Sierra Leone Journal of Biomedical Research

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

Assessment of Malaria Treatment Interventions: A Critical Analysis of Government Initiatives and causes of treatment failure at Port Loko Government Hospital, Sierra Leone

Lawrence Sao Babawo[1*], Rashid Bundu Kpaka[1], Daniel Karim Dauda Sesay[2]

[1]Faculty of Health Sciences and Disaster Management, Eastern Technical University of Sierra Leone

[2]District Health Management Team (DHMT), Karene District, Sierra Leone

***Corresponding Author: Lawrence Sao Babawo (**yeamamiesatta@gmail.com)

ABSTRACT:

Background: Malaria disease continues to be a leading cause of morbidity and mortality, particularly among children under five years of age and pregnant women in Sierra Leone. Malaria treatment interventions are the many, various, and conventional methods used to manage and control the disease with little to no harm to human health.While great progress has been made, the challenge persists, necessitating ongoing efforts and solid partnerships among key players to address successes and challenges in malaria control comprehensively. This research is crucial to identify gaps in current strategies, inform policy decisions, and improve the overall effectiveness of malaria prevention and treatment efforts.

Aims: The study aims to critically evaluate the existing government interventions for malaria diagnosis, treatment and prevention, shedding light on the causes of treatment failure and the accessibility and efficiency of available resources.

Methods: The study utilizes a cross-sectional study design using purposive stratified random sampling of 300 (that is, 150 women of childbearing age and 150 Health Workers) respondents. A structured survey questionnaire was used to obtain data from the respondents. Secondary data were also sourced from documents like the District Health Information System (DHIS). Data were analyzed using Statistical Package for Social Sciences (SPSS), version 28 for which the analysis was stratified by respondent groups, i.e., Health Workers vs. women of childbearing age. Descriptive statistics were computed to summarize participant characteristics and findings were presented using frequency tables and bar plots to enhance data interpretation.

Results: From the analysis**,** 41.0% of respondents (62 Out of 150 women of childbearing age) said poverty and other socio-economic conditions are responsible for the increase prevalence and spread of malaria and also 40.0% (600) of the same respondents affirm the nearest drug store to be the first point of contact when they feel unwell

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

as a result of poor socio-economic conditions. About 73.3% (110 out 150 health workers) of respondents mentioned malaria as the prevailing disease condition among women of childbearing age and other susceptible groups. 85.0% (128) of health workers' respondents reveal that there is a stock out of malaria commodities every month and 78.0% (117) of respondents said most malaria diagnoses and treatments are mostly ineffective and inadequate. The study further shows that Bekeh Loko Chiefdom, Port Loko District is at high risk of ACT drug resistance with 93.0% (140) of the health workers respondents referred to non-adherence to prescribed and appropriate treatment as the leading cause of the ineffectiveness of malaria treatment interventions.

Conclusion: Inadequate, inappropriate, and ineffective malaria prevention, control, treatment services and facilities, such as; RDTs, Microscopic/Laboratory Tests, Malaria Case Management (Antesunate Lumefantrine, Rectal Artesunate, Injectable Artesunate), IPTp and IPTi ;the lack of positive malaria social behaviours coupled with poor socio-economic factors in most malaria-endemic regions like Bekeh Loko Chiefdom, Port Loko District of Sierra Leone might be a contributing factor to the increase prevalence of the disease in the study area. Active community engagement and education, strengthening healthcare infrastructure, quality improvement in diagnosis and treatment, targeted interventions for pregnant women and women's livelihood empowerment, are urgently needed to control the high malaria prevalence in the study area and other endemic areas within the nation.

Keywords: Malaria, Treatment, Interventions, Port, Loko, Bekeh-Loko.

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

1. INTRODUCTION

Malaria, caused by Plasmodium parasites transmitted through female Anopheles mosquitoes, remains a substantial public health concern. Efforts to control and eradicate malaria involve case management interventions such as Rapid Diagnostic Tests (RDTs), Microscopic/Laboratory Tests, and Malaria Case Management and positive social behaviors like environmental sanitation, the use of treated nets, and minimizing mosquito exposure. However, despite various government interventions, treatment failure persists, posing challenges to effective malaria management and the disease persists as a significant public health challenge especially to vulnerable populations like infants, children, and pregnant women with compromised immunity [0], particularly in malaria-endemic regions like Sub-Saharan Africa (SSA) and in impoverished regions, such as Port Loko District of Sierra Leone [0]. While progress has been made in controlling prevalence, screening inefficiencies and inadequate treatment interventions contribute to stagnation in control gains [0]. Achievements toward elimination are commendable but require more focused and well-planned prevention, control, diagnostic, and treatment strategies to effectively reduce the incidence and prevalence of the disease. Understanding the factors contributing to treatment failure, assessing the accessibility and efficacy of available resources, and evaluating the socio-economic determinants are essential for informed decision-making in malaria control programmes.

Globally, malaria stands as a significant parasitic infection, causing 350-500 million clinical episodes annually, with mortality estimates ranging from 1 to 3 million deaths per year, predominantly affecting children in malaria-endemic countries [0, 0]. The World Malaria Report of 2020 disclosed 229 million cases in 2019, with 409,000 deaths, emphasizing the disproportionate impact on impoverished communities. In 2001, the World Health Organization (WHO) ranked malaria as the eighth-highest contributor to the global disease burden, particularly affecting Africa and poorest sections, such as urban slums and rural areas lacking protection through improved housing and a clean environment [0]. Children under five face the highest malaria burden due to super infections and nutritional deficiencies resulting from delayed healthcare-seeking, lack of accessible services, inadequate skills of healthcare providers, and ethical issues. In stable transmission areas, new-born acquire immunity through maternal antibodies via breastfeeding, with susceptibility increasing from three months to 3-5 years. In regions with seasonal

 https://dx.doi.org/10.4314/sljbr.v16i4.3

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

transmission, acquired immunity can last up to ten years, disappearing within subsequent years [0].

Efforts at global level, as outlined by WHO, target malaria elimination by 2030, focusing on prevention, diagnosis, and treatment accessibility. The goal is to reduce cases and deaths by 90%, making at least 35 countries malaria-free by 2015. While malaria intervention programmes primarily aimed at control, a shift towards elimination gained momentum in 2007, endorsed by global agencies and WHO. In essence, malaria's global impact is staggering, with a disproportionate burden on vulnerable populations. The push for elimination reflects a collective effort to enhance accessibility to preventive measures, diagnostics, and treatments. The emphasis on vulnerable groups, particularly young children, highlights the intricate link between healthcare access, nutritional status, and malaria prevalence, calling for comprehensive interventions to alleviate the public health and socio-economic burdens associated with this pervasive disease [0]

In Sub-Saharan Africa (SSA), recent data reveals an alarming 1.5 – 2.7 million annual malaria-related deaths, with the majority concentrated in this region. Contributing factors to the overwhelming malaria burden in SSA include ideal climatic conditions for transmission, highly efficient Anopheles mosquito vectors, prevalence of the virulent Plasmodium falciparum species, and the coexistence of poverty and inadequate healthcare infrastructure. SSA bears a significant portion of childhood mortality, with approximately 25% of deaths below the age of five attributed to malaria [0]. Survivors of cerebral malaria often face long-term neurological deficits, affecting various aspects such as weakness, spasticity, blindness, speech problems, and epilepsy. These children lack proper management and access to specialized educational facilities, potentially hindering future learning and development. Children under five are particularly vulnerable, although those with semi-immunity may be infected without severe manifestations [0, 0].

The Sierra Leone Malaria Indicator Survey (SLMIS-2021) indicates that malaria constitutes a significant public health challenge, accounting for 40.3% of outpatient morbidity for all ages. Furthermore, it represents 47% of outpatient morbidity for children under five and contributes to 37.6% of hospitalizations, with a case fatality rate of 17.6% [5]. Despite substantial efforts by the Government of Sierra Leone and its partners, including the National Malaria Control Program (NMCP) Strategic Plan 2016–2020 and the revision of prevention, control, and treatment guidelines, malaria remains endemic, with stable and perennial transmissions across the entire country [0]. Sierra Leone's Malaria Strategic

 https://dx.doi.org/10.4314/sljbr.v16i4.3

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

Plan emphasizes universal access to control and treatment interventions, acknowledging the dominance of Plasmodium falciparum, which accounts for over 95% of infections. The prevalence of chloroquine resistance (up to 79% of cases) prompted the official adoption of Artemisinin-based Combination Therapy (ACT) by the Government of Sierra Leone in alignment with WHO guidelines [7]. Malaria incidence is significantly higher in rural areas compared to urban regions, with the Northern Region, particularly Port Loko District, exhibiting the highest malaria prevalence rate in Sierra Leone. This is attributed to detrimental social behaviors, including delayed treatment-seeking, non-adherence to prescribed treatments, poor environmental sanitation, and ineffective utilization of Long Lasting Insecticide Nets (LLINs) [0, 0]. Addressing these behavioral and environmental factors is crucial for effective malaria control in the region.

The Ministry of Health and Sanitation (MoHS) and its collaborators have invested resources in preventing, controlling, treating, diagnosing, and eradicating malaria. However, the disease continues to be a leading cause of morbidity and mortality, particularly among children under five years of age and pregnant women. While progress has been made, the challenge persists, necessitating ongoing efforts and solid partnerships among key players to address successes and challenges in malaria control comprehensively.

The study aims to critically evaluate the existing government interventions for malaria treatment at Port Loko Government Hospital, shedding light on the causes of treatment failure and the accessibility and efficiency of available resources. This research is crucial to identify gaps in current strategies, inform policy decisions, and improve the overall effectiveness of malaria prevention and treatment efforts. By addressing socio-economic determinants and assessing healthcare infrastructure, the study contributes valuable insights to the broader discourse on malaria control in the specific context of Port Loko District, Sierra Leone.

1.1 Conceptual Framework

The theoretical framework that guided this research were key concepts from various theories and models to provide a comprehensive understanding of the factors influencing malaria incidence, the effectiveness of interventions, and the persistent challenges faced in the region. The framework draws on elements from the Health Belief Model and Systems Thinking.

Health Belief Model (HBM):

- **Perceived Susceptibility and Severity:** Individuals' beliefs about their susceptibility to malaria and the severity of its

 https://dx.doi.org/10.4314/sljbr.v16i4.3

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

consequences influence their health-related behaviors [0]. Understanding the perceived threat of malaria, especially among vulnerable groups like children under five and pregnant women, is crucial.

- **Perceived Benefits and Barriers:** The perceived effectiveness of interventions, such as Artemisinin-based Combination Therapy (ACT) and LLINs, along with the barriers to access and utilization, shapes individuals' decisions to adopt preventive measures and seek timely treatment [0].

Systems Thinking:

- **Feedback Loops:** Recognizes the interconnectedness of various elements in the malaria control system. Feedback loops, both reinforcing and balancing, are considered to understand how changes in one aspect may impact the entire system [0].
- **System Dynamics:** Acknowledges the dynamic nature of malaria transmission and control [0]. This involves understanding the complex interactions between human behavior, environmental factors, and the effectiveness of interventions over time.
- **Emergent Properties:** Considers the emergence of patterns and behaviors at the system level that may not be immediately evident when focusing solely on individual components [0]. This involves anticipating unintended consequences of interventions.

2. RESEARCH METHODS

2.1 Research Sites, Study Design, Sampling Method

The research was conducted at Port Loko Government Hospital, Bekeh Loko Chiefdom, Port Loko District. The study uses a cross-sectional study design incorporating quantitative research methods to critically investigate the research objectives. The research utilizes a purposive stratified random sampling technique to select 150 health workers and 150 women of childbearing age making a total of 300 respondents.

2.2 Research Tool, Data Collection Methods and Statistical Analysis

Data were obtained from both primary and secondary sources. The primary data were collected from respondents using a structured survey questionnaire and the secondary data were sourced from the District Health Information System (DHIS) and Health Facility Registers. To ensure internal validity, the research instrument underwent testing for internal consistency and reliability. The internal consistency and reliability of this instrument were assessed using the Crombach alpha coefficient; the

 https://dx.doi.org/10.4314/sljbr.v16i4.3

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

calculated Crombach alpha coefficient of 0.89 reflected a robust internal consistency, affirming the reliability of the data collection instrument used for entering hospital records.

The collected data underwent a two-step statistical analysis. First, it was exported into Microsoft Excel 2019 for data cleaning. Subsequently, the cleaned data were exported into Statistical Package for Social Sciences (SPSS) version 28.0 for in-depth analysis. Descriptive statistics were computed to summarize participant characteristics. The findings were visualized using frequency tables and bar plots to enhance data interpretation.

3. RESULTS

3.1 First point of contact by respondents when they feel unwell

Figure 1 reveals that 40.0% (60) of the women of child bearing age respondents go to their nearest drug store when they or any member of their household feel unwell, 37.7 % go to the nearest health facility and 5.0% (15) go to other places to seek treatments when they feel unwell.

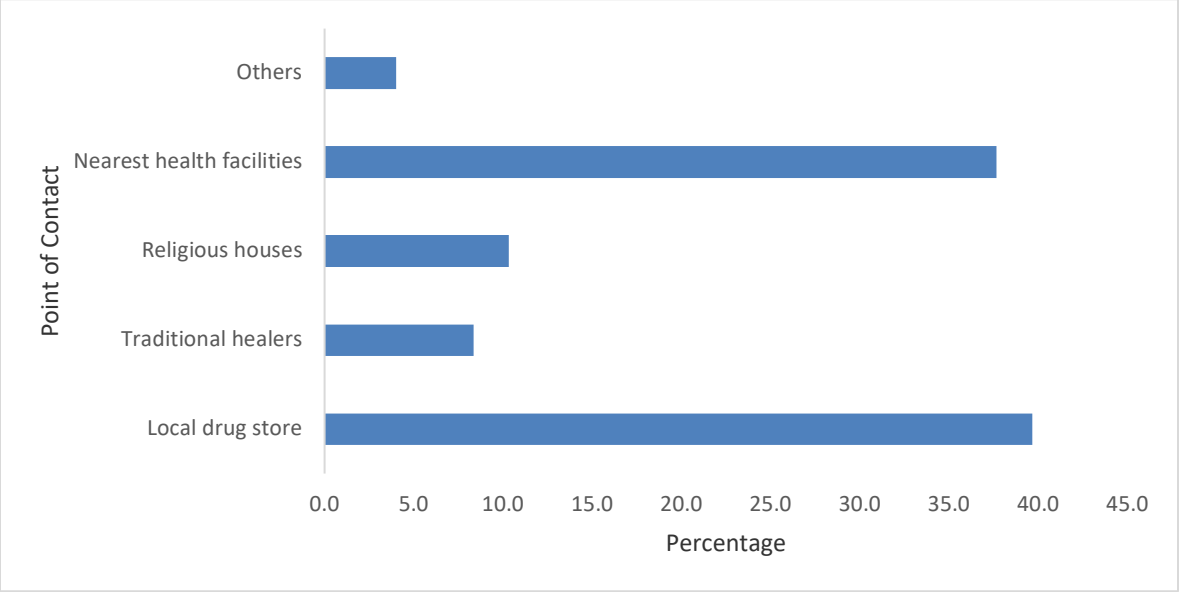

Figure 1: First point of contact by respondents when they feel unwell

 https://dx.doi.org/10.4314/sljbr.v16i4.3

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

3.2 Factors responsible for high Malaria prevalence

Table 1 reveals that 41.0% (62) of women respondents stated all factors as reasons for high malaria prevalence, 33.7 % stated poor environmental sanitation and 2.7% said hunger was a factor responsible for malaria prevalence.

Table 1: Factors responsible for high Malaria incidence and prevalence

Factors	Frequency	Percentage (%)
Poor environmental sanitation	51	33.7
Not Sleeping under a bed net	10	6.7
Lack of access and availability of health services	8	5.0
Sub-standard housing	17	11.0
Hunger	4	2.7
All of the above	62	41.0
Total	150	100.0

3.3 Most prevailing disease conditions of pregnant women that attend the ANC

Table 2 reveals that 73.3% (220) of HW respondents sighting most pregnant women that attend the clinic are malaria positive and 0.7% (2) of pregnant women that attended the clinic were positive for other conditions.

Table 2. Most prevailing disease conditions of pregnant women that attend a clinic

Disease Conditions	Frequency	Percentage (%)
Malaria	110	73.3
Iron deficiency	20	13.3
Pre-eclampsia	6	4.3
Typhoid	12	8.3
Others	1	0.7
Total	150	100.0

3.4 Availability of malaria diagnosis, treatment and prevention commodities (stock)

Figure 2 reveals that 85% of respondents (health care workers) experience stock out of malaria commodities every month and only 5% said essential commodities are always available at the hospital

 https://dx.doi.org/10.4314/sljbr.v16i4.3

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

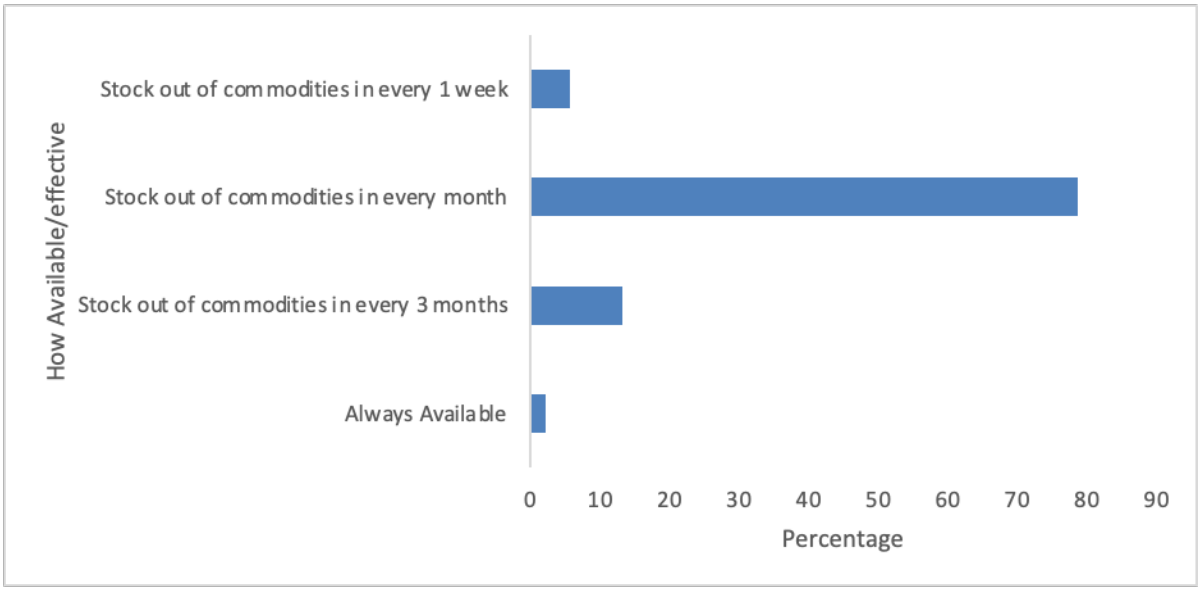

Figure 2: How available and adequate are these commodities for complicated and uncomplicated malaria

3.5 Perception of effectiveness of malaria diagnosis and treatment commodities/stock

Table 3 states that 78.0% (117 health care workers out of 150) of respondents said available commodities for malaria diagnosis and treatment are ineffective and 8% (12) said the available commodities are highly effective.

Table 2: Perception of how effective are these commodities for malaria diagnosis and treatment

How effective and adequate	Frequency	Percentage (%)
Highly Effective	12	8
Partially Effective	117	78
Not Effective	21	14
Total	150	100

 https://dx.doi.org/10.4314/sljbr.v16i4.3

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

3.6 Factors responsible for malaria treatment failure

Table 4, shows that 53.0% (80) of respondents mentioned drug overuse as a factor responsible for malaria treatment failure and 93.3% (140) stated Non-adherence to prescribed treatment as a factor responsible for malaria treatment failure

Table 3: frequency and percentage distribution of responses showing the factors responsible for malaria treatment failure

Parameters	**Frequency**			
Factors responsible for the ineffective malaria treatments	**Yes**	**No**	**% Yes**	**% No**
Non-adherence to prescribed treatment	140	10	93.3	6.7
Presumptive treatment	95	55	63.0	37.0
Drug overuse	80	70	53.0	47.0
Use of sub-therapeutic drugs	108	42	72.0	28.0

.

4. DISCUSSIONS

In this study, we critically assessed and sought the opinions of respondents using a stratified random selection of 150 health workers and 150 women of childbearing age making a total of 300 participants to determine the socio-economic status of susceptible malaria population, the malaria status of susceptible groups precisely women of childbearing age and also the availability and effectiveness of malaria treatment interventions available at the study site.

The study results show that 40.0% (60) of respondents go to their nearest drug store when they or any member of their household feel unwell and 5.0% go to other places to seek treatments when they feel unwell and this is in line with a study conducted in 2018 [0] and another study done in Nigeria in 2016[0], that poor socio-economic conditions, inadequate knowledge, wrong perceptions about malaria and its policies have immensely contributed to widespread malaria throughout SSA region.

The study also shows that poor socio-economic conditions affect the decision of where to seek

 https://dx.doi.org/10.4314/sljbr.v16i4.3

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

malaria treatment to the extent that, 41.0% (62) of respondents stated all factors as reasons for high malaria prevalence and only 2.7% said hunger as a factor responsible for malaria prevalence which confirms with these studies [0, 0] done in 2016 and 2018 respectively.

The study also reveals that 73.3% (110) of pregnant women that attend the antenatal clinic are malaria positive and 0.7% of pregnant women that attended the clinic are positive for other conditions and this is in line with a study conducted in Ethiopia-2018 [0] and in Sub-Saharan Africa-2015 (1), confirming malaria to be the leading prevailing condition of malaria susceptible groups, precisely women of childbearing age.

Consistent with previous studies[0,0 and 0], this study shows that 85% (128) of respondents (health care workers) experience stock out of malaria commodities every month and only 5% said essential commodities are always available at the hospital and such unavailability and inadequacy of essential malaria treatment interventions remain an ineptitude of SSA countries with high malaria burden.

This study further reveals that 78.0% (117) (health care workers) of respondents said available commodities for malaria diagnosis and treatment are ineffective , however only 8% (12) said the available commodities are highly effective and this is in line with a study done in 2015[0] and SSA-2017 (6).

From literature also it was observed that drug-resistant factors include but not limited to anti-malaria drug use practices/presumptive treatment, drug overuse, non-adherence to prescribed malaria treatment regimen, and host immunity remained very important drivers of drug resistance. The study reveals that 53% of respondents mentioned drug overuse as a factor responsible for malaria treatment failure and 93.3% stated Non-adherence to prescribed treatment as a factor responsible for malaria treatment failure, which is in line with studies conducted in SSA-2015 [0] and in 2016 [0] and in another study done by WHO-2015[0].

4.1 Study strengths and limitations

The strength of this study is mainly on working with community-based respondents that have been affected either directly or indirectly by the socio-economic malaria burden and according to the Sierra Leone Malaria Indicator Survey (SLMIS)-2021, Port Loko District is the highest malaria incidence and prevalence burden district in Sierra Leone.

The limitations of this study included inadequate time and resources for gathering data required, limiting the research to only Port Loko Government Hospital. Accessibility of data at health facilities was a challenge, and overcrowding of patients at

 https://dx.doi.org/10.4314/sljbr.v16i4.3

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

outpatient units during clinic days due to the infrastructural makeup of the facility is a severe Infection Prevention and Control (IPC) challenge.

5. CONCLUSION

Poor socio-economic conditions such as sub-standard housing, poor environmental sanitation, inadequate knowledge, and wrong perceptions about malaria and anti-malaria policies have contributed to widespread malaria in the study area. The study also depicts that, most people go to the nearest drug store as their first point of contact for treatment instead of the nearest health facility and as a result, blind treatments are often administered without proper and effective diagnostic tests to ascertain whether they are malaria positive or not before the administration of treatments.

The Prevalence of malaria among pregnant women, infants, and children from poor backgrounds have been reported in many studies as being high and this study has confirmed from the analysis that, malaria and its related conditions remain leading factors for maternal, infant, and child mortality in the study area.

It is evidenced from the study that inadequate, inappropriate, and ineffective malaria prevention, control, and treatment services and facilities, such as RDTs, Microscopic/Laboratory Tests, Malaria Case Management (Antesunate Lumefantrine, Rectal Artesunate, Injectable Artesunate), IPTp and IPTi, the lack of positive malaria social behaviours and poor socio-economic status remain the major contributing factors to the increase incidence and prevalence of the disease in Port Loko District.

The study serves as a useful resource for public health malaria interventions and control programmes in the local context. The findings shed light on the need for active intervention in Port Loko District and other malaria-prone areas of Sierra Leone. Active community engagement and education, strengthening healthcare infrastructure, quality improvement in diagnosis and treatment, targeted interventions for pregnant women are urgently needed to understand and control malaria prevalence. Future research on malaria drug resistance is needed.

AUTHOR CONTRIBUTIONS: LSB and DKDS conceived of the idea of the research and articulated the original manuscript. LSB, DKDS and RBK developed the questionnaire. RBK and LSB did the analysis. LSB articulated the discussion and conclusion.

ACKNOWLEDGEMENTS: The authors acknowledge and thank all the research participants, the staff of the Port Loko District Hospital and all other stakeholders who in one way or another were contacted for this study

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

FUNDING INFORMATION: There was no funding solicited or received for this study.

CONFLICT OF INTEREST STATEMENT: The authors declare no competing or conflict of interests.

DATA AVAILABILITY STATEMENT: The data presented in this study are available on request from the corresponding author upon reasonable request.

ETHICS STATEMENT: Ethical approval was sought from Njala University institutional review board (NUIRB)

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

References:

1.Taffese HS, Hemming-Schroeder E, Koepfli C, Tesfaye G, Lee M chieh, Kazura J, et al. Malaria epidemiology and interventions in Ethiopia from 2001 to 2016. Infect Dis Poverty. 2018 Dec;07(06):1–9.

2. Van Eijk AM, Hill J, Noor AM, Snow RW, ter Kuile FO. Prevalence of malaria infection in pregnant women compared with children for tracking malaria transmission in sub-Saharan Africa: a systematic review and meta-analysis. Lancet Glob Health. 2015 Oct 1;3 (10):e617–28.

3. Diseases JEAS, Organization WH, Abuja, Wondimagegnehu$WR N, Office WHOC, Abuja, et al. Investigation of a Suspected

Malaria Outbreak in Sokoto State, Nigeria, 2016. Open Access Libr J. 2017;04(12):1.

4. Winskill P, Walker PG, Cibulskis RE, Ghani AC. Prioritizing the scale-up of interventions for malaria control and elimination. Malar J. 2019 Apr 8;18(1):122.

5. Baltzell K, Harvard K, Hanley M, Gosling R, Chen I. What is community engagement and how can it drive malaria elimination? Case studies and stakeholder interviews. Malar J. 2019 Jul 17;18(1):245.

6. Boyce MR, O'Meara WP. Use of malaria RDTs in various health contexts across sub-Saharan Africa: a systematic review. BMC Public Health. 2017 May 18;17(1):470.

7. Organization WH. Global Technical Strategy for Malaria 2016-2030. World Health Organization; 2015. 35 p.

8.Varo R, Crowley VM, Sitoe A, Madrid L, Serghides L, Kain KC, et al. Adjunctive therapy for severe malaria: a review and critical appraisal. Malar J. 2018 Jan 24;17(1):47.

9. Smith Gueye C, Newby G, Gosling RD, Whittaker MA, Chandramohan D, Slutsker L, et al. Strategies and approaches to vector control in nine malaria-eliminating countries: a cross-case study analysis. Malar J. 2016 Jan 4;15(1):2.

10.Diseases AS and NC, Organization WH, Abuja, Diseases NEAS and NC, Organization WH, Abuja, et al. Universal Access to Malaria Prevention, Diagnosis, and Treatment as a Strategy toward Disease Control and Elimination: A Critical Look at Northeastern Nigeria. Open Access Libr J. 2019;06(11):1.

©SLJBR Volume 16. Number 4. May 2026 ISSN (Print), ISSN (Online First)

11. Rosenstock, I. M. (1974). The Health Belief Model and Preventive Health Behavior. Health Education Monographs, 2(4), 354–386.

12. Janz, N. K., & Becker, M. H. (1984). The Health Belief Model: A Decade Later. Health Education Quarterly, 11(1), 1–47.

13. Meadows, D. H. (2008). Thinking in Systems: A Primer. Chelsea Green Publishing.

14. Sterman, J. D. (2000). Business Dynamics: Systems Thinking and Modeling for a Complex World. Irwin/McGraw-Hill.

15. Anderson, P. W. (1972). More is Different. Science, 177(4047), 393–396.