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Epidemiological Assessment of Malaria Prevalence among Children Under 5 in Cameroon: A Cross-Sectional Study

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Abstract

Background: Malaria remains a significant public health challenge in Cameroon, particularly affecting children under 5 years of age. Despite these efforts, its prevalence persists, highlighting the need for comprehensive epidemiological studies to guide interventions.

Methods: A cross-sectional study was conducted in five randomly selected health areas across five regions of Cameroon. Data on sociodemographic profiles, insecticide-treated net utilization, and malaria incidence among children under 5 years of age were collected using structured questionnaires and rapid diagnostic tests. Statistical analysis was performed to identify factors associated with malaria positivity.

Results: The study included 1,200 households with children under 5 years of age, representing various sociodemographic profiles across regions. Among the respondents, 85% demonstrated a high awareness of malaria. While 92% reported ownership of insecticide-treated nets, only 67% reported consistent utilization. Alarmingly, 42% of children under 5 years of age tested positive for malaria. Factors associated with malaria positivity included the gender of the household head, marital status, insecticide-treated net availability, physical condition of insecticide-treated nets, and recent malaria episodes.

Conclusion: While the study provided valuable insights, limitations such as its cross-sectional design and potential biases necessitate caution in interpreting the results. To address these issues, rigorous data collection methods and statistical analysis were employed, emphasizing the importance of targeted interventions and ongoing surveillance to combat malaria effectively.

Keywords: Malaria, Cameroon, Children, Prevention

Introduction

Malaria represents a significant public health challenge worldwide. In 2021, there were an estimated 247 million cases of malaria worldwide (compared to 245 million cases in 2020), including 619,000 deaths (compared to 625,000 in 2020)[1]. The African Region, as reported by the World Health Organization (WHO), accounted for 95% of malaria cases and 96% of malaria-related deaths. Children under 5 years of age accounted for approximately 80% of all malaria deaths in the region. The region carries a disproportionately high share of the global malaria burden[1]. Among the 11 countries with the highest malaria burden, Cameroon has endemic malaria transmission [2]. In Cameroon, the entire population is exposed to

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malaria, and for this reason, this disease is highly endemic. According to the National Surveillance Report, every year, Cameroon registers approximately 6 million cases of malaria, and health facilities record approximately 4000 deaths, most of which occur in children younger than 5 years of age[3]. However, not all cases and deaths are recorded, and the WHO estimates that approximately 11,000 people die from malaria in Cameroon every year[3]. Approximately 30% of all outpatient visits to healthcare facilities are for malaria, making it a disease of great importance in Cameroon[3]. In 2021, the National Malaria Control Program (NMCP) of Cameroon reported 3,150,784 malaria cases and 3,863 deaths, representing 30% of the reasons for consultation, 29% in 2019 and 14.3% of deaths in health facilities in 2019, respectively, compared to 17.2% in 2020[4]. Children aged under five years are among the most vulnerable to malaria or serious consequences of the disease, especially in regions where transmission is intense[5]. This is because they have not yet developed immunity to malaria [6]. It is important to note that a child under 5 die of malaria almost every minute [7]. Among malaria-related deaths recorded worldwide in 2021, 77% occurred in children under 5 years of age, with an average of more than 1,000 children per day[7]. In 2019, in Cameroon, the proportional morbidity related to malaria in children under 5 years of age was 38.3%, for a mortality of 39.6% [8].

Despite extensive efforts, including vector control measures and enhanced treatment accessibility, malaria remains a formidable challenge for healthcare systems and communities across Cameroon. Given the sustained burden of malaria, especially among children under age 5 in Cameroon, there is an urgent need for comprehensive epidemiological studies to assess its prevalence and identify factors contributing to its transmission and persistence. Understanding these determinants is crucial for guiding targeted interventions and informing public health policies aimed at reducing disease incidence and improving health outcomes. Our study seeks to offer a comprehensive overview of malaria epidemiology in this demographic population, with a specific focus on identifying key factors associated with disease incidence.

Methods

To achieve our objective, we conducted a cross-sectional study with an analytical focus, employing a semiopen questionnaire. The study was carried out in five randomly selected health areas (Nsimeyong, Bépanda Omnisport, Ouro Kanadi, Ambam, and Fiala-Foréké) within five randomly selected regions of Cameroon (Centre, Littoral, North, South, and West, respectively). Data collection occurred in two phases (November 2020-July 2021 and December 2021-June 2022). The structured questionnaire encompassed inquiries into various domains, including the sociodemographic and economic profiles of the respondents, utilization of insecticide-treated nets (ITNs), and factors associated with malaria incidence.

To evaluate the physical condition of the ITNs, we followed the guidelines published in 2011 by the World Health Organization Pesticide Evaluation Scheme (WHOPES)[9]. These guidelines facilitate the assessment of the physical integrity of ITNs by quantifying the number of holes and calculating the proportionate hole index (pHI)[10]. The initial step involved determining hole sizes based on their approximate diameter relative to the thumb (0.5–2 cm), first (2–10 cm), head (10–25 cm), or larger than the head (≥ 25 cm). Holes with a diameter < 0.5 cm were excluded from the assessment, as the pHI method assumes that mosquitoes cannot pass through holes of this size [11]. The subsequent step involved determining the pHI by assigning weights to each hole based on its size and then summing these values for each net, as per the following formula [9]:

pHI= (n holes (a)) + (n holes (b) × 23) + (n holes (c) × 196) + (n holes (d) × 578)

where:

- n holes (a) = number of holes counted with diameter sizes between [0.5–2 cm]

- n holes (b) = number of holes counted with diameter sizes between [2–10 cm]

- n holes (c) = number of holes counted with diameter sizes between [10–25 cm]

- n holes (d) = number of holes counted with diameter ≥ 25 cm

The third step involved classifying ITN integrity based on the pHI into three categories: "good" (0 ≤ PHI ≤ 64; undamaged net with no reduction in efficacy), "acceptable" (65 ≤ PHI ≤ 642; efficacy reduced but still providing much greater protection than no net), and "too torn" (PHI ≥ 643; net to be replaced, significantly reduced protection) [9,12].

The malaria incidence was assessed by performing malaria RDTs by using the RDT VIKIA Malaria Ag P.f/Pan test (Biomerieux, France) to determine the malaria prevalence in children under 5 years of age. Children with a positive result were referred to one of the nearest health trainings for management according to national treatment guidelines.

The sampling included parents living with at least one child under 5 years of age in the health areas mentioned above during the study period. Only those parents who provided informed consent to participate in this study were included.

The data were initially entered into an Excel file, version 2016, and subsequently imported into R software, version

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4.1.3, for analysis. Normally distributed quantitative variables are reported as the means ± standard deviations, while nonnormally distributed variables are presented as medians with interquartile ranges. Qualitative variables are described as frequencies and percentages (%). Logistic regression analysis was employed to determine the factors associated with malaria incidence. Statistical significance was defined as a P value less than 5%.

Results

Sociodemographic characteristics

During our survey of 243 households, each with at least one child under 5, notable sociodemographic patterns emerged. Geographically, the North and West Cameroon regions accounted for the largest proportions, at 23.87% and 26.34%, respectively. Male-headed households slightly outnumbered female-headed households, comprising 58.44% and 41.56% of the total, respectively (Table 1). Most household heads were aged 31 to 40 years (41.56%), followed by those aged 21 to 30 years (34.98%). Marital status varied, with married individuals (22.63%) being slightly more prevalent than widowed and divorced individuals (22.63% and 21.81%, respectively) (Table 1). Education levels varied, with secondary education being the most common (29.63%), followed closely by primary education (30.45%). Regarding income, the majority reported earnings over 300,000 XAF (457.47 EUR), accounting for 37.86%, while incomes below 100,000 XAF (150.97 EUR) and between 200,000 and 300,000 XAF (304.98-457.47 EUR) represented 27.57% and 26.34%, respectively (Table 1).

Table 1: Sociodemographic characteristics

Variables	Modalities	Frequency (%)
Region	Centre	45 (18.52)
	Littoral	40 (16.46)
	North	58 (23.87)
	West	64 (26.34)
	South	36 (14.81)
Genre of the head of the household	Female	101 (41.56)
	Male	142 (58.44)
Age of the head of the household	21 to 30 years	85 (34.98)
	31 to 40 years	101 (41.56)
	41 to 50 years	21 (8.64)
	Over 50	36 (14.81)
Marital status	Single	64 (26.34)
	Cohabiting	16 (6.58)
	Divorced	53 (21.81)
	Married	54 (22.63)
	Widowed	55 (22.63)
Education level	Nonsolarized	58 (23.87)
	Primary	74 (30.45)
	Secondary	72 (29.63)
	University	39 (16.05)
Income	Less than 100.000 XAF (150.97 EUR)	67 (27.57)
	Between 100.000 and 200.000 XAF (152.49-304.98 EUR)	20 (8.23)
	Between 200.000 and 300.000 XAF (304.98-457.47 EUR)	64 (26.34)
	Over 300.000 XAF (457.47 EUR)	92 (37.86)

Knowledge about malaria

The surveyed population demonstrated a comprehensive understanding of malaria, with 100% awareness of the disease. Predominantly, respondents (90.12%) accurately identified malaria as a parasitic disease, while a smaller portion (9.88%) referred to it as contagious. Notably, no respondents associated malaria with hereditary factors, cancer, or witchcraft. All participants correctly recognized mosquitoes as the vector responsible for malaria transmission, indicating a solid grasp of disease transmission (Table 2). Prevention methods varied, with insecticide-treated nets (23.87%) being the most cited, followed by insecticides (34.16%) and incense (27.57%). Interestingly, no respondents mentioned other vulnerable groups besides children under 5 years of age (48.56%) or pregnant women with children under 5 years of age (41.15%). Overall, respondents demonstrated a medium (63.37%) to good (36.63%) level of knowledge about malaria, suggesting a strong foundation for targeted prevention efforts (Table 2).

Table 2: Knowledge about malaria

Variables	Modalities	Frequency (%)
Having heard about malaria	Yes	243 (0)
	No	0 (0)
Definition of malaria	parasitic disease	219 (90.12)
	Contagious disease	24 (9.88)
	Hereditary disease	0 (0)
	Cancer	0 (0)
	Witchcraft	0 (0)
Malaria vector	Fly	0 (0)
	Mosquito	243 (100)
	Bee	0 (0)
Time of day of the bite	Morning	0 (0)
	evening	243 (100)
	between sunset and sunrise	0 (0)

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Prevention methods	Insecticide treated net	58 (23.87)
	PID	0 (0)
	Insecticide	83 (34.16)
	Incense	67 (27.57)
	Mosquito net and Insecticide	35 (14.40)
Groups vulnerable to malaria	Children under 5	118 (48.56)
	Pregnant women	25 (10.29)
	Pregnant women and children under 5	100 (41.15)
	Elderly people	0 (0)
	Other	0 (0)
Level of knowledge about malaria	Low level	0 (0)
	Medium level	154 (63.37)
	Good level	89 (36.63)

ITN utilization among Children Under 5 Years Old

Regarding ITN utilization, we noted that all participants (100%) reported having at least one ITN. The majority (68.31%) possessed one ITN, 19.75% had two, and 11.93% had more than two (Table 3). Encouragingly, a high proportion (85.6%) of children under 5 slept under a mosquito net the previous night, underscoring the widespread use of ITNs for malaria prevention. An assessment of the physical condition of the ITNs used by the children revealed that 38.68% were in good condition, 36.63% were in acceptable condition, and 24.69% were damaged (Table 3).

Table 3: ITN Utilization among Children Under 5 Years Old

Variables	Modalities	Frequency (%)
Having at least one ITN in the household	Yes	243 (0)
	No	0 (0)
Number of ITN in the household	One	166 (68.31)
	Two	48 (19.75)
	More than two	29 (11.93)
Whether the child under 5 years old slept under the mosquito net last night	Yes	208 (85.6)
	No	35 (14.4)
pHI of ITN used by Child under 5 years old	Damaged	60 (24.69)
	Acceptable	89 (36.63)
	Good	94 (38.68)

Malaria incidence

During the survey, we assessed the incidence of malaria among children under 5 years of age in the past 12 months and 1 month, revealing that 51.44% and 24.28%, respectively, experienced malaria (Table 4). During our study, we also noted a P value of 37.

Table 4: Malaria incidence and prevention

Variables	Modalities	Frequency (%)
Whether the child under 5 years old suffered from malaria in the 12 months preceding the survey	Yes	125 (51.44)
	No	118 (48.56)
Whether the child under 5 years old suffered from malaria in the 1 month preceding the survey	Yes	59 (24.28)
	No	184 (75.72)
RDT results in children under 5	Negative	151 (62.14)
	Positive	92 (37.86)

Factors associated with malaria positivity in children under 5

To assess factors associated with malaria positivity, we conducted univariate and multivariate binary logistic regression tests. According to the univariate analysis, several factors were significantly associated with the probability of a positive RDT result in children under 5 years of age. These included gender of the head of the household (male: OR: 2.14, CI95%: 1.24-3.73, p = 0.0056), marital status (divorced: OR: 0.14, CI95%: 0.06-0.34, p < 0.0001; widowed: OR: 0.22, CI95%: 0.09-0.49, p = 0.0002), education level (primary: OR: 0.67, CI95%: 0.33-1.34, p = 0.2616; secondary: OR: 0.36, CI95%: 0.17-0.73, p = 0.0059; university: OR: 0.37, CI95%: 0.14-0.85, p = 0.0233), income (between 100000 and 200000 XAF: OR: 0.30, CI95%: 0.09-0.89, p = 0.0375; Over 300000 XAF: OR: 0.38, CI95%: 0.19-0.73, p = 0.0038), and number of ITNs in the household (Two: OR: 0.39, CI95%: 0.18-0.79, p = 0.0115; More than Two: OR: 0.19, CI95%: 0.05-0.51, p = 0.003), pHI of ITNs used by children under 5, and whether the child suffered from malaria in the 1 month preceding the survey (Yes: OR: 7.40, CI95%: 3.89-14.68, p < 0.0001) (Table 5). In the multivariate analysis, significant predictors of a positive RDT result included gender of the head of the household (male: OR: 3.05, CI95%: 1.22-7.88, p = 0.0187), marital status (widowed: OR: 0.16, CI95%: 0.05-0.51, p = 0.0023), number of ITNs in the household (two: OR: 0.57, CI95%: 0.18-1.73, p = 0.3182), pHI of ITNs used by children under 5 (acceptable: OR: 0.20, CI95%: 0.07-0.55, p = 0.0022; good: OR: 0.08, CI95%: 0.03-0.22, p = <0.0001), and whether the child suffered from malaria in the 1 month preceding the survey (yes: OR: 7.61, CI95%: 3.18-19.37, p < 0.0001) (Table 5).

Discussion

The sociodemographic profile revealed intriguing insights into the households surveyed. The geographic distribution suggests a balanced representation, with the North and West regions comprising 23.87% and 26.34% of the households, respectively. This diversity highlights the broader applicability of the study's findings across Cameroon. Male-headed households were more common (58.44%)

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Table 5: Factors associated with malaria positivity in children under 5

		Probability of obtaining a positive RDT in children under 5 (Univariate binary logistic regression)			Probability of obtaining a positive RDT in children under 5 (Multivariate binary logistic regression)		
Variables	**Modalities**	**OR (IC95%)**	**P.Value**	**Global P.Value**	**OR (IC95%)**	**P.Value**	**Global P.Value**
Region (Ref: Centre)	Littoral	1.08 (0.43-2.65)	0.8715	0.225	NA	NA	NA
	North	1.87 (0.84-4.24)	0.129		NA	NA	
	West	0.84 (0.37-1.93)	0.686		NA	NA	
	South	1.60 (0.65-3.98)	0.3079		NA	NA	
Age of the head of the household (Ref: 21 to 30 years)	31 to 40 years	0.89 (0.49-1.62)	0.722	0.5031	NA	NA	NA
	41 to 50 years	0.44 (0.13-1.25)	0.148		NA	NA	
	Over 50	0.81 (0.35-1.79)	0.603		NA	NA	
Gender of the head of the household (Ref: Female)	Male	2.14 (1.24-3.73)	0.0056*	0.0056*	3.05 (1.22-7.88)	0.0187*	0.0161*
Marital status (Ref: single)	Cohabiting	0.33 (0.09-1.02)	0.0639	<0.0001*	0.19 (0.03-1.16)	0.0754	0.0027*
	Divorced	0.14 (0.06-0.34)	<0.0001		0.13 (0.04-0.43)	0.0012*	
	Married	0.76 (0.36-1.56)	0.4511		0.60 (0.19-1.81)	0.3704	
	Widowed	0.22 (0.09-0.49)	0.0002		0.16 (0.05-0.51)	0.0023*	
Education level (Ref: Non Scolarized)	Primary	0.67 (0.33-1.34)	0.2616	0.0189*	2.47 (0.85-7.75)	0.1076	0.1181
	Secondary	0.36 (0.17-0.73)	0.0059		1.01 (0.32-3.31)	0.9964	
	University	0.37 (0.14-0.85)	0.0233		0.62 (0.16-2.38)	0.4866	
Income (Ref: Less than 100000 XAF (152.49 EUR)	Between 100000 and 200000 XAF (152.49-304.98 EUR)	0.30 (0.09-0.89)	0.0375*	0.0172*	0.76 (0.14-3.78)	0.7404	0.5476
	Between 200000 and 300000 XAF (304.98-457.47 EUR)	0.59 (0.29-1.17)	0.1314		1.78 (0.50-6.48)	0.3741	
	Over 300000 XAF (457.47 EUR)	0.38 (0.19-0.73)	0.0038*		1.99 (0.64-6.37)	0.2353	
Level of knowledge about malaria (Ref: Good level)	Medium level	0.48 (0.87-2.54)	0.1466	0.1466	NA	NA	NA
Number of ITN in the household (Ref: One)	Two	0.39 (0.18-0.79)	0.0115*	0.0003*	0.57 (0.18-1.73)	0.3182	0.0105*
	More than Two	0.19 (0.05-0.51)	0.003*		0.12 (0.02-0.51)	0.0068*	
Whether the child under 5 years old slept under the mosquito net last night (Ref: No)	Yes	1.63 (0.76-3.71)	0.2131	0.2131	NA	NA	NA
pHI of ITN used by Children under 5 (Ref: Damaged)	Acceptable	0.12 (0.06-0.27)	<0.0001*	<0.0001*	0.20 (0.07-0.55)	0.0022*	<0.0001*
	Good	0.15 (0.08-0.32)	<0.0001*		0.08 (0.03-0.22)	<0.0001*	
Whether the child under 5 years old suffered from malaria in the 12 months preceding the survey (Ref: No)	Yes	2.30 (1.35-3.95)	0.0022*	0.0022*	1.19 (0.43-3.30)	0.7321	0.7317
Whether the child under 5 years old suffered from malaria in the 1 month preceding the survey (Ref: No)	Yes	7.40 (3.89-14.68)	<0.0001*	<0.0001*	7.61 (3.18-19.37)	<0.0001	<0.0001*

*= statistically significant result (P value < 0.05)

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than female-headed households (41.56%), and 41.56% of household heads were aged 31 to 40. These findings align with those of studies by Smith and Whittaker and Clark et al., indicating a similar demographic trend in malaria-endemic regions [13,14]. Knowledge about malaria was high, with 100% of respondents familiar with the disease and 90.12% correctly identifying it as a parasitic disease transmitted by mosquitoes. These findings are consistent with studies in Cameroon, Ethiopia, and Kenya, which also reported high awareness and accurate knowledge of malaria transmission [15–17]. This underscores the effectiveness of public health campaigns in disseminating information on malaria prevention and control.

The high ownership and utilization of insecticide-treated nets (ITNs) among children under age 5 in our study area align with national malaria control efforts in Cameroon. The extensive distribution of ITNs and educational campaigns promoting their use have led to significant uptake among households [18]. Specifically, 85.6% of children under 5 slept under a mosquito net the previous night, with 38.68% of the nets in good condition. These findings align with those of studies by Eisele et al. and Lengeler, who demonstrated the effectiveness of ITNs in reducing malaria transmission [19,20]. However, 61.32% of children under 5 slept under nets in fair condition, highlighting the need to reinforce ITN awareness and maintenance. Despite these achievements, challenges remain, including a high malaria incidence among children under 5, with 51.44% experiencing malaria in the past 12 months and 24.28% in the past month. This underscores the persistent threat of malaria in Cameroon and the need to address underlying determinants to reduce morbidity and mortality, consistent with findings by Tusting et al. and Hemingway et al. [21,22]. Factors influencing malaria positivity among children under 5 include the gender and marital status of the household head, the quantity and quality of ITNs, and recent malaria episodes. Male-headed households exhibited a significantly higher likelihood of positive RDT results compared to female-headed ones (OR = 2.14, p = 0.0056), possibly due to differing health prioritization. However, this contradicts studies like Shino et al. (2022), where mother-headed households faced increased malaria risk due to socioeconomic factors. Female-headed households in Togo were vulnerable to catastrophic health expenditures, indicating heightened malaria risk from inadequate prevention and poor living conditions [23]. Marital status showed significant associations, with divorced and widowed heads having a lower probability of a positive RDT than single heads (divorced: OR = 0.14, $p < 0.0001$; widowed: OR = 0.22, p = 0.0002). This may be due to heightened awareness of health risks following disruptive events, leading to increased prioritization of disease prevention and proactive health measures.

The number of ITNs in the household also showed significance. More ITNs were associated with lower odds of a positive RDT (two: OR = 0.39, p = 0.0115; more than two: OR = 0.19, p = 0.003). This result highlights the importance of the availability of insecticide-treated nets for malaria prevention among children under five years of age. This finding is consistent with previous studies demonstrating that households with more than one ITN were more likely to obtain a negative malaria result [24]. This suggests that the availability of multiple insecticide-treated nets in a household can reduce the risk of malaria transmission by providing increased protection against bites from infected mosquitoes. These results emphasize the need for efforts to enhance access to ITNs in regions where malaria is endemic, particularly in households with young children. Regarding the physical condition of the ITNs where children sleep, we observed that the condition of the ITNs was highly significant. ITNs in good or acceptable condition showed significantly lower odds of yielding a positive RDT result compared to damaged ITNs (acceptable: OR = 0.12, $p < 0.0001$; good: OR = 0.15, $p < 0.0001$). This finding is consistent with numerous studies and underscores the importance of the condition of insecticide-treated nets in malaria prevention [11,25,26]. Compared with a damaged ITN, a well-maintained ITN provides increased protection against bites from infected mosquitoes. This highlights the need for awareness and education programs on ITN maintenance to optimize their effectiveness in regions where malaria is endemic. Regarding recent episodes of malaria, children who had experienced malaria in the preceding month had significantly greater odds of testing positive on the RDT (OR = 7.40, $p < 0.0001$). This may be explained by the fact that children who have recently had malaria may have a higher parasite load, increasing the likelihood of detecting the infection through the RDT. Additionally, these findings underscore the importance of prompt and effective management of malaria to prevent complications and reduce disease transmission.

Conclusion

Our study sheds light on malaria epidemiology among children under age 5 in Cameroon, revealing persistent challenges despite progress in malaria control. The high incidence among this group underscores the need for context-specific interventions tailored to diverse geographic and household characteristics. While knowledge about malaria and ITN ownership is high, consistent utilization and maintenance gaps remain. Addressing these issues through targeted education and awareness campaigns is crucial. Additionally, underlying social determinants such as gender, marital status, and socioeconomic factors significantly influence malaria risk. Improving ITN access, promoting proper use, and timely malaria management are essential.

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A sustained investment in comprehensive control strategies and robust research efforts are vital for reducing malaria morbidity and mortality.

Limitations

This study has several limitations to consider, including the use of a cross-sectional methodology that restricts the establishment of causal relationships, the risk of bias in data collection and interpretation, its limited geographical scope, and potential variations in result evaluation. To address these issues, appropriate statistical methods were employed, data collection was rigorously conducted with enhanced validation and awareness, and representative samples were selected to ensure the reliability and validity of the conclusions.

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Ethical declaration

Ethics approval: To conduct this study. We obtained the approval of the National Committee of Ethics Research for Human Health of Cameroon.

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Consent to participate: All participants voluntarily contributed to this study and provided informed consent prior to their participation, ensuring ethical approval throughout the research process.

Conflict of interest: The authors declare that they have no conflicts of interest.

Availability of data and materials

All datasets on which the conclusions of the research rely are presented in this paper. However, the data are available from the corresponding author upon reasonable request.

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