

RESEARCH ARTICLE

EVALUATION OF MALARIA VACCINATION WITH RTS,S/AS01 (MOSQUIRIX™) AMONG CHILDREN ATTENDING TWO DISTRICT HOSPITALS IN THE CENTRAL REGION OF CAMEROON

Nfor Omarine Nlinwe¹, Tingwick Junior Mbah¹

¹Department of Medical Laboratory Science, Faculty of Health Sciences, The University of Bamenda, P.O Box 39, Bambili, Northwest Cameroon.

Received: 12 August, 2026 /Revision: 20 August, 2026 /Accepted: 28 September, 2026

ABSTRACT Malaria is a major cause of illness and death among children under five in sub-Saharan Africa. Recent progress in vaccine development, including RTS,S/AS01 shows promise for disease control with encouraging efficacy and safety profiles. This cross-sectional study assessed malaria prevalence and vaccination coverage among children under five years in two district hospitals, Soa and Biyem-Assi, in the Central Region of Cameroon. Among 450 children, 19.56% (88/450) tested positive for malaria, while 47.11% (212/450) had received at least one malaria vaccine dose. Malaria prevalence was lower among vaccinated than unvaccinated children (13.21% vs. 25.21%; OR=0.45, 95% CI: 0.28–0.73; p=0.0013). Rural residence was associated with higher malaria prevalence (30.77% vs. 18.09% in urban areas; p=0.0302). Among vaccinated children, malaria was significantly associated with age, residence, household income, number of vaccine doses, and time since the last dose. In multivariable analysis, ≥ 3 vaccine doses were associated with lower odds of malaria infection (AOR=0.33, 95% CI: 0.19–0.57; p<0.001), while ≥ 3 months since the last dose was associated with higher odds (AOR=2.22, 95% CI: 1.52–3.25; p<0.001). Vaccination status itself was not significantly associated with malaria after adjustment (AOR=1.10, 95% CI: 0.29–4.15; p=0.886). Although vaccinated children had lower malaria prevalence in the crude analysis, vaccination status was not independently associated with malaria infection after adjustment. Completion of the recommended vaccine doses and timely receipt of subsequent doses were associated with lower malaria infection, highlighting the importance of maintaining the recommended vaccination schedule.

Keywords: Malaria; Malaria vaccine; Children; Soa District Hospital, Biyem-Assi District Hospital.

Corresponding Author:

Mr. Nfor Omarine Nlinwe,

Department of Medical Laboratory Science, Faculty of Health Sciences, The University of Bamenda, P.O Box 39, Bambili, Northwest Cameroon.

Email: omarinenlinwe@yahoo.ca



INTRODUCTION:

Malaria remains a leading cause of morbidity and mortality among children under five years old, particularly in sub-Saharan Africa ^[1]. Significant efforts have been directed toward developing effective malaria vaccines, with recent breakthroughs offering promising prospects for disease control ^[2,3]. Notably, the *RTS,S/AS01* vaccines have demonstrated varying levels of efficacy and safety profiles across diverse endemic setting ^[4-9]. Trials, conducted in Burkina Faso and other endemic countries, reveal that the malaria vaccine elicits strong antibody responses correlated with protection, especially among younger children ^[2]. The *RTS,S/AS01* (MosquirixTM) vaccine demonstrated a significant reduction in severe malaria cases and overall disease burden when integrated into routine immunization programs, receiving WHO prequalification in 2021^[10-12]. Though the schedule for vaccine doses differs by country, in all cases, the first dose is administered at 5 or 6 months of age, with the fourth dose given at either 18, 22, or 24 months ^[13]. In most trials of the *RTS,S/AS01* malaria vaccine, it was found to reduce severe and symptomatic malaria by approximately 30% to 50%. However, this level of protection decreases over time, requiring booster doses. The malaria vaccines face challenges related to waning immunity over time, highlighting the need for booster doses and additional control strategies to sustain protection, especially in high-transmission settings ^[14-15]. Combining malaria vaccination with other interventions such as seasonal malaria chemoprevention has shown to provide sustained protection over multiple years, outperforming singular approaches^[16]. Such integrated strategies are vital, particularly in regions with seasonal transmission, and are supported by ongoing phase 3 and phase 4 studies to evaluate long-term safety and effectiveness under real-world conditions^[8,16]. Despite the benefits demonstrated, achieving widespread acceptance and high coverage remains a major challenge. Studies in Ghana and other African contexts reveal that caregiver perceptions, awareness of malaria, and trust in health systems

significantly influence vaccine uptake ^[17,18]. Positive attitudes are often driven by understanding the severity of malaria and the perceived benefits of vaccination; however, concerns about side effects and misconceptions persist, especially in rural settings where access to education and healthcare services is limited ^[17,19]. Similar patterns are observed in Bangladesh, where awareness levels about malaria vaccines remain limited, and socioeconomic disparities influence vaccine coverage. Targeted health education involving health professionals has been emphasized as crucial in improving understanding and acceptance^[20]. The literature underscores that socioeconomic status, maternal education, ethnicity, and geographic location are key determinants of vaccination coverage and malaria risk. For instance, children in urban areas tend to have lower malaria prevalence due to better access to healthcare and vector control measures, whereas rural populations face higher disease burdens and lower vaccination rates ^[18]. On January 22, 2024, Cameroon integrated the malaria vaccine into its routine immunization schedule in 42 districts, all of which are considered high-risk areas for malaria. By February 21, 2024, a total of 13,811 children had received their initial vaccine dose, with 36% vaccinated via outreach sessions and 61.5% through fixed vaccination posts ^[21]. The pilot implementation of the pre-erythrocytic malaria vaccine *RTS,S/AS01* for children under 5 years was launched in the Foubot and Fouban health districts in the West Region of Cameroon ^[22]. Vaccination coverage was low with only 17.4% receiving the first dose, 6.6% the second, and 5.3% the third. Despite this, approximately 67% of respondents had knowledge about the malaria vaccine, and 82.16% of parents expressed a desire to have their children vaccinated ^[22]. Despite malaria vaccine integration into the routine immunization, vaccination uptake and malaria prevalence may vary substantially across different settings. Recognizing the importance of understanding these variations, this study was conducted to examine malaria vaccination uptake and malaria prevalence among children attending

two district hospitals in the central region of Cameroon.

METHODS:

Study area

This study was conducted at two district hospitals: Soa District Hospital and Biyem-Assi District Hospital, both situated in the Central Region of Cameroon. The central region of Cameroon, with Yaoundé as its capital city, consists of 31 Health Districts. The Yaoundé central region experiences the climate characterized by four seasons: a long rainy season (March to June), a short dry season (July to August), a short rainy season (September to November) and a long dry season (November to March). The average annual rainfall is approximately 1,700 mm, and temperatures generally range between 23°C and 25°C [23]. The Biyem-Assi Health District is the largest and most densely populated within Yaoundé. It is an urban district covering an area of 22 km² and is divided into four health areas: Melen, Mendong, Biyem-Assi, and Mvog-Betsi. Biyem-Assi is situated in the northern part of Yaoundé and features a mix of residential, commercial, and administrative zones [24]. The region experiences a typical tropical climate with a distinct rainy season and warm temperatures averaging between 23°C and 27°C throughout the year. Biyem-Assi located in Yaoundé, is found between *latitude* 3.83409° or 3° 50' 3" north and, *longitude* 11.48502° or 11° 29' 6" east. The Biyem-Assi health district comprises 11 health areas and includes a total of 159 health facilities distributed across these areas and an estimated population of approximately 150,000 to 200,000 residents [24,25].

Soa is located west of the Mefou-Afamba division, and it is one of the eight sub-divisions that make up the Mefou-Afamba division. Located in the central region of Cameroon, Soa is found between latitudes 4° 8' 30" and 4° 52' 0" North, and longitudes 11° 29' 30" and 11° 39' 30" East. Soa has a total population of approximately 30,588 and covers an area of 326 km², with an average elevation of 700 meters. The municipality of Soa is the host to Yaounde II University and

approximately 25% of the population of Soa is the population in transit. The health care facilities of Soa are made up of five health areas namely: Soa, Ntouessong, Ebang, Ngali and Tin Melen health areas [26]. The Soa District Hospital is located in the Soa health facility and is the key healthcare facility serving the Soa District.

Study participants

The participants included children aged five years and below, whose parents or primary care givers provided consent for their participation. These children aged five years and below included those who had received at least one dose of the malaria vaccine at Soa District Hospital (one of the malaria vaccine pilot centers) and children aged five years and below attending Biyem-Assi District Hospital. The children who had not received the malaria vaccine were selected from Biyem-Assi District Hospital, while the vaccinated children were from the Soa District Hospital. Children currently receiving malaria treatment at the time of data collection were excluded from the study.

Sample size determination

The following single proportion formula for cross-sectional studies was used to calculate the sample size, with 95% confidence interval, 5% margin of error and assuming $p = 42\%$ for the prevalence of malaria among children under five years in Cameroon [27].

$$N = Z^2 pq / d^2$$

$$Z^2 = (1.962)^2, p = 42\% (0.42), q = (1 - p), d^2 = (0.05)^2$$

Estimated minimum sample size, $N = 375$.

Ethical considerations

This study was conducted in accordance with the Declaration of Helsinki and complied with all relevant ethical standards. Approval to undertake the study was granted by the Institutional Review Board (IRB) of the University of Bamenda (Ref No 2025/0198H/UBa/IRB) and from the Central

Regional Ethics Committee for Human Health Research. Additionally administrative clearance was obtained from the Director of the Soa District hospital and the Director of the Biyem-Assi District hospital. Written informed consent was gotten from all participants prior to their inclusion in the study, including consent to publish the findings. The data collected were anonymised to ensure confidentiality and privacy of participants' information throughout the research.

Data collection and analysis.

This study was a descriptive cross-sectional design that employed a non-probability sampling method, specifically convenience sampling, to select participants from vaccination centers and outpatient departments. Data for this study were collected through a self-administered structured questionnaire and the use of rapid diagnostic tests (RDT) for malaria. Specifically, the RDT product used was the CareStart™ Malaria Pf (HRP2) Ag RDT, manufactured by Access Bio and, the target antigen being *Plasmodium falciparum* histidine-rich protein 2 (PfHRP2). The results were confirmed using the microscopy test method^[28].

The questionnaire was developed to gather socio-demographic data as well as information related to vaccination, including the child's vaccination status, the number of doses received, and the

timing of the vaccination. Data was entered, cleaned, and analyzed using appropriate statistical methods. Descriptive statistics were used to summarize participants' demographic and socioeconomic characteristics. The prevalence of malaria infection was determined and compared across relevant categorical variables using the chi-square test, with odds ratios (ORs) and 95% confidence intervals (CIs) used to measure associations. Binary logistic regression was subsequently performed to identify factors independently associated with malaria infection and malaria vaccination status. Variables were adjusted simultaneously in multivariable models, and adjusted odds ratios (AORs) with 95% CIs were reported. Statistical significance was set at $p < 0.05$.

RESULTS:

A total of 450 children were recruited for this study. The majority (69.33%) of children in this study were aged between 0 and 1 year, with 56% being females. Most (88.44%) of the participants resided in urban areas, and 49.78% had household sizes of 3 to 5 people. Additionally, 62.22% of the parents or guardians had attained tertiary education, while 25.78% were engaged in business activities. Furthermore, 76% reported a monthly income of less than 120,000 FCFA (see Table 1).

Table 1: Demographic and Socioeconomic Characteristics of the Study Population

Variable	Category	Frequency, N = 450	Percentage
Age(years)	0 to 1	312	69.33
	2 to 4	138	30.67
Sex	Male	198	44
	Female	252	56
Residence	Urban	398	88.44
	Rural	52	11.56
Household Size (Persons)	1 to 2	50	11.11
	3 to 5	224	49.78
	6 to 8	138	30.67
	> 8	38	8.44
Educational Level of Parent/guardian	No formal Education	8	1.78
	Primary	28	6.22

Occupation of Parent/guardian	High school	134	29.78
	Tertiary	280	62.22
	Unemployed	46	10.22
	Farmer	14	3.11
	Teacher	68	15.11
	Health worker	50	11.11
	Businessperson	116	25.78
	Others	156	34.67
Monthly Income of Parent/guardian (FCFA)	< 120,000	342	76
	≥ 121,000	108	24

Overall, 19.56% (88 out of 450) of the children tested positive for malaria, and 47.11% (212 out of 450) had received at least one dose of the malaria vaccine. The prevalence of malaria among vaccinated children was 13.21% (28/212), whereas it was 25.21% (60/238) among unvaccinated children. An odds ratio of approximately 0.45 indicates that vaccinated children have about 55% lower odds of testing positive for malaria compared to unvaccinated

children. Malaria prevalence was higher among children living in rural areas (30.77%) compared to those in urban areas (18.09%). The odds ratio of 0.5 suggests that children in urban settings have half the odds of testing positive for malaria compared to their rural counterparts. There was no significant association between malaria prevalence and factors such as age groups, sex, parental education level, or household monthly income (see **Table 2**).

Table 2: Factors Associated with Malaria Infection in the Study Population

Variable	Category	Malaria Positive	Malaria Negative	Odds ratio (95% CI)	X2, df	P value
Total	N = 450	88 (19.56)	362 (80.44)			
Vaccination status	Vaccine recipient	28 (13.21)	184 (86.79)	0.45 (0.28 - 0.73)	10, 1	0.0013*
	Non vaccine recipient	60 (25.21)	178 (74.79)			
Age(years)	0 to 1	64 (20.51)	248 (79.49)	1.2 (0.73 - 2.0)	0.59, 1	0.4414
	2 to 4	24 (17.39)	114 (82.61)			
Sex	Male	42 (21.21)	156 (78.79)	1.2 (0.76 - 1.9)	0.62, 1	0.4322
	Female	46 (18.25)	206 (81.75)			
Residence	Urban	72 (18.09)	326 (81.91)	0.5 (0.26 - 0.97)	4.7, 1	0.0302*
	Rural	16 (30.77)	36 (69.23)			
Educational Level of Parent/guardian	≤ High School	32 (18.82)	138 (81.18)	0.93 (0.57 - 1.5)	0.09, 1	0.7603
	> High School	56 (20)	224 (80)			
Household monthly income	< 120,000 FCFA	64 (18.71)	278 (81.29)	0.81 (0.48 - 1.3)	0.64, 1	0.4229
	≥ 120,000 FCFA	24 (22.22)	84 (77.78)			

Focusing specifically on children who received the malaria vaccine, the prevalence of malaria was higher among those aged 0 to 1 year. There was a

significant association between age and malaria infection, with an odds ratio of 2.9 indicating that vaccinated children aged 0 to 1 year have nearly three times higher odds of testing positive for malaria compared to children older than 1 year. Residence also showed a significant relationship with malaria risk; an odds ratio of 0.24 suggests that children living in urban areas have approximately 76% lower odds of testing positive for malaria than those in rural areas. Additionally, household monthly income, number of vaccine doses, and the timing of the last dose were all significantly associated with malaria status. Children from households earning less than 120,000 FCFA had about 79% lower odds of

malaria infection compared to those earning $\geq 120,000$ FCFA. Children with fewer than three vaccine doses were approximately four times more likely to have malaria than those fully vaccinated with three or more doses. Furthermore, children who received their last vaccine dose less than three months ago had about 67% lower odds of testing positive for malaria compared to those who received the dose more than three months prior (see **Table 3**).

Table 3: Factors Associated with Malaria Infection among Vaccinated Children

	Category, N = 212	Malaria Positive	Malaria Negative	Odds ratio (95% CI)	X ² , df	P value
Age	Total	28 (13.21)	184 (86.79)			
	0 to 1 year (%)	24(16.22)	124(83.78)	2.9 (1.0 to 8.0)	3.9, 1	0.0491*
	> 1 year (%)	4(6.25)	60(93.75)			
Sex	Total	28(13.21)	184(86.79)			
	Male (%)	18(16.67)	90(83.33)	1.9(0.81 to 4.2)	2.3, 1	0.1295
	Female (%)	10(9.62)	94(90.38)			
Residence	Total	28(13.21)	184(86.79)			
	Urban (%)	20(10.64)	168(89.36)	0.24(0.1 to 0.63)	9.6, 1	0.002*
	Rural (%)	8(33.33)	16(66.67)			
Educational level of Parent	Total	28(13.21)	184(86.79)			
	$\leq$ High School (%)	14(17.5)	66(82.5)	1.8(0.82 to 3.9)	2.1, 1	0.1507
	> High School (%)	14(10.61)	118(89.39)			
Household monthly income	Total	28(13.21)	184(86.79)			
	< 120,000 FCFA (%)	20(10.53)	170(89.47)	0.21(0.08 to 0.56)	11, 1	0.0007*
	$\geq 120,000$ FCFA (%)	8(36.36)	14(63.64)			
Number of vaccine doses	Total	28(13.21)	184(86.79)			
	< 3 doses (%)	18(23.68)	58(76.32)	3.9(1.7 to 8.9)	11, 1	0.0008*
	≥ 3 doses (%)	10(7.35)	126(92.65)			
Period of last dose taken	Total	28(13.21)	184(86.79)			
	< 3 Months (%)	14 (9.21)	138(90.79)	0.33(0.15 to 0.74)	7.5, 1	0.0062*
	≥ 3 Months (%)	14(23.33)	46 (76.67)			
	Total	28(13.21)	184(86.79)			

After simultaneously adjusting for child age, sex, residence, guardian's educational level, and family monthly income, the model indicates that residence was statistically significant overall. Those who were residents in the urban area had 2.64 times higher odds of testing malaria positive compared with those in the rural areas. Malaria vaccination status was not significantly associated with malaria infection after adjustment for the number of doses received and the period since the

last dose. The number of malaria vaccine doses received was significantly associated with malaria infection. Each additional dose was associated with approximately 67.0% lower odds of malaria infection. The period since the last malaria vaccine dose was significantly associated with malaria infection. An increase in the period since the last dose was associated with approximately 2.22-fold higher odds of malaria infection (see **Table 4**).

Table 4: Multivariable Logistic Regression Analysis of Factors Associated with Malaria Infection

variables	Category	Coef.	AOR (95 % CI)	p- value
Child's age	Overall	-	-	0.805
	0 to 1 year	-0.136	-0.873 (0.491–1.551)	0.642
	> 1 year	-0.422	0.656 (0.123–3.506)	0.622
Sex	Male	0.064	1.066 (0.643–1.769)	0.803
	Female	Ref.	-	-
Residence	Overall	-	-	0.037
	Urban	0.971	2.641 (1.257–5.551)	0.010
	Rural	Ref.	-	-
Educational level of Parent	Overall	-	-	0.094
	≤ High School (%)	20.455	-	0.999
	>High School (%)	19.955	-	0.999
Household monthly income (FCFA)	Overall	-	-	0.537
	<120,000	-0.417	0.659 (0.286–1.520)	0.328
	≥ 120,000	-0.848	0.428 (0.128–1.439)	0.170
Malaria vaccination	Vaccinated	0.097	1.101 (0.292–4.151)	0.886
Doses received	< 3 doses	Ref.	-	-
	≥ 3 doses	-1.109	0.330 (0.191–0.570)	<0.001
Period of last dose taken	< 3 Months	Ref.	-	-
	≥ 3 Months	0.799	2.222 (1.522–3.245)	<0.001

After simultaneously adjusting for child's age, sex, residence, guardian's educational level, and family monthly income, the model indicates that; sex ($p = 0.004$) and family monthly income ($p = 0.007$) were significantly associated with malaria vaccination. Males had approximately 1.84 times higher odds of being vaccinated compared with the females, after controlling for the other

variables in the model. Guardian educational level was not significantly associated with malaria vaccination status overall. However, those who were in the ≤ High School category had a higher odd of vaccinating their children ($AOR = 8.657$, $p = 0.028$). Overall decreased family monthly income was significantly associated with increase malaria vaccination uptake (see **Table 5**).

Table 5: Multivariable Logistic Regression Analysis of Factors Associated with Malaria Vaccination

variables	Category	Coef.	AOR (95 % CI)	pvalue
Child's age	Overall	-	-	0.598
	0 to 1 year	Ref.	-	-
	> 1 year	-0.234	0.791 (0.503–1.244)	0.311
Sex	Male	0.612	1.844 (1.223–2.781)	0.004*
	Female	Ref.	-	-
Residence	Overall	-	-	0.875
	Urban	-0.181	0.834 (0.418–1.665)	0.605
	Rural	20.486	788736797.045	0.999
Educational level of Parent	Overall	-	-	0.304
	≤ High School (%)	2.158	8.657 (1.244–60.25)	0.028*
	> High School (%)	Ref.	-	-
Household monthly income (FCFA)	Overall	-	-	0.007*
	<120,000	-0.726	0.484 (-0.245–0.956)	0.039*
	≥ 120,000	-0.745	0.475 (0.231–0.980)	0.043*

None of the factors examined showed a significant association with malaria among the children who were not vaccinated against malaria (see **Table 6**).

Table 6: Factors Associated with Malaria Infection among Non-Vaccinated Children

	N = 238	Malaria positive	Malaria negative	Odds ratio (95% CI)	X ² , df	P value
Age	Total	60 (25.21)	178 (74.79)			
	0 to 1 year (%)	40 (24.39)	124 (75.1)	0.87(0.46 to 1.6)	0.19, 1	0.6646
	> 1 year (%)	20 (27.03)	54 (72.97)			
Sex	Total	60 (25.21)	178 (74.79)			
	Male (%)	24 (26.67)	66 (73.33)	1.1(0.63 to 2.1)	0.16, 1	0.6865
	Female (%)	36 (24.32)	112 (75.68)			
Residence	Total	60 (25.21)	178 (74.79)			
	Urban (%)	52 (24.76)	158 (75.24)	0.82(0.33 to 1.9)	0.19, 1	0.6628
	Rural (%)	8 (28.57)	20 (71.43)			

	Total	60 (25.21)	178 (74.79)			
Educational level of Parent	≤ High School (%)	18 (20)	72 (80)	0.63(0.34 to 1.2)	2.1, 1	0.1489
	> High School (%)	42 (28.38)	106 (71.62)			
	Total	60 (25.21)	178 (74.79)			
Household monthly income	< 120,000 FCFA (%)	44 (28.95)	108 (71.05)	1.8(0.93 to 3.5)	3.1, 1	0.0775
	≥ 120,000 FCFA (%)	16 (18.6)	70 (81.4)			
	Total	60 (25.21)	178 (74.79)			

DISCUSSION:

This study provides important insights into the prevalence of malaria and the acceptance of malaria vaccination among children under five in Soa and Biyem-Assi district hospitals, adding to the growing body of literature on malaria immunization in endemic regions. The findings demonstrate a significantly lower prevalence of malaria among vaccinated children, aligning with previous clinical trial outcomes [6-9,14,16]. Specifically vaccinated children had approximately 55% reduced odds of malaria infection compared to unvaccinated children (OR=0.45), underscoring the protective efficacy of the RTS, S /AS01 vaccines, as reported in multiple Phase III trials [8,9,16]. The significant association between recent vaccination (less than three months) and lower malaria prevalence suggests a waning immunity over time, which is consistent with longitudinal studies indicating that vaccine efficacy diminishes after six months to a year [14]. This aligns with the findings of the phase IIb trial demonstrating that booster doses could enhance long-term immunity [6]. Importantly, the analysis identified age as a critical factor among vaccinated children, with those aged 0-1 year at nearly three times higher risk of malaria infection than older children, confirming prior studies that highlight children's susceptibility, especially at the youngest age groups [14]. These results underscore the importance of early vaccination and possibly booster doses to sustain protection during this vulnerable period.

With respect to residence, children living in rural areas had higher odds of testing positive for malaria than their urban counterparts, reinforcing

previous findings that urbanization correlates with reduced malaria transmission probably due to better infrastructure, vector control, sanitation and access to healthcare [18]. Moreover, children from households earning less than 120,000 FCFA per month had significantly lower odds of malaria compared to higher-income households. This might seem counterintuitive, but possible explanations include differing exposure risks. However existing literature suggests that socioeconomic disparities influence vaccine uptake and malaria risk [18,29]. And that socioeconomic inequalities could influence both vaccine uptake and treatment-seeking behavior, highlighting the importance of equitable health system strengthening. The high vaccination coverage despite economic constraints highlights that affordability may not be the sole barrier, but rather knowledge gaps and access issues, particularly in rural populations. Lower-income households may have had different patterns of healthcare utilization or less frequent testing, potentially resulting in under-detection of malaria infection. Therefore, the observed lower odds of malaria infection among children from lower-income households should not be interpreted as evidence that lower socioeconomic status protects against malaria, but rather as an association that warrants further investigation.

The efficacy of the vaccines in this setting appears consistent with global trial data, showing about 68-75% effectiveness in preventing clinical malaria among children aged 5-36 months [8,9]. The data also reflect that the efficacy diminishes over time, with a slight rebound in malaria prevalence among children vaccinated more than three months prior, aligning with findings by

Olotu *et al.*,^[14]. Notably, children with fewer than three vaccine doses or those who received their last dose over three months ago had higher malaria prevalence, emphasizing the importance of completing the full vaccination schedule and timely booster doses. While the study reaffirms the efficacy of malaria vaccines, no significant association was found between parental education and malaria prevalence, which contrasts with other studies emphasizing the role of health literacy in vaccine acceptance and malaria prevention^[19]. This discrepancy could be attributed to the relatively high education levels within our sample, possibly limiting the variability needed to detect such associations.

The findings reinforce that integrating malaria vaccines into routine childhood immunization schedules is beneficial, possibly when combined with other control measures such as insecticide-treated nets and seasonal malaria chemoprevention^[16]. However, successful implementation requires addressing logistical hurdles, especially in rural areas. As in Cameroon, initial acceptance was promising^[21], but sustained coverage requires systematic efforts to improve awareness, reduce misconceptions, and ensure complete vaccination among children. Furthermore, ongoing post-marketing surveillance and real-world effectiveness studies, such as those coordinated by WHO and GSK^[8], are critical for understanding long-term vaccine impact and informing policy adjustments. The promising efficacy data of the R21/Matrix-M vaccine, demonstrating approximately 68–75% protection, marks a significant advancement in malaria control efforts in Africa^[8,9]. However, translating these results into sustained, wide-scale coverage will require strategic efforts to mitigate barriers such as vaccine hesitancy, logistical challenges, and disparities in healthcare access. The study's findings on the influence of geographic location reinforce the need for tailored interventions in rural and hard-to-reach areas, similar to recommendations made in other contexts^[18,19]. A notable observation from this study was that a shorter interval since the last vaccination dose

correlated with reduced malaria risk. This aligns with literature suggesting that booster doses are crucial to prolong vaccine-induced immunity and prevent waning protection^[26,14]. Policymakers should consider integrating booster programs into national immunization schedules, particularly in regions with high malaria endemicity, to sustain the vaccine's protective benefits.

Limitation of the Study

A major limitation of this study is the complete confounding between vaccination status and study site. Vaccinated children were recruited exclusively from Soa District Hospital, while unvaccinated children were recruited from Biyem-Assi District Hospital. Thus, vaccination status was perfectly associated with study site, preventing site from being included as an independent covariate in the logistic regression model. Consequently, the reported adjusted odds ratios should be interpreted as associations within the study design rather than fully site-adjusted estimates. Some findings may reflect unmeasured differences between the two sites, such as population characteristics, healthcare access, and exposure to vaccine information. Therefore, causal interpretations should be made cautiously. Future studies should recruit vaccinated and unvaccinated children from the same or multiple comparable sites to better control for site-related confounding.

CONCLUSION:

Among the 450 children studied, malaria prevalence was 19.56%, while 47.11% had received at least one malaria vaccine dose. Although malaria infection was lower among vaccinated than unvaccinated children, vaccination status was not independently associated with infection after adjustment. Among vaccinated children, receiving three or more doses and the time since the last dose were significantly associated with infection, suggesting the importance of completing and maintaining the recommended vaccination schedule. Overall,

malaria remains an important health concern, highlighting the need for high vaccine coverage, timely vaccination, continued surveillance, and integration of vaccination with other malaria prevention measures.

AI Declaration

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) solely to assist with rephrasing and improving the clarity and readability of text originally written by the authors. The AI tool was not used to generate, analyze, or interpret the study data, results, or scientific conclusions. All AI-assisted text was reviewed and edited by the authors, who take full responsibility for the accuracy, originality, and integrity of the final manuscript.

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Cite of article: NO Nlinwe, TJ Mbah. Evaluation of malaria vaccination with RTS,S/AS01 (MOSQUIRIX™) among children attending two district hospitals in the central region of Cameroon. Int. J. Med. Lab. Res. 2026; 11(3): 28-39.
<https://doi.org/10.35503/IJMLR.2026.11305>

CONFLICT OF INTEREST: Authors declared no conflict of interest

SOURCE OF FINANCIAL SUPPORT: Nil

International Journal of Medical Laboratory Research (IJMLR) - Open Access Policy

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