

ASSOCIATION BETWEEN PATIENTS BEHAVIOR, HOUSING CONDITIONS AND MALARIA SEVERITY IN THE FOURTEEN MILITARY HOSPITAL, MARGIBI COUNTY, LIBERIA

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Abstract

Introduction: Malaria has been a significant public health issue in Liberia, with behavioural and environmental factors influencing transmission and consequences. This study evaluated the association between patient behavior and housing condition with malaria status and severity in a military hospital in Margibi County, Liberia, in 2024. **Methods:** A cross-sectional study utilising 54 patients infected with *P. falciparum*, where 53.7% were male, aged 20 to 49, and 46.3% were female, examining the association between patients' behaviour, housing condition and malaria severity in the Fourteenth Military Hospital in 2024. The association between variables was analysed using Chi-square and Fisher's exact tests. **Results and Discussion:** The association between patient behavior and housing conditions with malaria case status was statistically insignificant, as was the association between these factors and malaria severity. Small sample sizes and unmeasured confounders may not have provided sufficient statistical power to detect significant differences between groups, even though stronger associations between certain variables might exist but were undetected due to limited data. Further research with a more controlled design and larger sample sizes will be necessary to investigate the association between these variables further. **Conclusion:** There was no significant association between patient behavior and housing conditions with malaria case status or severity. A more systematic approach to data collection, incorporating factors related to malaria status and severity, could provide a clearer understanding of the contributors to *P. falciparum* infection status and disease, which can be correlated with patient behavior.

INTRODUCTION

Malaria continues to be a significant global public health issue (1-2). The World Malaria Report 2024 estimates that there were 263 million cases and 597,000 malaria-related fatalities globally in 2023 (3). Despite decades of effort, global advancements in malaria control have stagnated due to reasons including drug resistance, vector resistance to insecticides, and healthcare disruptions resulting from the COVID-19 epidemic (4). *Plasmodium falciparum* and *Plasmodium vivax* are the predominant species responsible for human

malaria, with children under five years constituting the bulk of malaria-related fatalities (5-6).

Sub-Saharan Africa remains the epicentre of malaria, accounting for 94% of worldwide infections and 95% of fatalities in 2022 (7). Nations such as Nigeria, the Democratic Republic of Congo, Uganda, and Mozambique have the highest incidence of cases, with *P. falciparum* as the predominant species. Contributing characteristics encompass elevated transmission intensity, restricted healthcare access, favourable environmental circumstances, and perennial rainfall. Interventions, including insecticide-treated nets (ITNs) and artemisinin-

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based combination therapies (ACTs), have diminished malaria morbidity and death; nevertheless, progress is still precarious and inconsistent throughout the region (8–11).

In Liberia, malaria is widespread and continues to be a primary cause of illness and mortality (12). In 2022, the Ministry of Health documented 760,056 malaria cases resulting in 353 fatalities, which escalated to 814,113 cases in 2023 (3,13). The 2018 Malaria Indicator Survey revealed that *P. falciparum* constituted more than 90% of malaria infections. Approximately 45% of children aged 6–59 months tested positive utilising fast diagnostic testing, with a higher frequency observed in rural locations (9,14). Malaria remains the primary reason for outpatient consultations, especially during the rainy season (April to August) when transmission reaches its zenith (15–16). Data from the Ministry of Health's 2022 Malaria Indicator Survey (MIS) reveals that Greater Monrovia has the least dependence on mass distribution of mosquito nets, at 57.3%. Conversely, a greater proportion of residents in this region (15.6%) acquire nets from retail establishments or markets (9,17). Regions with elevated malaria prevalence, like North Central and Southeastern A, acquired almost 80% of their nets via campaigns. The allocation of insecticide-treated nets (ITNs) and long-lasting insecticidal nets (LLINs) has been a significant tactic in Liberia's National Malaria Control Program, bolstered by foreign partners (18). This campaign has been essential in addressing malaria, especially among at-risk groups, including children under five and pregnant women. In areas such as Greater Monrovia, where malaria prevalence is markedly reduced to 12%, mosquito nets' extensive availability and proper utilisation have enhanced public health outcomes (19). Margibi County endures continuous malaria transmission, predominantly attributed to *P. falciparum*. The Q4 2023 NMCP scorecard indicated a malaria incidence rate of 9 cases per 1,000 inhabitants in Margibi, signifying moderate yet continuing transmission. Since 2017, Margibi has served as a sentinel site for the PMI Vector Link project, focusing on entomological surveillance and insecticide resistance monitoring, facilitating chlorfenapyr-based IG2 nets in 2021. Academic research, including the NIAID-funded cross-sectional study (NCT03719599, 2019–2021), bolsters vector monitoring initiatives in the area (4).

Human behaviour significantly influences malaria transmission (20). Risk behaviours, including nocturnal outdoor activities, residing in unscreened accommodations, and inconsistent application of preventive measures, heighten susceptibility to infection (19,21). In contrast, preventative measures such as the regular utilisation of insecticide-treated

nets (ITNs), appropriate treatment-seeking behaviour, and the avoidance of self-medication are essential for diminishing the frequency and severity of malaria (18,21). Consequently, comprehending patient behaviour in malaria-endemic regions is crucial for informing effective therapies. This study aims to investigate the correlation between patient behaviour and malaria severity at the Fourteen Military Hospital in Margibi County, Liberia, particularly in 2024.

METHODS

Ethics Approval and Consent to Participate

All participants supplied written informed consent to partake in this study. All documents about ethics approval and the research proposal have been evaluated by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Airlangga, as outlined in the Ethical guidelines. Exemption No. 108/EC/KEPK/FKUA/2024.

Study Design and Setting

This study utilised a cross-sectional design to evaluate the association among patient behaviour, housing conditions, malaria prevention behaviours, self-medication history, malaria case status, and the severity of *Plasmodium falciparum* infection. The research was conducted at the Fourteenth Military Hospital in Margibi County, Liberia.

Study Population and Sample

The study group comprised patients clinically diagnosed with *P. falciparum* malaria who exhibited symptoms in 2024. The study included 54 individuals from various age categories, including males and females. All subjects willingly pursued treatment at the Fourteenth Military Hospital and provided informed consent before participation.

Data Sources and Variables

Primary data were collected through patient interviews and medical records. The patients' characteristics assessed included age, sex, occupation, education, and economic status; patients' behavior, including use of mosquito bed nets, use of insecticides (sprays, coils, lotions), and self-medication practices, including history of antimalarial drug use without prescription. Housing conditions include door and window screens, mosquito bed nets, and distance from health facilities. Based on hospital medical records, clinical data include malaria case status (new and not new) and malaria severity (mild, moderate, or severe).

Data Sources and Variables

Primary data were obtained via patient interviews, and secondary data were medical records obtained from the military hospital in Margibi County, Liberia.

Data Analysis

Descriptive statistics summarised patient characteristics and behavioural factors. Associations between independent variables (e.g., behaviour, housing, self-treatment) and dependent outcomes (malaria severity and case status) were evaluated using Chi-square and Fisher's exact tests, with a significance threshold established at $p < 0.05$. All analyses were performed utilising SPSS version 26.0 (IBM Corp., IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp).

RESULTS

A total of 54 patients diagnosed with *Plasmodium falciparum* malaria were included in the analysis. Most respondents were male (53.7%) and within the age range of 20–49 years. Approximately 61.1% were unemployed, and 53.7% had only completed primary education or less (Table 1). Regarding severity, 40.7% of patients were classified as having mild malaria, 35.2% moderate, and 24.1% severe (Table 2). More than half of the patients reported previous malaria episodes, and 56.1% reported self-medicating with antimalarial drugs. The socio-demographic data of 54 patients are presented in Table 1.

Table 1. Socio-Demographic Characteristics of Respondents (n=54)

Characteristics	Categories	n (%)
Sex	Female	25 (46.3%)
	Male	29 (53.7%)
Religion	Christian	27 (50.0%)
	Muslim	20 (37.0%)
	Other	7 (13.0%)
	Married	19 (35.2%)
Marital Status	Divorced	10 (18.5%)
	Not married	25 (46.3%)
Occupation	Working	21 (38.9%)
	Not working	33 (61.1%)
Age Group	10–19 years	6 (11.1%)
	20–29 years	10 (18.5%)
	30–39 years	20 (37.0%)
	40–49 years	14 (25.9%)
	50–59 years	4 (7.4%)
Education Level	No school/Primary school	29 (53.7%)
	Secondary school and above	25 (46.3%)

Table 2. Clinical and Behavioral Characteristics of Patients (n=54)

Variable	Category	n (%)
Malaria Severity	Mild	22 (40.7%)
	Moderate	19 (35.2%)
	Severe	13 (24.1%)
Malaria Case Status	New case	28 (51.9%)
	Not a new case	26 (48.1%)
Self-treatment History	Yes	32 (59.3%)
	No	22 (40.7%)

Statistical analysis of the association between patient behaviour and malaria case status ($n = 54$) is presented in Table 3. The behaviours such as the use of bed nets (66.7% in not new cases vs. 33.3% in new cases; $p = 0.058$) and use of mosquito coils (66.7% in new cases vs. 33.3% in not new cases; $p = 0.070$) approached statistical significance, suggesting these behaviours may be linked to repeated malaria episodes or prevention strategies. Other behaviours like staying outdoors overnight, using insecticides, and hanging clothes indoors showed no significant difference between new and not new malaria cases.

Table 3. Association Between Patient Behavior and Malaria Case Status (n=54)

Behavior / House Condition	New Case n (%)	Not New Case n (%)	p-value
Windows and door screens	11 (47.8%)	12 (52.2%)	0.81
Mosquito bed nets in all rooms	7 (33.3%)	14 (66.7%)	0.058
Use of mosquito spray every day	1 (25.0%)	3 (75.0%)	0.342
Stay outdoors overnight	13 (46.4%)	15 (53.6%)	0.752
Use of mosquito coil before bed	4 (66.7%)	2 (33.3%)	0.070
Use of blanket at night	13 (56.5%)	10 (43.5%)	0.752
People living in the house (2–6 vs. 7–11)	20 (58.8%)	14 (41.2%)	0.291
Hang clothes inside the room	18 (50.0%)	18 (50.0%)	0.923
Ever treated for malaria	25 (52.1%)	23 (47.9%)	1.000
Times treated for malaria (1 vs ≥ 2)	6 (60.0%)	4 (40.0%)	0.661
Buy malaria drugs without a prescription	17 (53.1%)	15 (46.9%)	1.000
Frequency of buying without a prescription	18 (56.3%)	14 (43.8%)	0.515
Treated by a health provider	9 (40.9%)	13 (59.1%)	0.290
Malaria drug intake frequency (2x/day vs. 3x/day)	16 (52.2%)	11 (47.8%)	1.000
Duration of drug intake (7 days vs. 2–3 days)	11 (44.0%)	14 (56.0%)	0.424
Distance from house to facility	1 (50.0%)	1 (50.0%)	1.000

Behavior / House Condition	New Case n (%)	Not New Case n (%)	p-value
Visit a health facility when sick	10 (45.5%)	12 (54.5%)	0.515
Knowledge about malaria	8 (50.0%)	8 (50.0%)	1.000
Hospital admission for malaria	5 (45.5%)	6 (54.5%)	0.890
History of blood transfusion	7 (46.7%)	8 (53.3%)	0.866
Agree that education helps reduce malaria	19 (57.6%)	14 (42.4%)	0.438

In Table 4, patients who used mosquito spray daily had a higher proportion of severe malaria (50.0%) than those who did not ($p = 0.157$). Similarly, individuals who bought malaria drugs without a prescription tended to have more severe outcomes (28.1%) compared to those who did not ($p = 0.090$). Visiting health facilities when sick was more common among patients with mild malaria (54.5%) compared to those with severe malaria (9.1%), with a p -value approaching significance ($p = 0.059$). These patterns suggest possible behavioural links with disease severity, though further studies with larger sample sizes are needed.

Table 4. Association Between Patient Behavior and Malaria Severity (n=54)

Behavior / House Condition	Mild n (%)	Moderate n (%)	Severe n (%)	p-value
Windows and door screens	9 (39.1%)	10 (43.5%)	4 (17.4%)	0.457
Mosquito bed nets in all rooms	10 (47.6%)	7 (33.3%)	4 (19.0%)	0.671
Use mosquito spray every day	0 (0.0%)	2 (50.0%)	2 (50.0%)	0.157
Stay outdoors overnight	12 (37.5%)	13 (40.6%)	7 (21.9%)	0.425
Use a mosquito coil before bed	16 (47.1%)	3 (8.8%)	3 (8.8%)	0.477
Use a bedsheet at night	8 (34.8%)	9 (39.1%)	6 (26.1%)	0.742
People living in the house (2–6 vs. 7–11)	15 (44.1%)	12 (35.3%)	7 (20.6%)	0.700
Hang clothes inside the room	14 (38.9%)	14 (38.9%)	8 (22.2%)	0.112
Treated for malaria before	17 (45.9%)	13 (35.1%)	7 (18.9%)	0.117
Times treated for malaria (1 vs. ≥ 2)	7 (36.8%)	6 (31.6%)	6 (31.6%)	0.490
Buy drugs without a prescription	10 (31.3%)	13 (40.6%)	9 (28.1%)	0.090
Frequency of buying without a prescription	11 (34.4%)	11 (34.4%)	10 (31.3%)	0.274
Treated by a health provider	7 (31.8%)	10 (45.5%)	5 (22.7%)	0.393
Drug intake per day (2x vs. 3x)	8 (34.8%)	10 (43.5%)	5 (21.7%)	0.544
Duration of malaria treatment (7 vs. 2–3 days)	10 (41.7%)	11 (45.8%)	3 (12.5%)	0.311
Distance to facility (1–6 vs. ≥ 7 min)	1 (50.0%)	1 (50.0%)	0 (0.0%)	1.000
Visit a health facility when sick	12 (54.5%)	8 (36.4%)	2 (9.1%)	0.059
Knowledge about malaria	9 (56.3%)	4 (25.0%)	3 (18.8%)	0.323
Hospitalized for malaria	3 (27.3%)	6 (54.5%)	2 (18.2%)	0.358
Blood transfusion for malaria	8 (53.3%)	2 (13.3%)	5 (33.3%)	0.471
Agree that education helps reduce malaria	13 (39.4%)	13 (39.4%)	7 (21.2%)	0.782

Table 5 shows that the distribution of malaria severity was further analysed concerning case status (new or not new). Among new cases, moderate and severe malaria were more common (12 and 8 patients, respectively) than mild cases (8 patients). In contrast, not new cases showed a higher frequency of mild malaria (14 patients), followed by moderate (7) and severe (5) cases. Although the association was not statistically significant ($p > 0.05$), this pattern suggests that individuals with prior malaria experience may present with less severe clinical symptoms, potentially due to partial acquired immunity or earlier recognition and management of symptoms.

Table 5. Association Between Malaria Case Status and Severity

Malaria Case Status	Mild n (%)	Moderate n (%)	Severe n (%)	p-value
New Case	8 (28.6%)	12 (42.9%)	8 (28.6%)	0.167
Not New Case	14 (53.8%)	7 (26.9%)	5 (19.2%)	

DISCUSSION

This study examined the association between patient behaviour and the severity of *P. falciparum* malaria in a military hospital setting in Liberia. Although no statistically significant associations were found, several meaningful trends offered insight into the behavioural determinants of malaria severity. Patients who reported using mosquito bed nets or coils generally presented with milder forms of malaria. Although these associations did not reach statistical significance, the direction of the findings aligns with previous research highlighting the protective effects of insecticide-treated nets (ITNs) and personal mosquito control measures (22). The relatively low uptake of these preventive tools in the study population suggests a need to strengthen behaviour change communication around vector control.

Self-treatment with antimalarial drugs, especially without a prescription, was commonly reported and appeared more frequent among patients with moderate or severe disease (23–26). This may reflect improper drug use or delayed care-seeking, both of which can lead to treatment failure and worsening illness. Previous studies in sub-Saharan Africa have raised similar concerns about widespread self-medication and its role in disease progression (9).

The data in Table 2 reveal a balanced distribution of malaria severity among patients, with 40.7% experiencing mild, 35.2% moderate, and 24.1% severe symptoms. This distribution indicates that a significant number of individuals advanced beyond moderate sickness, underscoring the persistent clinical burden of malaria in the region. The presence of moderate and severe cases could be influenced by factors such as delayed diagnosis, limited access to healthcare, or drug

resistance, which are challenges commonly observed in malaria-endemic regions (5,27). Addressing these clinical factors is essential to reduce the proportion of moderate-to-severe malaria cases and improve early intervention strategies (28-29). Furthermore, the data show that 51.9% of patients were new malaria cases, while 48.1% were not new, indicating persistent or recurrent infections. Notably, 59.3% of patients reported a history of self-treatment, which raises concerns about inappropriate drug use and potential resistance. Self-medication is widely practised in many low-resource settings and has been associated with poor treatment outcomes and increased severity due to delays in seeking professional care (30-31). These findings underscore the urgent need for community education and strengthened malaria control policies to discourage self-treatment and promote timely medical consultation. The number of new malaria falciparum cases in 2024 could be due to increased transmission, new outbreaks, reduced preventive measures, self-medication, buying malaria drugs without a doctor's prescription, and higher mosquito breeding due to environmental factors (32). A study along the China-Myanmar border revealed that treatment-seeking behavior (TSB) for malaria among patients was generally inappropriate, characterized by delays and visits to non-laboratory testing sites such as drug stores and private clinics before seeking proper diagnosis and treatment. More than half of the malaria patients initially self-medicated or sought treatment at facilities without laboratory confirmation, and only 38.1% sought appropriate treatment, defined as visiting health facilities with laboratory testing within 48 hours of symptom onset (33). Other findings suggest improving patient knowledge through education can enhance self-treatment efforts and prevention. Still, they must be encouraged and provided with practical support to reduce malaria incidence effectively. This underscores the importance of integrating health education programs with behavioral interventions to foster better patient self-care and malaria prevention (34). Liberia possesses a tropical climate characterised by consistent heat and humidity throughout the year, with a rainy season occurring from May to October, attributed to the African monsoon, which creates numerous hatching grounds for mosquitoes due to frequent precipitation. This shift suggests an outpouring of first-time infections in 2024, potentially linked with additional factors such as environmental change and the rise in swampy land, which creates stagnant water ideal for mosquito breeding (2). Reduced dryland may also concentrate populations in riskier swamp-adjacent areas. Additionally, weakened prevention efforts, gaps in health education, or improved case detection in 2024

could explain the rise in new admissions (35). The lower number of "not new cases" might reflect better treatment adherence or reduced reinfections, though further investigation is needed to disentangle environmental, behavioural, and healthcare factors driving these trends. This study found no significant association between patient variables, including sex, age, education level, and occupation, and either the status (new or not-new case) or the severity of *Plasmodium falciparum* infection. While these sociodemographic factors are commonly considered in epidemiological analyses of malaria, their influence may not always be direct or measurable, particularly in retrospective analyses using secondary data (36). For example, although age and sex are often linked to immune response or exposure risk, these variables may interact with unmeasured factors such as nutritional status, genetic predisposition, or frequency of prior malaria episodes. Similarly, education level and occupation are typically proxies for awareness and exposure. However, in endemic settings like Liberia, even individuals with higher education or indoor occupations may still be exposed to transmission due to widespread mosquito presence and limited environmental protection (37). Additionally, the lack of statistical significance could result from limited variation in these characteristics across the study population or insufficient sample size to detect small effect sizes. It is also possible that other more proximal determinants, such as health-seeking behaviour, housing quality, or timely access to treatment, play a stronger role in influencing disease severity and recurrence than sociodemographic factors alone (10,38).

Importantly, patients who reported visiting health facilities promptly when feeling unwell were more likely to have mild malaria, suggesting that early diagnosis and treatment play a critical role in preventing complications. This finding underscores the value of community-level education campaigns to encourage timely healthcare utilisation. Regarding malaria case status, the study observed that new cases were more likely to have higher disease severity than recurrent cases. Although not statistically significant, this pattern may reflect a lack of acquired immunity among first-time patients, a phenomenon documented in endemic regions where partial immunity develops after repeated exposure (3,39-40).

Table 5 highlights the distribution of malaria severity among patients based on their case status (new vs. not new). New cases were more likely to present with moderate (42.9%) and severe (28.6%) malaria, compared to not-new cases, which had a greater proportion of mild presentations (53.8%). Although this suggests that

new cases may be more clinically severe, the absence of statistical significance ($p = 0.167$) indicates that the observed differences may be attributable to chance.. Nevertheless, other studies have found that new malaria infections, particularly in individuals with limited prior exposure or immunity, can lead to more severe outcomes. (41-42). The higher severity in new cases may also relate to delays in diagnosis or inadequate early treatment, especially in populations lacking prior knowledge or access to preventive care. In contrast, individuals with recurrent or previous malaria episodes may have partial immunity or better awareness, leading to milder outcomes and earlier intervention (5,43). While this study's data do not show a statistically significant association, the trend aligns with broader evidence highlighting the importance of early detection, education, and access to care in reducing malaria severity in newly infected individuals.

This research possesses multiple limitations. The limited sample size constrained statistical power, and the utilisation of secondary data may have introduced information bias. Additionally, behavioural data were self-reported and thus subject to recall bias. Nonetheless, the findings offer valuable insights from a military hospital context, an under-researched setting in malaria studies.

Subsequent research should encompass larger and more heterogeneous groups to corroborate these findings. Longitudinal studies could also help clarify the temporal relationship between behavioural risk factors and malaria severity (44-45). Overall, the observed trends highlight the importance of combining individual behavioural change strategies with systemic health interventions to reduce malaria severity and improve patient outcomes in endemic settings like Liberia.

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CONCLUSION

This study, conducted at the Fourteen Military Hospital in Margibi County, Liberia, highlights how patient behaviour and experience may influence malaria outcomes. Although no statistically significant associations were found, descriptive analyses revealed

patterns suggesting that practices such as bed net use, prompt health facility visits, and avoidance of self-medication may contribute to less severe malaria outcomes. Patients with repeated malaria exposure also appeared to experience milder symptoms, possibly due to acquired immunity. These findings underscore the need for public health education campaigns focused on behaviour change and adherence to preventive measures. Further research with larger sample sizes and prospective designs is recommended to validate these observations.

AUTHORS' CONTRIBUTION

G.Z., MTS: Data collection, interviewing of the patients. G.Z., H.A., L.D., M.T.S., A.A.: Original draft preparation. G.Z, H.A, L.D: Writing concept and study designs. G.Z, H.A, L.D, M.T.S, A.A: Statistical data analysis and data curation. G.Z, H.A, L.D, M.T.S, A.A: Editing the manuscript and Results.

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