

- Organize workshops to launch the new module(s). This corresponds to anything that has already been input into the system.
- Develop frameworks or guidelines for the review and supervision of data recording practices to ensure ongoing data quality.
- Hold regular data review meetings to identify issues or areas for improvement. These should be ongoing and integrated into a routine way of working. Capture and review user feedback during these review meetings, or through designated feedback channels, to continuously improve and tailor the NMDR to user needs and evolving programmatic requirements.
- Establish SOPs for maintenance and channels to promote continuous feedback to improve and refine the system.
- Develop strategies for continuous M&E of the system in order to understand how the NMDR is being used and measure its impact and overall usefulness for malaria surveillance. This should include measuring key metrics.

Box 9. Helpful resource: Digital Solutions for Malaria Elimination user training best practices document

The Digital Solutions for Malaria Elimination community of practice has developed a guidance document on user training best practices.

There are several aspects to consider for planning and conducting successful user training. Apart from training materials, such as manuals and videos, there are various peripheral activities such as creating an effective meeting agenda, ensuring adequate infrastructure at the venues, providing post-training support and helpdesk structure for end users, developing test scenarios, and so on.

Access the User training best practices document.

This document includes:

1. ideal meeting agenda
2. cascade training design
3. server configuration and user set-up
4. infrastructure and deployment
5. test scenario types
6. helpdesk structure
7. training modes and feedback process.

Box 10. Country example: ongoing considerations and lessons learned from managing Nigeria's NMDR

As part of ongoing management, the NMDR team holds quarterly review meetings and conducts periodic user surveys to monitor functionality, awareness and areas for improvement.

Key lessons learned in this context are related to the importance of countries planning for:

- training and retention of a core team, with strategies in place for sustaining or replacing technical capacity when staff transition;
- building reliable infrastructure to support efficient data throughput, minimize downtime and sustain interoperability with other platforms; and
- securing sustainable financing beyond initial donor-supported deployment.

The 2024 NMDR User Survey confirmed strong utility: 117 respondents found the platform to be useful and 90 valued the malaria bulletin. However, the survey also highlighted gaps, including limited awareness of training materials and the need to strengthen engagement at the local government area level.

Interoperability has been a major achievement – for example, with the Red Rose platform for SMC data since 2024. These linkages have reduced fragmentation and enabled triangulation of campaign and routine data sets.

The programmatic impact has been significant. Previously, the malaria programme struggled with siloed and fragmented data sources; manual collation from HMIS, LMIS and partner spreadsheets often delayed planning and resource mobilization. With the NMDR, high-quality, consolidated data are now rapidly accessible within a single platform. This enabled the timely development of the 2021–2023 funding request to the Global Fund and the 2021–2025 National Malaria Strategic Plan. More recently, the NMDR has supported the production of malaria bulletins, interactive dashboards and drill-down analytics that inform decision-making at the national and subnational levels.

Case study. Mozambique's Integrated Malaria Information Storage System

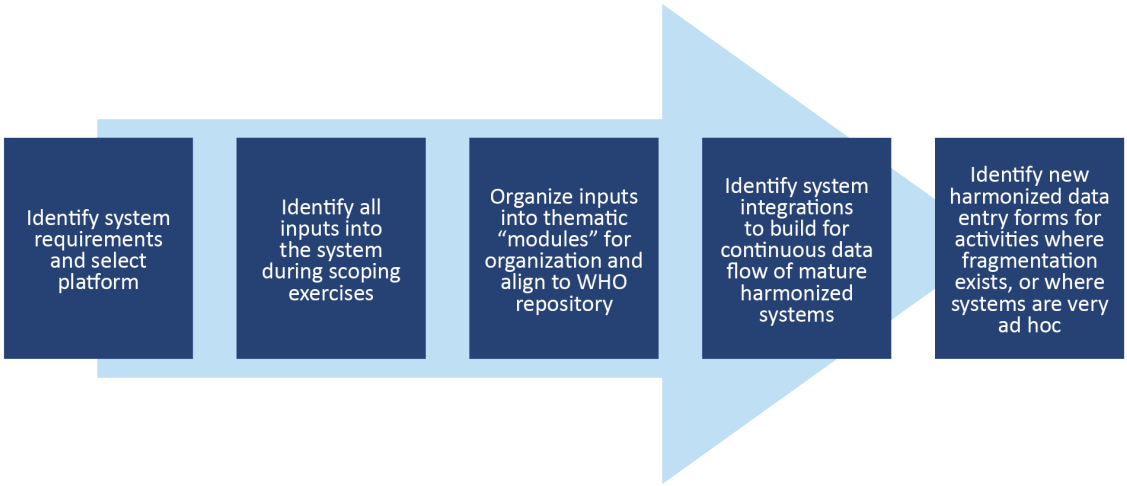
The formation of the Integrated Malaria Information Storage System (iMISS) has been a key priority in Mozambique's National Strategic Plan for malaria (2017–2022). The purpose of the iMISS is to help address four key challenges identified during a surveillance assessment in 2016, specifically:

- multiple sources of data with different definitions;
- lack of standardization in reporting tools and indicators;
- poor accessibility and integration of data; and
- no automated data outputs.

These challenges resulted in a fragmented body of data, impeding evidence-based decision-making and complicating the deployment of properly targeted control interventions.

To address this issue, the NMP launched the groundwork for the iMISS in 2017, led by CHAI, in conjunction with the Malaria Consortium and the Gates Foundation. The following planning and scoping steps were identified (see Fig. 8).

Fig. 8. Process followed by Mozambique in setting up an NMDR



1. Platform selection

DHIS2 was chosen by the programme because of its sustainability and the option for built-in data entry and data output capabilities. Key features identified as relevant included the following:

Inputs

- the ability to enter data directly via computer or mobile devices
- automated importation of data through integrations with other systems
- support for manual importation of ad hoc data

Outputs

- alerts and notifications
- individual form review and quality assurance
- data visualization options, including charts, tables and dashboards.

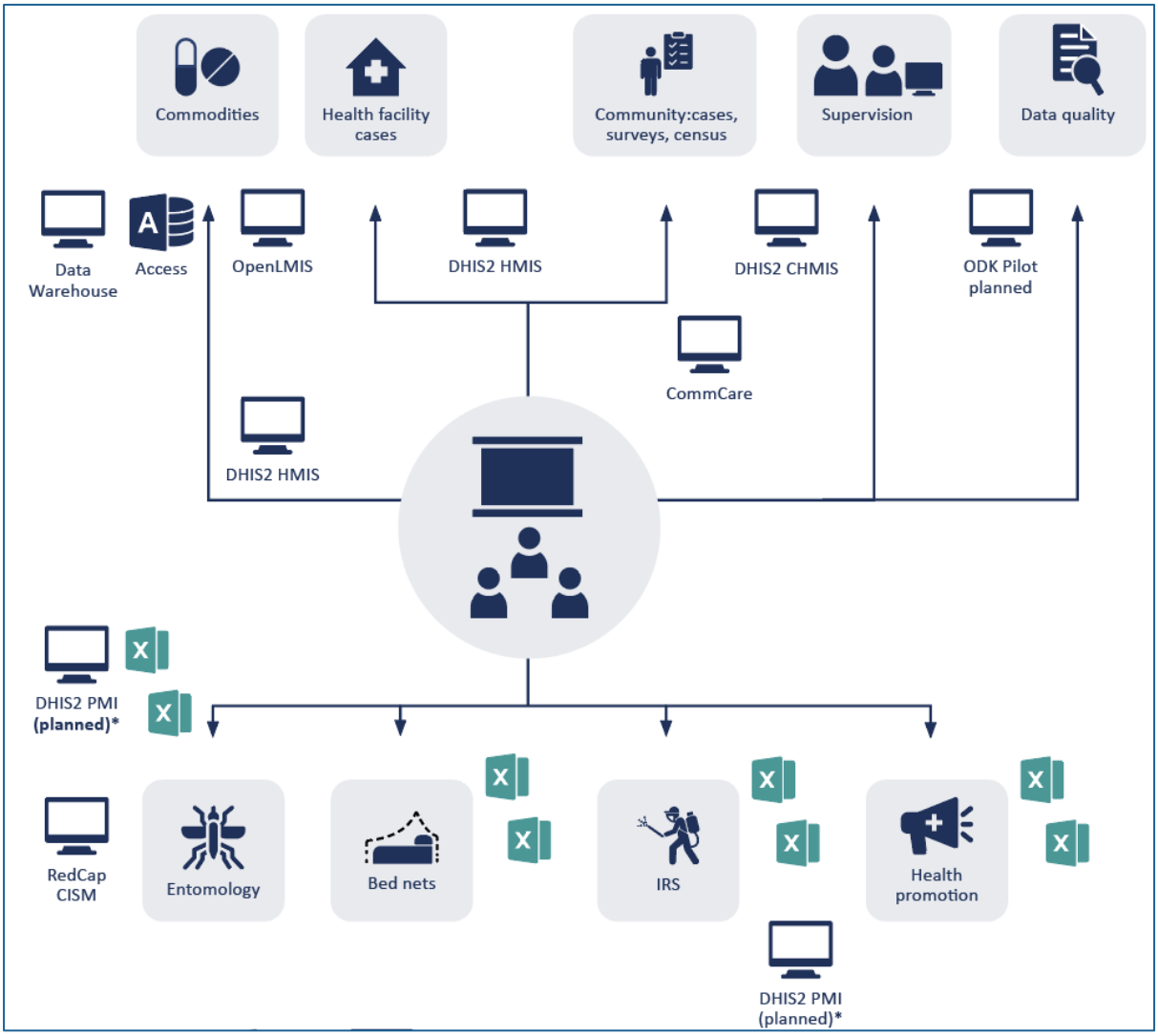
2. Itemize and prioritize existing data sources

Next, the focus for the iMISS shifted to understanding programme needs for an integrated database. Scoping began with the existing National Strategic Plan M&E framework. Working groups were convened in 2018 to select desired indicators from the National Strategic Plan framework, as well as to brainstorm other indicators of value. Additional indicators were also selected from WHO malaria repository documentation.

Through this initial scoping exercise, different programmatic areas were identified (e.g. IRS, ITNs). Existing thematic technical working groups (e.g. the vector control technical working group for IRS and ITNs) were then convened to conduct a detailed data audit and mapping exercise to understand all the potential inputs for each indicator, as well as all the existing data streams that would need to be accounted for in the NMDR.

The result of this exercise was the identification of numerous potential source systems and files relevant to the iMISS initiative (see Fig. 9).

Fig. 9. Data mapping carried out by Mozambique



This data audit and mapping exercise revealed a high volume of data that was deemed too malaria-specific for existing cross-cutting systems. Mozambique's Ministry of Health therefore decided to create a new dedicated DHIS2 instance to serve as the iMISS repository. Once this platform decision had been made, the next challenge was to make sense of the many potential sources of data and plan a way forward for how each data source would be incorporated into the iMISS.

3. Data system integration and organization

To tackle this challenge, identified systems were categorized according to five general scenarios, with a recommendation made for integration of data flows in each case (see Table 8).

Table 8. Data system integration for different scenarios

Scenario 1 A mature and robust system exists	**Recommendation:** Plan for integration so that data can automatically flow into the malaria database (DHIS2, OpenLMIS, CommCare).
Scenario 2 An ad hoc system is in place and data are routine	**Recommendation:** Try to transfer the same data entry form into the planned malaria information system platform. Therefore, rather than inputting data into Excel or ODK, the programme can simply enter data directly into the iMISS platform.
Scenario 3 An ad hoc system is in place and data are infrequent	**Recommendation:** For desired but infrequent survey data, configure a data dictionary that can capture the final results at a level that is appropriate for decision-making. These data can be imported as needed through an Excel template, or manually entered every few years. The malaria indicator survey, for example, was ultimately configured as an aggregate DHIS2 data set at the provincial level to capture these important survey-based indicators.
Scenario 4 A fragmented mix of systems exist (i.e. from different partners working in the same programmatic area)	**Recommendation:** The programme and partners must agree on a set of essential data elements that are common to everyone and considered stable. From these agreed-upon fields, design a harmonized data entry form built into the iMISS, and then reach consensus on how each party will submit data. Some partners may choose to upload aggregate data on a monthly or quarterly basis, whereas others may choose to enter in each report on an ongoing basis.
Scenario 5 No existing system (activity is planned)	**Recommendation:** Design a form to be built into the iMISS, or pick a robust tool that can be integrated with the system and initiate planning for the integration. There should be clear justification and rationale for selecting an external tool.

This approach enabled the programme to ensure that there was a strategy in place for including data from all relevant sources.

These design choices were then consolidated into a user requirements document, which listed the agreed-upon specifications of the iMISS for a developer audience. Compiling this document also required extensive stakeholder meetings to agree on:

- the required data points and indicators for the repository;
- the data process flow for how all newly generated data would flow into the system (via automated integrations with other systems, periodic bulk uploads using an import template, or direct entry through an embedded reporting form);
- data visualization and dashboard needs for different user profiles;
- mobile reporting needs; and
- other general platform and system requirements.

The end result is a comprehensive malaria information system that complements and plugs into existing systems to meet the goal of a standardized, integrated malaria system for Mozambique (see Figs. 10 and 11).

Fig. 10. Simplified diagram of Mozambique's ultimate iMISS architecture and process

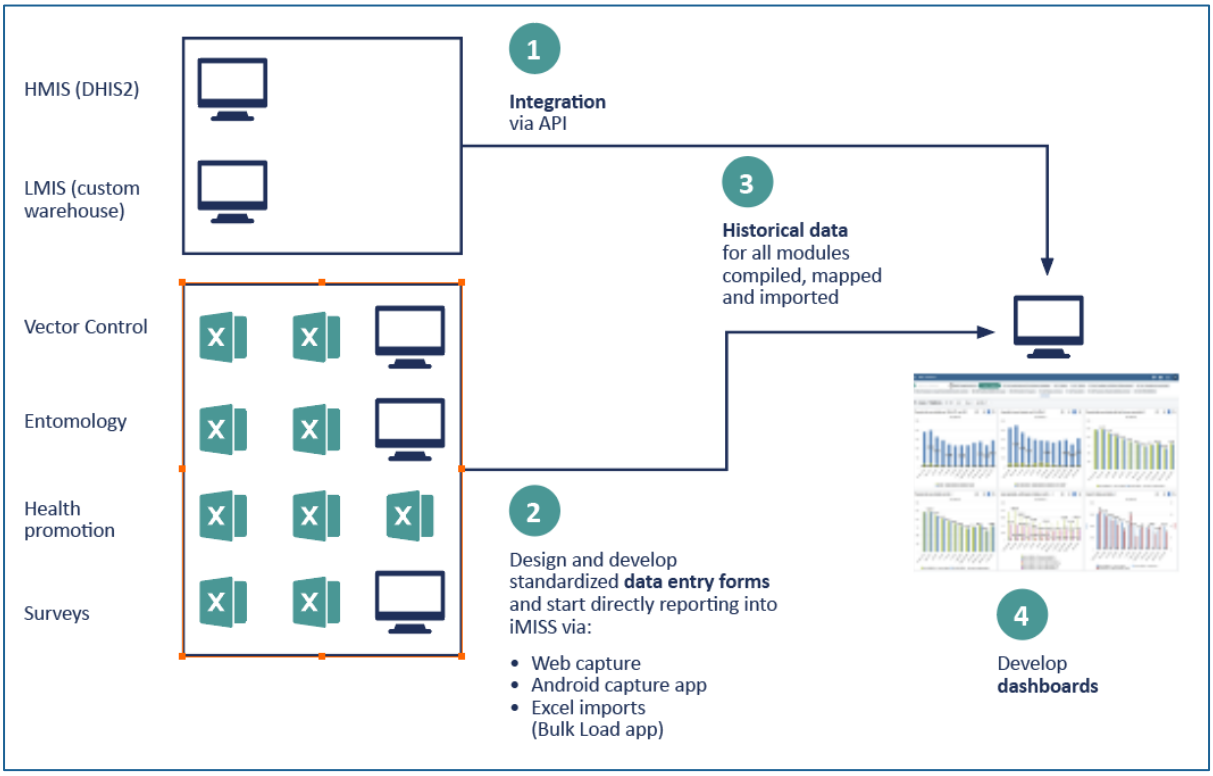
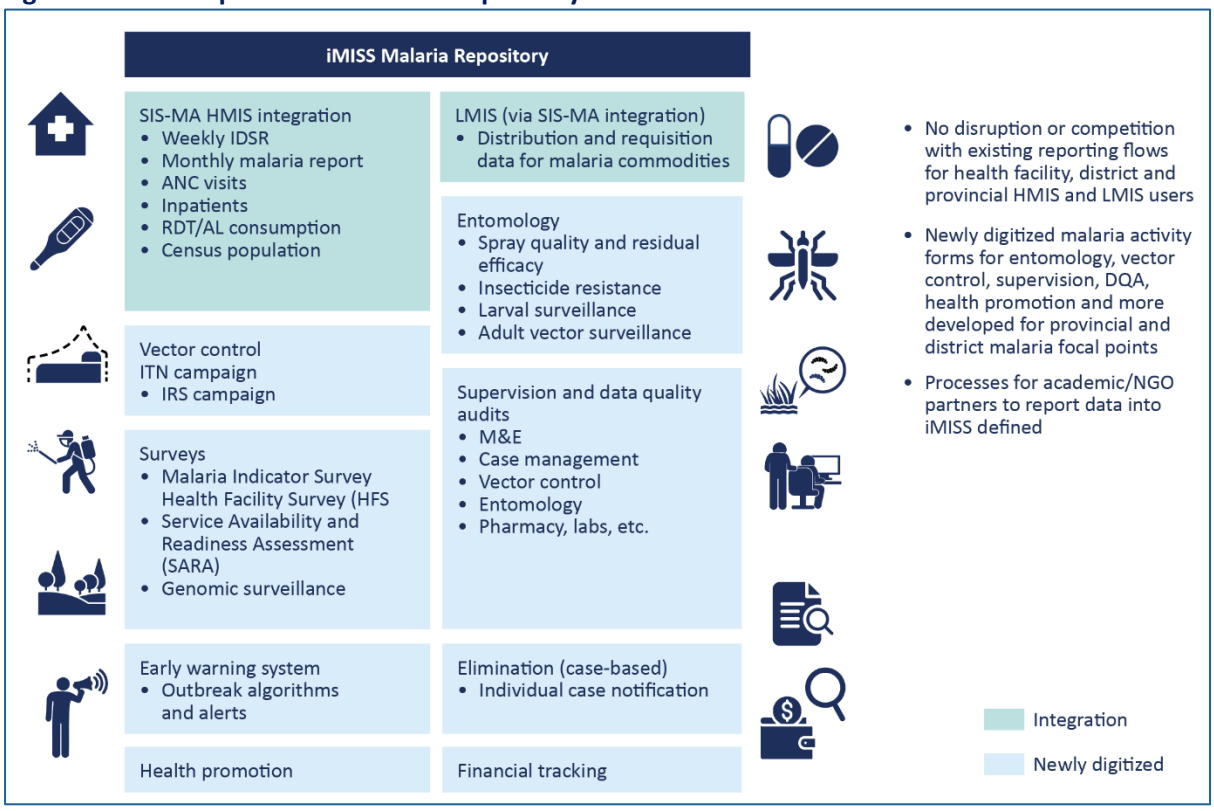


Fig. 11. Mozambique's iMISS malaria repository



IDSR: Integrated Disease Surveillance and Response; ANC: antenatal care ; RDT: rapid diagnostic test; AL: artemether–lumefantrine; DQA: data quality assurance

Annotated bibliography

Malaria surveillance, monitoring and evaluation: a reference manual, second edition. Geneva; World Health Organization: 2025 (https://iris.who.int/handle/10665/381864).

Pillar 3 of the WHO *Global technical strategy for malaria 2016–2030* calls for the transformation of malaria surveillance into a core intervention in all malaria-endemic countries, as well as in countries that have eliminated malaria but remain susceptible to re-establishment of transmission. This reference manual covers subjects that are relevant to both settings.

The target readership of this manual includes staff working in ministries of health, NMPs and health information systems; partners involved in malaria surveillance; and WHO technical officers who advise countries on malaria surveillance.

World Health Organization, United States Agency for International Development, University of Oslo. **Health facility & community data toolkit**. Geneva: World Health Organization; 2014 (https://iris.who.int/handle/10665/329458).

The aim of this toolkit is to provide an overview of best practices, innovations, tools and methods that are available to countries to support the strengthening of health facility information system components. The materials are presented according to an organizing framework for the key components of a country health facility information system, namely: governance (an overarching component); data collection and management; data quality and analysis; and data dissemination and use. Within each section, key action steps are identified for countries and examples of available tools and resources to support country action are provided. A checklist of key items and attributes is also provided to facilitate monitoring of progress towards defined standards (also available as a separate spreadsheet). The checklist can be used to monitor progress and should be completed through a collaborative process with all stakeholders, including data producers and data users.

Health Metrics Network, World Health Organization. **Framework and standards for country health information systems, second edition**. Geneva: World Health Organization; 2012 (https://iris.who.int/handle/10665/43872).

The Health Metrics Network is the first global health partnership that focuses on two core requirements of health systems strengthening in low- and low-middle-income countries: first, the need to enhance entire health information and statistical systems, rather than focusing only on specific diseases; and second, to concentrate efforts on strengthening country leadership for health information production and use. To help meet these requirements and advance global health, it has become clear that there is an urgent need to coordinate and align partners around an agreed-upon framework for the development and strengthening of health information systems.

Malaria surveillance assessment toolkit [digital toolkit]. Geneva: World Health Organization; 2022 (https://malsurtoolkit.who.int/).

The malaria surveillance assessment toolkit provides a standardized but adaptable assessment framework and an associated package of tools that enable results to be compared between

countries, between regions within a country, and over time. The assessment framework is based on four key objectives: performance, context and infrastructure, technical and processes, and behaviour. A set of associated subobjectives and indicators are used to evaluate performance and the determinants of that performance. The toolkit consists of two modules specifically tailored to assess surveillance in burden reduction and/or elimination settings. A high-level surveillance assessment of other malaria control interventions and strategies can also be carried out to understand how data are collected and used alongside routine malaria case surveillance data. Further details on the toolkit and a step-by-step guide on how to carry out a malaria surveillance assessment are shown in the implementation reference guide. An overview of the toolkit is also provided.

WHO toolkit for routine health information systems data [digital toolkit]. Geneva: World Health Organization; 2024 (https://www.who.int/data/data-collection-tools/health-service-data/toolkit-for-routine-health-information-system-data/modules).

The routine health information systems toolkit is a collection of resources for countries to enhance the collection, quality, analysis and use of routine facility data. This toolkit is the result of collaborative efforts involving various WHO programmes and partners. Its core objective is to advocate for an integrated, standards-based methodology, emphasizing a select set of standardized core indicators along with suggested analytics, data visualizations and dashboard tools.

The toolkit consists of a series of integrated general and programme-specific modules that contain guidance documents, electronic configuration packages and training materials.

Toolkit for analysis and use of routine health facility data: general principles. Geneva: World Health Organization; 2023 (https://iris.who.int/handle/10665/367106).

This module introduces key concepts of routine health facility data analysis that are applicable to all modules, including:

- standardized core indicator lists;
- representativeness of routine facility data;
- key dimensions of data quality assessment;
- challenges of population estimates and denominators;
- basic analytical concepts;
- principles for presentation and communication of data; and
- basic concepts for data interpretation and use.

Toolkit for analysis and use of routine health facility data: core health facility indicators [working document]. Geneva: World Health Organization; 2021 (https://cdn.who.int/media/docs/default-source/world-health-data-platform/rhis-modules/facilityanalysisguidance-indicators-2021--01-21.pdf).

This module provides a list of core indicators that can be calculated using routine health facility data. It includes all the indicators (with metadata) from the guidance for planners and managers and programme-specific guidance documents.

Data analysis and use can be strengthened by focusing on a limited, standardized list of core indicators that:

- reflect programmatic and service delivery standards;
- can be used to guide country selection of indicators and definitions;
- promote alignment among programmes and other stakeholders; and
- can promote a reduction in the reporting burden of health facility workers.

Analysis and use of health facility data: guidance for malaria programme managers [working document]. Geneva: World Health Organization; 2018 (https://www.who.int/publications/m/item/analysis-and-use-of-health-facility-data-guidance-for-malaria-programme-managers).

This module provides guidance on the analysis and use of routine malaria data collected at the facility level. The module reviews core facility indicators and analysis, provides suggestions for questions on data quality, and discusses considerations and limitations for using the data and analysis.

The standard modules are health facility-based and cover routine data collection. This usually involves data that are aggregated at the health facility on a weekly or monthly basis and added into the HMIS. Standardized data elements and indicators are provided for:

- cases and deaths;
- laboratory results;
- case and focus investigation;
- population at risk;
- routine interventions (such as ITN distributions); and
- some stock tracking elements along with stock-outs.

Conclusion

NMDRs offer malaria-endemic countries a strategic solution to overcome fragmented data systems and elevate the quality and use of surveillance data. By centralizing malaria-related data from routine systems, laboratories, interventions, entomology, climate and other critical sources, the NMDR enhances a country's ability to monitor, analyse and make decisions based on available data. This not only supports more effective malaria control and elimination strategies, but also strengthens the national data ecosystem by digitizing outdated processes and reducing reliance on siloed systems. This document outlines a practical, phased approach for building and institutionalizing an NMDR, grounded in best practices and lessons learned from partners and early country implementers. It is intended to be a living document and so will be revised and enriched regularly with new experiences, detailed examples and alternative approaches – including the use of non-DHIS2 platforms or hybrid technologies – so that countries can adapt the guidance to fit their specific needs and technical contexts.

Annexes

Note: Some of the annexes contain supporting tools, templates and reference materials that may be revised and updated more frequently than the main guidance document. Users are encouraged to check for the most recent versions to ensure that they are working with the latest information.

Annex 1. List of NMDR modules

NMDRs can be implemented in a modular fashion based on a prioritized list of thematic areas (or modules), including but not limited to the following:

Module	Denomination	Module description
Module 1	Epidemiological (monthly malaria surveillance)	Provides data quality (completeness, promptness), input availability, malaria prevention (IPT, ITNs, SMC), case management (confirmation, treatment), intervention impact (incidence, positivity, lethality, mortality).
Module 2	Weekly or case-based surveillance	Shows the weekly epidemiological situation (cases, deaths, incidence, lethality, mortality) and monitoring of malaria and other outbreak-prone diseases.
Module 3	Stock management	Provides information on the availability of malaria control inputs: orders, deliveries, shortages, losses and expiries; and supply chain efficiency at all levels of the health care system.
Module 4	Demographics	Provides population data and target estimates according to health care delivery activities; population data by health division, by target and vulnerable populations, and by zones and distances of intervention coverage; population data projections.
Module 5	Climate	Provides meteorological data (rainfall, temperature), the epidemiological situation in relation to meteorological parameters (cases, deaths), and rainfall and temperature forecasts.
Module 6	Studies/surveys/research	Provides data on indicators evaluated in various surveys, studies and research that are not part of the routine data collection system. Examples include Demographic and Health Surveys, malaria indicator surveys, workforce surveys, research on parasite drug resistance (in vitro sensitivity testing), etc.
Module 7	Entomology (insecticide resistance, identification of vectors, monitoring of breeding sites)	Provides information on vector mapping, vector density and species, vector resistance to insecticides, insecticide efficacy by vector species, resistance mapping.
Module 8	Interventions/vector control (ITN bioefficacy surveillance, IRS)	Provides information on the optimal and minimal efficacy of community-distributed ITNs in households, physical integrity and the median lifespan of ITNs.

		Provides information on coverage of IRS activities in households and coverage by type of insecticide.
Module 9	ITN campaigns	Provides information on the coverage of the different ITN campaigns in the country, for all the years of implementation. Indicators on the target reached and on the coverage and use of ITNs.
Module 10	SMC campaigns	Provides information on the coverage of the various SMC campaigns in the country, for all years of implementation. Coverage and compliance with the various SMC rounds.
Module 11	Malaria vaccination campaign	Contains information on the introduction of the new malaria vaccine, including coverage by target and by different implementation strategies: fixed, advanced and mixed.
Module 12	Behaviour change communication	Provides information on behaviour change communication activities and coverage according to specific messages.
Module 13	Finances/budget	Provides information on the financing of the elimination programme: amount planned, amount mobilized, amount allocated, amount spent, financing gaps, sources of financing.
Module 14	Human resources	Contains information on HR capacity building for malaria control activities, including coverage of trained HR profiles, training on applicable protocols and standards.
Module 15	Activity planning	Shows the chronogram of activities and the monitoring of implementation (activities carried out, activities partially carried out, activities not carried out).
Module 16	Data quality	Provides indicators on the completeness and promptness of data reporting in the various health centres. Provides quality control of the consistency of data elements and indicators across all modules.
Module 17	Coverage of community services	Provides indicators on the contribution and performance of the community level, including all community malaria management activities.

The most recent version of the list of modules is available on the NMDR GitHub repository: List of NMDR modules.

Annex 2. Establishing an NMDR: example templates

This annex contains a collection of adaptable Excel templates designed to assist countries in planning, developing and rolling out their NMDR. The templates provide practical frameworks for organizing activities, budgeting and technical implementation. They are intended to be adapted to the country context, reflecting local priorities, resources and workflows. By using these templates, countries can streamline stakeholder collaboration, standardize processes, monitor progress and ensure sustainability of the NMDR through structured planning, budgeting and documentation.

Contents:

1. **Sample work plan** – a sample workplan outlining NMDR project steps as an iterative process involving stakeholder collaboration, continued improvement, standardization of data processes, system testing, and end-user training and support.
2. **Sample alternative work plan** – an alternative workplan focusing specifically on activities.
3. **Sample budget sheet** – illustrates how each activity has an associated cost, highlighting the need for adaptation to the country context and potential additional expenses such as hardware, software and module-specific training.
4. **Example workshop activities for data integration** – activities for 1–2-week workshops used successfully in some countries to integrate modules into the NMDR.
5. **NMDR data itemization and planning** – template for listing data sets used in indicator calculations, documenting current and proposed data flows, identifying new electronic forms, and specifying required system integrations.
6. **Example data dictionary** – example of a detailed data dictionary to guide developers when digitizing forms or integrating data from other systems, reducing ambiguity and minimizing rework.

The most recent versions of these templates are available on the NMDR GitHub repository: Establishing an NMDR: example templates.

Annex 3. Readiness assessments

This annex contains tools to help countries assess their preparedness to establish and implement an NMDR. The readiness assessments provide a structured approach to identifying strengths, gaps and capacity needs across key domains required for successful NMDR development.

Two complementary readiness assessments are recommended: the **National Data Storage Assessment Tool** self-assessment tool for pre-NMDR settings to define scope and feasibility, and the **National Data Repository Self-Assessment Tool** for existing NMDRs to evaluate performance, identify gaps and guide targeted improvements.

The most recent versions of these readiness assessment tools are available on the NMDR GitHub repository:

National Data Storage Assessment Tool

National Data Repository Self-Assessment Tool

Annex 4. NMDR indicator list

The NMDR indicator listing provides a comprehensive catalogue of standardized malaria indicators used across programme areas. It serves as a foundational reference for countries implementing an NMDR, ensuring consistency in indicator definitions, disaggregations, and metadata across surveillance, programme monitoring and reporting functions.

Annex 5. Additional information on DHIS2

1. DHIS2 set-up

When establishing a DHIS2-based NMDR, countries should appoint appropriately experienced technical personnel to handle initial set-up and ongoing maintenance of the system. The following subsections detail a typical set-up procedure and some common problems that may be encountered during this process.

1.1. Step-by-step approach on how to set up the repository on a separate DHIS2 instance

1. Download a recent version of DHIS2 from https://www.dhis2.org/ (recommended to use the version that the HMIS is on or version 2.40 or higher).
2. See new server specifications (specs).
3. Install a DHIS2 instance on a new server following the instructions (Installation guide).
4. Download and install Metadata Synchronization (MD Sync) app for DHIS2 (MD Sync app).
5. Replicate the metadata (malaria and related data) on the new DHIS2 server using the MD Sync app.
    a. Instructions: MD Sync
    b. Follow the Manual Sync Metadata to set up the new server with malaria-related metadata:
        i. organization units (down to health facility level)
        ii. data elements, indicators, category combos, etc.
    c. Set up the initial and subsequent data synchronization (MD Sync walkthrough tutorial):
        i. source instance: routine HMIS DHIS2 instance
        ii. target instance: repository.
6. If the routine HMIS DHIS2 instance (source instance) already has the malaria module installed, as described here, proceed to the next step.
7. To explore the different packages available:
    a. Hosted by UiO Demo | Packages
    b. Please see the discovery server for entomological modules:
        i. DHIS2-discovery.

1.2. Common issues during DHIS2 set-up

When embarking on the establishment of an NMDR, it is crucial to be aware of potential technical challenges related to the compatibility of HMIS tools and DHIS2 versions. These issues can be effectively managed with the right strategies. Common technical challenges include version disparities and DHIS2 dynamics.

Version disparities: Different versions of HMIS tools may have varying data structures and functionalities. This diversity can lead to compatibility challenges when integrating the NMDR with these tools. Understanding these disparities is key to a smoother implementation.

DHIS2 dynamics: The dynamic nature of DHIS2, with frequent updates and new versions, introduces an additional layer of complexity. Ensuring that the NMDR remains compatible with the diverse DHIS2 ecosystem requires careful consideration and planning.

To address compatibility concerns, consider implementing the following strategies:

Metadata synchronization tool: Use tools such as MD Sync to generate module versions tailored to specific DHIS2 releases. This approach ensures adaptability, enabling the NMDR to integrate seamlessly with various HMIS tools and different versions of DHIS2. MD Sync is a DHIS2 application that simplifies and automates the process of sending data and metadata from one DHIS2 instance to one or several other DHIS2 implementations, regardless of how different they might be (i.e. between a HMIS DHIS2 instance and a malaria DHIS2 instance). MD Sync can synchronize metadata, events and aggregated data. For more information on MD Sync, review the documentation on the tool here.

Dynamic module versioning: Implement a dynamic approach to module versioning. This enables ongoing updates to accommodate the evolving landscape of HMIS tools and DHIS2 versions. A flexible system ensures resilience against compatibility challenges.

Downloadable module versions: Make generated module versions available for download. This facilitates a straightforward process for stakeholders to update their installations, keeping the NMDR in sync with the latest developments in HMIS tools and DHIS2.

2. DHIS2 modules

A range of standard modules have been developed to support countries to improve the collection of data used to inform programmatic decisions.

What is a DHIS2 module?

Each module comprises metadata elements essential for effective data management. These elements include the following:

- Data points (names and definitions): These are specific pieces of information, such as malaria incidence rates, intervention coverage and entomological data, each with a clear name and definition.
- Indicators (names, definitions, formulas): Indicators are derived measures that provide a consolidated view of the data. They include names, definitions and formulas that define how the indicator is calculated.
- Data entry forms: Forms are structures for collecting data. For malaria modules, these forms are designed to capture relevant information related to the specific module, ensuring standardized data collection.
- Data validation: Validation rules are implemented to ensure that the data entered into the system adhere to predefined standards. This helps to maintain data quality and integrity.

Below are some features of the modules and metadata:

Tailoring to settings: The metadata within each module is adaptable to the specific settings and requirements of individual countries. Tailoring the modules requires a thorough consideration of a country's specific characteristics, analytical needs, reporting requirements and workflow processes. This flexibility ensures that the modules can be customized to align with the unique characteristics

of each country's malaria landscape. Recognizing the significance of this phase is crucial for addressing the specific requirements of the country and fostering a sense of national ownership. The importance of this step cannot be overstated.

Continuous enhancement and iteration: The loading of malaria modules is not a one-time process. It involves continuous enhancement and iteration. As the understanding of malaria dynamics evolves, new data points, indicators or forms may be identified and added to the modules. Similarly, updates may be made to improve the efficiency and relevance of the existing metadata.

Integration with routine health data: While these modules offer specialized functionalities, they are designed to seamlessly integrate with routine health data. This integration ensures that the malaria modules complement and enhance the overall health information system, providing a comprehensive view of the health landscape.

3. Comparing DHIS2 and non-DHIS2 implementations

In some cases, countries may decide to implement a non-DHIS2 system for their NMDR. There are several key considerations and points of comparison to keep in mind in making this decision (see Table A3.1).

Table A3.1. Comparing DHIS2 and non-DHIS2 implementations

Consideration	DHIS2 implementation	Non-DHIS2 implementation
Overview	DHIS2 can be a more sustainable option for health data management, as many countries already use this system and there is a large community of practice.	Implementing a non-DHIS2 solution may provide different options in terms of flexible design and customization, enabling countries to tailor systems to their specific contexts.
Capacity and community of practice	**Local capacity:** DHIS2 often leverages the existing expertise and capacity within the ministry of health or other local health authorities. This means that the people working on the system are already familiar with the local context, health data and specific needs. They are more likely to remain in their positions and continue maintaining the system over time. **Institutional knowledge:** By using a platform like DHIS2, the institutional knowledge and skills are developed and retained within the ministry of health. This knowledge is not dependent on external vendors or consultants, which	**Community support gap:** Non-DHIS2 solutions may lack the extensive community support and collaboration that DHIS2 enjoys. The absence of a collaborative community can impact the availability of resources, updates and shared best practices.

	can be costly and may not always be available for long-term support. **Community of practice:** DHIS2 has a global community of users and developers who contribute to its ongoing development and support. This community can provide guidance and assistance, making it easier for local users to get help and share experiences.	
Customization	**Customization:** DHIS2 is highly customizable to local needs. Health authorities can tailor the system to their specific requirements, which increases the chances of adoption and long-term use. This flexibility is essential for sustaining the system.	**Tailored flexibility:** Non-DHIS2 solutions offer the freedom to design and customize information systems according to specific national requirements. This flexibility allows for a more tailored approach to data management.
Data integration and formatting	**Configured data dictionary and clear guidelines required for data integration:** DHIS2 data integration capabilities (via an API and computability with middleware layers such as OpenHIM) enable the platform to fetch information from diverse data sources. DHIS2 has also been used as a data integration platform in many countries. However, there is often a lack of discussion around potential limiting factors, including the fact that data can only be integrated into DHIS2 when you have: (i) a configured data dictionary; and (ii) clear guidelines/SOPs for the mechanism of getting those data into the system (import from Excel periodically, develop a system integration, change reporting processes/flows so data generators begin reporting directly into the system). Data can also be manually imported into DHIS2 through Excel files and formats including JSON, CSV, XML, ADX and PDF.	**Decentralized data integration:** In contrast to the centralized nature of DHIS2, non-DHIS2 implementations can accommodate decentralized data storage. They can fetch information from diverse sources, including DHIS2, Excel, Access databases, or SQL databases, and consolidate it into a unified repository. Some can act as a data lake, but require data science capacity (e.g. Python, R). **Standardization challenges:** The lack of a standardized data model may lead to challenges in standardization and interoperability. Varying data formats and structures across different sources can impede seamless data exchange.

	Standardized data format: Data being entered into DHIS2 can only be integrated/imported using DHIS2's native data model and schema. All data inputs must therefore be appropriately defined or structured. This means that the DHIS2 platform can function as both an information system and an integration/warehousing platform, but not a data lake (i.e. it cannot serve as a repository of both structured and unstructured data).	
Dashboards	**Data visualization:** Data visualization and dashboarding capabilities are built-in and offer easy analysis capabilities for end users, but visualization options are less extensive compared to dedicated BI tools such as Tableau, Power BI and Superset. However, these tools can be connected to DHIS2 to supplement visualization options.	**Customized dashboards:** Like DHIS2, non-DHIS2 solutions can also enable the creation of customized dashboards, providing stakeholders with a user-friendly interface to access and analyse information. This can enhance the usability and relevance of data for decision-making.
Cost-effectiveness	**Cost-effectiveness:** Building and maintaining a system like DHIS2 is often more cost-effective in the long run. While there might be upfront costs for implementation and training, this investment can lead to reduced dependence on third-party vendors for ongoing support and reduce the need to keep users trained on multiple software technologies.	**Variable costs:** Costs associated with non-DHIS2 platforms may vary depending on the availability of technical expertise for system maintenance and the ease of integrating with other systems.
Scalability and maintenance	**Sustainable scalability:** DHIS2's scalability and community-driven maintenance model may provide a more sustainable framework over time.	**Scalability and maintenance concerns:** Ensuring scalability and long-term maintenance can be more challenging with non-DHIS2 solutions.
Training and capacity building	**Training resources available:** DHIS2 has established training materials and resources, easing the capacity-building process.	**Development of training materials:** Opting for a non-DHIS2 solution might require additional efforts in developing training materials and building user and administrator capacity.

4. Tools to support metadata and data integration

Step-by-step instructions for integrating metadata and data.

DHIS2 standard malaria modules toolkit

Video walkthroughs:

- Bulk load walkthrough tutorial
- MD Sync walkthrough tutorial

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