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Parasitaemia at Presentation among Adolescents with Malaria in Libreville-Gabon: Findings from Routine Clinical Surveillance

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ABSTRACT

Background: *Adolescents are increasingly recognised as an epidemiologically relevant but under-targeted group for malaria in sub-Saharan Africa. However, clinical and operational data from Central Africa, including Gabon, remain limited.*

Methods: *We analysed routine data from the malaria sentinel surveillance site of the Estuaire Regional Hospital in Melen, Gabon. Febrile patients or those with a recent history of fever received free malaria testing. Adolescents aged 10–19 years with microscopy-confirmed malaria (quality-controlled thick blood smear using the Lambaréné method) were included. Parasitaemia was summarised using medians and interquartile ranges (IQR). Group comparisons used the Mann–Whitney U test; categorical comparisons used χ^2 or Fisher's exact test as appropriate.*

Results: *A total of 1,262 adolescents were included; median age was 13 years (IQR: 12–14) and 52.6% were male (sex ratio M/F 1.11). Median temperature at presentation was 38.0°C (IQR: 37.0–39.0). Overall median parasitaemia was 4,200 parasites/µL (IQR: 700–21,000). High parasitaemia (>100,000–250,000/µL) occurred in 4.0% and hyperparasitaemia (>250,000/µL) in 1.0% of cases. Parasitaemia did not differ by age group ($p = 0.118$) or sex ($p = 0.867$). Among participants with available data (n=96), prior self-medication was reported in 18.8% and was associated with markedly lower parasitaemia (242 [35–2,100] vs 10,500 [2,275–39,025] parasites/µL; $p < 0.001$).*

Conclusions: *Adolescents in this Gabonese sentinel site showed heterogeneous parasite burdens, including high-density infections, and self-medication strongly modified parasitaemia at presentation—supporting adolescent-inclusive surveillance and behavioural measurement in routine monitoring.*

Keywords

Malaria, Adolescents, Parasite density, Self-medication, Sentinel surveillance.

Introduction

Malaria remains a major public health problem in sub-Saharan Africa despite substantial progress achieved through the scale-up of vector control, diagnostic testing, and effective antimalarial treatment. While children under five years of age and pregnant

women have traditionally been prioritised in malaria control strategies, increasing evidence suggests that school-age children and adolescents (10–19 years) represent a substantial, yet insufficiently addressed, component of the malaria burden.

Over the past decade, a growing body of literature has highlighted that adolescents often exhibit malaria prevalence comparable to, or even higher than, that observed in younger children, particularly in settings of moderate to high transmission. School-based cohort studies conducted in Uganda have consistently shown high parasite prevalence among children aged 10–19 years, frequently exceeding that of younger age groups, despite lower rates of clinical presentation [1-3]. These findings challenge the assumption that increasing age is uniformly associated with reduced malaria burden and underscore the epidemiological relevance of adolescence.

A key feature emerging from these studies is the high proportion of asymptomatic or minimally symptomatic infections among adolescents. Several investigations have demonstrated prolonged parasite carriage in this age group, often undetected by routine healthcare services and therefore largely absent from national surveillance statistics [4,5]. Asymptomatic infections in adolescents have been shown to contribute disproportionately to malaria transmission, through sustained gametocyte carriage and continued exposure of mosquito vectors [6,7]. Collectively, these observations position adolescents as a silent reservoir of infection, insufficiently targeted by existing control strategies.

Beyond infection prevalence, the parasitological and haematological consequences of malaria during adolescence remain underappreciated. Contrary to the widespread perception that adolescents are largely protected against high parasite densities, several studies have reported non-negligible parasite loads, as well as a significant burden of chronic or recurrent anaemia in this age group [8-10]. Malaria-associated anaemia in adolescents is often multifactorial, interacting with nutritional deficiencies, helminth infections, and repeated low-grade parasitaemia. Importantly, these subclinical consequences have been associated with fatigue, impaired school performance, reduced physical capacity, and altered cognitive development, raising concerns that the impact of malaria during adolescence extends well beyond acute morbidity [11,12].

In parallel, the literature has identified risk factors that are specific or amplified during adolescence. Several studies have documented a progressive decline in insecticide-treated net use with increasing age, particularly among adolescents, who may sleep outside protected spaces, engage in nocturnal social activities, or display lower risk perception [13,14]. Socio-economic inequalities, school attendance patterns, and limited access to adolescent-friendly health services further contribute to delayed diagnosis and treatment. These behavioural and structural factors interact with biological exposure, creating a complex risk profile that is insufficiently addressed by child-centred malaria programmes.

Despite this growing evidence, important gaps remain. Adolescents continue to be underrepresented in malaria research compared with children under five years of age and pregnant women. When included, adolescents are often analysed as secondary subgroups, rather than as a population of interest in their own right. Moreover, much of the existing literature is derived from community-based or school-based surveys, with relatively few studies drawing on routine clinical or operational data, particularly in Central Africa, where malaria transmission patterns, urbanisation dynamics, and healthcare access differ from those in East and West Africa.

In Gabon, malaria remains endemic, with persistent transmission in both urban and semi-urban settings despite sustained control efforts. Sentinel surveillance systems have documented fluctuating malaria prevalence over time, reflecting heterogeneous exposure, behavioural factors, and evolving health system performance. However, data specifically focusing on adolescents remain scarce, and the parasitological profiles of adolescents presenting to routine care settings are poorly characterised. This gap limits the ability of national programmes to fully integrate adolescents into malaria surveillance, case management, and targeted interventions.

Thus, the present study aimed to describe parasite density patterns and associated factors among adolescents aged 10–19 years with microscopy-confirmed malaria attending a malaria sentinel surveillance site in Gabon. Using routinely collected clinical and laboratory data generated under real-world conditions, this study addresses a critical gap in the literature by providing clinical and operational evidence from an urban/semi-urban Central African context. By focusing on parasite density, age and sex patterns, and treatment-seeking behaviours such as self-medication, our findings contribute to ongoing debates regarding the role of adolescents in malaria epidemiology and offer insights with direct relevance for surveillance strategies and public health decision-making.

Methods

Study design and setting

This study was conducted using routinely collected data from the malaria sentinel surveillance site of the Estuaire Regional Hospital in Melen, Gabon. The site is part of the national malaria surveillance system and provides free malaria diagnostic testing for febrile patients. Surveillance and research activities at this site are coordinated by the Clinical and Operational Research Unit (URCO) of the Department of Parasitology, Mycology and Tropical Medicine, Université des Sciences de la Santé (USS), Gabon.

Study population

The study population consisted of children and adolescents presenting with fever or a recent history of fever who underwent malaria testing as part of routine clinical care at the sentinel site. For the present analysis, we included adolescents aged 10–19 years with microscopy-confirmed malaria. Patients aged ≥20 years and those with missing or invalid parasitaemia data were excluded.

Data collection

Data were retrospectively extracted from URCO malaria

surveillance registers, which systematically record demographic, clinical, and laboratory information for all patients tested at the sentinel site. Collected variables included age (in months), sex, body temperature at presentation, parasitaemia, prior antimalarial self-medication, and area of residence. All records were anonymised before analysis to ensure confidentiality.

Malaria diagnosis and laboratory procedures

Malaria diagnosis was performed by thick blood smear microscopy using the Lambaréné method, as originally described by Planche et al. Briefly, thick blood films were stained with Giemsa and examined by trained microscopists for parasite detection and quantification.

A quality control system based on double reading was implemented. Each slide was read independently by two experienced microscopists blinded to each other's results. In case of discordance, a third independent reading was performed, and the final result was determined by consensus. Parasite density was calculated and expressed as parasites per microlitre of blood (parasites/µL).

Definition of parasite density categories

Parasite density was categorised a priori into three groups based on clinically relevant thresholds:

- **Low parasitaemia**: ≤100,000 parasites/µL
- **High parasitaemia**: >100,000 to ≤250,000 parasites/µL
- **Hyperparasitaemia**: >250,000 parasites/µL

These thresholds were selected to reflect increasing parasite burden and potential clinical relevance in non-severe malaria.

Statistical analysis

All analyses were performed using tatview 5.0. Continuous variables were summarised using medians and interquartile ranges (IQR), given the non-normal distribution of parasite density. Categorical variables were described using frequencies and percentages. Comparisons of parasitaemia distributions between groups (age groups 10–14 vs 15–19 years, females vs males, and self-medication vs no self-medication) were performed using the Mann–Whitney U test. Associations between categorical variables and parasite density categories were assessed using the χ^2 test, or Fisher's exact test when expected cell counts were <5. A two-sided *p* value <0.05 was considered statistically significant.

Ethical considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. Patient confidentiality and data protection were strictly respected. The malaria sentinel surveillance site operates under official authorisation from the Ministry of Health of Gabon, which permits the use of routinely collected patient data for research purposes and for informing public health decision-making. As the study relied exclusively on anonymised routine surveillance data, individual informed consent was not required.

Results

Study population

A total of 1,158 adolescents aged 10–19 years with microscopy-confirmed malaria were included. The median age was 13.0 years (IQR: 11.0–15.0). Adolescents aged 10–14 years accounted for 77.0% of cases, while those aged 15–19 years represented 23.0%. The sex distribution was balanced, with a male-to-female ratio close to 1 (Table 1).

Table 1: Characteristics of adolescents with microscopy-confirmed malaria.

Variable	Value
N	1262
Age, median (IQR)	13.0 (12.0–14.0)
Age group 10–14, n (%)	975 (77.3)
Age group 15–19, n (%)	287 (22.7)
Male sex, n (%)	664 (52.6)
Bed net use, n (%)	0 (0.0)
Self-medication, n (%)	18 (1.4)
Parasitaemia, median (IQR)	4200 (700–21000)
High parasite density >100,000/µL, n (%)	63 (5.0)
Hyperparasitaemia >250,000/µL, n (%)	12 (1.0)

Overall parasite density

Parasite density showed a wide and right-skewed distribution. The overall median parasitaemia was 4,200 parasites/µL (IQR: 700–20,475 parasites/µL). Using predefined thresholds, both high parasite density (>100,000 parasites/µL) and hyperparasitaemia (>250,000 parasites/µL) were observed among adolescents (Figure 1).

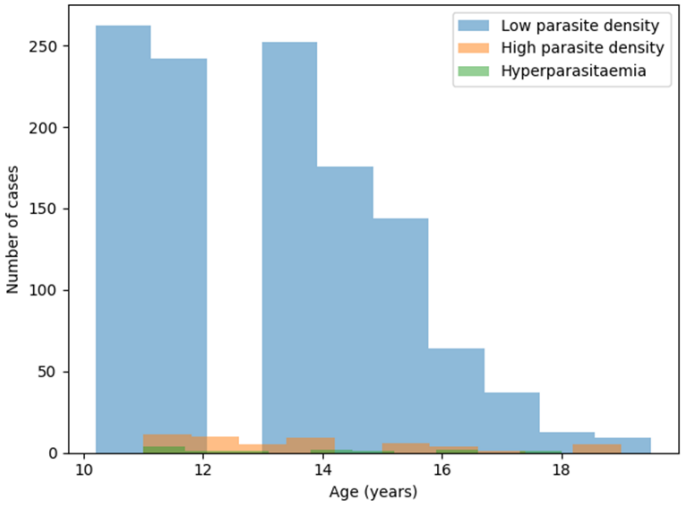

Figure 1: Parasitaemia according to age group.

Parasite density according to age

Parasite density did not differ significantly between age groups. Adolescents aged 10–14 years had a median parasitaemia of 3,733 parasites/µL (IQR: 700–19,688), compared with 5,600 parasites/µL (IQR: 838–21,000) among those aged 15–19 years (*Mann–Whitney U test, p = 0.118*). High parasite density and

hyperparasitaemia were nonetheless observed in both age groups, indicating that substantial parasite burdens persist throughout adolescence.

Parasitaemia according to sex

Median parasitaemia was comparable between sexes. Females presented a median parasite density of 4,081 parasites/µL (IQR: 700–19,525), while males had a median of 4,270 parasites/µL (IQR: 700–21,000). This difference was not statistically significant (*Mann–Whitney U test, $p = 0.867$*). Importantly, cases of high parasite density and hyperparasitaemia were documented in both sexes.

Impact of antimalarial self-medication on parasite density

In contrast, prior antimalarial self-medication was strongly associated with parasite density at presentation. Adolescents reporting self-medication had a markedly lower median parasitaemia of 242 parasites/µL (IQR: 35–2,100), compared with 10,500 parasites/µL (IQR: 2,275–39,025) among those who did not report self-medication. This difference was highly significant (*Mann–Whitney U test, $p < 0.001$*).

Despite lower median parasitaemia, cases of high parasite density and hyperparasitaemia were still observed among adolescents reporting self-medication.

Discussion

This study provides operationally relevant evidence from a long-standing malaria sentinel surveillance site in Gabon, showing that adolescents with microscopy-confirmed malaria can present with substantial and heterogeneous parasite densities, including very high burdens. These findings reinforce the increasingly recognised concept that school-age children and adolescents remain epidemiologically important and should not be treated as a "low-priority" group in routine malaria control.

Adolescents as a persistent reservoir and a programmatically relevant group

Although malaria control frameworks have traditionally focused on under-fives and pregnant women, several studies now indicate that school-age children and adolescents contribute disproportionately to the infectious reservoir, often through infections that are less likely to be captured and treated promptly. In Malawi, school-age children were described as an underappreciated reservoir of malaria infection, with implications for intervention targeting beyond early childhood [15]. In parallel, molecular and transmission-focused work has shown that school-age groups may account for a large share of onward transmission events and mosquito infections, supporting demographically targeted strategies [16-18]. More recently, data combining parasite and gametocyte metrics have further demonstrated that even when infections are asymptomatic, parasite density correlates positively with gametocyte density and infectiousness, reinforcing the biological plausibility of adolescents as contributors to transmission [19].

Taken together, this literature is consistent with our observation that adolescents at the sentinel site still carry a wide spectrum of parasite densities, including high-density infections, and supports the interpretation that adolescence may represent a critical "gap" age group for surveillance and control.

Age and sex patterns: interpretation in light of evidence

In our dataset, parasitaemia did not differ meaningfully by adolescent age subgroup or sex. This is not inconsistent with the broader literature, where age-related declines in parasite burden are neither linear nor uniform once individuals reach middle childhood, because exposure, immunity acquisition, and access to interventions become heterogeneous. In fact, reviews emphasise that infection risk and reservoir potential remain substantial across childhood and adolescence, particularly in settings with persistent transmission [20].

Similarly, sex differences in parasitaemia are often modest in children and adolescents, and when present may reflect behavioural or care-seeking differences rather than intrinsic biological susceptibility. In such contexts, programme design is usually better guided by exposure patterns and healthcare access than by sex alone.

Table 2: Parasitaemia profile by parasite density category.

	High parasite (>100,000-250,000/µL)	p (Low/High)	Low parasite (≤100,000/µL)	Hyper parasite (>250,000/µL)	P (Low/Hyper)
Median age, years (IQR)	13.0 (12.0–15.0)	0.223	13.0 (12.0–14.0)	13.5 (11.0–15.2)	0.717
Median temperature, °C (IQR)	38.0 (37.2–39.0)	0.462	38.0 (37.0–39.0)	37.5 (37.0–38.5)	0.264
Age groups					
10–14, n (%)	35 (68.6)	0.177	932 (77.7)	8 (66.7)	0.318†
15–19, n (%)	16 (31.4)		267 (22.3)	4 (33.3)	
Gender					
F, n (%)	30 (58.8)	<0.001†	563 (47.0)	3 (25.0)	0.219
M, n (%)	20 (39.2)		635 (53.0)	9 (75.0)	
Self medication					
Yes, n (%)	0 (0.0)	0.590†	18 (1.5)	0 (0.0)	0.97†
No, n (%)	6 (11.8)		72 (6.0)	0 (0.0)	

† Fisher's exact test was used when expected cell counts were <5; otherwise χ^2 test was applied.

Self-medication: a strong operational signal with clinical and surveillance implications

A key contribution of this study is the clear signal around prior antimalarial self-medication and parasitological profiles at presentation. Self-medication is widely documented across sub-Saharan Africa and is driven by barriers to access, cost, convenience, and perceptions of malaria as a familiar illness. A recent systematic review and meta-analysis underscores both the frequency of malaria self-medication and its structural drivers in the region [21].

From a mechanistic standpoint, lower parasite densities at presentation among self-medicating patients are biologically plausible and have been described in earlier work showing that antimalarial exposure before clinical assessment can reduce detectable parasitaemia without necessarily eliminating infection [22]. Crucially, however, partial treatment may also delay appropriate care, mask clinical severity, and complicate interpretation of routine surveillance data. In Gabon specifically, recent paediatric sentinel-site analyses have documented self-medication trends and their relationship to hospital attendance patterns, reinforcing the operational importance of measuring this variable routinely [23].

In practical terms, these findings suggest that sentinel-site surveillance should not treat self-medication as a minor covariate: it may be a major modifier of apparent parasite density and thus a source of bias when comparing parasite density distributions over time or across subgroups. Clinically, self-medication highlights the need to reinforce diagnostic confirmation and appropriate treatment pathways, particularly for adolescents who may delay formal consultation.

Laboratory approach and data quality considerations

Our results are strengthened by the use of quality-assured microscopy with parasite quantification. The Lambaréné method provides a rapid and robust alternative for thick film assessment and was explicitly described and validated for clinical use [24]. Comparative methodological work also emphasises that parasite quantification can vary by counting approaches and that validity/reliability considerations matter for interpretation and comparability across settings—supporting the value of standardised methods and quality control procedures in sentinel surveillance [14,25].

Public health and clinical implications

The findings support three actionable implications. Evidence increasingly supports school-age targeted approaches—such as school-based testing and treatment strategies, adolescent-focused health education, and youth-friendly access to diagnosis and effective case management—because this group contributes meaningfully to the infectious reservoir [15-18]. Beyond being a behavioural indicator, self-medication affects parasitaemia at presentation and can distort surveillance trends. Programmes should strengthen regulation of antimalarial access, improve community messaging, and promote rapid access to confirmed diagnosis and effective treatment [21-23]. without detailed clinical severity outcomes, categorising parasite density (including hyperparasitaemia) can flag clinically relevant presentations and identify subgroups where delayed care or inappropriate treatment practices may be occurring.

Limitations

The main limitations are inherent to routine sentinel data: incomplete information on timing/dose of self-medication, inability to measure asymptomatic carriage, and limited covariate depth for socio-economic or exposure-related drivers. Nonetheless, in a sentinel surveillance context, the strength of this work lies in its real-world operational relevance and its use of quality-assured microscopy.

Conclusion

In conclusion, our findings add evidence that adolescents remain a meaningful malaria group, with heterogeneous parasite burdens and a strong operational signal from self-medication. This supports expanding malaria surveillance and targeted interventions to adolescents and integrating self-medication as a routine variable in sentinel-site monitoring to improve both clinical management and the public health interpretation of parasitological trends.

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