

Research Article

Epidemiological and Clinical Profile of Severe Malaria in Hospital Facilities in Mali: January–December 2024

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Abstract

Background: Mali is among the countries with the highest malaria burden worldwide, accounting for 3.1% of global malaria cases, 2.4% of global malaria-related deaths in 2023, and 6.6% of malaria cases in West Africa. The aim of this study was to describe the epidemiological and clinical profile of severe malaria among children aged 1 month to 15 years admitted to seven hospital facilities in Mali.

Methods: We conducted a descriptive cross-sectional study among children aged 1 month to 15 years hospitalized for severe malaria between January and December 2024 in seven hospitals across Mali: Foussemi Daou Hospital (Kayes, first administrative region), Regional Hospital of Koulikoro (second administrative region), Sikasso Hospital (third administrative region), Nianankoro Fomba Hospital (Ségou, fourth administrative region), Sominè Dolo Hospital (Mopti, fifth administrative region), Regional Hospital of Gao (seventh administrative region), and Gabriel Touré University Teaching Hospital (Bamako District).

Results: The highest frequency of severe malaria was recorded in Koulikoro (78.9%), followed by Gao (47.8%). Children under five years of age constituted the majority of cases in most hospitals, and males predominated in all study sites. Most admissions occurred during the rainy season, with a peak in October. Severe malarial anemia was the predominant clinical presentation in most hospitals, reaching 93.9% in Koulikoro and 63.5% in Gao. In contrast, neurological severe malaria predominated in Mopti (42.1%) and Sikasso (38.4%). The highest case-fatality rate was observed at Gabriel Touré University Teaching Hospital in Bamako (15.1%), whereas the lowest was recorded in Koulikoro (3.0%).

Conclusion: Severe malaria remains highly prevalent across all regions of Mali. Strengthening malaria prevention strategies could contribute to reducing the persistently high case-fatality rates observed in hospital settings.

INTRODUCTION

Malaria remains one of the greatest public health challenges in tropical countries, affecting millions of people every year [1]. It is a potentially life-threatening disease caused by the infection of red blood cells by protozoan parasites of the genus *Plasmodium*, which are transmitted to humans through the bites of infected female *Anopheles* mosquitoes belonging to the family *Culicidae* [2].

Despite significant progress in malaria control, the disease continues to pose a major global health burden. In 2024, an estimated 282 million malaria cases and 610,000 malaria-related deaths were reported worldwide [3]. This represents a slight increase compared with 2023, when 263 million cases and 597,000 deaths were recorded. It

is estimated that a child dies from malaria nearly every minute [4].

According to the World Health Organization (WHO), the African Region accounted for approximately 236 million malaria cases (95% of the global burden) and 590,935 deaths (97% of malaria-related deaths worldwide) in 2022 [4].

The WHO African Region remained the most heavily affected in 2024, accounting for 94% of global malaria cases and 95% of malaria-related deaths. Approximately 75% of malaria deaths in the region occurred among children under five years of age, who have not yet developed partial immunity against the parasite. Nearly two-thirds of the global malaria burden is concentrated

in eleven African countries: Burkina Faso, Cameroon, the Democratic Republic of Congo, Ghana, Mali, Mozambique, Niger, Nigeria, Sudan, Uganda, and the United Republic of Tanzania. Between 2017 and 2024, malaria incidence and mortality in these countries declined by approximately 1% and 14%, respectively. Over the period 2015–2024, the WHO African Region achieved a 2% reduction in malaria incidence and a 17% reduction in malaria mortality [3].

Mali is among the countries bearing the highest malaria burden worldwide, accounting for 3.1% of global malaria cases, 2.4% of malaria-related deaths in 2023, and 6.6% of all malaria cases in West Africa. Between 2022 and 2023, malaria incidence in Mali decreased by 2%, from 353 to 346 cases per 1,000 population at risk, while malaria mortality declined by 31%, from 0.87 to 0.60 deaths per 1,000 population at risk [4].

According to Doumbo et al. [5], Mali can be divided into five epidemiological malaria transmission zones:

- Long seasonal transmission zone (4–6 months): This corresponds to the southern Sudanian–Guinean ecological zone (Sikasso), where malaria transmission is holoendemic (continuous and intense). Partial immunity is generally acquired by the age of five years.
- Short seasonal transmission zone (3–4 months): This includes the northern Sudanian savannah and Sahel regions (e.g., Kangaba), where malaria is hyperendemic, with intense seasonal transmission. Partial immunity is usually acquired around nine years of age.
- Sub-Saharan northern zone: Malaria transmission is sporadic or epidemic in Gao, Timbuktu, and Kidal, as well as in some localities of Koulikoro (Nara) and Kayes (Nioro and Yélimané). Populations living in these areas are at increased risk of severe malaria.
- Inner Niger Delta and irrigated areas: This includes Selingué, Manantali, and Markala, where transmission is bimodal or multimodal and classified as mesoendemic, with transmission intensity varying according to local environmental conditions. Malaria-related anemia is particularly common among children younger than nine years.
- Low-transmission urban areas: Urban settings such as Bamako and Mopti are relatively unfavorable for malaria transmission because of environmental pollution, urbanization, and improved access to healthcare. These areas are considered hypoendemic, with low transmission intensity.

However, this hypoendemicity exposes urban children to severe and complicated malaria at older ages compared with children living in rural endemic areas.

The present study aimed to describe the epidemiological and clinical profile of severe malaria among children aged 1 month to 15 years admitted to seven hospital facilities across Mali, with the ultimate objective of contributing to improved strategies for reducing malaria-related morbidity and mortality.

PATIENTS AND METHODS

Study design and setting

We conducted a cross-sectional, descriptive, and analytical study from January 1 to December 31, 2024 (12 months).

The study included all children aged 1 month to 15 years who were hospitalized with severe malaria, confirmed by thick blood smear and/or malaria rapid diagnostic test (RDT), in seven hospital facilities across Mali:

- Fousseni Daou Hospital, Kayes (First Administrative Region);
- Regional Hospital of Koulikoro (Second Administrative Region);
- Sikasso Hospital (Third Administrative Region);
- Nianankoro Fomba Hospital, Ségou (Fourth Administrative Region);
- Sominè Dolo Hospital, Mopti (Fifth Administrative Region);
- Regional Hospital of Gao (Seventh Administrative Region);
- Gabriel Touré University Teaching Hospital (CHU Gabriel Touré), Bamako District.

Data collection

Data were extracted retrospectively from hospital admission registers and patients' medical records in the pediatric departments of the participating hospitals.

The variables collected included

- Sociodemographic characteristics: age, sex, and month of hospital admission;
- Clinical characteristics: clinical phenotype of severe malaria;

- Laboratory findings: thick blood smear and/or rapid diagnostic test (RDT) results;
- Outcome variables: patient survival or death during hospitalization.

Statistical analysis

Data entry and statistical analyses were performed using IBM SPSS Statistics version 27.0. Graphs were produced using Microsoft Excel 2013.

Descriptive statistics were used to summarize the data. Qualitative variables were expressed as frequencies and percentages.

For bivariate analysis, comparisons of proportions were performed using the Pearson chi-square test or Fisher's exact test, as appropriate. A two-sided p-value < 0.05 was considered statistically significant.

RESULTS

Sociodemographic characteristics

The highest proportion of severe malaria cases was recorded in Koulikoro (78.9%), followed by Gao (47.8%). Children younger than five years represented the majority of cases in most hospitals, except in Kayes (72.8%) and Gao (51.8%), where children aged five years and older predominated (Figure 1).

At Fousseni Daou Hospital (Kayes), children aged 5 years and older accounted for 72.8% of cases (Figure 2). The male-to-female ratio was 1.4, and malaria transmission peaked in October (19.9%) and November (19.8%) (Figure 3).

At the Regional Hospital of Koulikoro, children younger than five years represented 74.1% of patients. The male-to-female ratio was 1.4, with marked transmission peaks in October (26.8%) and November (26.3%).

At Sikasso Hospital, more than half of the patients

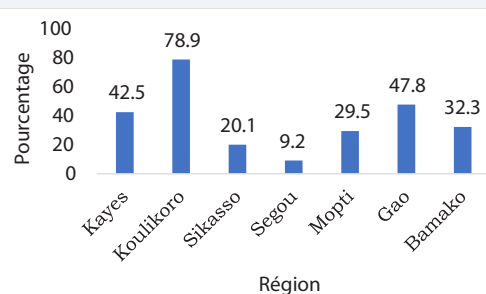


Figure 1 Distribution of patients by region

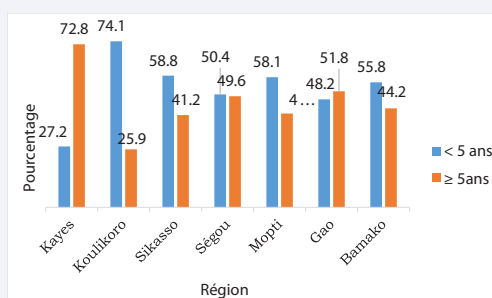


Figure 2 Distribution of patients by region and age

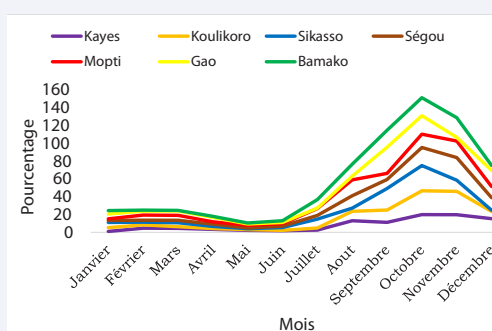


Figure 3 Distribution of patients by region and month of admission

(58.8%) were younger than five years. The male-to-female ratio was 1.4, and the highest numbers of admissions occurred in September (24.2%) and October (28.4%).

At Nianankoro Fomba Hospital (Ségou), children younger than five years accounted for 50.4% of admissions. The male-to-female ratio was 1.1, and the highest frequencies were observed in October (20.3%) and November (25.5%).

At Sominè Dolo Hospital (Mopti), children younger than five years represented 58.1% of patients. The male-to-female ratio was 1.7, with two transmission peaks occurring in August (17.8%) and November (18.5%).

At the Regional Hospital of Gao, located in northern Mali within a desert area, 51.8% of patients were five years of age or older. The male-to-female ratio was 1.3, and the highest number of admissions occurred in September (29.4%).

At Gabriel Touré University Teaching Hospital, a tertiary referral center, children younger than five years accounted for 55.8% of cases. The male-to-female ratio was 1.7, and November (22.1%) recorded the highest number of admissions.

Clinical characteristics

Severe malarial anemia was the predominant

clinical phenotype in most participating hospitals, with particularly high proportions in Koulikoro (93.9%) and Gao (63.5%). In contrast, neurological severe malaria was the predominant presentation in Mopti (42.1%) and Sikasso (38.4%).

At Fousseni Daou Hospital (Kayes), severe malarial anemia accounted for 43.2% of cases, neurological severe malaria for 41.2%, and the mixed phenotype (severe anemia plus neurological involvement) for 15.2%.

At the Regional Hospital of Koulikoro, severe malarial anemia was overwhelmingly predominant (93.9%), whereas neurological severe malaria represented only 0.9% of cases.

At Sikasso Hospital, neurological severe malaria was the leading clinical phenotype (38.4%), followed by severe malarial anemia (33.9%) and the mixed phenotype (20.1%).

At Nianankoro Fomba Hospital (Ségou), severe malarial anemia accounted for 36.2% of cases, neurological severe malaria for 35.1%, and the mixed phenotype for 25.8%.

At Sominè Dolo Hospital (Mopti), neurological severe malaria represented 42.1% of cases, severe malarial anemia 38.7%, and the mixed phenotype 18.5%.

At the Regional Hospital of Gao, severe malarial anemia was the predominant presentation (63.6%), followed by neurological severe malaria (24.6%) and the mixed phenotype (10.8%).

At Gabriel Touré University Teaching Hospital, severe malarial anemia accounted for 37.6% of cases, neurological severe malaria for 34.8%, and the mixed phenotype for 20.7% (Figure 4).

Outcomes

The highest case-fatality rate was recorded at Gabriel Touré University Teaching Hospital (15.1%), whereas the lowest was observed at the Regional Hospital of Koulikoro (3.0%) (Figure 5).

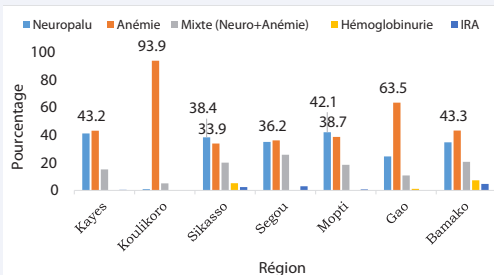


Figure 4 Distribution of patients by clinical phenotype across hospitals

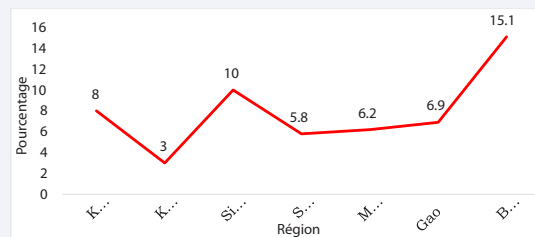


Figure 5 Distribution of hospital case-fatality rates

At Fousseni Daou Hospital (Kayes), the case-fatality rate was 8.0%. Significant associations were found between the clinical phenotype and mortality ($p = 0.001$), the clinical phenotype and age ($p = 0.001$), and age and mortality ($p = 0.006$).

At the Regional Hospital of Koulikoro, the case-fatality rate was 3.0%.

At Sikasso Hospital, located in southern Mali, the case-fatality rate reached 10.0%. Significant associations were observed between the clinical phenotype and age ($p = 0.011$) and between age and mortality ($p = 0.021$).

At Nianankoro Fomba Hospital (Ségou), the case-fatality rate was 5.8%. There was a significant association between the clinical phenotype and mortality ($p = 0.021$), as well as between the clinical phenotype and age ($p = 0.001$).

At Sominè Dolo Hospital (Mopti), the case-fatality rate was 6.2%. Significant associations were found between the clinical phenotype and mortality ($p = 0.010$) and between the clinical phenotype and age ($p = 0.001$).

At the Regional Hospital of Gao, the case-fatality rate was 6.9%. A significant association was observed between the clinical phenotype and age ($p = 0.001$).

DISCUSSION

Study limitations

The main limitations of this study were its retrospective design and the security situation in Mali, which complicated data collection from patients' medical records and hospital admission registers.

The hospital frequency of severe malaria was highest in Koulikoro (78.9%), followed by Gao (47.8%) and Kayes (42.5%). These findings are consistent with those reported by Doumbo et al. [5], who described Koulikoro, Kayes, and Gao as belonging to the Sudanian and Sahelian epidemiological zones, where malaria transmission is unstable and epidemics may occur. The high prevalence

observed in Mali may also be partly explained by the increasing resistance of malaria vectors to insecticides [6].

Bah et al. [7], reported a hospital frequency of 53.2% in Ségou in 2021, whereas Fofana [8], found 40.2% at Gabriel Touré University Teaching Hospital in 2024. Similar studies conducted in Niger, Guinea, and Madagascar reported frequencies of 62%, 52%, and 91.4%, respectively [9-11]. These variations are likely related to differences in geographical location, malaria transmission intensity, and epidemiological settings. Nevertheless, the consistently high frequencies observed across these studies confirm that severe malaria remains a major public health problem in sub-Saharan Africa.

Children younger than five years represented the largest proportion of patients in our study, accounting for 74.1% in Koulikoro, 58.8% in Sikasso, 50.4% in Ségou, 58.1% in Mopti, and 55.8% in Bamako. Similar findings have been reported by Keita et al. [12], Amadou et al. [9], and Andriatahirintsoa et al. [11], all of whom observed a predominance of severe malaria among children under five years of age.

This age distribution may be explained by the immaturity of the immune system and the absence of naturally acquired partial immunity in young children, supporting the need to strengthen preventive interventions targeting this vulnerable age group.

Conversely, children aged five years and older predominated in Kayes (72.8%) and Gao (51.8%). These regions are characterized by unstable malaria transmission, where repeated exposure to *Plasmodium* parasites is less frequent, resulting in delayed acquisition of protective immunity. These findings support extending Seasonal Malaria Chemoprevention (SMC) to older children in such epidemiological settings.

Male children predominated in all participating hospitals. Similar male predominance has been reported by Keita et al. [12], Fofana [8], Amadou et al. [9], and N'Guessan et al. [13], with male-to-female ratios ranging from 1.02 to 1.80.

Several hypotheses may explain this observation. Male newborns appear to have a less reactive innate immune response and experience a more rapid decline in maternally acquired passive immunity. In addition, boys may spend more time outdoors during dusk hours, thereby increasing their exposure to mosquito bites [14,15].

In all participating hospitals, severe malaria admissions peaked during the rainy season, particularly in October

and November. Peak transmission occurred in October in Kayes (19.9%), Koulikoro (26.8%), and Sikasso (28.4%), whereas Ségou and Mopti recorded their highest numbers of cases in November (25.5% and 18.5%, respectively).

These findings are consistent with those reported by Fofana [8], Diarra [16], and Keita et al. [12]. The rainy season provides favorable environmental conditions for mosquito breeding through the formation of numerous larval habitats. Increased humidity also prolongs the lifespan of adult mosquitoes, thereby enhancing malaria transmission [17,18].

Severe malarial anemia was the predominant clinical phenotype in Kayes (43.2%), Koulikoro (93.9%), Ségou (36.2%), Gao (63.5%), and Bamako (43.3%). These findings are in agreement with those of Amadou et al. [9], and Sogoba [19], who also identified severe anemia as the most frequent presentation.

The predominance of severe anemia can be explained by the rapid destruction of parasitized and non-parasitized erythrocytes, a well-recognized pathophysiological mechanism of severe malaria.

In contrast, neurological severe malaria predominated in Sikasso (38.4%) and Mopti (42.1%). This differs from the findings of Maiga et al. [20], who reported anemia as the most common manifestation in Sikasso. This discrepancy may be attributable to differences in the study populations, as their study included only children aged 0–5 years.

A significant association between clinical phenotype and age was observed in Kayes ($p = 0.001$), Sikasso ($p = 0.011$), Ségou ($p = 0.001$), and Mopti ($p = 0.001$).

Cerebral malaria occurred more frequently among older children (11–15 years), whereas severe malarial anemia mainly affected children younger than five years. This age-related pattern may be explained by the loss of maternally acquired antibodies after approximately six months of age, before effective naturally acquired immunity has developed. Young children are therefore more susceptible to intense parasitemia, accelerated erythrocyte destruction, limited iron stores due to rapid growth, and profound anemia. Conversely, cerebral malaria is primarily related to the cytoadherence of parasitized erythrocytes within the cerebral microvasculature, a complication more commonly observed in older children.

The highest case-fatality rate was observed at Gabriel Touré University Teaching Hospital (15.1%). Fofana [8], reported an even higher rate (20.8%) in the same institution. These figures exceed those reported by Keita et al. [12], (5.5%) and Sogoba [19] (2.8%).

The high mortality observed at Gabriel Touré University Teaching Hospital is likely explained by its role as a national tertiary referral center, receiving the most critically ill patients from other health facilities. Additional contributing factors include shortages of blood products during periods of intense malaria transmission and delays in referral and initiation of appropriate treatment.

In Sikasso, 82.2% of deaths occurred among children younger than five years, and a significant association was found between age and mortality ($p = 0.021$).

The lowest case-fatality rate (3.0%) was recorded at the Regional Hospital of Koulikoro. The close proximity of Koulikoro to Bamako may facilitate the referral of the most severe cases to Gabriel Touré University Teaching Hospital, thereby contributing to the lower mortality observed locally.

CONCLUSION

Malaria remains a public health problem, and the prevalence of severe malaria remains high in our country. Children under the age of five remain the most vulnerable, with high case-fatality rates.

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