

Service delivery strategies and health information systems: Impact on malaria elimination in Ethiopia

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Abstract

Background: Ethiopia's progress toward malaria elimination requires a comprehensive, evidence-based approach, assessing the health system's readiness to support these efforts. This study aims to evaluate the capabilities of the Ethiopian health system, particularly focusing on service delivery strategies and health information data utilization for malaria elimination.

Methods: A cross-sectional survey was conducted from June to August 2017, targeting health offices at the federal, regional, zonal, and district levels, as well as health facilities across 239 malaria elimination-planned districts. Data were collected using a smartphone-based questionnaire, informed by the World Health Organization's frameworks for supply chain management, health information systems, and service delivery. Ethical approval was granted by the Scientific and Ethical Review Office-Institutional Review Board of the Ethiopian Public Health Institute.

Results: Challenges identified at all government levels included deficiencies in the Public Health Emergency Management (PHEM) system, such as poor phone network coverage, lack of standardized reporting formats, delayed and incomplete report submissions, and absence of an electronic database. Malaria control efforts were further hindered by inadequate funding, limited technical capacity, shortages of malaria-related supplies and medications, barriers to inter-sectoral collaboration, difficulties in reaching remote populations, low community engagement, and poor treatment-seeking behaviors.

Conclusions: The findings underscore the need for substantial improvements in PHEM reporting formats, phone communication systems, timeliness of report submissions, the adoption of electronic databases, and the accuracy of data reporting. Addressing barriers such as insufficient funding, technical limitations, inadequate supplies, limited cross-sectoral cooperation, and poor community involvement is crucial for successfully achieving malaria elimination in Ethiopia.

Keywords: Malaria elimination, health information systems, health service delivery, Public Health Emergency Management

Introduction

Ethiopia's Federal Ministry of Health (FMOH) has set an ambitious goal to eliminate malaria by 2030, with the expectation that sub-national malaria elimination efforts will precede national-wide eradication due to regional variability in malaria transmission rates (Federal Ministry of Health 2014). The strategy for malaria elimination follows a staged approach, focusing initially on low-transmission areas and their surrounding zones to gradually reduce malaria transmission and the geographical extent of the disease (Federal Ministry of Health, 2016). The elimination phase involves halting local transmission through early diagnosis and treatment, while preventing new infections in areas where malaria has been eliminated.

To achieve these objectives, the health system's capacity must be enhanced in key areas such as skilled human resources, financing, and logistics (Molla 2016). A crucial component of this capacity is the surveillance system, which requires reorientation to ensure timely case detection, reporting, and response. Regular monitoring of drug and insecticide resistance is essential

to inform appropriate interventions (World Health Organization 2012). Additionally, the active involvement of targeted communities in the planning and implementation of malaria control interventions is critical for the sustainability and success of malaria elimination efforts (Ghebreyesus et al. 1996).

As part of the malaria elimination efforts, it is necessary to assess information gaps in the malaria control program at the baseline stage in districts earmarked for elimination. This understanding will provide valuable insight into the interventions that have been implemented and how they have contributed to reducing malaria prevalence, ultimately guiding future strategies and evaluations (Federal Ministry of Health 2017). Furthermore, the expertise of scientists, healthcare providers, and public health specialists is crucial to filling these gaps and driving progress toward malaria elimination (Bryce et al. 1994).

This study aims to assess the health system capacity in Ethiopia's 239 malaria elimination-planned districts, with a focus on malaria surveillance, monitoring and evaluation systems, health service delivery, case

management, vector control, community participation, and supply chain management. This baseline survey provides a foundation for an evidence-based program to evaluate Ethiopia's readiness for the malaria elimination process.

Materials and Methods

Study Area and Period: This survey was conducted between June and August 2017 in 239 districts across Ethiopia that were stratified for malaria elimination. The malaria status of the country was determined using data from the Health Management Information System (HMIS) and Public Health Emergency Management (PHEM), as outlined in the Malaria National Strategic Plan (NSP: 2017-2020). The districts were stratified based on the Annual Parasite Incidence (API) per 1,000 people, and four categories were established: low (API <5), moderate (API ≥5 and <100), high (API >100), and malaria-free (API = 0). The distribution of the strata across regions.

Study Design: A cross-sectional survey was conducted to assess health facilities and health bureaus at the federal, regional, zonal, and district levels within the 239-malaria elimination-planned districts.

Data Collection: Data were collected through direct interviews with malaria focal persons at the federal, regional, zonal, and district health offices using structured and semi-structured questionnaires. The survey targeted hospitals, select private health clinics, and health posts within the study districts. At each health facility, data on the population served, as well as GPS coordinates and altitude, were recorded. A total of 47 data collection teams were established, with each team responsible for gathering data from five or six districts, depending on geographic proximity. Each team comprised a laboratory technician and a malaria focal person from one of the selected districts.

Data Collection Tool: The data collection tool consisted of structured and semi-structured questions addressing key areas, including malaria surveillance, monitoring and evaluation (M&E), social and behavior change communication (SBCC), community participation, anti-malaria treatment, vector control activities, and laboratory capacity (equipment and supplies). The questionnaires were pre-programmed into smartphones (Samsung I9300 S3 Neo) with GPS functionality, enabling efficient data capture in the field.

Data Quality Assurance: Data quality was ensured through the use of standardized data collection tools and close monitoring of the data collection process. Smartphones played a critical role in enhancing the data collection procedure. Data were entered into the smartphones using a locally developed software program, *EpiSample*, and transmitted in real time to the central server at the Ethiopian Public Health Institute (EPHI) via the internet. This system enabled immediate

feedback and quality control during the data collection process.

Statistical Analysis: Data were entered and analyzed using STATA 14 statistical software. Descriptive analyses, including proportions, ratios, and percentages, were conducted to summarize the findings. The results were presented in graphical and chart formats for easy interpretation.

Training of Data Collectors: Data collectors were selected by EPHI based on the districts chosen for malaria elimination. They received a one-week training session on the use of the survey questionnaires (printed in hard copy) and the *EpiSample* program for data collection. The training ensured that all data collectors were proficient in the use of the data collection tools and familiar with the study objectives.

Results

Health Information System

Malaria Surveillance

The National Malaria Control Program (NMCP) tracks malaria indicators such as Annual Parasite Incidence (API), Total Positivity Rate (TPR), total malaria cases, and the proportion of cases attributable to *Plasmodium falciparum* and *Plasmodium vivax*. It also monitors the percentage of cases associated with fever and malaria-related hospital admissions. The Ministry of Health (MOH) failed to update the expected reporting requirements for healthcare facilities, including private ones. While the PHEM system included reports from private, Non-Governmental Organization (NGO) facilities, and other healthcare settings, there was limited reporting of these sources. Weekly epidemiologic bulletins were produced by the national PHEM, which also provided input to regional surveillance efforts. A regular six-month inspection was conducted as part of the national malaria control program. The Health Management Information System (HMIS), PHEM, and the program's reporting system were the primary tools used by the NMCP, and feedback was provided to lower-level facilities.

Malaria surveillance indicators, including API and TPR, were monitored in five of the six study regions (83.3%), and in nine study zones (75%) for API and four zones (66.7%) for TPR. At the district level, 39.6% followed API, while 50.9% tracked TPR. Among district hospitals and health centers, 46.4% and 42.1%, respectively, used the correct formula for API, while only 8.3% and 11.8% used the correct formula for TPR (Table 2). At various health facilities, epidemic-monitoring charts were used, with 35.5% of health posts, 19.7% of hospitals, and 51.7% of health centers displaying them. Among the districts that had epidemic-monitoring charts, 89.4% maintained current patient loads, and 92.2% had the threshold data (Figure 1).

Regarding data completeness, 33.3% of regions, 25% of zones, and 22.4% of districts reported deficiencies in data elements. Half of the regions and zones lacked

electronic malaria databases, and 33.3% of regions and some zones reported the use of non-disaggregated reporting (Table 1).

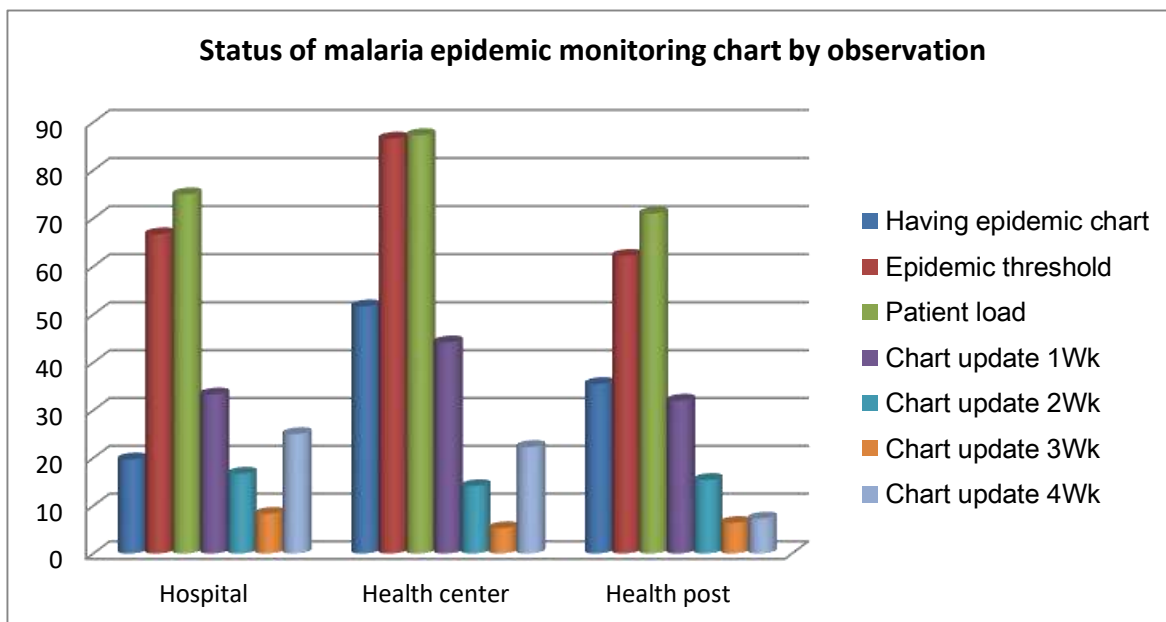


Figure 1: Epidemic-monitoring chart, baseline health system capacity assessment for malaria elimination in Ethiopia, June-Aug 2017

Table 1: Lists the reported shortcomings of the surveillance (PHEM) system, according to a baseline assessment of Ethiopia's health system's capacity for eliminating malaria, June–August 2017

Levels	There is no limitation	Limited data elements/variables/indicators in the format	unavailability of electronic database for malaria	Paper based reporting	Reporting form is not in local language	Reports are not disaggregated by health facility	Other (Specify)
Region(n=6)	2 (33.4)	2 (33.4)	3 (50)	3 (50)	1 (16.7)	2 (33.4)	0 (0)
Zone(n=12)	1 (8.4)	3 (25)	6 (50)	3 (25)	1 (8.4)	1 (8.4)	5 (41.7)
District (n=215)	114 (53)	48 (22.4)	39 (18.1)	35 (16.3)	19 (8.8)	14 (6.5)	23 (10.7)
Hospital (n=61)	36 (59)	10 (16.4)	6 (9.8)	2 (3.3)	2 (3.3)	1 (1.6)	13 (21.3)
Health Centre(n=547)	354 (64.7)	62 (11.3)	84 (15.4)	58 (10.6)	25 (4.6)	18 (3.3)	58 (10.6)
Health post (n=1775)	1279 (72)	136 (7.7)	112 (6.3)	122 (6.8)	228 (12.8)	41 (2.3)	104 (5.9)

Health Service Delivery

Case Management

The NMCP procures rapid diagnostic tests (RDTs), microscopes, anti-malarial medications, and other supplies through competitive bidding, adhering to WHO quality standards. The FMOH and the Ethiopian Food, Medicine, and Health Care Administration and Control Authority (EFMHACA) are responsible for monitoring the quality of these supplies. NMCP faced challenges, including poor-quality Giemsa reagents and problems with microscope maintenance (Table 4). The Pharmaceutical Fund and Supply Agency (PFSA) and the FMOH regularly assess the stock balance at the national level via phone communications. The Ethiopian Public Health Institute (EPHI) conducts periodic

evaluations of the therapeutic efficacy of anti-malarial drugs.

Malaria Vector Control

The WHO recommends using Long-Lasting Insecticidal Nets (LLINs), Indoor Residual Spraying (IRS), and Larval Source Management (LSM) for malaria vector control. The FMOH has operational guidelines for these measures and assesses the effectiveness of interventions quarterly. However, entomological surveillance is not currently conducted in Ethiopia. Key challenges identified for IRS included insecticide resistance and a lack of alternative insecticides. Issues with LLINs included transportation and distribution challenges, misuse, and low community awareness.

Table 2: Accessibility of documents, available/observed malaria-related guidelines and manuals at each level, June-Aug 2017

Availability of any malaria related guideline	Region(n=6)	Zone(n=12)	District (n=212)	Hospital (n=60)	Health Centre (n=544)	Health Post (n=1775)
	6 (100)	8 (66.7)	126(59.4)	22 (36.7)	249 (45.8)	296 (16.7)
Manual for the laboratory diagnosis of malaria. FMOH (EHNRI). First edition, Sep.2012, Addis Ababa, Ethiopia.	NA		15 (11.9)	NA	59 (23.7)	13 (4.4)
Malaria Laboratory Diagnosis External Quality Assessment Scheme Guideline. FMOH (EHNRI). First edition, Sep.2009, Addis Ababa, Ethiopia.	4 (66.7)	4 (50)	10 (7.9)	NA	21 (8.4)	6 (2)
Sample collection SOP.	NA	NA	2 (1.6)	NA	21 (8.4)	18 (6.1)
Giemsa working Reagent Preparation SOP.	NA	NA	0 (0)	NA	20 (8)	0(0)
Blood Film Preparation SOP.	NA	NA	1 (0.8)	NA	21 (8.4)	1 (0.3)
Blood Film Staining SOP.	NA	NA	0 (0)	NA	17 (6.8)	2 (0.7)
Malaria Microscopy Examination and Reporting SOP.	NA	NA	2 (1.6)	3 (13.6)	19 (7.6)	5 (1.7)
Job Aid for Malaria Light Microscopy. Prepared by EHNRI and PMI/ International Center for AIDS Care and Treatment Programs (ICAP).	NA	NA	1 (0.8)	2 (9.1)	7 (2.8)	4 (1.4)
Malaria manuals	NA	NA	29 (32.0)	6 (27.3)	50 (20.1)	58 (19.6)
Malaria treatment guideline	5 (83.3)	5 (62.5)	67 (53.2)	NA	104 (41.8)	77 (26)
National malaria strategic plan	4 (66.7)	4 (50)	NA	NA	NA	NA
Elimination road map	4 (66.7)	1 (12.5)	NA	NA	NA	NA
Implementation manuals SOPS	4 (66.7)	3 (37.5)	NA	NA	NA	NA
Advocacy communication and social mobilization manuals Sops	4 (66.7)	2 (25)	NA	NA	NA	NA
Vector control SOPS	4 (66.7)	2 (25)	NA	NA	NA	NA
Surveillance and M&E SOPs	4 (66.7)	3 (37.5)	NA	NA	NA	NA
Other (specify)	6 (100)	3 (37.5)	52 (41.3)	2 (9.1)	72 (28.9)	0 (0)

Table 3: Malaria medications and commodities interruption before to data collection for six months, June and August 2017

	Zone(n=12)	District (n=215)	Hospital (n=62)	Health Centre (n=546)	Health Post (1774)
Any interruption	8 (66.7)	92 (42.8)	25 (40.3)	265 (48.5)	833 (47)
	Zone(n=8)	District (n=92)	Hospital (n=25)	Health Centre (n=265)	Health Post (833)
Microscopes	3 (37.5)	17 (18.5)	1 (4)	22 (8.3)	NA
Giemsa	2 (25%)	39 (42.4)	7 (28)	67 (25.3)	NA
methanol	2 (25)	30 (32.6)	4 (16)	56 (21.1)	NA
Slide	2 (25)	22 (23.9)	2 (8)	36 (13.6)	NA
Blade lancet	2 (25)	17 (18.5)	4 (16)	37 (13.9)	270 (32.4)
Oil immersion	2 (25)	26 (28.3)	4 (16)	39 (14.7)	NA
RDT	5 (63.5)	62 (67.4)	11 (44)	153 (57.7)	688 (82.6)
ITN/LLIN	4 (50)	17 (18.5)	4 (16)	51 (19.3)	NA
Chloroquine (tablet)	4 (50)	44 (47.8)	13 (52)	126 (47.6)	NA
Chloroquine (syrup)	4 (50)	44 (47.8)	9 (36)	130 (49.1)	NA
Primaquine	6 (75)	43 (45.7)	5 (20)	120 (45.3)	NA
Coartem (any formulation)	4 (50)	44 (47.8)	14n(48)	119 (44.9)	NA
Artesunate (injectable)	4 (50)	41 (44.6)	11 (44)	124 (46.8)	NA
Artesunate (suppository)	5 (62.5)	41 (41.6)	9 (36)	139 (52.5)	NA
Quinine (tablet)	4 (50)	45 (48.9)	10 (40)	126 (47.6)	NA
Quinine (Injection)	4 (50)	49 (53.3)	12 (48)	140 (52.8)	NA
alcohol	NA	NA	NA	NA	209 (25)
Other (Specify)	0 (0)	3 (3.3)	12 (48)	11149 (56.2)	97 (11.6)

Social Behavioral Change Communication (SBCC)

The national SBCC strategies for malaria included community discussions, health education, mass media campaigns, school-based malaria clubs, and printed materials such as posters, pamphlets, and billboards. The NMCP rated these efforts as effective, although challenges such as insufficient leadership commitment and lack of partner engagement were noted. These difficulties were similarly reported across regions and health posts.

Malaria-Related Guidelines: Malaria-related guidelines were assessed across administrative levels. The most frequently observed guideline was the Laboratory Diagnosis External Quality Assessment Scheme, reported by 66.7% of regions, 50% of zones, and 7.9% of districts. Access to malaria-related guidelines and manuals decreased as the level of administration became more localized, with health posts having the least access to these documents (Table 2).

Supply Chain Management: Malaria supply chains were evaluated across various levels of the health system. Stock determination was based primarily on the number of malaria cases in 49.2% of districts, while 9.5% relied on guesswork, and 22.2% used prior experience. Health facilities reported interruptions in malaria medications and supplies in the six months prior to data collection. Interruption rates were highest in RDTs and medications such as chloroquine and primaquine (Table 3). Additionally, 27.3% of zones, 39.2% of districts, and 33.5% of health centers reported challenges in distributing adequate supplies, while 36.4% of zones and 56.1% of hospitals had issues with the timely delivery of supplies close to expiration dates (Table 4). These findings underscore the need for improvements in malaria surveillance, service delivery, and supply chain management to enhance the effectiveness of Ethiopia's malaria elimination efforts.

Table 4: Lists the difficulties encountered when using the IPLS (Integrated Pharmaceutical Logistics System), June and August 2017

Levels	Late response	Distributing inadequate supplies	Damping unnecessary supplies	Mismatched delivery	Delivering near expiry date supplies	Inappropriate cold chain system during transportation	Other: (Specify)
Zone(n=11)	5 (45.5)	3 (27.3)	1 (9.1)	3 (27.3)	4 (36.4)	1 (9.1)	2 (18.2)
Districts (n=240)	99 (41.3)	94 (39.2)	42 (17.5)	55 (22.9)	87 (36.3)	5 (2)	5 (2)
Hospital (n=57)	28 (49.1)	23 (40.4)	11 (19.3)	20 (35.1)	32 (56.1)	3 (5.3)	10 (17.5)
Health Centre(n=430)	0 (0)	144 (33.5)	86 (20)	96 (22.3)	174 (40.5)	23 (5.4)	147 (34.2)
Health post (n=1775)	972 (54.8)	516 (29.1)	379 (21.4)	50 (2.8)	87 (4.9)	261 (14.7)	110 (6.2)

Discussion

Health Information System: The surveillance system plays a critical role in malaria elimination efforts, with the goal of identifying, investigating, and addressing foci of ongoing transmission, as well as preventing and treating illnesses and confirming elimination. In Ethiopia, NMCP relies on both the Public Health Emergency Management (PHEM) and Health Management Information System (HMIS) for malaria data collection and analysis. PHEM data is analyzed weekly, with feedback provided monthly, although it is reported that there is insufficient data coverage due to a lack of essential indicators in the reporting format. This presents an opportunity for the FMOH to improve the reporting system by incorporating necessary data elements, as highlighted in the study. The current PHEM format does not adequately support detailed reporting, which hampers accurate surveillance and response activities.

Malaria elimination efforts in several African nations, including Ethiopia, Gambia, Kenya, and Togo, have demonstrated the importance of robust health information systems (HIS) for effective malaria control. These systems are vital for ensuring that malaria control interventions are timely and targeted. The role of

surveillance in this context is clear, as countries that have successfully eliminated malaria have done so by maintaining strong HIS. This finding is consistent with global recommendations from the World Health Organization (WHO), which stresses the need for systematic surveillance to guide elimination strategies (World Health Organization, 2018; UCSF Global Health Group, 2014).

The integration of mobile technologies and Geographic Information Systems (GIS) for malaria data collection, as demonstrated in Papua New Guinea, has shown the potential for improving data quality, timeliness, and geographical accuracy, which is essential for successful malaria elimination efforts (Rosewell et al., 2017). Such innovations, when incorporated into national health systems like Ethiopia's eNHIS, can enhance flexibility and sustainability in managing malaria data.

Despite the strides made, the study found substantial gaps in the use and understanding of malaria monitoring indicators like the Annual Parasite Incidence (API) and the Test Positivity Rate (TPR). While malaria program officers reported using both indicators, many were not familiar with their formulas, which can hinder effective monitoring. Woyessa et al. (2013) emphasize that

training malaria program officers on proper surveillance and response strategies is crucial to improving the sensitivity and effectiveness of malaria surveillance systems.

Several challenges identified in the study were related to poor network coverage, lack of standardized reporting formats, delayed report submissions, and incomplete reports at district levels. These challenges were also evident at lower administrative levels, such as hospitals and health posts. Strengthening the surveillance system and addressing these gaps is essential for enhancing data quality and ensuring that timely, actionable information is available for malaria elimination efforts. The WHO (2012) advocates for a stronger health information system that includes electronic databases, disaggregated data, and standardized reporting practices, all of which are necessary for informed decision-making and targeted interventions.

Supply Chain Management: Efficient supply chain management is critical for the success of malaria elimination programs. The study highlighted various challenges in the procurement and distribution of malaria commodities, such as poor quality of Giemsa stains, unreliable microscopes, and issues with maintaining equipment. These supply chain challenges are not isolated but are part of a broader issue in ensuring timely availability and distribution of essential malaria commodities. Findings from the survey indicated that stock management practices varied widely between districts, with some based on malaria case numbers, others on assumptions or previous experience, and a few on epidemic preparedness plans. This lack of uniformity in stock estimation practices underscores the need for standardized guidelines and practices to ensure that malaria commodities are available in the right quantities and distributed effectively.

Malaria commodity shortages were reported at various administrative levels, including health posts and health centers, with nearly half of the surveyed health posts reporting interruptions in the supply of anti-malarial medications and other necessary commodities. Such interruptions are a significant threat to malaria elimination efforts, as they undermine the availability of effective case management tools. Reinforcing supply chain management systems, including the Integrated Pharmaceutical Logistics System (IPLS), is necessary to address challenges such as slow response times, mismatched deliveries, and the mismanagement of supplies.

Health Service Delivery: Timely diagnosis and treatment are cornerstones of malaria case management. The study found a shortage of antimalarial drugs, including Artemisinin-based Combination Therapies (ACTs), and gaps in the training of healthcare providers at various levels. These shortcomings indicate weaknesses in the malaria treatment infrastructure that

must be addressed to improve health service delivery. The WHO (2017) recommends that malaria programs be strengthened through effective case management and regular monitoring of malaria treatment and drug resistance. Additionally, ensuring the availability of sufficient antimalarial medications at all levels is essential for the successful elimination of malaria.

The study also identified barriers to successful malaria treatment, such as patients sharing medications, non-compliance with treatment regimens, and the reliance on traditional healers. These issues call for improved health education, increased training of healthcare providers, and community mobilization to ensure adherence to treatment protocols. The work by Potter et al. (2023) on the role of private providers in malaria case care underscores the need for comprehensive support systems, including training, regular supervision, and the provision of necessary commodities, to enhance malaria treatment outcomes.

Social and Behavioral Change Communication (SBCC): Effective Social and Behavioral Change Communication (SBCC) is essential for malaria control, yet the study found significant gaps in SBCC implementation at all administrative levels. The challenges identified included insufficient funding, lack of leadership focus, and inadequate partner participation. Strengthening SBCC efforts is critical for improving community engagement, increasing knowledge about malaria prevention, and encouraging the appropriate use of antimalarial medications. Effective communication strategies are necessary to mobilize communities, raise awareness about malaria control, and promote the active involvement of community members in malaria elimination efforts (Xia et al., 2014).

Conclusions

This study highlights critical gaps in the malaria elimination efforts in Ethiopia, particularly in the areas of health information systems, supply chain management, health service delivery, and social and behavioral change communication. To strengthen these areas, the Federal Ministry of Health should consider revising the PHEM reporting format, standardizing malaria commodity estimation practices, improving the training of healthcare providers, and addressing gaps in SBCC. Additionally, enhanced coordination among national, regional, and local health entities, along with sustained donor support, will be crucial for Ethiopia to successfully transition to the pre-elimination phase and achieve malaria elimination. The findings suggest that a comprehensive approach involving all stakeholders, including health ministries, healthcare providers, and communities, is essential for the successful elimination of malaria in Ethiopia.

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Availability of data and materials: The data that support the findings of this study are available from National Data Management Center (NDMC) of Ethiopian Public Health Institute. Data are however available from the authors upon reasonable request and with the permission of NDMC.

Ethics and consent: The EPHI's Scientific and Ethical Review Committee (SERO) gave the research proposal approvals. The participating health bureaus received an official letter from the EPHI requesting their cooperation. For participating health experts and healthcare facilities, study information was made available.

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Paper context: For the country to gradually shrink its malaria map, an evidence-based program and an assessment of the country's readiness for the elimination path are essential. In order for the national elimination initiative to be successful, the competency of the country's health system in terms of the availability of qualified human resources, proper money, and logistics needs to be ensured.

For the purpose of future measures, it is critical to identify these data gaps in the baseline stage of the malaria control program in the areas where elimination is envisaged. We can estimate our accomplishments and changes tomorrow by knowing which strategies were used to lower malaria prevalence from its baseline to present levels.

Notes on contributors: AdA and DsN: Conceptualization, designing, data collection, analysis, write-ups & coordination. BG, GT, SM, AbA, DD, GA and DM: Conceptualization, designing, data collection & analysis. DaB, analysis & write-ups. AW: Conceptualization, designing, analysis, and write-ups.

AdA and DB wrote the final manuscript. All authors read and approved the final manuscript.

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