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The Role of Adaptive Surveillance as a Core Intervention to Achieve Malaria Elimination

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Abstract

Adaptive surveillance systems are essential for national programmes to achieve their malaria elimination goals. Core principles of surveillance systems including accurate diagnosis and reporting of malaria cases, integration of health data across administrative levels and the need to link data to a response are well defined by international guidelines. Nevertheless, while the requirements of surveillance systems along the transmission continuum are clearly documented, the operationalization remains challenging for national programmes. Firstly, because the multi-level increase of surveillance efforts demanding real-time and case-based data as well as the capacity of the health force to trigger locally customized responses, is resource intensive and requires substantial investment. Secondly, because there is a gap in international alignment on best tools and practices on how to operationally implement these requirements. Recently, several initiatives have started to address this gap in international coordination, aiming to establish the operational guidance for elimination programmes to successfully implement adaptive surveillance systems.

Keywords: malaria elimination, adaptive surveillance, case investigation, digital systems, responsiveness

1. Introduction

The Global Technical Strategy for Malaria 2016–2030, published by the World Health Organization (WHO) in 2015, emphasizes surveillance as a core intervention for accelerating progress towards malaria elimination across endemic settings [1]. The successful and optimal implementation of other malaria interventions, including early detection and treatment and vector control measures, depend on the effectiveness of countries surveillance systems. Surveillance systems comprise all steps from the recording and reporting of data to data analysis and presentation, interpretation and evaluation and finally the dissemination and use of information [2]. The functioning of these systems depend on a competent and adequately resourced health force that adheres to surveillance requirements outlined national strategic plans, ensures high data quality throughout the system, and has the capacity to translate data into action while enabling rapid adaptations to respond to evolving contextual factors. Effective malaria surveillance systems allow national programmes to continuously monitor and evaluate the progress of their

programmes, detect and respond to outbreaks in time, and identify gaps in service delivery and intervention coverage in order to (re-)allocate resources in line with the programmatic needs.

We argue that the ability of surveillance systems to adapt to changing circumstances is a crucial element to resilient and effective systems that can support the achievement of national elimination targets. Changing circumstances may include changes to in-country transmission dynamics, e.g. moving from control to elimination settings or implementing context-specific surveillance approaches that respond to in-country heterogeneous malaria transmissions. These may also include external factors that may impact on malaria trends by altering specific malaria surveillance indicators (e.g. due to disruptions to access to care as observed during the COVID-19 pandemic) which require careful and ongoing interpretation of generated data in such rapidly changing environments. This has been shown to be an especially important factor during the COVID-19 pandemic where programmes are now required to understand the influence of COVID-19 on malaria indicators in order to correctly interpret observed malaria trends and take appropriate actions [3].

Despite the importance of strong surveillance systems, national programmes continue to experience challenges in the operational implementation of their surveillance systems particularly at the lowest levels. A landscaping exercise of surveillance systems from elimination countries in 2015–2016 reported that “surveillance systems in 2015–2016 [were] insufficient to support planning and implementing of targeted interventions and to measure progress towards malaria elimination” [4]. While progress has been made since then, countries continue to experience challenges in implementing adaptive surveillance systems.

In the following sections, we outline the importance of adaptive surveillance as a core intervention to malaria elimination. First, we describe the key elements of a functioning adaptive surveillance system capable of responding to all needs across the malaria transmission continuum. Then, we focus on the implications for surveillance system when transitioning from control to elimination settings. Lastly, we describe remaining challenges and rising opportunities in establishing resilient and effective surveillance system across countries to accelerate the elimination of malaria.

2. What are the key elements of a functioning adaptive surveillance system capable of responding to all needs across the malaria transmission continuum?

A malaria surveillance system is considered functional and responsive when it can produce evidence-based information (from quality data) that is routinely used for planning and decision making. To provide guidance on the principles and requirements for a strong malaria surveillance system, a reference manual was published by WHO in 2018 [2]. These principles are essential for guiding the establishment of a malaria surveillance system’s core competencies, operationalizing surveillance systems in malaria endemic countries remains challenging. Outlines the following key principles of the design and establishment of malaria surveillance systems (**Table 1**).

It is worth noting that countries that have eliminated malaria—or have nearly done so—have documented significant improvements in their surveillance systems that made them possible to deploy a range of interventions and adapt them to needs over time. This ability to develop an adaptive responsive surveillance and information systems has been consistently reported as a key components of elimination programmes [5, 6]. Adaptive surveillance and information systems mean that

#	Principles	Description
1	Accurate parasitological diagnosis of a malaria case	Considered the foundation of a malaria surveillance system. Diagnoses should be made with either quality-assured malaria microscopy or rapid diagnostic tests (RDTs).
2	Integration	All major components of a malaria surveillance system should be integrated into broader health management information systems (HMIS). The HMIS system should, in turn, be responsive to the promptness and granularity of data required for effective malaria surveillance.
3	Responsiveness to country needs and country heterogeneity (malaria surveillance as a continuum)	National SOPs for surveillance should be based on a country's needs and on WHO recommendations and be able to address the heterogeneity of malaria within a country's boundaries. The Global Technical Strategy for Malaria 2016–2030 introduced the concept of a continuum, whereby progress towards malaria elimination is considered to be a continuous process rather than a set of independent stages. [1]
4	Functional capacity to analyze, use and act on data	Regardless of the malaria burden, front-line staff involved in the detection, recording and reporting of cases should also be the first users of data. Necessary investments in surveillance and system transition, including in human resources, should be made to respond to the anticipated reduction in disease burden and be alert after interruption of transmission.
5	Surveillance data must be linked to a response	All surveillance data must be linked to a decision at some level of the health system, even if the decision results in no immediate change in interventions.
6	Multisectorial approach	In all transmission settings, a concerted effort must be made to include cases detected in other sectors (e.g. in private and other nongovernmental health care facilities), as well as those detected in public health facilities.
7	Enable innovations to accelerate efforts	Like most other health interventions, surveillance is likely to benefit from innovation and advances in technology.
8	Be able to track rapid changes of malaria epidemiological factors	Good understanding of the biology and behavioral ecology of vector species is essential for making programmatic decisions and monitoring and evaluating vector control interventions, including quality assurance.
9	Allow for continuous improvements	Surveillance systems should be assessed routinely to ensure their accuracy, reliability, completeness, precision, timeliness and integrity. The assessment should also include the appropriateness of actions taken as a consequence of the results of surveillance

Table 1.
Key principles of a malaria surveillance system (adapted from [2]).

they undergo through continuous improvement cycles that are triggered through the evolving country specific malaria epidemiological factors as well as changing external factors, ultimately leading to a resilient and robust system capable of responding to all malaria transmission contexts and reach malaria elimination. The next section details the specific implications of adaptive surveillance systems when transitioning across the continuum of malaria transmission intensities.

Only when health information systems (HIS) lead to public health decision-making, can surveillance systems be considered functional. For National Malaria Control Programmes, a good malaria information system (MIS) permits decisions on resource allocation to be done on and informed and unbiased way. A key step to understand MIS performance is to assess the quality of data, the use of information made by decision makers and the enabling organizational, technical and behavioral factors that influence MIS performance. System performance is measured through

the quality of data produced and the effective use that is given to information produced [7]. Data quality can be assessed through its composite indicators: completeness, timeliness and accuracy and should be conducted at different levels of the system (community, health facility and district). Use of information is assessed through the production, sharing and discussion of relevant reports that guide programmatic activity implementation. Technical, organizational and behavioral components should also be routinely assessed at all levels as they constitute an integral part of the surveillance system.

Establishing and institutionalizing a data demand and data use culture is one of the most challenging components to effectively operationalize at country level as it requires significant investments for resourcing long-term organizational capacity across all administrative levels to implement actionable responses using existing health information systems and based on the surveillance intelligence produced. The following sections outline the key adaptations, challenges and opportunities that malaria surveillance systems face to respond to all levels of malaria transmission in the move towards elimination.

3. What are implications of transitioning from control to elimination?

Delivering on the key principles outlined in the previous section can be challenging for national programmes transitioning towards elimination. Surveillance systems in elimination and control settings are designed to achieve their respective goals, i.e. control and elimination of malaria. While in control setting, the goal is to provide data insights to guide interventions at scale, e.g. mass net distributions, in elimination settings, the focus shifts to quickly trigger locally targeted responses to every single case. These goals require different granularity levels in terms of temporal and case (investigation) resolution. We use the term resolution here to describe the level of needed data granularity. While periodic reporting is sufficient in control settings, surveillance systems in elimination settings strive for real-time reporting to trigger immediate responses, i.e. they strive for high temporal resolution. Similarly, in control settings, caseload is usually investigated at higher administrative levels leading to a response at national, province or district level, while in elimination settings, every single case needs to be investigated to trigger targeted local responses, i.e. elimination settings require high case-level resolution [8, 9].

Figure 1 depicts the levels of temporal and case resolution needed along the transmission continuum.

When transitioning from control to elimination settings, national programmes need to continuously adapt their surveillance systems in order to cater to these new requirements and trigger appropriate responses. As the term transmission continuum suggests, transitioning from one phase to the next happens gradually and in specific geographical areas within countries (hence increasing the heterogeneity of the malaria transmission in that country) [10]. It is therefore advisable to strengthen and adapt surveillance components gradually and timely to ensure they are functioning when the elimination phase is reached.

In elimination settings, notification of every very case within 24 h, to trigger timely case investigation (often within 3 days), enabling a timely investigation of transmission foci (often within 7 days) [2]. This case-based surveillance approach has been named the “1–3–7 approach” and was launched in China in 2012 and has since been adapted to other country contexts, including Cambodia and Myanmar [11–13]. This approach demands the redesign of reporting structures to deliver on these timely reporting and response requirements. A priority is ensuring quality data reporting from both public and private service. It is a known challenge to



Figure 1.
Changes in surveillance system requirements along transmission continuum (adapted from [9]).

successfully integrate data from the private sector into the national surveillance system [14]. To achieve this, there is an increasing need to establish digital data collection to ensure rapid and complete case reporting from all health system levels, including the private sector [9, 15]. Many countries have developed digitalized reporting systems. One example is Mozambique, a country with high transmission heterogeneity, where, since 2016, community health workers are equipped with smartphones carrying an app through which they can report every patient consultation – including malaria cases. This facilitates the notification of community cases to higher administrative levels that carry out case investigations [16].

Additional to this temporal component of early case notification and investigations, surveillance system need to increase the case resolution to inform customized and locally targeted responses. This includes case investigations, focus investigation and the development of related data collection tools. Programmes also need to expand their case detection approaches to not only detect symptomatic cases actively seeking care with health providers (passive case detection), but also detect asymptomatic cases and populations that might not be easily reached through existing health system structures (active case detection) [2]. Active case detection requires more investment from existing health staff to go out to test remote populations and/or new personnel who carry these additional responsibilities. Sri Lanka’s elimination strategy developed a specific approach where active case detection was carried out by mobile malaria clinics targeting remote areas with no immediate access to alternative health system structures [17]. More recently, Cambodia, where remaining malaria cases cluster along international borders and hard-to-reach forests, followed this example with a similar approach. The national programme has introduced the role of mobile malaria workers who go on outreach activities and actively approach forest workers including mobile and migrant populations, the population group most at risk of malaria infection. This approach has proven to be successful, with Cambodia aiming for *P. falciparum* malaria elimination by 2023 [18–20].

Once high-resolution data is available, national programmes need to generate insights through data analysis [9]. Previously, this required input from expert data analysts limiting the extent to which national programme could actually produce the necessary outputs to guide decision making. More recently, analytical outputs

can be made available more easily through digitalized automated solutions. Data analysis in elimination setting should facilitate the identification of specific populations at risk, and should allow the micro-stratification of risk areas based on individual case data. Timely analysis of individual-level case data is crucial to improve early warning systems and establish robust alert systems to prevent epidemics and control foci. At this point, visualizing trends and risks via appropriate tools including charts and maps is essential.

Following data visualization and interpretation, the final and arguably most important step is linking data to action. The health force needs to be trained to interpret these high-resolution outputs and trigger targeted responses. Functioning communication flows between different administrative levels, decision-makers and other stakeholders are the enabling environment needed to link surveillance data to action. A case study mention “a well-coordinated surveillance system with excellent vertical and horizontal communication” as a key component that lead to the successful malaria elimination in Sri Lanka [17].

Lastly, it is critical that all these components are facilitated via an integrated platform with clear procedures for data recording, reporting, visualization and use. Systems should be built around central data storage and management system to ensure smooth integration of malaria indicators and data sources into routine HIS [9]. New digital solutions can facilitate this. The project Visualize No Malaria that has been implemented in Zambia since 2015 has exemplified an approach where a range of new digital tools facilitated linkages between exiting routine and non-routine database, automated data workflows, and create customized data visualizations to generate one integrated surveillance system [21]. Experiences from Cambodia outline the process and challenges of shifting from an offline information system towards an integrated web-based surveillance system for malaria elimination [22]. New digital solutions also help make surveillance systems more resilient to changes in external circumstances by allowing simple adaptations that were previously difficult to implement. External circumstances like the COVID-19 pandemic require rapid adaptations of surveillance systems [3, 23]. In a before mentioned project in Mozambique where community health workers submit data through a smartphone app, the underlying digital platform was adapted in response to the COVID-19 pandemic. Now, the app includes education modules related to COVID-19, and data entry forms for COVID-19 symptom tracking (some symptoms like fever overlap with malaria symptoms). This enabled the Ministry of Health to rapidly gather essential insights on COVID-19 knowledge gaps among community health workers and will strengthen malaria surveillance by providing insights into how community health workers handle the similarity of malaria and COVID-19 symptoms [24, 25].

These increased demands of the surveillance system require resources to create functioning data systems, procure appropriate testing (e.g. malaria species-sensitive tests that are able to differentiate between *P. falciparum* and *P. vivax* malaria to allow species-specific responses where required), develop new guidelines and build the capacity of the health force to fulfill these new/additional requirements. Due to these intensified focus on surveillance, the proportional spending on the surveillance component of malaria programmes increases and case studies show that programme expenses to achieve malaria elimination can even be greater than the expenses during the control phase, while international supporting funding of the health system decreases [26, 27]. This may put a specific strain on national programmes catering to the needs of multiple transmission strata at the same time. However, as surveillance systems become more resilient, resources and personnel can progressively shifts tasks and embed additional roles and responsibilities to optimize resources and expertise. Thailand for example has identified the need to integrate malaria services into the general health service system rather than

continuing to implement a vertical malaria programme. Building capacity and mobilizing resources at all health system levels will support the achievement of the country's malaria elimination goal by 2024 [28].

4. What are the current gaps in surveillance systems of elimination countries and how to overcome?

One of the remaining challenges for many eliminating countries is the limited capacity of their surveillance systems to monitor and track interventions against *Plasmodium vivax* and monitor vivax relapses. In countries where both *Plasmodium falciparum* and *Plasmodium vivax* are present, malaria interventions have led to steady declines of falciparum malaria, resulting in an increase of the relative contribution of vivax malaria (among all infections). As opposed to *P. falciparum* infection, which does not have latency (dormant stages), treatment of *P. vivax* malaria poses a particular challenge to elimination efforts due to its potential to cause periodic relapses [29, 30]. A fit for purpose surveillance system in these countries should not only be able to monitor the delivery of tailored *P. falciparum* interventions, but also track the implementation of approaches to safely deliver appropriate treatment to *P. vivax* cases.

While the requirements of surveillance systems along the transmission continuum are clearly documented through comprehensive guidance documents outlined in previous sections, the operationalization of this guidance remains challenging for national programmes. Even though many countries are successful in establishing functioning systems on the path to elimination, as shown in previous sections [6], they mostly rely on a learning by doing approach. There remains a gap in coordinating and standardizing efforts among the wider surveillance community. In December 2020, the Malaria Policy Advisory Committee within WHO has acknowledged this “lack of coordination and standardization of tools to monitor the quality of malaria surveillance and to understand its strengths and weaknesses” [31]. Recently, several initiatives have started to address this gap, aiming to establish the operational guidance and best practices for surveillance systems of malaria elimination programmes. The WHO has recently developed a surveillance assessment toolkit which will be published in the first quarter of 2021 [31]. This toolkit will frame a systematic approach on how to measure the performance of malaria surveillance systems which will harmonize the way national programmes assess the quality of their surveillance systems and identify needs for improvement. The WHO has further announced the set-up of a Malaria Strategic Information Reference Group (MSIRG). The MSIRG will focus on five main areas: Guidance, digital solutions, surveillance assessments and system strengthening, programme reviews and subnational tailoring of interventions and burden estimation. The RBM Surveillance, Monitoring and Reference Group (SMERG) is a global platform to foster communication on malaria surveillance, monitoring and evaluation and convenes members to coordinate related activities. The SMERG is currently in the process of establishing a Committee dedicated to Surveillance Practice and Data Quality (SP&DQ Committee) with the key objectives to improve the visibility of surveillance and data quality improvement initiatives and to strengthen global coordination on surveillance-related efforts. The two groups (MSIRG and SMERG) will work closely together to ensure synergic efforts between their recent initiatives [32].

These recent initiatives will lay the groundwork for more efficient international alignment of surveillance efforts and improved harmonization of systems in the future.

5. Conclusions

A strong surveillance system is critical to implementing an efficient and effective malaria program to monitor disease trends and optimize targeting of interventions to accelerate progress towards malaria elimination. For countries to strengthen and sustain the practice of using data for decision-making and accelerate efforts towards malaria elimination, dynamic and adaptive surveillance systems are needed. To accelerate efforts towards malaria elimination, surveillance systems must be able to respond to the dynamic and evolving external socio-ecological patterns (as recently experienced through the COVID-19 pandemic) guided by lessons learned on resilience and adaptive management in order to effectively operate at national and subnational levels. Several global initiatives to document these best practices are on the way and will provide international alignment of surveillance efforts and improved harmonization of systems in the future.

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