

Strengthening Capacity in High-Burden Malaria-Endemic Countries: A Strategic Analysis of Training Gaps and Blended Learning Solutions in National Malaria Control Programs

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Abstract

Background

Malaria remains a significant public health challenge worldwide, with approximately 70% of the disease burden concentrated in 11 High-Burden to High-Impact (HBHI) countries, as identified by the World Health Organization (WHO). Notwithstanding considerable investments and advancements in malaria interventions, such as Insecticide-Treated Nets (ITNs), rapid diagnostic tests (RDTs) and Artemisinin-based Combination Therapy (ACT), Indoor Residual Spraying (IRS), Seasonal Malaria Chemoprevention (SMC), and the recent introduction of vaccines, persistent Human Resource (HR) capacity deficiencies considerably undermine the effectiveness and sustainability of malaria control initiatives. Pre-service training and continuing education are often sub-optimal for Community Health Workers (CHWs), district health officials, and national program managers with respect to diagnostic procedures, case management, prevention, community engagement, data analytics, and program implementation, particularly in remote and high-transmission environments.

Methods

This analysis employed a mixed-methods approach that integrated a review of peer-reviewed literature, reports from the WHO and donor agencies, and case studies from HBHI countries. Data from national health information systems, such as District Health Information System 2 (DHIS2), and malaria program reports were compiled and evaluated using an Impact-Feasibility Matrix. Systemic relationships were mapped across the community, district, and national levels. At the same time, recommendations were substantiated through consultations with technical experts, Malaria Policy Advisory Group (MPAG) members, managers of National Malaria Control Programs (NMCP), and partner organizations.

Results

Significant training and workforce shortages were identified at all tiers of the health system. At the community level, deficiencies in CHW training and supervision were correlated with instances of misdiagnosis, treatment delays, and low levels of community engagement. District-level challenges included suboptimal supply chain management, insufficient surveillance mechanisms, and limited managerial capabilities. At the national level, constraints involved inadequate expertise in research, surveillance, data analysis for policy adaptation and prioritization for subnational tailoring, and leadership. To mitigate these issues, a blended learning strategy that encompasses self-paced digital modules, virtual mentoring, and Outreach Training and Supportive Supervision (OTSS) is recommended. An application of Kirkpatrick's four-level evaluation framework of outcomes was also recommended to assess the impacts of the proposed training strategies that would enhance learner satisfaction, knowledge acquisition, practical application, and the overall health outcomes. The Training Resource Hub, created by Malaria Eradication Scientific Alliance (MESA), has been strengthened by the inclusion

of data from this study to provide an inventory of blended malaria-related training opportunities to malaria program leaders worldwide.

Conclusions

Enhancing the workforce capacity for malaria control through blended learning methodologies can effectively bridge critical HR gaps in HBHI countries. By incorporating context-specific training, digital resources, and sustainable mentorship frameworks, malaria programs can significantly improve operational efficiency, service delivery, and strategic planning. Many of these strategies have already demonstrated benefits at the local or regional level, and the wider application of lessons learned is essential if malaria elimination targets in resilient health systems are to be achieved. With the threat of an imminent decrease in donor funding, it is more important than ever that local capacity is strengthened for implementation of best practice at all levels of the health care system.

Background

Malaria remains one of the most pressing global health challenges of the 21st century, with its burden disproportionately concentrated in the WHO African Region. In 2018, the WHO identified 11 HBHI countries, Burkina Faso, Cameroon, the Democratic Republic of the Congo, Ghana, Sudan, Mali, Mozambique, Niger, Nigeria, Uganda, and Tanzania, that collectively account for approximately 70% of global malaria cases and deaths [1]. This classification emerged as a strategic response to stalled progress in malaria control, spearheaded by the WHO and the Roll Back Malaria (RBM) Partnership to End Malaria [1]. The World Malaria Report 2024 underscores the persistent severity of the crisis, documenting an estimated 263 million malaria cases and 597,000 deaths globally in 2023, with 95% of fatalities occurring in HBHI nations [2]. Despite significant advancements since 2000, including the prevention of 2.2 billion cases and 12.7 million deaths through scaled-up interventions, these countries missed the 2020 Global Technical Strategy (GTS) targets of reducing malaria mortality rates by at least 40% and reducing malaria case incidence by at least 40%, achieving only a 25% reduction in mortality and a 10% reduction in morbidity instead [3, 4].

The past two decades have seen HBHI countries deploy evidence-based strategies to combat malaria, including vector control through ITNs and IRS, preventive chemotherapy such as SMC for children under five, and improved case management via RDTs and ACT [5]. The recent introduction of the Mosquirix vaccine adds another important tool for control, but on its own, will not be enough to eliminate malaria. Unfortunately, systemic weaknesses in health systems, particularly HR capacity gaps that cascade across all levels of malaria programming [6, 7], reduce the impact of these strategies and threaten the sustainability of these hard-won gains.

Amid these challenges, several country-level successes offer practical lessons for regional scale-up. For example, targeted training of CHWs in Burkina Faso significantly improved the accuracy and uptake of RDT-based diagnosis, leading to timely treatment and a measurable reduction in severe malaria cases

[8]. Similarly, integrating malaria training into routine maternal and child health (MCH) services in Nigeria enhanced SMC delivery coverage, particularly in hard-to-reach areas [9]. Beyond country examples, regional coordination efforts have yielded impactful results. The Greater Mekong Subregion's regional approach to drug resistance containment, including coordinated surveillance and synchronized policy implementation, has demonstrated how cross-border collaboration can mitigate emerging threats and slow the spread of antimalarial resistance [10]. These models hold valuable implications for similar regional strategies in West and Central Africa, where cross-border population movement and ecological similarities pose shared challenges.

Nonetheless, persistent health system weaknesses, especially in HR capacity, supervision, and retention, continue to limit the effectiveness and sustainability of these efforts. Critical HR gaps, from national program managers to frontline CHWs, weaken service delivery, data quality, and program adaptability in the face of evolving malaria epidemiology [11].

At the community level, frontline health workers, especially CHWs in rural, high-transmission zones, often lack formal training in essential skills such as malaria diagnostics, RDT utilization, integrating malaria control into maternal health, and ACT administration. Additionally, they are often not well-versed in elements of vector control, such as overseeing the control of breeding sites, using ITNs, adhering to treatment recommendations, and understanding IRS requirements. These gaps are multifaceted and interconnected, involving various cadres of health workers such as CHWs, health promoters/volunteers, village midwives, and medical assistants. Studies indicate that over 60% of health facilities in sub-Saharan Africa lack staff proficient in malaria case management [12], leading to misdiagnosis, inappropriate treatment, and suboptimal community engagement. Cultural barriers, including attributing symptoms to non-biomedical causes, further reduce intervention uptake [13–15]. These gaps are exacerbated by infrequent refresher training, leaving workers unprepared for emerging challenges like drug resistance or updated WHO guidelines.

District-level health systems face parallel deficiencies, particularly in surveillance and supply chain management. Weak data collection and analysis capabilities delay outbreak responses and distort resource allocation, as seen in Nigeria and Mozambique, where surveillance breakdowns exacerbated commodity stockouts [7, 16, 17]. Logistics training gaps contribute to frequent shortages of ITNs, RDTs, and ACTs, documented in Uganda and Ghana, which undermine the effectiveness of vector control and case management [18, 19]. Compounding these issues, district managers often lack leadership skills for cross-sector coordination, advocacy, monitoring and evaluation, and community mobilization, resulting in fragmented programs and demoralized staff [5, 20]. Yet progress is possible: in the Greater Mekong Subregion, a coordinated approach to training, drug resistance surveillance, and cross-border collaboration has successfully contained artemisinin resistance and offers a regional model for building system resilience [10]. These examples suggest that tailored training and structured district-level capacity-building can yield scalable gains in malaria control.

Nationally, NMCPs struggle with critical shortages of technical expertise, including epidemiologists, data analysts, and policy specialists, that is essential for “subnational tailoring” of strategy rather than a “one-size fits all approach”. This impedes the implementation of WHO’s “surveillance as a core intervention” strategy [21, 22] and hinders context-specific adaptation of global guidelines. In Nigeria, for instance, inconsistent comprehension of policies led to erratic execution and compromised data quality [23]. Financial sustainability remains precarious, with 67% of funding derived from a relatively small number of international donors (primarily the U.S., UK, and Global Fund) between 2010–2023 [2], thus creating vulnerability to shifting donor priorities.

These interconnected HR gaps generate a vicious cycle: inadequate community-level training reduces intervention efficacy, district-level surveillance failures impede targeted resource deployment, and national leadership deficiencies delay evidence-based policymaking. Consequently, operational inefficiencies proliferate, including stockouts, diagnostic errors, and reactive rather than proactive outbreak responses. The 2021 update to the WHO Global Technical Strategy for Malaria 2016–2030 estimates rising financial needs from USD 6.8 billion in 2020 to USD 10.3 billion by 2030, highlighting the urgency of optimizing HR investments [5].

Against this backdrop, this study addresses a critical evidence gap by systematically mapping HR capacity deficiencies across HBHI countries and proposing a tiered, blended learning framework for sustainable capacity strengthening. By integrating digital tools, multi-level partnerships, and context-adapted methodologies, NMCPs can better prepare and support the people necessary to accelerate progress toward malaria elimination.

Methods

We employed a mixed-methods research design combining literature review, case studies, health system data analysis, and stakeholder consultation. This approach ensured a comprehensive understanding of HR capacity challenges and training gaps in HBHI countries.

Mixed-Methods Approach

A review of over 30 sources, including peer-reviewed articles, WHO and RBM reports, Global Fund documentation, and national strategic plans, was conducted to identify HR capacity themes. Complementary case studies were drawn from exemplar countries demonstrating both challenges and successful interventions in malaria training and health workforce development. An online training Resource Hub, building on the work of MESA, was developed to provide blended malaria-related training opportunities to malaria program leaders worldwide.

Data Collection and Analysis

Quantitative data were drawn from DHIS2 platforms across multiple countries to evaluate trends in malaria incidence, intervention coverage, stockouts, and health workforce distribution. Qualitative data

from WHO, NMCP reports, stakeholder consultations, and regional program evaluations provided contextual depth.

Prioritization Framework

We employed an impact-feasibility matrix to prioritize gaps according to their potential to significantly reduce malaria morbidity and mortality and the feasibility of addressing them within existing systems. Systemic linkage analysis was also used to examine how gaps at one level exacerbate challenges at others. Findings were discussed with members of MPAG and malaria program leaders.

Results

Areas of Capacity Gaps

Across community, district, and national levels, HBHI (High Burden to High Impact) countries face persistent human resource capacity challenges that undermine malaria control and elimination efforts.

At the community level, many CHWs lack comprehensive pre-service training in malaria diagnostics, case management, and health education, as well as in-service updates aligned with evolving technologies. They are often unprepared to administer or interpret RDTs, deliver treatment using ACTs, or educate households on ITN use. Moreover, they frequently lack training in basic vector control strategies such as larval source management, adherence to IRS protocols, and understanding of breeding site dynamics. Inadequate data literacy also hampers accurate reporting, an essential component of real-time surveillance. These challenges are compounded by limited access to culturally adapted tools, supervision, and regular refresher training, leading to reduced community trust and poor health outcomes.

Despite these challenges, targeted training efforts have proven effective in some settings. In Uganda, when CHWs received structured training on RDT use and fever case management, correct diagnosis rates improved significantly, and overtreatment with ACTs decreased by over 25% [24].

At the district level, malaria program managers often contend with weak surveillance systems and insufficient numbers of staff with skills required for their position. Many lack the technical skills needed to analyze DHIS2 data, forecast commodity needs, and oversee supply chain logistics. As a result, facilities experience recurrent stockouts of RDTs, ACTs, and ITNs, delays in outbreak detection, and fragmented intervention deployment. Training deficits in strategic management, monitoring and evaluation, and multisectoral coordination further hinder the alignment of district activities with national malaria strategies.

However, district-focused capacity-building has shown impact. In Nigeria, the Global Fund's implementation reviews led to on-the-job training in DHIS2 analysis and supportive supervision, which significantly improved data completeness and triggered earlier outbreak responses [25]

At the national level, malaria control programs face chronic shortages in specialized cadres such as epidemiologists, digital health specialists, entomologists, and M&E experts. These gaps weaken the ability to adapt WHO guidelines to local contexts, lead operational research, and scale evidence-based interventions. A lack of structured leadership development pipelines within NMCPs also contributes to limited program ownership and over-reliance on external technical partners.

Nonetheless, progress is possible. The Mekong Subregion offers a broader example: through regional training hubs and phased transfer of responsibilities from donor-funded technical teams to local malaria programs, countries achieved improved implementation of drug resistance monitoring and more autonomous national response plans [10]

These examples underscore that while capacity gaps are deep and persistent, well-designed, context-specific training programs, especially when followed by structured transition to local leadership, can yield measurable improvements in malaria outcomes and health system resilience.

Implications of These Gaps for Malaria Control and Elimination

The implications of these capacity gaps are multifaceted and deeply interconnected. Inadequate CHW training directly contributes to misdiagnosis, improper treatment, and missed opportunities for early intervention, ultimately sustaining transmission cycles in high-burden communities. Data inaccuracies arising from poor training and supervision distort malaria burden estimates, leading to resource misallocation and delayed response to epidemics. District-level inefficiencies in supply chain management and program oversight manifest in recurring stockouts of RDTs, ACTs, and ITNs, eroding public confidence in the health system.

At the national level, the absence of a technically proficient and strategically agile workforce undermines surveillance, monitoring, and evaluation, and timely adaptation of interventions. Without skilled leadership, NMCPs are often unable to coordinate effectively with partners or advocate for increased domestic financing. This perpetuates dependency on external funding and limits long-term program resilience. Cumulatively, these deficiencies create systemic weaknesses that obstruct malaria elimination and compromise overall health system performance in HBHI countries.

Recommendations

To address these capacity gaps, a comprehensive, multi-tiered educational approach is needed using appropriate online methods where possible, combined with mentoring and assessment of improvement in the outcomes of interest. It is recommended that NMCPs report on capacity gaps and training needs in each annual report.

Blended Learning Strategy: A blended learning strategy combining self-directed and virtual learning should be central to this approach. Self-directed online modules can deliver foundational knowledge in malaria case management, data reporting, and vector control, with content localized for language and cultural context and accessible on mobile devices. Virtual mentorship and peer exchange should

complement these modules by facilitating case discussions and problem-solving using platforms like WhatsApp, Zoom, and e-learning portals. Many appropriate courses and online modules are already available and can be reviewed through the GMP website or the Training Resource Hub (Ref)

Face-to-Face Training, Outreach Training and Supportive Supervision

These training strategies should be implemented to provide direct supervision, skill assessments, and hands-on learning opportunities in clinical and community settings. Quarterly OTSS visits for face-to-face supportive supervision and assessment of outputs are recommended. For example, in Zambia, focused OTSS interventions led to significant improvements in malaria diagnostic and treatment indicators across frontline health facilities [26]. Similarly, supportive supervision programs across sub-Saharan Africa were shown to strengthen microscopy competencies and improve the accuracy of malaria diagnosis [27]. Structured mentoring programs and interactive workshops, when consistently applied, can enhance practical competencies and ensure the quality of clinical supervision.

Curriculum Reform and Pre-service Training

These are also essential to the sustainability of capacity-building strategies. Integrating malaria-specific modules into medical, nursing, and public health training programs will ensure that new health professionals enter the workforce with relevant, up-to-date skills. This should be supported by Ministries of Health and Education and aligned with the WHO competency frameworks. The Strengthening Laboratory Management Toward Accreditation (SLMTA) program offers a strong example of such curriculum reform, having transformed laboratory training and competency development in countries like Ethiopia through standardized pre-service and in-service curricula and mentoring [28].

Leadership Development

Leadership development must target district and national program managers, providing them with training in strategic planning, resource mobilization, advocacy, and adaptive leadership in NMCPs, health departments, and partnership with communities. Fellowships, leadership retreats, and mentorship initiatives can help cultivate a skilled cadre capable of navigating complex health system demands.

Digital Literacy and Data Use

Investing in digital literacy and data utilization is essential. Where relevant, malaria-specific modules should be included in training of health workers in use of tools such as DHIS2, Geographic Information System (GIS), and other analytic software for surveillance and response. This will enhance capabilities to communicate surveillance data, monitor program performance, and make data-informed decisions in response to emerging threats.

Engage the Private Sector

It is important to engage the private sector, particularly pharmacies and informal providers, through targeted training and established reporting protocols to ensure alignment with national case management standards and appropriate reporting.

Address High Attrition Rates

Addressing high attrition rates requires regular and specific assessment of staff turnover and analysis of exit interviews to identify and address gaps in programs as part of a retention strategy. This should include provision of career advancement opportunities, mentoring, OTSS, recognition programs, and both financial and non-financial incentives. Implementing structured supervision, offering continuous education opportunities, and ensuring safe working environments will also contribute to improved employee retention.

Application of Kirkpatrick Four-Level Evaluation Framework

Too often, the end of a training course is a test on acquisition of a specific skill without assessment of a health outcome but to ensure that these recommendations yield the best possible results, the Kirkpatrick Four-Level Evaluation Framework can be used as part of the approach to building capacity and monitoring the impact of such capacity-building strategies [29]. At the **Reaction** level, participant feedback helps assess satisfaction, cultural relevance, and user experience with training content. Surveys and focus groups provide insights into acceptability and engagement. At the **Learning** level, pre- and post-training assessments measure knowledge acquisition, while practical evaluations test skill competency. At the **Behavior** level, workplace observations and performance metrics such as error rates, referral practices, and reporting accuracy reveal the degree of behavior change resulting from training. Finally, at the **Results** level, improvements in malaria case detection, reduced stockouts, increased intervention coverage, and enhanced local leadership provide evidence of organizational impact.

Implementing the Kirkpatrick framework allows NMCPs and their partners to track training outcomes across the continuum from learner experience to system-wide health improvements. Embedding this model into national evaluation systems ensures that training efforts are not only delivered but are continuously refined, scaled, and sustained for long-term impact.

The role of external partners

External partners have an important role to play in supporting capacity building. In the past, some funders have been so focused on purchase of materials such as nets, insecticides, and medications, that insufficient attention has been given to development of capacity of the staff who will decide where the resources can be most effectively used then supervise implementation and sustainability of the programs to deliver those materials. Skills transfer, mentoring, provision of external opportunities and most importantly allowance for training as a key part of budgetary allocation are essential,

Discussion

The findings from this strategic analysis underscore the persistent and multifactorial human resource constraints impeding malaria control efforts in HBHI countries. Despite substantial investments in commodities, technologies, and strategic planning frameworks, progress toward malaria elimination is being undermined by fundamental capacity gaps across all levels of the health system.

At the community level, the lack of consistent and comprehensive training for CHWs significantly impairs their ability to provide accurate malaria diagnosis, effective case management, and proactive prevention education. This not only compromises clinical outcomes but also reduces community trust in the health system. District-level managers face parallel deficits, particularly in supply chain forecasting, data interpretation, and leadership skills, which lead to inefficient program implementation and delayed responses to outbreaks. At the national level, NMCPs often lack the specialized technical personnel required for surveillance, policy adaptation, operational research, and monitoring and evaluation, creating a bottleneck in the coordination and scaling of high-impact interventions.

These challenges are not new. However, this study reports some more recent examples of successful training that can be reviewed through the GMP or Training Resource Hub and potentially replicated in other settings. The review highlights the critical importance of a multi-tiered and blended learning approach as a sustainable solution. Unlike fragmented, donor-dependent short courses or ad hoc workshops, a blended model allows for scale, contextual relevance, and continuity. Self-directed modules and virtual peer engagement provide accessible entry points for frontline staff, while OTSS and district mentorship reinforce hands-on learning and real-world application. Embedding malaria training into pre-service curricula ensures the next generation of health workers is equipped from the start, and integrating digital literacy elevates the use of surveillance platforms such as DHIS2 and GIS for timely and targeted decision-making. Malaria-specific components should also be included in training for MCH health workers, pharmacists, and CHWs, or others responsible for the first line of patient care.

Leadership development is essential to overcome strategic and operational barriers. The NMCPs should adopt leadership fellowships such as the Magill Fellowship, blended online/in-person courses such as MalariaX, Science of Eradication [30], and Training-of-Trainers models to cultivate future leaders. Cross-country peer-learning, such as South–South exchanges at the Rethinking Malaria Leadership Forum, reinforces adaptive management. The University of Pretoria’s SADC-focused leadership course exemplifies successful regionally relevant training aligned with WHO competency frameworks and increasing gender equity in leadership.

Nevertheless, implementing such a broad strategy comes with practical and structural barriers. These include limited infrastructure for digital learning in rural areas, high attrition rates among health workers, and the complexity of aligning training with rapidly evolving WHO guidelines. Solutions must therefore be built on inclusive stakeholder engagement, government ownership, and robust monitoring systems.

The application of the Kirkpatrick Framework offers a robust foundation for evaluating both the short-term effectiveness and long-term impact of training investments. As demonstrated in this study, improvements in satisfaction, knowledge acquisition, behavior change, and system outcomes are all

measurable and can guide iterative refinement of capacity-building initiatives. However, institutionalizing this framework within national evaluation systems remains a priority for ensuring training programs lead to meaningful and sustained improvements in malaria control outcomes.

Conclusions

This study highlights the pressing need to address persistent human resource challenges as a central pillar of malaria control and elimination in HBHI countries. While technical solutions such as ACTs, RDTs, ITNs, and chemoprevention have been widely deployed, their full impact is constrained by critical gaps in workforce capacity, supervision, leadership, and data use at all levels of the health system.

To overcome these limitations, we propose a multi-tiered, blended learning strategy that combines self-directed modules, virtual peer engagement, and face-to-face mentorship. This model not only facilitates broad access to training but also supports sustained skill development and contextual learning. When complemented by pre-service curriculum reforms, structured leadership development, private sector integration, and retention incentives, such a strategy can significantly strengthen national malaria control programs and improve service delivery.

Importantly, we recommend the adoption of the Kirkpatrick Four-Level Evaluation Framework to guide the assessment of training outcomes. The framework offers a practical, well-established methodology for evaluating the effectiveness of training programs, ranging from participant satisfaction to systemic health outcomes. Embedding this model into national monitoring and evaluation systems will ensure accountability and continuous improvement.

As HBHI countries strive toward malaria elimination goals, targeted investment in human capital development must be elevated as a strategic priority. Institutionalizing capacity-building initiatives within national systems, backed by government ownership and cross-sector collaboration, will be essential to sustaining progress. With the right training structures and evaluation mechanisms in place, health systems can use resources in the most effective manner and become more responsive, resilient, and capable of delivering the high-quality malaria services needed to eliminate the disease.

Declarations

Author Contribution

M.A. led the conceptualization, literature review, data analysis, and manuscript drafting. D.W. provided strategic oversight, refined the study design, and contributed critical revisions. G.B. contributed expert input on training strategy and malaria elimination policy, and reviewed manuscript drafts. S.A. provided guidance on regional capacity-building priorities and validated findings with programmatic insights. All authors read and approved the final manuscript.

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