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Research Article

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Comparison of Malaria Prevalence and Risk Factors in Urban and Rural Areas of Forest Guinea

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ABSTRACT

Introduction: Malaria is a major public health problem in sub-Saharan Africa. In Guinea, the disease is widespread throughout the country, particularly in the forest region where it is endemic. The objective of this study was to assess the prevalence of malaria in urban and rural areas of Guinea's forest region by identifying potential socio-economic factors associated with the onset of the disease.

Method: Blood samples of 280 patients suffering from malaria (102 and 178 patients in urban and rural areas, respectively) were collected between early May and late August 2022 across healthcare facilities of the forest Guinea, and analysed in the laboratory of the International Centre for Research on Tropical Infections of Guinea (CIRIT-Guinea) for the presence of Plasmodium using the loop-mediated isothermal amplification (LAMP) technique. A questionnaire was used to record information on socio-demographic characteristics of patients such as age, gender, place of residence and occupation.

Results: Results showed that 63.6% of malaria cases occurred in rural area, compared with 36.4% in urban area, although the difference was not statistically significant ($p = 0.12$). This could indicate widespread endemicity of the disease in the region. The absence of any significant difference in the distribution of patients by age group ($p = 0.76$) and gender ($p = 0.47$) indicates that control strategies should be comprehensive, without prioritizing certain demographic groups. In terms of occupation, malaria was overrepresented among farmers in rural areas ($p = 0.03$), probably reflecting ongoing exposure to mosquito breeding sites, particularly irrigated farms and stagnant water.

Conclusion: These results highlight the need to develop differentiated approaches according to the people occupation. There is need to provide healthcare facilities with additional medical staff and laboratory equipment to ensure reliable diagnosis and to conduct door-to-door awareness campaigns in rural and urban communities on preventive measures against malaria.

Key Words: Farmers, Urban environment, Rural environment, Prevention, Awareness-raising, reliable diagnosis

INTRODUCTION

Malaria is still a major public health problem in sub-Saharan Africa.[1,2] It is one of the leading causes of death in developing countries of Africa.[3] The World Health Organisation (WHO) estimates that 263 million cases and 597 000 deaths from malaria were recorded worldwide in 2023,[4] compared to 229 million cases and 409 000 deaths in 2019.[5] Africa is the most affected region, with 94% of cases (246 million) and 95% of deaths (569 000) recorded in 2023.[4] The disease is caused by parasites of the genus *Plasmodium*, of which the five main species infecting humans are *Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale, Plasmodium malariae* and *Plasmodium knowlesi.*[6] Of these five *Plasmodium* species, *P. falciparum* is reported to be the most formidable.[7] Guinea is one of the 17 countries with the highest malaria burden in the world, and accounts for 3.6% of malaria cases in the West Africa region.[3,8] The country's malaria rate varies greatly according to place of residence (53% in rural areas compared with 18% in urban areas). In addition, 49% of women suffered from anaemia, with a higher incidence of malaria among women living in rural areas (52%) compared to those in urban areas (44%). Regionally, Faranah (66%) and Nzerekore (59%) stand out as having the highest

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prevalence. The main vector found throughout the country is *Anopheles gambiae*. The dominant parasite species is *P. falciparum,* representing 96.5%. *P. malariae* and *P. ovale* account for 3.3% and 0.13% respectively.[8] The dominant vector is *A. gambiae*. Forest Guinea is a highly malaria endemic area. These last few years, the emergence of the disease has been linked to the rapid environmental changes occurring in the area, particularly land use changes associated with deforestation.[9] The vectorial capacity of mosquitoes can be enhanced under ecologically disturbed environments, especially peridomestic habitats.[10] Since the beginning of the 2000s, Guinea has faced rapid population growth, uncontrolled urbanization, illegal logging, open-air breeding, changes in land use, forest degradation and biodiversity loss that may affect vector-host susceptibility and adaptation.[9] The interactions between physical and certain socio-economic factors (i.e. people occupation) in the forest region amplify the emergence of malaria. Although land use changes have been associated with increased malaria transmission, regional malaria disparities by occupation in southeastern Guinea are still to be investigated. The aim of this study was to assess the prevalence of malaria in urban and rural areas of Forest Guinea and infer the potential socio-economic factors associated to the emergence of the disease.

MATERIALS AND METHODS

Study area

Forest Guinea, one of Guinea's four natural regions, is administratively divided into two zones: an urban zone and a rural zone, representing the study area illustrated in Figure 1. It covers an area of 49,374 km², or 20% of the country's total area. In terms of population, Forest Guinea had 1,989,740 inhabitants in 2016, compared to 1,986,329 in 2014. It is bordered by Upper Guinea to the north, Ivory Coast to the east, Liberia to the south and Sierra Leone to the west. The climate is tropical and humid, with two main seasons throughout the year: an eight-month rainy season from April to November and a dry season from December to March. The vegetation cover is characterised by dense tropical forest, which forms the natural landscape of this region. The rich fauna promotes the development of parasites and includes various species of vectors. Annual rainfall varies between 1,700 and 3,000 mm, and the temperature between 19 °C and 29 °C, with an annual average of 24 °C, which promotes the proliferation of malaria vectors.[8,11]

Study population

The study population consisted of patients who had consulted a health facility and received a positive diagnosis of malaria in urban and rural health facilities in Guinea's forest region, regardless of their social class, gender or age. A total of 280 patients were diagnosed with malaria, including 102 in urban areas and 178 in rural areas.

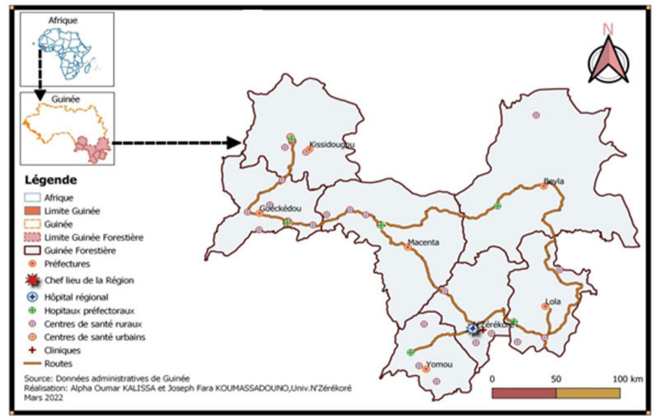

Figure 1: Map showing the health facilities investigated in rural and urban areas of the Forest Guinea region

Collection of qualitative data from patients

Data was collected based on a questionnaire designed in accordance with the objective of the study. The data was collected between the beginning of May and the end of August 2022. The questionnaire was used to record information on socio-demographic characteristics (age, gender, place of residence, occupation).

Analytical technique

Blood samples were taken to the laboratory of the International Research Centre for Tropical Infections of Guinea (CIRIT-Guinea) for analysis. We used the LAMP (Loop-Mediated Isothermal Amplification) technique or Illumigen-Malaria Test to detect the malaria parasites in the blood. The DNA primers have been specially designed to give DNA amplification under isothermal conditions. The test developed here targets a region of the Plasmodium genome conserved within human Plasmodium. The kit targets a 214 bp non-coding mitochondrial DNA sequence. The amplification derivative is magnesium pyrophosphate, which gives a cloudy solution.[12,13]

The M-PREP (Preparation Medium) protocol was adopted. Whole blood is subjected to size exclusion chromatography to separate and purify nucleic acids. The M-PREP columns contain the matrix to purify the DNA, the buffer to facilitate cell lysis and elution. Whole blood is treated with 3 buffers: Buffer 1 enables lysis, Buffer 2 facilitates sample migration through the column using a non-reactive dye as an indicator, and Buffer 3 penetrates the column matrix to recover the purified DNA ready for the amplification phase.[12,13]

In the amplification phase, the nucleic acids obtained after extraction are placed in two chambers of a device, which contains a bead of lyophilized amplification reagent in each of the two chambers: a TEST chamber with primers specific to *Plasmodium* and a Control chamber with primers specific to human mitochondrial DNA.[12,13]

Assay validity

For assay validity, threshold values were predefined for the Control chamber. Indeed, final signal/initial signal ratios below 90% in the Control chamber were presented as Valid and, lead to the presentation of results in the test chamber (positive or negative). Final signal/initial signal ratios below 70% were presented by the machine as positive results, and ratios above 70% were presented as negative results. The machine printed the results after 25 minutes.[12,13]

Statistical analyses

Data were presented either as mean ± standard deviation (patient age) or frequencies and percentages (sex, profession, place of residence). The Chi² test was used to compare the proportion of cases between urban and rural areas. Similarly, factors associated with malaria were assessed either using the Chi² test for data relating to patients' sex and occupation, or the Student's t test to compare age between urban and rural patients All statistical analyses were performed using the software GraphPad Prism version 5.00 (GraphPad Software, San Diego, CA, USA, www.graphpad.com).

Ethical Approval and Consent to Participate

Ethical Clearance was obtained from the ethics committee of University of N'Zerekore (Reference Number: 0329/UZ/RECT/SG/2022). Before the start of this study, Commitment of the Researchers and Consent Form were signed between the participants and researchers conducting the study. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

RESULTS

Prevalence of malaria by area of residence

The results presented in table 1 and figure 2 show that 63.6% of malaria cases (178/280) originated in rural areas, compared with 36.4% (102/280) in urban areas. Although prevalence was numerically higher in rural areas, the difference was not statistically significant ($p = 0.12$, Chi² test). This suggests that malaria remains a public health problem in both areas, but contextual factors such as the population's access to healthcare and the density of mosquitoes that carry the disease could explain this trend.

Table 1: Distribution of patients by area of residence, age and sex

Parameter		Area of residence		p-value (Chi²)
		Rural (n=178)	Urban (n=102)	
Age groups	< 18 years	81 (45.51%)	50 (49.02%)	0.76
	18 - 35 years	67 (37.64%)	34 (33.33%)	
	> 35 years	30 (16.85%)	18 (17.65%)	
Genre	Male	78 (43.81%)	49 (48.04%)	0.47
	Female	100 (56.23%)	53 (52.02%)	

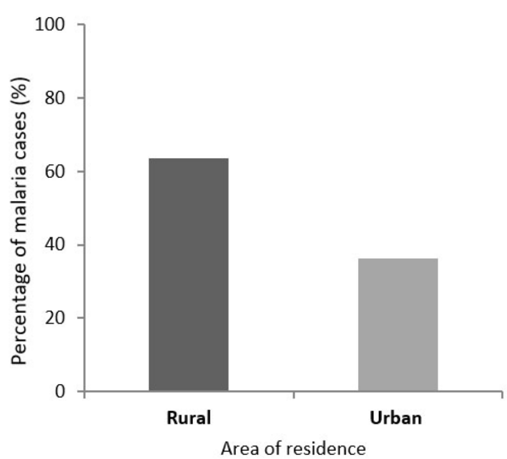

Figure 2: Prevalence of malaria by area of residence.

Distribution of patients by gender and age

The results presented in table 1, and figure 3 show that the study included male and female patients, ranging in age from under 18 to over 35. The absence of any significant difference in the distribution of patients by age group ($p = 0.76$) and gender ($p = 0.47$) indicates that malaria affects all demographic categories without distinction, regardless of area of residence. This reinforces the hypothesis of similar exposure to mosquito vectors and probably risk behaviours.

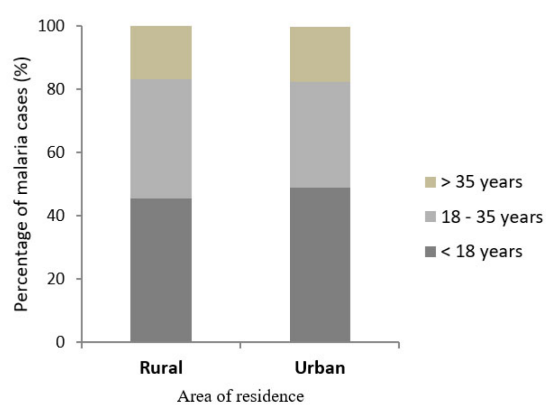

Figure 3: Distribution of age groups by area of residence.

Distribution of patients by occupation

The over-representation of farmers in rural areas (p = 0.03, Chi² with Bonferroni correction, Table 2, Figure 4) probably reflects permanent exposure to breeding sites, in this case irrigated fields and stagnant water. This result highlights the need to target agricultural workers as a priority in prevention campaigns (raising public awareness, distribution of impregnated mosquito nets, etc.). Add to this the poor access to health facilities in rural areas.

Table 2: Breakdown of patients by profession and area of residence

Occupation	Area of residence		p-value (Chi²)
	Rural (n=178)	Urban (n=102)	
Shopkeeper	90 (50.56%)	41 (40.2%)	0.03*
Manual worker	42 (23.6%)	30 (29.41%)	0.27
Employee	27 (15.17%)	20 (19.61%)	0.33
Farmer	12 (6.74%)	8 (7.84%)	0.73
Unemployed	7 (3.93%)	3 (2.94%)	0.66†

* Chi² test + Bonferroni multiple comparisons test significant at p < 0.05

† Fisher's exact test

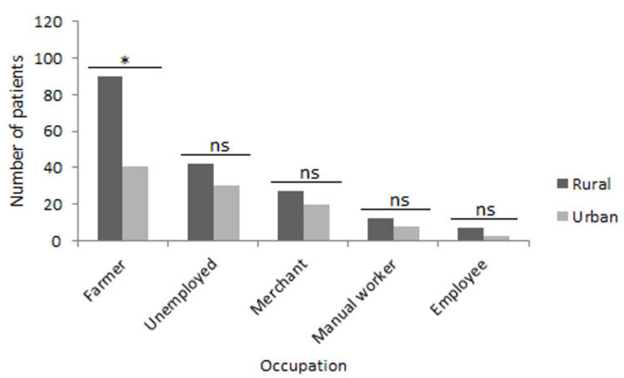

Figure 4: Comparison of occupations by area of residence. *Significant difference at p < 0.05. ns = not significant

DISCUSSION

The results obtained showed that 280 patients were diagnosed with malaria in urban and rural areas of Forest Guinea. The prevalence of malaria was numerically higher in rural areas, although the difference was not statistically significant (p = 0.12), which could indicate widespread endemicity of the disease in the region. These same observations were made by the National Malaria Control Programme (PNLP) in Guinea in 2014, which recorded 53% of malaria cases in rural areas compared with 18% of cases in urban areas. In addition, the Parasite Prevalence Survey of Malaria and Anaemia (EPPA) in Guinea in 2016 reported 66.08% of malaria cases in rural areas, compared with 32.98% in urban areas.[8,11]

In rural areas, economic inequality, neglect, routine-based partial consultations and widespread corruption are all factors that contribute to keeping people away from health facilities. Most health centres do not have diagnostic equipment to detect parasites. Patients have to travel long distances to find a health facility due to inadequate health infrastructure.[8,11] In this study, the occupation 'farmer' was significantly associated with rural areas (p = 0.03), highlighting a vulnerable group requiring targeted interventions by public authorities. These results differ from those found by Matembéra et al. in 2015 in DR Congo, who recorded the same percentage of malaria cases (77.52%) in rural and urban areas. Our findings are justified by the fact that farmers spend most of their time in the bush and are much closer to breeding sites, which are numerous in fields and stagnant water. These farmers are victims of Anopheles bites, easily contract and develop the disease, which leads to sick leave, resulting in considerable productivity losses and economic slowdowns not only at the regional level, but also at the national level.

The lack of significant variation by age or gender of patients diagnosed in this study indicates that control strategies should be comprehensive, without prioritizing certain demographic groups. Our results contrast with observations made by the 2016 Malaria and Anaemia Parasite Prevalence Survey, which recorded a high percentage of malaria patients in the under-18 age group, 41% in rural areas compared with 21% in urban areas. In this study, although variations between males and females were not statistically significant by area of residence, it should be noted that the number of patients of both sexes was numerically higher in rural areas. The conclusions of the studies initiated by the public authorities through the National Malaria Control Programme (PNLP) in Guinea in 2016 recorded slightly higher rates of malaria infection among female subjects living in rural areas (52%) compared with those in urban areas (44%).[8,11] This trend could be explained by the fact that in rural areas, women, who are more sedentary, stay longer in the fields until dusk, exposing them to Anopheles bites. In addition, girls and women who are regularly responsible for household chores (fetching water and cleaning the yard early in the morning or at dusk) carried out at times when Anopheles mosquitoes are active are also exposed.[8,11]

CONCLUSION

The results of our study show that malaria is endemic in rural and urban areas of Guinea's forest region. It constitutes a major public health problem and hinders the socio-economic development of communities. Malaria prevalence was higher in rural areas when associated with agriculture. These results highlight the importance of developing differentiated approaches according to environment (rural and/or urban) and occupation, while confirming the widespread impact of malaria on the population. A door-to-door awareness campaign should be conducted in all rural and urban communities. Health centres should be equipped with additional nursing staff and laboratory equipment to ensure reliable diagnosis.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTION

JFK participated in the design of the study and preparation of the manuscript. JFK, NAA, and MMK participated in the collection and analysis of the data, NAA and MMK participated in the correction of the manuscript. MSB and MCB participated in the proofreading of the manuscript. All authors read and approved the final version of the manuscript.

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