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Evaluation of the Effectiveness of Malaria Surveillance System in Southern Libya and It's Impact on Public Health in the Context of Irregular Migration

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ABSTRACT:

Background: Malaria still poses an important public health threat in Libya, complicated by the ongoing influx of irregular migrants through its southern borders. Although Libya was certified free of malaria in 1973, recent cases have occurred, mostly associated with travel to adjacent countries where malaria is endemic.

Objects: The aim of this study is to assess the effectiveness of malaria surveillance in southern Libya. And its capacity to address threats posed by irregular migration.

Materials and Methods: A cross-sectional study was conducted to evaluate the malaria surveillance system in southern Libya, using standard questionnaires from CDC guidelines, distributed to monitoring and rapid response teams, supported by official reports. The analysis included 2022 laboratory data from Sabha Medical Center using rapid tests and peripheral blood smears were analyzed to characterize the epidemiological profile.

Results: a total of 79-suspected cases in 2022, including 48 confirmed infections. Of these, 37 (77%) were Libyan citizens and 11 (23%) were irregular migrants from Chad, Niger, Nigeria, Sudan and Ghana. Most cases were documented at Sabha Medical Center, with the 20-30 age group being the most affected (29%). It is worth noting that 79% of patients had recently traveled to Chad, Niger, or Nigeria, which are malaria-endemic areas. Plasmodium falciparum accounted for 75% of infections. The monitoring system's performance was 54%, and it was rated as "unacceptable" with a critical score of 0.18. Major shortcomings included delays in reporting, incomplete data, and instability, especially at border crossings. The emergence of malaria is due to cross-border migration from endemic countries and a weak effective public health surveillance system.

Conclusion: There is a fundamental and systemic dysfunction across most operational and organizational domains. The capacity to safeguard public health or to manage acute emergencies is extremely limited. Addressing this requires expanding the scope of surveillance coverage, strengthening data analysis, and enforcing inspection at the southern border entry points. It also necessitates targeted traveler education and improved diagnostic capabilities to prevent local transmission of malaria.

INTRODUCTION

Malaria is still a major global public health problem, especially in regions with large flows migration [1]. However, the disease remains a challenge internationally driven by emerging insecticide resistance, climate change and increased human mobility [1, 2]. Malaria is caused by *Plasmodium parasites* and transmitted from infected female *Anopheles mosquitoes* via a bite, leading to febrile illness and severe complications such as cerebral malaria/organ failure if left untreated[3] Thus, successful control measures require strong vector control and early diagnosis, as well as intensive surveillance to follow transmission trends and act when necessary[1, 2]. Libya malaria-free status recognized by the WHO (World Health Organization) in 1973 is now threatened by a possible re-introduction of the disease [4]. Its geographical location makes the country a strategic transit point for migrants moving from endemic sub-Saharan African countries, like Chad, Niger, Nigeria and Sudan, on their way to Europe. This continued migration raised concerns about both importation of cases and the potential for renewed local malaria transmission [3, 4]. Former studies suggest the vast majority of migrants reaching Libya test positive for malaria antibodies, which emphasizes migration as a determinant of the disease burden in nationals[4] among Libyan nationals with travel history to endemic area have highlighted the necessity for a feasible surveillance system that could detect and contain indigenes outbreaks[4, 5]. Effective malaria surveillance serves to enable early case detection and decision-making for public health; highlighting the role of robust surveillance. Assessing these systems also allows the identification of important gaps – such as data quality and timeliness [6-8] To facilitate effective measures a framework utilizing rapid diagnostic tests (RDTs), systematic reporting and rapid response such as insecticide-treated nets-ITNs, indoor residual spraying- IRS [2] is needed. Nevertheless, Libya has very weak infrastructure with respect to systematic epidemiological monitoring system at border points and detention centers [4, 7-9] in 2021, National Center for Disease Control (NCDC) reported 19 cases, some of with no obvious travel history implying the likelihood of unrecognized local transmission [9] several factors exacerbate this vulnerability. Besides [migration] as a major driver, climate change and extending vector ecology, poor waste management increase transmission risks[1, 9] These challenges are further complicated by political instability that undermines public health services, limits funding, and inhibits effective monitoring of control, awareness campaigns and treatment). Ultimately, optimizing surveillance disease[4]. Screening is not conducted at entry points, permitting undetected cases to build up in southern Libya before potentially spreading to other areas [4, 10]Ultimately, these dynamics strain Libya's resource-limited health care system and complicate alignment with the WHO is Global Technical Strategy for Malaria 2016–2030 [1, 9, 11].

CONCEPTUAL FRAMEWORK

The effectiveness of Libya's infectious disease surveillance system is evaluated through key performance attributes, including "simplicity, flexibility, data quality, acceptability, sensitivity, timeliness, completeness, stability, and Usefulness"[12] As illustrated in **Figure 1**, system effectiveness is influenced by a multi-dimensional set of determinants: human and social factors, environmental and climatic conditions, systemic health infrastructure, and political and administrative constraints. These determinants operate through intermediary mechanisms, specifically: 1- Data Management: systematic collection and reporting; 2- Diagnostics: laboratory confirmation via rapid diagnostic tests (RDTs) and peripheral blood smears, 3- Public health action: Epidemiological Investigation and health response activities (field response, vector aligning national health policies with the World performance is a prerequisite to reducing malaria morbidity and Health Organization's strategies (2016–2030).

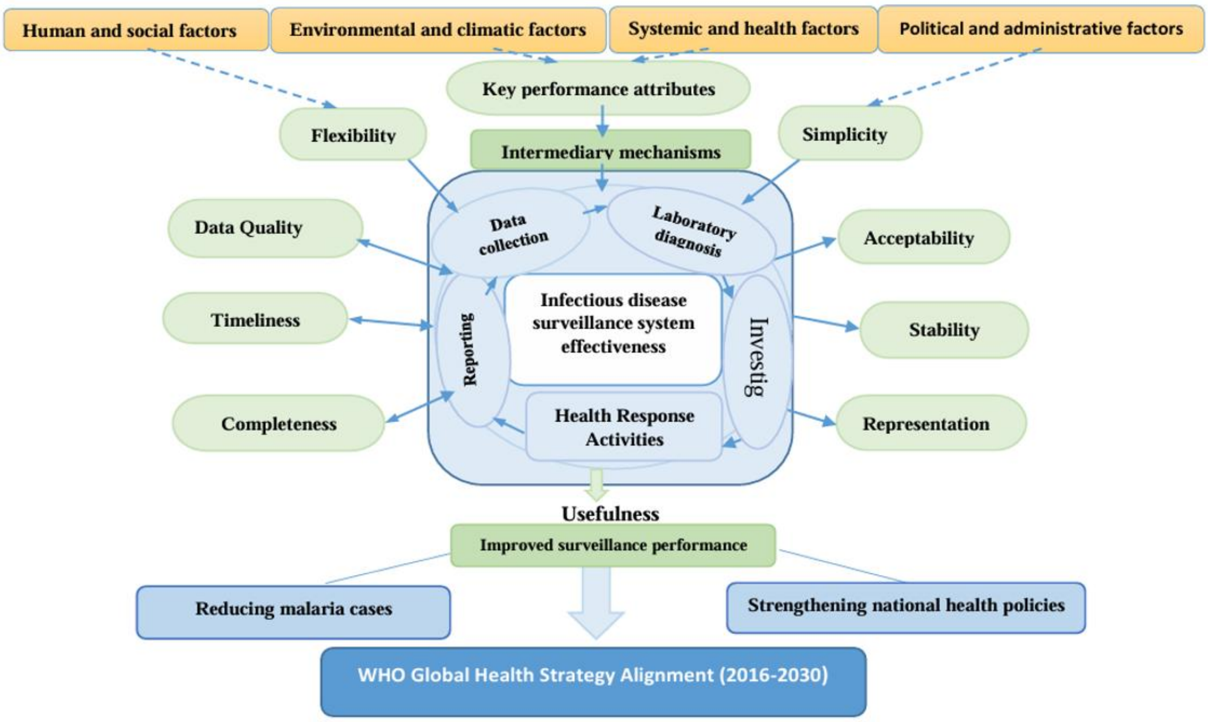

Figure 1. A framework for understanding and evaluating the effectiveness of the infectious disease surveillance system in Libya

Research Questions

To address the identified knowledge gap, this study seeks to answer the following:

1. What are the primary strengths and vulnerabilities of the current malaria surveillance system in southern Libya regarding its capacity for early detection and rapid response?
2. Which strategic interventions are necessary to enhance malaria surveillance and control, based on a systematic performance assessment?
3. To what extent does irregular migration contribute to the risk of malaria re-emergence and sustained transmission within the Libyan healthcare system?

Research Objectives

By analyzing 2022 surveillance data, this study aims to evaluate systematic gaps and identify priority areas through the following objectives:

1. To characterize the epidemiological and clinical profiles of malaria cases reported within the national surveillance framework in 2022.
2. To evaluate the performance of the malaria surveillance system, by assessing its core structural features and quantitative /qualitative attributes (e.g., timeliness, completeness, and stability).
3. To identify the critical infrastructure gaps and systematic strengths within the current surveillance system to inform evidence based public health recommendations.
4. To examine the relationship between migration patterns and Malaria importation risks in southern Libya to support targeted border health strategies.

MATERIALS AND METHODS

Study Design

A descriptive, cross-sectional study was conducted using a mixed-methods approach. This included a retrospective analysis of

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malaria surveillance data between January 1 and December 31, 2022, followed by a structured survey of health care workers within Rapid Response Teams (RRTs) in the Southern Region. In this study, we focus on the Southern Region, even though the surveillance system is national; indeed, confirmed cases were totally concentrated in this region during the duration of the study.

Study Setting

The study area was the Southern Region of Libya, which represents a wide range of territory between approximately longitudes 9°00'E and 15°00'E, and latitude 19°30'N to 30°00'N. This area is a key transnational corridor that shares borders with Algeria, Niger and Chad. Climatically, the zone is mainly arid desert (Köppen-Geiger: BWh), while Shuwairif municipality being a semi-arid zone [13] Public health here faces particular challenges: extreme heat, irregular rainfall and the logistical difficulties of monitoring a highly mobile population across vast desert expanses Sabha serves as the central administrative hub, supported by a network of municipalities including Ghat, Ubari, Murzuq, Qatrun and Shuwairif.

The Malaria surveillance system

The malaria Surveillance mechanism is an integral component of Libya National Center for Disease Control framework. It operates as a continuous, passive surveillance system throughout the year. Data collection is decentralized across primary health care units (PHCs), public clinics, and central hospitals (such as Sabha Medical center).

- **Data flow:** Local health monitors weekly and monthly standardized reports to municipal focal points. This data is aggregated by the Regional Surveillance Supervisor and transmitted to the NCDC central administration for analysis and strategic decision-making.
- **Response Mechanism:** Approximately 15 Rapid Response Teams (RRTs) operate within the region, and coordinated with both the NCDC, the Ministry of Health and the WHO. The system structure is summarized in Figure 2.

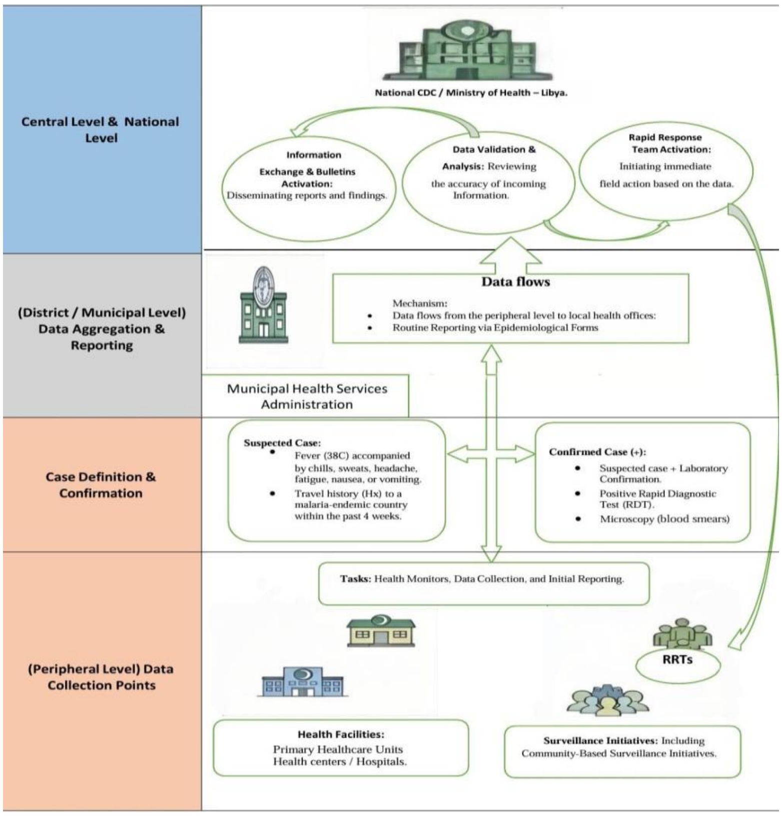

Figure 2. Structure of the Malaria Surveillance System - Libya: Data Flow & Operational Mechanism

Case Definitions and critical criteria

To minimize differences in reported data the following definitions were applied:

Suspected Case: Any person with fever (≥38°C) and one or more of the following symptoms: chills, sweats, headache, fatigue, nausea, or vomiting. The history of travel to a malaria-endemic country within the last 4 weeks was noteworthy: in the case of suspected cases, it remained sufficient even in isolation from other symptoms reported.

Confirmed Case: A suspected case with laboratory-confirmed malarial parasites in the blood.

Diagnostic procedures

Laboratory Diagnosis was centrally established at the Sabha Medical Center based on a two-tier approach:

- **Rapid Diagnostic Tests (RDTs):** Immunochromatographic assays as a method for immediate antigen detection and screening[3].
- **Microscopic Examination:** Thick and thin blood smears were prepared, Giemsa stain & examined at a light microscope (100 fields at 100X magnification). These were regarded as the gold standard for definitive diagnosis, parasite density estimation and species identification [3].

Data Sources and Collection

Retrieved data from the national malaria surveillance database based on RRT reports in the southern Libya.

The following variables were extracted from the anonymized case report forms:

Demographics: (age, sex, nationality and residence)

Epidemiology: travel history (country and date returned) and date of symptom onset.

Clinical and diagnostic: Symptoms at presentation; Results of RDT, Description of microscopy results, *Plasmodium* species identification.

Outcomes: Treatment results and notification timeliness. To capture qualitative operational insights, structured questionnaires were distributed to RRT fiels prationners. These on the perceived simplicity, acceptability and flexibility of the surveillance tools.

Evaluation framework and scoring

The assessment framework was derived from the U.S. Centers for Disease Control and Prevention (CDC) Guidelines for Evaluating Public Health Surveillance Systems and aligned with minimum data requirements set forth by WHO [12, 14, 15] Nine core attributes were assessed: "simplicity flexibility, data quality, acceptability, representativeness, timeliness, stability completeness and usefulness"[12] Performance on HISPIX benchmark was assessed using a semi-quantitative scoring system. For the qualitative indicators based on binary (Yes/No) questions, positive responses were calculated as a proportion of all responses to give an indicator score. The ratio was hence converted into HISPIX (0-1) based on the established thresholds and The World Health Organization recommends the use of the Health Information System Performance Index (HIS-PIX) to evaluate the health information system because of its accuracy in assessing the ability of health systems to deal with infectious diseases with epidemiological characteristics. This tool assesses a country's ability to collect relevant data at specific and appropriate time intervals to identify and address gaps in terms of their periodicity, timing, contents of data collection tools and availability of data on key indicators, as well as the country's capabilities to collect, analyze and validate data. [16, 17]. Table 1 Quantitative indicators (in percentage) were transcribed into four point ordinal scale (0 to 1), in order to standardize results:

Table 1. The HISPIX scale (0 to 1) for Quantitative indicators (expressed as percentages).

Percentage	Score	Performance Category
≥90%	1.00	Excellent/High Quality
80%-90%	0.66	Good/Acceptable
70%-79%	0.33	Poor/Needs Improvement
<70%	0.00	Unacceptable/Data Gap

Attribute-level scores were determined by calculating the arithmetic meaning of their associated indicators.

The Overall System Classification was derived from the mean of the attribute scores [16].

Data Analysis

Data were systematically aggregated and structured employing Microsoft Excel, then exported for analysis to the Statistical Package for the Social Sciences (SPSS, version 23). Descriptive statistics, including frequencies, percentages, means, and standard deviations, were employed to characterize confirmed malaria cases and provide a comprehensive epidemiological overview. Cases were stratified by demographic and clinical variables, including age, sex, and nationality, geographic location within the Southern Region, *Plasmodium* species, and seasonality. A critical distinction was made between imported cases (Those with documented travel to malaria-endemic countries) and those with no reported travel history. Furthermore, survey responses from Rapid Response Team (RRT) personnel were integrated qualitative indicators. These data were used to calculate the performance scores for the surveillance system key attributes, providing insights into the operational limitations and practical utility of the existing surveillance tools.

RESULTS

Epidemiological and demographic Profile of confirmed malaria cases

In 2022, 79 suspected malaria cases were recorded in Libya of which 48 (60.8%) were laboratory-confirmed. Parasitological analysis identified *Plasmodium falciparum* as the predominant species, accounting for 36 cases (75%), while the remaining 12 cases (25%) were attributed to mixed parasitic infections. The demographic distribution revealed a higher prevalence among males (65%; n=31), likely reflecting occupational exposure and migration patterns. While Libyan nationals constituted the majority of cases (77.1%; n=37), irregular migrants from Sub Saharan Africa- including Chad, Niger, Nigeria, Sudan, and Ghana accounted for (22.9%; n=11), of the confirmed infections.

The demographic most affected was 20-30 age group (29.2%; n=14), followed by 30-40 and 10-20 groups (14.6%; each), indicating a high prevalence among young, mobile population. Geographically, nearly 80% cases (n=38) were concentrated in Sabha, reinforcing its status as a migration and transit corridor. Travel history analysis showed that a vast majority of patients had recently visited Malaria-endemic regions, specifically Chad (47.9%) and Niger (29.2%). Notably, four cases appeared to have no documented travel history or an unknown destination, suggesting a critical need to monitor potential local transmission. **Table 2.**

Table 2. Epidemiological and demographic Characteristics of confirmed Malaria cases (n=48).

Variable	Category	N	%
laboratory result	positive cases	48	60.8
	negative cases	31	39.2
Parasitology	P. falciparum	36	75.0
	Mixed	12	25.0
Gender	Male	31	65.0
	Female	17	35.0
Age Group (years)	<5	4	8.3
	5 to <10	5	10.4
	10 to <20	7	14.6
	20 to <30	14	29.2
	30 to <40	7	14.6
	40 to <50	5	10.4
	≥50	6	12.5
Nationality			
	Libyan	37	77.1
	Non-Libyan (Migrant)*	11	22.9
Primary Location			

	Sabha	38	79.2
	Other Southern Districts	10	20.8
Top Travel History			
	Chad	23	47.9
	Niger	14	29.2
	Others (Nigeria, Sudan, Algeria, Ghana.)	7	14.5
	Not travel reported	4	8.3

**Includes nationals from Chad, Niger, Nigeria, Sudan, and Ghana.*

Temporal Distribution and Seasonality

The temporal analysis of confirmed cases in 2022 indicates a distinct a distinct seasonal pattern Figer.3. While sporadic cases were identified at the beginning of the year (January and February), a prolonged period of zero transmission was observed from March through June.

A sharp upward trend commenced in July, peaking during the fourth quarter of the year the highest incidence was recorded in October (n=14) followed by November (n=13) and September (n=11).

This late-year surge accounts for the majority of the annual disease burden likely correlating with post-rain season ecological shifts or increased regional migration during these months.

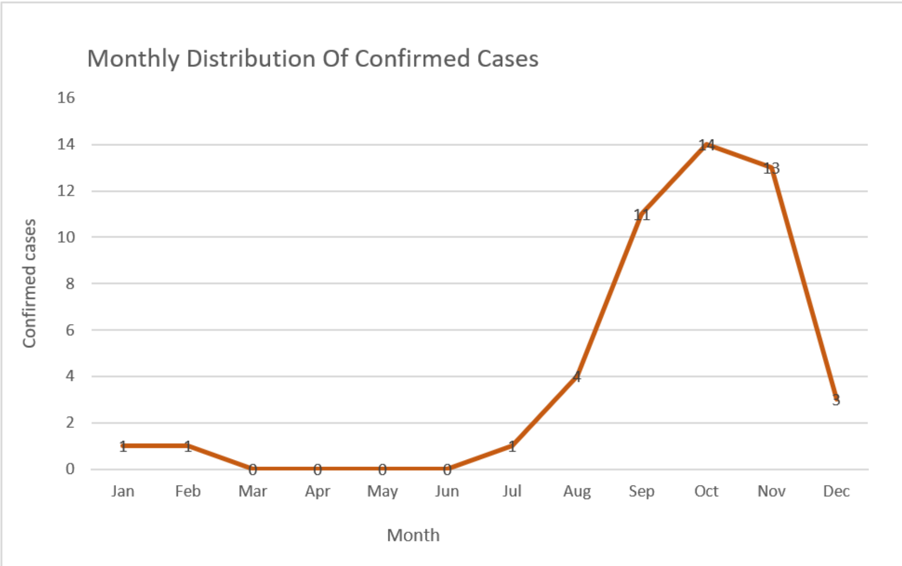

Figure 3. Monthly Distribution and Seasonality of Laboratory-Confirmed Malaria Cases in Southern Libya, 2022 (n=48). Cases**.**

Socio-demographic characteristics of healthcare workers

The cohort consisted of 75 healthcare workers involved in infectious disease surveillance in the Southern Region. Most staff were public health specialists (32.0%), medical laboratory technicians (29.3%), physicians (24.0%) or data entry personnel (14.7%). 42.7% operating in primary care units and 25.3% in health centers. Participants mean age was 42.9 ±6.4years, and average disease surveillance experience was 4.17 ±2.22 years.

Performance Metrics of Surveillance System Attributes

The system's effectiveness was quantified using nine core attributes based on the HIPIX standardized scale (0-1) Figure 4 Presents a radar chart analysis of the nine evaluated attributes, highlighting the systemic gaps and the overall performance score. The average malaria surveillance system Performance score in Southern Libya was 0.18, falling within "Unacceptable Performance/Data Gap" category. This low composite score reflects significant systematic failures across multiple dimensions of the framework.

Utility (0.66-Acceptable)

This was the highest scoring attribute.

Participants agreed that the surveillance system remains capable of detecting outbreaks and monitoring disease burden, despite operational challenges

Flexibility (0.44-Needs Improvement)

While the system's structure allows for addition of new variables or diseases (0.66), participants noted that implementing actual changes to case detection procedures or reporting formats was nearly impossible (0.0).

Simplicity (0.28-Unacceptable)

Although the clinical case definitions are considered clear and easy to understand (0.66), but the system does not allow data entry for all levels of health professionals. Also furthermore, the time required for data collection and laboratory confirmation was rated at a zero score level, indicating a highly inefficient workflow.

Data Quality (0.23- Unacceptable)

While the physical forms were rated as clear to read (0.66), the actual quality of the data is compromised by a high percentage of unknown responses in the final reports (0.0).

Critical systematic Failure (score 0.0)

Several key attributes – Representativeness, Timeliness, Completeness, and Stability- received a score of zero. These scores highlight a total absence of on time reporting, a lack of regular weekly submissions, and an operational fragility caused by constant restructuring and a lack of essential resources. Specifically, the system showed a clear urban bias, failing to represent the rural and border areas most affected by migration.

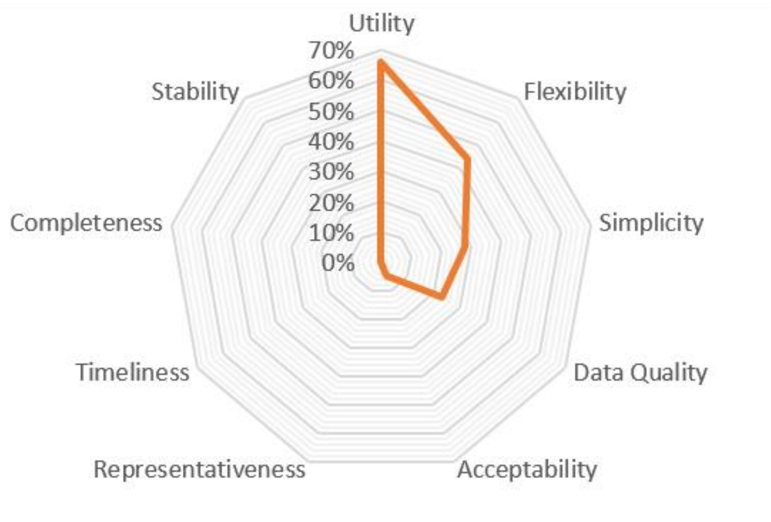

Figure 4. Radar Chart Illustration of the Nine Performance Attributes of the Malaria Surveillance in Southern Libya (HISPIX Scale 0–1).

Table 3. Mean scores for resident characteristics and indicator measures for the malaria surveillance system in southern Libya*

Attributes (Key Indicator Finding)	**Indicators**	**Scores**	**Mean score**
Utility (Outbreak detection and prevention assessment)	1. Early detection of the outbreak to allow accurate diagnosis?	**0.66**	**0.66**
	2. To assess the magnitude of morbidity and mortality?	**0.66**	
	3. To support the assessment of the impact of the effect of prevention and control programs?	**0.66**	

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	4. To support research intended to lead to prevention and control?	**0.66**	
Flexibility (Ability to add new diseases/variables)	1. Can the existing reporting forms be utilized for other emerging health events (diseases) with minimal difficulty?	0.33	**0.44**
	2. Do you believe that any modifications to the current procedures for case detection and reporting formats will be challenging to implement?	0.0	
	3. Is the system facile for incorporating additional variables?	0.66	
	4. Is the surveillance system readily integrable with other systems?	0.66	
	5. Is the surveillance system facile for incorporating new diseases into reports?	0.66	
	6. Is the system facile in incorporating new information technology?	0.33	
Simplicity (Clarity of definitions vs. time-intensive reporting)	1. Is the case definition accessible for case identification by health professionals at all levels?	0.66	0.28
	2. Does the surveillance system permit all tiers of health professionals to input data?	0.0	
	3. Does the surveillance system facilitate timely data recording and reporting?	0.33	
	4. Does the surveillance system have necessary data needed for an investigation?	0.66	
	5. Does the surveillance system permit data updates on the cases?	0.33	
	6. What is the duration required to complete the form?	0.0	
	7. What is the duration required for laboratory confirmation?	0.0	
Data Quality (Completeness of records and legibility)	1. Are all submitted forms Complete?	0.66	0.23
	2. If the answer to Q1 is No, how many unfilled spaces are your?	0.0	
	3. Percentage of unrecognized or blank responses pertaining to variables in relation to the aggregate reports?	0.0	
	4. Percent of reports that are completed (i.e., devoid of any blank or unrecognized responses) in relation to the overall number of reports?	0.0	
	5. Is the captured data legible and comprehensible?	0.66	
	6. If the response to Q5 is No, how many records are ambiguous or challenging to comprehend?	0.0	
	7. Percentage of records that are ambiguous or challenging to comprehend?	0.33	
Acceptability (Engagement and awareness among staff)	1. Do you believe that all reporting agents are accept and actively participating in the surveillance activities?	0.0	0.05
	2. If affirmative, what is the number of active participants among the anticipated?	0.33	
	3. Should the answer to the above inquiry be 'No', what were the primary considerations that limited their involvement surveillance activities?	0.0	
	4. Did all participants utilize the standard case definition for cases identification?	0.0	
	5. All reporting agents must submit their reports using the current and suitable surveillance reporting format?	0.0	
	6. Were all the health professionals informed about the surveillance system?	0.0	
	7. Did all health professionals tasked with surveillance submit their reports punctually?	0.0	
Representativeness	1. Was the surveillance system capable of monitoring health and health	0.0	0

(Coverage of rural vs. urban populations)	related events throughout the entire community?		
	2. If the response to Q1 is negative, who do you believe derives the most advantage from the surveillance system?	0.0	
	3. Are all the Socio - demographic characteristics incorporated in the surveillance reporting format?	0.0	
Timeliness (Frequency of on-time reporting)	1. Are all reporting sites submitting their reports punctually?	0.0	0
	2. Percentage of reporting stations that submit reports punctually?	0.0	
Completeness (Regularity of weekly submissions)	1. Are all reporting platforms operational?	0.0	0
	2. Percentage of Health centers and PH entities that submit weekly reports?	0.0	
Stability (Impact of restructuring and resource lack)	1. Did any resent restructuring impact the methods and operations of surveillance?	0.0	0
	2. Was there a deficiency of resources that disrupted the surveillance system?	0.0	
	3. Were there any instances or conditions in which the surveillance was not operational?	0.0	
Overall total		**0.18**	

- The HISPIX system served as a benchmark for quantifying performance indicators in the Southern Libyan malaria surveillance system. Percentage scores were translated into ordinal score as follows: :< 70% [Score 0.00]: Unacceptable performance / Data gap, 70%-79% [Score 0.33]: Poor performance / Needs improvement, 80%-89% [Score 0.66]: Good performance / Acceptable quality 90% [Score 1.00]: Excellent performance / High quality.
- Indicators were defined according to the structured answers and technical appraisals of health professionals from municipal surveillance and rapid response teams including physicians, public health specialists, medical laboratory technicians and data entry personnel.

DISCUSSION

Epidemiological and Demographic Implications

The surveillance results in Southern Libya demonstrate a high degree of effectiveness in identifying imported malaria cases, predominantly linked to travel from endemic regions such as Chad and Niger. This is consistent with previous national reports classifying Libya as a non-endemic zone where transmission is primarily driven by cross-border mobility[3, 18] Our findings reinforce the premise that monitoring travel networks is essential for understanding the epidemiological trends of imported diseases[19].

The geographic clustering of cases in Sabha (79.2%) followed by Al-Qatrun and Murzuq Underscores these locations 'roles as strategic transit hub along migration corridors. These urban centers, characterized by high population density and proximity to porous borders, represent high-risk zones for disease introduction [20]. Furthermore, the predominance of *Plasmodium falciparum* (75%) mirrors the epidemiological profile of the sub-Saharan Africa, posing a significant public health threat due to the potential for severe clinical outcomes.[21, 22]. The observed temporal peak (September - November) suggests a seasonal interaction between climatic factors and population movement. While studies in Nigeria report peaks from April to September, [6] the shift observed here may reflect the time lag associated with migratory transit or local ecological conditions post rainfall. Demographically the higher incidence among young males Aligns with findings from Nigeria, Ghana, and Mali, where occupational exposure and travel behaviors significantly increase the risk for working-age men [6, 23].

System Performance and Operational Gaps

Despite the system's ability to detect cases, the overall performance score of 0.18 (unacceptable) reveals a critical "implementation gap". The zero-scores in Representativeness, Timeliness, Completeness, and stability, highlight a system in a state of operational fragility" This findings parallel challenges documented in Uganda and Tanzania where delayed reporting and incomplete data remain significant barriers to effective malaria control.[24, 25].

Interestingly, while simplicity (0.28) and data quality (0.23) were rated unacceptable, they outperformed the structural attributes, suggesting that the system's design is clearer than its execution. This further evidenced by a flexibility score of 0.44, indicating that the framework has the theoretical potential for integration and expansion- a trait shared by surveillance system in Ethiopia and Tanzania.[26, 27].

The most striking finding is the utility score (0.66). The fact that health care workers perceive the system as "good" for decision-making despite its "unacceptable" operational scores suggests that the system functions thought the sheer persistence of field teams rather than thought robust infrastructure. This discrepancy underscores a need for strategic interventions that move beyond theoretical design to focus on human resources and resource continuity.

We recommend strengthening public-private partnerships to include private clinics and informal settlements, thereby improving representativeness[6] Enhancing laboratory response times and providing continuous fiels training are essential to move from "passive " to " active" surveillance[28, 29].

Strneghts of the study

This research provides several key contributions to the field of malaria surveillance in North Africa. First, to our knowledge, this is the first study to apply the HISPIX standardized framework to evaluate malaria surveillance in Southern Libya. By quantifying qualitative attributes into a reproducible 0-1 scale, it establishes a critical baseline for future longitudinal assessments. Second, the identified resilient design utility (0.66) and flexibility (0.44) of the system indicate that the core architecture is sound and recognized by the workforce. This suggests the system is capable of rapid improvement with targeted investment in stability and timeliness. Finally, this research directly supports the WHO Global Technical Strategy for Malaria by giving top priority to making surveillance a fundamental public health strategy in high-risk, non-endemic areas.

Limitations

Despite these strengths, certain limitations must be acknowledge. The study relies on passive surveillance data from public facilities, which may underestimates the true disease burden among irregular migrants who may avoid formal health care due to legal concerns of fear of deportation, additionally the reliance on rapid diagnostic tests (RDTs) and microscopy rather than molecular tools (PCR), limits the detection of sub-microscopic infections.

In addition, health care personnel may be influenced by recall and social desirability biases in the evaluation of system attributes. Lastly, the lack of entomological data to delineate Anopheles vector activity and the absence of integrated reporting from the private sector limit our capacity to completely elucidate what local receptive capacity for malaria re-emergence exists in the Region.

CONCLUSION

The malaria Surveillance and Response System in the Southern Region of Libya has demonstrated its capability in identifying imported cases, reinforcing the classification of Libya as a non endemic country where transmission is primarily driven by migration from endemic countries such as Chad and Niger. The geographical concentration of cases in Sabha, followed by Qatrun and Murzuq, reveals a critical dependency on migration networks, establishing these locations as high-risk transit hubs. Furthermore, demographic trends indicate a higher incidence among working-age males, driven by occupational exposure and travel behaviors. Regarding system performance, the monitoring framework achieved an average indicator rating of 54%, resulting in a composite performance score of 0.18 "unacceptable performance/data gap". While the system possessed core strengths in simplicity, flexibility, and perceived utility significant operational weaknesses. Were identified in timeliness, completeness, stability and representativeness. To ensure the sustainability of malaria control efforts, the surveillance coverage must be expanded to include private health facilities, and informal settlements housing migrants, and internally displaced persons, in alignment with WHO border surveillance guidelines. This study underscores the urgent need strategic investments in reporting efficiency, laboratory response times, and field training to transform the current framework into a robust, proactive mechanism capable of early epidemic detection and effective response.

ETHICAL DECLARATIONS

Acknowledgements

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Ethics approval statement

This study was undertaken as a formal evaluation of the Malaria Surveillance System in southern Libya. The study received approval from the Scientific Committee of Sabha Medical Centre, as protocol [No.126|2025]. All health care personnel and participants provided informed consent before data collection. The study conformed to the ethical standards of the latest revision of the Declaration of Helsinki.

Consent for publication

Not Applical.

Data availability statement

Data generated and analyzed as part of the current study are not publicly available due to institutional data privacy regulations but are available from the corresponding author on reasonable request.

Disclosure statement

The authors declare no competing interests.

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Authors' Contributions

Conceptualization: MIA. Data curation: MIA, MG, MY, NAI, RJF and AAA. Formal analysis: MIA, MG, WFN, MY. Methodology: MIA, MG, AMML, AAA. Writing - review & editing: MIA, NAI, MG, AMML, AAA, WFN, MY.

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