Caregiver Socio-Demographic Factors That Influence the Uptake of Third and Fourth Doses of Malaria Vaccine Among Under-Fives in Muhoroni Sub-County, Kenya

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ABSTRACT

Malaria remains a leading cause of morbidity and mortality among children under five in sub-Saharan Africa, accounting for approximately 90% of childhood malaria deaths (WHO, 2023). The RTS, S/AS01E malaria vaccine, administered in four doses at 6, 7, 9, and 24 months, has shown moderate efficacy in reducing clinical and severe malaria (WHO, 2022). Despite promising outcomes, uptake of the third and fourth doses remains suboptimal in Kenya, particularly in high-burden areas such as Muhoroni Sub-County, where coverage drops from 72.1% for the first dose to 31.4% for the fourth dose (Okanda et al., 2023). Understanding sociodemographic factors that influence the poor uptake of third and fourth vaccine to dose uptake is critical for sustaining malaria prevention gains.

An analytical cross-sectional study employing mixed methods was conducted among 289 caregivers of children aged 9–60 months who had completed the first two doses of the malaria vaccine in Muhoroni Sub-County. Stratified random sampling was used to select participants. Quantitative data were collected via structured questionnaires and analysed using SPSS v27. Descriptive statistics summarized uptake patterns, while Chi-square tests and logistic regression identified predictors of third and fourth dose uptake at a 95% confidence interval. Qualitative data from key informant interviews were thematically analysed using NVivo software.

The uptake of the third dose was 50.9% (n=147), while only 10.4% (n=30) received the fourth dose. Higher caregiver education was significantly associated with third dose uptake (OR=1.27; 95% CI: 0.56–2.89; p=0.043). Greater distance to health facilities reduced the odds of third dose uptake by 81% (OR=0.19; 95% CI: 0.11–0.31; p<0.001). Cultural beliefs discouraging vaccination were negatively associated with uptake of the third dose (χ^2=11.17; p=0.001), while the perception that children receive “too many vaccines” was linked to lower fourth dose uptake (χ^2=4.17; p=0.041). Qualitative findings reinforced these results, highlighting logistical barriers, misinformation, and limited community engagement as key obstacles.

Third and fourth dose uptake of RTS, S/AS01E remains far below WHO targets in Muhoroni Sub-County. Education level, proximity to health services, and socio-cultural perceptions significantly influence uptake. Targeted strategies, including community-driven awareness campaigns, improved vaccine accessibility, and culturally sensitive health messaging, are essential to close the late-dose coverage gap and reduce malaria-related child mortality.

Keywords: Malaria vaccine, RTS, S/AS01E, third dose, fourth dose, uptake, socio-demographic factors

INTRODUCTION

Malaria continues to be a leading cause of morbidity and mortality in low- and middle-income countries (LMICs), with children under five bearing the greatest burden (WHO, 2023). Globally, nearly half of the population is at risk, with approximately one million malaria-related deaths annually—nine in ten occurring in

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sub-Saharan Africa's young children【WHO, 2023】. Beyond its health impact, malaria imposes significant social and economic costs, particularly among rural, low-income households (Elnour et al., 2023; Watts et al., 2021).

In Kenya, malaria remains a persistent public health concern despite the implementation of the National Malaria Policy and the Kenya Malaria Strategy, which aim to achieve >90% immunization coverage in endemic areas and reduce malaria-related morbidity and mortality by 75% from 2016 levels by 2023. The RTS, S/AS01E malaria vaccine—endorsed by the World Health Organization in 2021—offers a novel preventive tool when integrated with existing interventions such as insecticide-treated nets, chemoprophylaxis, and prompt case management【WHO, 2022】. Administered in four doses at 6, 7, 9, and 24 months of age, the vaccine has demonstrated moderate efficacy in reducing clinical malaria by 39% and severe malaria by 29% (Praet et al., 2021).

However, evidence from Western Kenya, including Muhoroni Sub-County, indicates substantial drop-off in vaccine uptake after the initial doses. Data show coverage rates of 72.1% for the first dose, 59.4% for the third dose, and only 31.4% for the fourth dose (Okanda et al., 2023). These figures fall short of both national and WHO targets, undermining the vaccine's potential impact in high-transmission areas such as the Lake Victoria region. Previous studies have linked low uptake to factors such as limited caregiver awareness, logistical challenges, vaccine stock-outs, negative provider attitudes, and socio-cultural beliefs (Grant et al., 2022; Hoyt et al., 2023).

Given the high malaria burden in Muhoroni and the observed disparities in late-dose coverage, there is a pressing need to investigate the barriers specific to third and fourth dose uptake. Such insights are vital for designing targeted, context-sensitive interventions to enhance immunization completion and reduce malaria-related child mortality.

METHODS

Study design and setting

An analytical cross-sectional study employing both quantitative and qualitative approaches was conducted between June and July 2025 in Muhoroni Sub-County, Kisumu County, Kenya. Muhoroni is predominantly rural, with a population of 154,116 and a high malaria transmission intensity, situated within the endemic Lake Victoria basin. The sub-county covers approximately 658 km², comprising two divisions, 10 locations, and 35 sub-locations. A sample size of 289 respondents obtained using Fishers sample determination formula was interviewed.

Study population

The study population comprised caregivers of children aged 9–60 months who had completed the first two doses of the RTS, S/AS01E malaria vaccine. The target population was 14,726 caregivers, distributed across 41 Community Units (CUs) in the sub-county.

Inclusion and Exclusion Criteria

The study included caregivers who had resided in Muhoroni Sub-County for at least one year and were responsible for children aged 9–60 months who had received the first two doses of the malaria vaccine.

Caregivers with severe medical conditions that prevented participation, as well as those whose children were too ill to participate during the study period, were excluded.

Sample Size Determination and Sampling Procedure

The sample size was determined using Fisher's formula, based on an estimated malaria vaccine uptake prevalence of 75%, a 95% confidence level, and a 5% margin of error, resulting in a total of 289 caregivers.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VIII August 2025

Stratified random sampling was used to ensure representation from all 41 CUs, proportionate to population size.

Data Collection

Quantitative data was collected using structured, pre-tested researcher-administered questionnaires covering socio-demographic characteristics, health service factors, and socio-cultural beliefs.

Qualitative data was obtained through Key Informant Interviews (KIIs) with the Kisumu County Director of Health Services and the Medical Superintendent of Muhoroni Sub-County Hospital, using semi-structured interview guides.

Data collection was conducted by the principal investigator and four trained research assistants, with supportive supervision to ensure data quality

Data analysis

Quantitative data were entered and analysed using SPSS version 27. Descriptive statistics summarized socio-demographic characteristics and uptake patterns. Chi-square tests assessed associations between variables and vaccine uptake. Variables with $p<0.05$ in bivariate analysis were entered into logistic regression models to identify independent predictors, with results reported as odds ratios (ORs) and 95% confidence intervals (CIs).

Qualitative data from KIIs were transcribed verbatim and analysed thematically using NVivo software, allowing triangulation with quantitative findings.

Ethical Considerations

The study adhered to the Declaration of Helsinki ethical principles. Approval was obtained from the Great Lakes University of Kisumu Scientific and Ethical Review Committee (GLUSERC). A research permit was granted by the National Commission for Science, Technology, and Innovation (NACOSTI). Written informed consent was obtained from all participants. Confidentiality was maintained by assigning unique codes in place of personal identifiers, and participation was voluntary with the option to withdraw at any time without penalty.

RESULTS

Participants characteristics

The study targeted a sample of 289 participants of whom all were accessible; hence, a response rate of 100% is reported herein. The mean age of the caregivers was 42.02±2.442 years, whereas the mean age for children was 27.11±2.45 months. Amongst the caregivers, most of them 71 (24.6%) reported to have one (1) child. More than average; 154 (53.3%) of the caregivers reported that their children were up to date with malaria vaccination as scheduled.

Regarding other immunizations, 254 (87.9%) of the caregivers reported that their children were up to date with all other required immunizations. On diagnosis with malaria in the last six (6) months, a high proportion; 130 (45.0%) observed that their children had been diagnosed with malaria, but it was not severe. When it came to seeking treatment, it was slightly above average; 155 (53.6%) reported that they sought treatment from hospital. Almost all of the participant; 274 (94.8%), reported that they received information (Table 1).

Table 1. Participant Profile

	n=289	

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VIII August 2025

Characteristic	n	Percentage (%)
Up to date with malaria vaccine schedule		
No	135	46.7
Yes	154	53.3
Up to date with other immunizations		
Yes	254	87.9
No	35	12.1
Diagnosis with malaria last 6 months		
No	93	32.2
Yes, and it was severe	66	22.8
Yes, and it was not severe	130	45.0
Place of treatment for children above 9 months		
Buy drugs from pharmacy	79	27.3
Hospital	155	53.6
Manage symptomatically	55	19.0
Receipt of information on malaria vaccine from county		
Yes	274	94.8
No	15	5.2

About gender, a high proportion of the participants; 209 (72.3%) were females, with a high percentage of them 106 (36.7%) reporting to have certificate as the highest level of education. In line with marital status, slightly more than average; 151 (52.2%) were married. Slightly more than a quarter of the participants; 75 (26.0%) reported that farming was their main source of income

Uptake of Third and Fourth Doses

Regarding the uptake of malaria vaccine, an average; 147 (50.9%) had received the third dose of malaria vaccine whereas a paltry; 30 (10.4%) had received the fourth dose of malaria vaccine as shown in figure 1. A few key informants said the uptake has excitement after birth, which then slows down; This may be attributed to overwhelmed and unfriendly staff and stocks outages at health facilities offering immunization. KII Muhoroni Subcounty Community Focal Person

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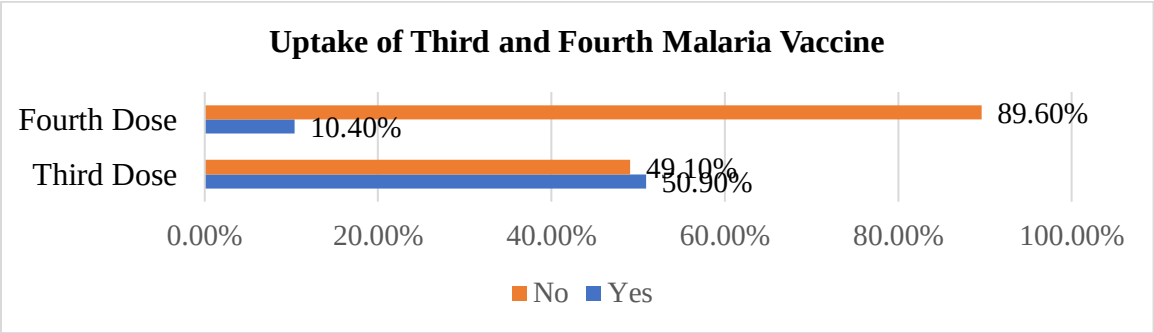

Figure 1. Uptake of Third and Fourth Doses

Factors Associated with Third Dose Uptake

Chi-square analysis indicated that the highest level of education was significantly associated with uptake of the third dose (χ^2=8.331, df=3, p=0.040). Gender, marital status, and income source were not statistically significant. Logistic regression showed that caregivers with a bachelor's degree had 1.3 times higher odds of third dose uptake compared to those with no formal education (OR=1.27; 95% CI: 0.56–2.89; p=0.043) (Table 2).

Table 2. Association between socio-demographic factors and uptake of third dose of malaria vaccine

Variables	**Uptake of Third Dose**		**χ^2**	**p-value**
Socio-demographic characteristic	**Yes n (%)**	**No n (%)**		
Male	35 (12.1)	45 (15.6)	2.241	0.086
Female	112 (38.8)	97(33.6)		
Highest level of education				
Bachelors' degree	17 (5.9)	17 (5.9)	8.331	0.040*
Certificate	48 (16.6)	58 (20.1)		
Diploma	52 (18.0)	29 (10.0)		
No formal education	30 (10.4)	38 (13.1)		
Marital status				
Divorced	13 (4.5)	9 (3.1)	6.177	0.186
Married	83 (28.7)	68 (23.5)		
Separated	9 (3.1)	11 (3.8)		
Single	24 (8.3)	39 (13.5)		
Widowed	18 (6.2)	15 (5.2)		

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VIII August 2025

Income source				
Farming	42 (14.5)	33 (11.4)	6.286	0.179
Formal employment	30 (10.4)	38 (13.1)		
Informal employment	19 (6.6)	18 (6.2)		
Large scale business	23 (8.0)	12 (4.2)		
Small scale business	33 (11.4)	14.2)		

Factors Associated with Fourth Dose Uptake

Participant's gender was significantly associated with uptake of fourth malaria vaccine ($\chi2$=5.228, df=1, p=0.022, CI=95%). In addition, highest level of education was significantly associated with uptake of fourth malaria vaccine ($\chi2$=16.556, df=3, p=0.001, CI=95%). Income source was further found to be significantly associated with uptake of fourth vaccine does ($\chi2$=9.834, df=4, p=0.043, CI=95%). However, marital status did not demonstrate significant associations with uptake of fourth dose of malaria vaccine (p=0.341) as shown in Table 3

Table 3. Association between socio-demographic factors and uptake of fourth dose of malaria vaccine

Variables	**Uptake of Fourth Dose**		**χ^2**	**p-value**
	Yes n (%)	**No n (%)**		
Socio-demographic characteristic				
Male	3 (1.0)	77 (26.6)	5.228	0.022*
Female	27 (9.3)	182 (63.0)		
Highest level of education				
Bachelors' degree	4 (1.4)	30 (10.4)	16.556	0.001*
Certificate	3 (1.0)	103 (35.6)		
Diploma	8 (2.8)	73 (25.3)		
No formal education	15 (5.2)	53 (18.3)		
Marital status				
Divorced	1 (0.3)	21 (7.3)	4.513	0.341
Married	21 (7.3)	130 (45.0)		
Separated	1 (0.3)	19 (6.6)		
Single	5 (1.7)	58 (20.1)		
Widowed	2 (0.7)	31 (10.7)		

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VIII August 2025

Income source				
Farming	11 (3.8)	64 (22.1)	9.834	0.043*
Formal employment	8 (2.8)	60 (20.8)		
Informal employment	7 (2.4)	30 (10.4)		
Large scale business	1 (0.3)	34 (11.8)		
Small scale business	3 (1.0)	71 (24.6)		

Logistic regression analysis showed that gender influenced uptake of fourth dose of malaria vaccine by 5 times (OR=4.647, 95% CI=1.305-16.543, p=0.018). Logistic regression analysis showed that education level did not have a significant influence on uptake of fourth dose of malaria vaccine (OR=0.522, 95% CI=0.119-2.289, p=0.388). Similarly, main source of income level did not have a significant influence on uptake of fourth dose of malaria vaccine (OR=3.499, 95% CI=0.874-14.011, p=0.077).

Qualitative Findings

The key informants also described the third and fourth uptake is erratic. This is confirmed by the quantitative data. According to the key informants, the high uptake of initial doses may be due to many factors, including convenient schedule with the other vaccines in the KEPI schedule, effective public mobilization and education through the community strategy(CHPs) , accessibility of the vaccine as it was offered in all the health facilities, availability of the vaccine, and the high morbidity and mortality of the children due to malaria that made the caregivers count on the new intervention. "…The initial doses are considered by the caregivers as important, and they are timed at crucial months when the child is vulnerable and is still a priority to the mother and visits the health facility regularly for other services. The caregiver does not need to make a trip just for the malaria vaccine, but for other child wellness clinic (CWC) services.…"

DISCUSSION

This study investigated socio-demographic factors influencing the uptake of the third and fourth doses of the RTS, S/AS01E malaria vaccine in Muhoroni Sub-County, Kenya. The findings reveal a substantial drop in vaccine coverage from the third to the fourth dose, consistent with national and regional patterns (Moturi et al., 2023; Okanda et al., 2023).

Interpretation of Key Findings

The uptake of the third dose (50.9%) and especially the fourth dose (10.4%) falls significantly short of the WHO target of 90% for complete malaria vaccination. Higher caregiver education was associated with increased likelihood of third dose uptake, echoing previous research linking education to vaccine literacy, understanding of disease prevention, and health service utilization (Kempter & Upadhayay, 2022; Chukwuocha et al., 2018).

For the fourth dose, gender, education, and income were significantly associated in bivariate analysis, although only gender remained significant after adjustment. This suggests that female caregivers may be more committed to ensuring completion of the vaccination schedule, potentially due to their primary role in child healthcare, a finding supported by studies in similar African settings (Ateke et al., 2024; Yeboah et al., 2022).

Barriers to Vaccine Completion

Qualitative findings identified several barriers: vaccine fatigue, competing household responsibilities, perceived side effects, unfriendly health worker attitudes, and occasional stock-outs. These factors mirror those

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VIII August 2025

reported in Western Kenya and other malaria-endemic regions (Hill et al., 2024; Hoyt et al., 2023). The alignment of early vaccine doses with other routine immunizations may partially explain higher initial uptake, while the 24-month schedule for the fourth dose, often requiring a separate visit, contributes to attrition.

Comparison with Existing Literature

The observed dose completion gap aligns with the Health Belief Model and Social Cognitive Theory, which highlight how perceived benefits, barriers, and cues to action influence health behaviours (Rosenstock et al., 1988; Strecher & Rosenstock, 1997). Trust in the healthcare system, convenience of services, and accurate information emerge as critical determinants of vaccine adherence. Similar multi-factorial barriers have been reported in Ghana, Cameroon, and Nigeria, underscoring the need for locally adapted strategies (Grant et al., 2022; Asmare, 2022; Ojakaa et al., 2014).

Implications for Practice and Policy

Improving completion rates for the RTS, S/AS01E malaria vaccine in Muhoroni Sub-County requires a combination of community engagement, health system strengthening, and targeted follow-up. Community-driven awareness campaigns led by trusted leaders, including religious and cultural influencers, can help address misinformation, cultural barriers, and misconceptions about vaccine safety and necessity. Strengthening the health system to ensure consistent vaccine availability, reducing waiting times, and enhancing the friendliness of service delivery will improve caregiver satisfaction and encourage return visits for subsequent doses. Integrating the later malaria vaccine doses with other child health services, such as growth monitoring or deworming, can reduce the burden of additional clinic visits and help sustain adherence. Furthermore, targeted follow-up of households at higher risk of default—particularly those with lower education or income levels—through home visits, reminder systems, or transport support may close the gap in late-dose uptake. These combined strategies can address both demand- and supply-side barriers, ultimately improving vaccine completion rates and contributing to sustained malaria control in high-transmission settings.

Strengths and Limitations

The study's strengths include a sub-county-wide sampling frame, 100% response rate, and the use of mixed methods, which allowed triangulation of quantitative and qualitative data. However, the cross-sectional design limits causal inference, and self-reported data may be affected by recall or social desirability bias. Findings may not be generalizable beyond similar rural, high-transmission settings.

CONCLUSION

This study demonstrates that uptake of the third and fourth doses of the RTS, S/AS01E malaria vaccine in Muhoroni Sub-County remains well below the WHO target of 90%. Education level, gender, income source, and access to health facilities were key factors influencing uptake, while cultural beliefs, vaccine fatigue, competing responsibilities, and stock-outs emerged as significant barriers. These findings highlight the need for targeted interventions that combine community-driven awareness campaigns, culturally sensitive health education, integration of later doses with other child health services, and system-level improvements to ensure consistent vaccine availability. Addressing both demand- and supply-side challenges will be essential to improving vaccine completion rates, maximizing the protective benefits of the RTS, S/AS01E vaccine, and reducing malaria-related morbidity and mortality among children in high-transmission settings.

RECOMMENDATIONS

Based on the study findings, the following recommendations are crucial to enhance the uptake of the third and fourth doses of Malaria vaccine:

Due to the 3rd and 4th vaccine dose not meeting WHO uptake target, action from all stakeholders implementing the malaria vaccine in Muhoroni Subcounty is required to intensify the uptake in the rolling out

the malaria vaccination programs in this area with specific focus to strategies which can accelerate the fourth dose uptake. The intervention needs to take into context the demographic factors

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