

Factors Associated with Mother's Adoption of the Malaria Vaccine in the Allada-Toffo-Zè Health Zone in Benin, 2025

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Abstract

Background: Vaccine hesitancy in communities is recognized as one of the major threats to public health and remains a significant challenge in the control of vaccine-preventable infectious diseases. In 2024, Benin introduced the malaria vaccine (MV) on a pilot basis in three health zones, including the Allada-Toffo-Zè (ATZ) Health Zone, due to the high malaria endemicity reported in these areas by the national health information system. **Objective:** To investigate the factors associated with the uptake of the malaria vaccine among mothers of children aged 6 to 18 months in the ATZ Health Zone, Benin, in 2025. **Methods:** This was a descriptive and analytical cross-sectional study conducted from December 1, 2024, to June 28, 2025. The survey included 604 mothers of children, recruited through a three-stage cluster probability sampling method. Data analysis was performed using R software, version 4.3.3. **Results:** Mothers were predominantly aged 26 to 35 years (47.4% among the 572 mothers with recorded age; median age: 26 years, IQR: 22 - 30), and the median age of selected children was 12 months (IQR: 9 - 18 months), ranging from 6 to 18 months, with 57.0% aged 12 to 18 months and a female predominance of 50.7%. At the time of the survey, 72.6% of mothers had had their children vaccinated with the MV, being up to date for their age with respect to the MV vaccination schedule. The main factors associated with MV uptake were the intention to vaccinate the child (aOR = 6.69; 95% CI: [2.18 - 20.54]; $p = 0.002$), a favorable perception of MV effectiveness (aOR = 9.46; [2.92 - 30.62]; $p = 0.001$), strong community endorsement of the MV (aOR = 2.62; 95% CI: [1.37 - 5.00]; $p = 0.006$), and a favorable opinion from parents or close friends (aOR = 3.84; 95% CI: [1.63 - 9.04]; $p = 0.004$). **Conclusion:** These find-

ings highlight the need to strengthen healthcare workers' interpersonal communication skills regarding the malaria vaccine, particularly the content of key messages; revise communication strategies on the malaria vaccination schedule to better align with existing community practices; and improve the accessibility and quality of vaccination services.

Keywords

Associated Factors, Malaria Vaccine Uptake, Malaria Vaccine, Mothers, Benin

1. Introduction

Malaria remains a major cause of morbidity and mortality among children aged 0 to 5 years in Africa; it is one of the leading reasons for consultations, hospitalizations, and deaths among these children. The World Health Organization (WHO) recorded about 233 million of the 240 million cases registered worldwide, with 627,000 deaths in 2022 [1]. In the same year, Benin recorded more than 5.1 million malaria cases and more than 11,000 deaths [2], despite high coverage of preventive measures such as long-lasting insecticide-treated nets, seasonal malaria chemoprevention, and indoor residual spraying in endemic areas. The introduction of malaria vaccines (MV) represents a new strategy complementary to existing interventions; its effectiveness depends not only on the vaccine's biological performance but also on its adoption by target communities and populations. Persistent gaps between vaccination intention and full coverage have been observed in several studies. These have identified barriers to malaria vaccine adoption in West Africa, including perceived side effects, persistent cultural beliefs, logistical and financial obstacles, as well as mistrust of vaccines, reinforced by the experience of the COVID-19 pandemic [3] [4].

The MV was introduced in Benin on Thursday, April 25, 2024, building on the program's pilot phase conducted in Ghana, Kenya, and Malawi [2]. Integrated into the Expanded Program on Immunization, it targets children aged 6 to 18 months. The MV dosing schedule currently adopted in Benin is as follows: first dose at 6 months, second dose at 7 months, third dose at 9 months, and fourth and final dose at 18 months of age. The Allada-Toffo-Zè health zone, one of the first pilot health zones for the progressive introduction of the MV in Benin, has a high malaria endemicity (40% of the 203,844 cases notified in 2023 involved children under five), a population with a low rate of health service utilization estimated at 43.11% according to 2022 annual statistics, and a routine measles-containing vaccine (VAR) coverage rate of 84.49% representing children fully vaccinated according to the vaccination schedule preceding the introduction of the MV [5]. A range of barriers may create an unfavorable context for the adoption of any new vaccine [6], including, among others, mothers' lack of financial means, information gaps or lack of knowledge about vaccination or its benefits, long waiting times at vaccination sessions, the long distance between place of residence and

the vaccination site fostering inequitable access, rumors, negative beliefs toward childhood vaccines, historical mistrust or misunderstandings (partly due to the negative influence of social media), negative individual experiences, and vaccine side effects [7] [8]. Our research may help to examine the rate of MV uptake among children aged 6 to 18 months as well as the factors associated with its adoption by mothers in the ATZ health zone. The findings of our research may serve as contextual input to anticipate potential reluctance during the expansion or scale-up of the vaccine.

2. Study Methods

2.1. Study Setting

The study took place in the Atlantique department, specifically in the Allada-Toffo-Zè (ATZ) health zone, located in southern Benin. The health zone has an estimated population of about 740,000 inhabitants and comprises 33 districts (arrondissements) and 76 health facilities.

2.2. Study Type and Period

This was a descriptive, analytically oriented cross-sectional study, conducted from December 1, 2024, to June 28, 2025.

2.3. Study Population

The study population consisted of mothers of children aged 6 - 18 months residing in the ATZ health zone, representing the study's primary target. We excluded from the study individuals unable to answer questions clearly and precisely, those who did not give consent to participate, and incomplete forms (26).

2.4. Sampling

The sampling method was a three-stage probability cluster design for the selection of mothers of children (respectively at the district [arrondissement], city ward [quartier], and household levels). As the health zone is subdivided into three (3) communes, a simple random sample of four (4) districts per commune was drawn. Within each district, a further simple random sample of three (3) city wards per district was drawn, yielding a total of 36 city wards. Within each ward, households were selected at random by bottle-spinning, with subsequent households then identified. The starting point in each ward was the ward center, identified by the local official who administratively heads the ward (the authority in charge of the ward, commonly called the "ward chief"), which corresponded to the central crossroads. From this crossroads, the direction of progression was determined by bottle-spinning, allowing the direction to be selected. Once the street was selected, the first household was chosen (a household being defined here as a group of persons, or a single person, sharing the same dwelling, generally eating together, and constituting the basic unit for assessing health risks, hygiene conditions, and access to care) by random drawing among the households of the compound. If a

household was absent when the interviewer visited, the next household was chosen, with no subsequent return visit. In the absence of an eligible mother, the household was declared ineligible and replaced according to the same rule. Once all households along the selected direction had been covered, the next direction connected to the crossroads was selected, and so on until the desired cluster size was reached. In total, 630 mothers were approached; 604 questionnaires were retained after excluding 26 incomplete forms, corresponding to a response rate of 95.9% (604/630). Within each household, one mother of a child was randomly selected among those present in the household. The minimum sample size was determined using Schwartz's formula: $n = Z\alpha^2 \times (p \cdot q / i^2) \times d$, with $Z\alpha = 1.96$ for $\alpha = 0.05$, p the probability of occurrence of the event ($p = 0.60$) [9] [10], q the probability of non-occurrence of the event ($q = 1 - p = 0.40$), i the precision, and d the design effect correction factor ($i = 0.05$ and $d = 1.5$). The minimum sample size was thus estimated at 554 mothers. In total, 604 mothers of children aged 6 to 18 months were selected.

2.5. Data Collection

Data were collected from mothers of children through interviewer-administered interviews. The interviewers comprised six (6) men and women, holders of degrees in health sciences, with at least two prior experiences in electronic data collection, good command of local dialects, and formal training. Quantitative data were collected using a structured, digitized questionnaire administered face-to-face. The questionnaire, based on the WHO's BeSD framework [11], covered sociodemographic characteristics, views and feelings toward malaria and the MV, social norms and connections, motivation for vaccine uptake, practical issues related to the MV and the organization of vaccination services, and the child's vaccination status verified against the vaccination record (carnet).

2.6. Variables

The dependent variable of the study was the child's adoption of the malaria vaccine (MV), defined as actual uptake or non-uptake of the malaria vaccine in accordance with the current vaccination schedule, verified from the vaccination record. Benin's MV dosing schedule comprises four doses, administered at 6, 7, 9, and 18 months respectively. A child was considered up to date for their age if, at the time of the survey, they had received all doses for which the eligibility age had already been reached (for example, an 8-month-old child was expected to have received doses 1 and 2, without the absence of dose 3, due at 9 months of age and therefore not yet due, being counted as a vaccination gap). The independent variables were grouped according to the dimensions of the WHO's Behavioral and Social Drivers of Vaccination (BeSD) framework. Sociodemographic characteristics included the child's age, the child's sex, the mother's age, education level, marital status, religious affiliation, occupation, monthly income, and the distance between the home and the health center. Variables related to knowledge of malaria

covered knowledge of the disease, its causes, its clinical signs, its progression to severe forms or death, as well as knowledge of seasonal malaria chemoprevention in children. Variables related to views and feelings toward malaria and the malaria vaccine included the perceived risk of malaria occurrence in the child, the perceived risk of progression to a severe form or death, the perceived financial and social impact of malaria, trust in childhood vaccines, awareness of the existence of the malaria vaccine, knowledge of its dosing schedule, trust in the MV, and perceptions of its effectiveness, safety, and importance for the child's health. Variables related to social norms and connections included perceived community endorsement of the MV, exposure to community discussions about the vaccine, the opinion of close parents and friends regarding the MV, the mother's decision-making autonomy, the person authorizing vaccination when decision-making depends on someone else, and perceived equality of access to MV information between men and women. Motivation variables mainly comprised the intention to have the child vaccinated against malaria. Variables related to practical issues and the organization of vaccination services included the perceived financial ease of obtaining the vaccine (overall direct and indirect costs of vaccination for the child, including transportation, meals, any incidental costs, and the opportunity cost linked to interrupting an income-generating activity on the day of vaccination), ease of access to vaccination services, availability of transportation, evaluation of the quality of vaccination services, evaluation of the quality of reception at health centers, and whether or not the mother had received information or advice about the MV from a health worker.

2.7. Data Processing and Analysis

Data were analyzed using R software, version 4.3.3. Quantitative variables were described using their median and interquartile range. Qualitative variables were summarized using frequencies and proportions. Associations between qualitative variables and malaria vaccine uptake were assessed using the Rao-Scott adjusted χ^2 test, suited to complex sampling designs, via the `svychisq` function of the R survey package. When cell counts were insufficient for certain categories, these were merged to satisfy analysis conditions. Variables showing an association with a p -value < 0.20 by the Rao-Scott adjusted χ^2 test were retained as candidates for the multivariable model. Factors associated with malaria vaccine uptake were identified using binary logistic regression accounting for the sampling design. The survey design was specified using the R survey package, in accordance with the three-stage probability cluster sampling design. Results are presented as adjusted odds ratios (aOR) with their 95% confidence intervals (95% CI). The statistical significance threshold was set at $p < 0.05$. Missing data were handled by excluding incomplete observations, with no imputation method applied.

2.8. Ethical Considerations

Data collection was preceded by the required administrative authorizations: a re-

search authorization from the Department of Public Health of the Faculty of Health Sciences at the University of Abomey-Calavi (No. 165/FSS/DSP/SCOM of December 12, 2024), followed by a survey authorization from the Departmental Health Directorate of the Atlantique department (No. 097/25/MS/SGM/DDS ATL/SPAF/SA of February 10, 2025). In addition, written informed consent was obtained from each participant. Data confidentiality and participant anonymity were guaranteed throughout the study.

3. Results

A total of 604 mother-child pairs were included in the quantitative data collection. According to the survey findings, mothers' intention to have their child vaccinated stood at 89.4%, and 72.6% of surveyed mothers had had their child vaccinated with the MV, with vaccination status up to date with respect to the new vaccination schedule in force in the ATZ health zone. This coverage figure is a point-in-time estimate collected at a particular moment along the MV diffusion curve, and not the coverage of a mature, routine vaccine; the vaccine having been introduced into Benin's Expanded Program on Immunization approximately one year before our survey was conducted.

3.1. Sociodemographic Characteristics of Mothers and Children

The median age of selected children was 12 months (IQR: 9 - 18 months), ranging from 6 to 18 months, with 57.1% aged 12 to 18 months. The majority of children (50.8%) were female. The median age of surveyed mothers was 26 years (IQR: 22 - 30 years), ranging from 16 to 45 years, calculated on 572 valid observations (age could not be recorded for 32 of the 604 mothers: 5.3%). The 26 - 35 age bracket was the most represented (47.4%). Most mothers were in a cohabiting or common-law union (69.3%) and of Christian faith (86.9%). Overall education level was low: 57.4% had no formal schooling. Regarding income, 96.9% of mothers reported very low income (0 - 50,000 FCFA/month), working mainly in the informal sector (petty traders/vendors 36.8%, homemakers 25.0%). Nearly all (77.5%) lived less than 5 km from a health center. Regarding association with vaccine uptake, these variables generally showed no statistically significant relationship with vaccine uptake: neither the child's age ($F = 3.70$; $p = 0.063$), nor sex ($F = 0.34$; $p = 0.707$), nor the mother's age ($F = 0.04$; $p = 0.963$), marital status ($F = 0.61$; $p = 0.518$), religion ($F = 0.47$; $p = 0.683$), education level ($F = 0.18$; $p = 0.940$), income level ($F = 2.58$; $p = 0.117$), or occupation ($F = 1.45$; $p = 0.204$) (**Table 1**).

3.2. Malaria Knowledge and Malaria Vaccine Uptake

Knowledge of malaria among mothers was nearly universal (99.3%). The majority of mothers (94.4%) correctly attributed the cause to mosquito bites, although a minority cited alternative causes such as sun exposure (12.7%) or spiritual causes (0.2%). Nearly all mothers (96.9%) knew the signs (at least two (2) clinical signs) of the disease, and 68.9% were aware that the disease could progress to severity.

Table 1. Sociodemographic characteristics of surveyed mothers and children in the Allada-Toffo-Zè health zone, 2025.

Variables	Yes n (%)	No n (%)	Total n (%)	Rao-Scott F (p)
Child's age				
[6 - 11]	177 (68.3)	82 (31.7)	259 (42.9)	F = 3.70; <i>p</i> = 0.063
[12 - 18]	261 (75.7)	84 (24.3)	345 (57.1)	
Child's sex				
Twins	3 (75.0)	1 (25.0)	4 (0.7)	F = 0.34; <i>p</i> = 0.707
Girl	227 (73.9)	80 (26.1)	307 (50.8)	
Boy	208 (71.0)	85 (29.0)	293 (48.5)	
Mother's age (n = 572)				
[16 - 25]	200 (71.9)	78 (28.1)	278 (48.6)	F = 0.04; <i>p</i> = 0.963
[26 - 35]	197 (72.7)	74 (27.3)	271 (47.4)	
[36 - 45]	17 (73.9)	6 (26.1)	23 (4.0)	
Marital status				
Single	2 (100.0)	0 (0.0)	2 (0.3)	F = 0.61; <i>p</i> = 0.518
Cohabiting/common-law union	297 (71.1)	121 (28.9)	418 (69.2)	
Married	139 (75.5)	45 (24.5)	184 (30.5)	
Religion				
Christian	377 (71.8)	148 (28.2)	525 (86.9)	F = 0.47; <i>p</i> = 0.683
Muslim	12 (85.7)	2 (14.3)	14 (2.3)	
Endogenous religion	38 (76.0)	12 (24.0)	50 (8.3)	
No religion	11 (73.3)	4 (26.7)	15 (2.5)	
Education level				
Literate (non-formal)	2 (66.7)	1 (33.3)	3 (0.5)	F = 0.18; <i>p</i> = 0.940
Primary	121 (73.3)	44 (26.7)	165 (27.3)	
No schooling	249 (71.8)	98 (28.2)	347 (57.5)	
Secondary	65 (73.9)	23 (26.1)	88 (14.6)	
Higher education	1 (100.0)	0 (0.0)	1 (0.2)	
Household income (FCFA)				
Very low (0 to 50,000 FCFA)	421 (72.0)	164 (28.0)	585 (96.9)	F = 2.58; <i>p</i> = 0.117
Low (50,001 to 130,000 FCFA)	17 (89.5)	2 (10.5)	19 (3.1)	
Occupation				
Farmer	47 (64.4)	26 (35.6)	73 (12.1)	F = 1.45; <i>p</i> = 0.204
Petty trader/vendor	170 (76.6)	52 (23.4)	222 (36.8)	
Graduate, unemployed	6 (100.0)	0 (0.0)	6 (1.0)	
Homemaker	108 (71.5)	43 (28.5)	151 (25.0)	

Continued

Manual worker/artisan	101 (70.6)	42 (29.4)	143 (23.7)
Private-sector employee	2 (40.0)	3 (60.0)	5 (0.8)
Public-sector employee	3 (100.0)	0 (0.0)	3 (0.5)
Other (student)	1 (100.0)	0 (0.0)	1 (0.2)

*32 missing values for mother's age, corresponding to mothers whose age could not be determined.

Mothers' knowledge of malaria was not significantly associated with MV uptake (Rao-Scott $F = 1.47$; $p = 0.234$). Knowledge of the disease's signs was likewise not associated with uptake ($F = 2.49$; $p = 0.124$). By contrast, knowledge of malaria chemoprevention as a preventive measure was significantly associated with uptake, but in a counter-intuitive direction: mothers who did not spontaneously mention it had a higher uptake rate (78.2% versus 50.0%; $F = 21.17$; $p < 0.001$), likely reflecting confusion between chemoprevention and vaccination in the responses. Awareness of the MV's existence remained the knowledge factor most strongly associated with uptake (87.6% versus 31.1%; $F = 143.42$; $p < 0.001$), as was knowledge of the vaccine's dosing frequency ($F = 11.14$; $p < 0.001$) (**Table 2**).

Table 2. Association between knowledge of malaria/the malaria vaccine and MV uptake among children aged 6 to 18 months.

Variables	Yes n (%)	No n (%)	Total n (%)	Rao-Scott F (p)
Knowledge of malaria				
No	4 (100.0)	0 (0.0)	4 (0.7)	F = 1.47; <i>p</i> = 0.234
Yes	434 (72.3)	166 (27.7)	600 (99.3)	
Knowledge of malaria signs				
No	16 (84.2)	3 (15.8)	19 (3.1)	F = 2.49; <i>p</i> = 0.124
Yes (at least 2 signs)	422 (72.1)	163 (27.9)	585 (96.9)	
Knowledge of malaria chemoprophylaxis				
No	378 (78.2)	105 (21.7)	482 (79.8)	F = 21.17; <i>p</i> < 0.001
Yes	61 (50.0)	61 (50.0)	122 (20.2)	
Awareness of MV existence				
No	50 (31.1)	111 (68.9)	161 (26.7)	F = 143.42; <i>p</i> < 0.001
Yes	388 (87.6)	55 (12.4)	443 (73.3)	
Knowledge of MV dosing frequency				
No	283 (64.5)	156 (35.5)	439 (72.7)	F = 11.14; <i>p</i> < 0.001
Yes, 4 doses	129 (92.8)	10 (7.2)	139 (23.0)	
Yes, at 6, 7, 9 and 18 months	26 (100.0)	0 (0.0)	26 (4.3)	

3.3. Perceived Malaria Risk and Malaria Vaccine Uptake

The proportion of mothers who had their child vaccinated with the MV was

higher among those who perceived a substantial risk of malaria occurrence in their child; 80.5% of mothers rating this risk as very high had vaccinated their child, versus 72.7% among those perceiving a high risk and 71.9% among those citing a moderate risk ($F = 4.43$; $p = 0.006$). A similar trend was observed for perceived severity of malaria. Uptake concerned 75.4% of mothers perceiving a high risk of progression to a severe form or death ($F = 4.47$; $p = 0.003$). In financial terms, 79.3% of mothers (among the 597 who answered this question) perceived a substantial financial and social impact of malaria; however, this did not reach the significance threshold ($F = 1.60$; $p = 0.182$) (Table 3).

Table 3. Association between perceived malaria risk in the child and malaria vaccine uptake.

Variables	Yes n (%)	No n (%)	Total n (%)	Rao-Scott F (p)
Perceived risk of malaria occurrence in the child				
Low/very low	16 (43.2)	21 (56.8)	37 (6.1)	F = 4.43; <i>p</i> = 0.006
Moderate	22 (71.0)	9 (29.0)	31 (5.1)	
High	293 (72.7)	110 (27.3)	403 (66.7)	
Very high	107 (80.5)	26 (19.5)	133 (22.0)	
Perceived risk of malaria progressing to severity/death				
Very high	67 (72.0)	26 (28.0)	93 (15.4)	F = 4.47; <i>p</i> = 0.003
High risk	331 (75.4)	108 (24.6)	439 (72.7)	
Moderate risk	25 (69.4)	11 (30.6)	36 (6.0)	
Low risk	6 (60.0)	4 (40.0)	10 (1.7)	
Don't know how to assess	9 (34.6)	17 (65.4)	26 (4.3)	
Perceived financial and social impact of the disease (n = 597)				
Very high impact	84 (81.6)	19 (18.4)	103 (17.3)	F = 1.60; <i>p</i> = 0.182
High impact	270 (72.8)	101 (27.2)	371 (62.1)	
Moderate impact	67 (68.4)	31 (31.6)	98 (16.4)	
Low impact	4 (57.1)	3 (42.9)	7 (1.2)	
No impact at all	2 (50.0)	2 (50.0)	4 (0.7)	
Don't know how to assess	8 (57.1)	6 (42.9)	14 (2.3)	

*n = 597 due to 7 missing responses.

3.4. Trust, Perceptions, and Attitudes toward the Malaria Vaccine

Trust in childhood vaccines in general was significantly associated with malaria vaccine uptake ($F = 7.46$; $p < 0.001$); 80.1% of mothers with very high trust in childhood vaccines had their child vaccinated against malaria. Trust specifically in the malaria vaccine was likewise strongly associated with uptake ($F = 30.56$; $p < 0.001$). The uptake rate reached 84.6% among mothers with very high trust in the MV and 82.1% among those with high trust. Perceived effectiveness of the

malaria vaccine emerged as one of the variables most strongly associated with MV uptake ($F = 72.86$; $p < 0.001$). Among mothers who considered the vaccine very effective, 94.5% had their child vaccinated. A similar association was observed for perceived safety of the vaccine ($F = 56.35$; $p < 0.001$). Mothers who rated the vaccine as “safe” or “very safe” had uptake rates of 92.6% and 91.4% respectively.

Perceived importance and benefits of the malaria vaccine were also strongly associated with uptake ($F = 26.58$; $p < 0.001$). Vaccination concerned 89.9% of mothers who rated the vaccine as very important and 81.3% of those who rated it as important (Table 4).

Table 4. Association between mothers’ trust, perceptions, and attitudes toward vaccines and the malaria vaccine, and malaria vaccine uptake in the Allada-Toffo-Zè health zone, 2025.

Variables	Yes n (%)	No n (%)	Total n (%)	Rao-Scott F (p)
Trust in childhood vaccines in general				
Very high	129 (80.1)	32 (19.9)	161 (26.7)	F = 7.46; <i>p</i> < 0.001
High	301 (72.7)	113 (27.3)	414 (68.5)	
Moderate	5 (31.2)	11 (68.8)	16 (2.6)	
Low	0 (0.0)	4 (100.0)	4 (0.7)	
Very low trust	1 (16.7)	5 (83.3)	6 (1.0)	
Prefers not to answer	2 (66.7)	1 (33.3)	3 (0.5)	
Trust in the MV specifically				
Very high	33 (84.6)	6 (15.4)	39 (6.5)	F = 30.56; <i>p</i> < 0.001
High	375 (82.1)	82 (17.9)	457 (75.7)	
Moderate	27 (34.2)	52 (65.8)	79 (13.1)	
Low	2 (8.3)	22 (91.7)	24 (4.0)	
Very low	1 (20.0)	4 (80.0)	5 (0.8)	
Perceived effectiveness of the MV				
Very effective	378 (94.5)	22 (5.5)	400 (66.2)	F = 72.86; <i>p</i> < 0.001
Moderately effective	18 (64.3)	10 (35.7)	28 (4.6)	
Not very effective	3 (27.3)	8 (72.7)	11 (1.8)	
Not effective at all	0 (0.0)	1 (100.0)	1 (0.2)	
Doesn't know	39 (23.8)	125 (76.2)	164 (27.2)	
Perceived safety of the MV				
Very safe	148 (91.4)	14 (8.6)	162 (26.8)	F = 56.35; <i>p</i> < 0.001
Safe	249 (92.6)	20 (7.4)	269 (44.5)	
Moderately safe	8 (33.3)	16 (66.7)	24 (4.0)	
Not very safe	1 (10.0)	9 (90.0)	10 (1.7)	
Not safe at all	0 (0.0)	2 (100.0)	2 (0.3)	

Continued

Doesn't know	32 (23.4)	105 (76.6)	137 (22.7)	
Perceived importance/benefits of the MV				
Very important	134 (89.9)	15 (10.1)	149 (24.7)	$F = 26.58; p < 0.001$
Important	277 (81.2)	64 (18.8)	341 (56.5)	
Moderately important	0 (0.0)	6 (100.0)	6 (1.0)	
Somewhat important	1 (16.7)	5 (83.3)	6 (1.0)	
Not important at all	0 (0.0)	2 (100.0)	2 (0.3)	
Doesn't know	26 (26.0)	74 (74.0)	100 (16.6)	

3.5. Social Norms, Community Influences, Motivation, and Malaria Vaccine Uptake

Perceived community endorsement of the malaria vaccine was strongly associated with MV uptake ($F = 29.05; p < 0.001$); 94.7% of mothers perceiving very strong community endorsement of the vaccine had their child vaccinated. Exposure to community discussions about the malaria vaccine was likewise associated with uptake ($F = 21.71; p < 0.001$). Among mothers exposed to discussions about the MV within their community, 89.6% had their child vaccinated, versus 67.7% among those who had not participated in or been exposed to such discussions. Similarly, a favorable opinion of close family and friends toward the MV was significantly associated with uptake ($F = 36.20; p < 0.001$); 74.8% of mothers benefiting from a favorable opinion from those around them had their child vaccinated, versus only 27.6% among those reporting an unfavorable opinion. Regarding the mother's decision-making autonomy, it was not significantly associated with malaria vaccine uptake ($F = 0.41; p = 0.524$). The uptake rate was 73.6% among mothers reporting that they made vaccination decisions for their child themselves, versus 69.8% among those depending on another person for this decision. However, among mothers lacking decision-making autonomy, the person granting vaccination permission was significantly associated with uptake ($F = 6.68; p = 0.015$). When permission came from the respondent's own mother, 83.8% of children were vaccinated, versus only 60.4% when this decision depended on the head of household. Perceived equal access to vaccine information between men and women was significantly associated with MV uptake ($F = 5.20; p = 0.029$). Mothers perceiving equal access to information had an uptake rate of 77.8%, versus 63.7% among those perceiving inequality. The intention to vaccinate the child remained, by far, the determinant most strongly associated with actual uptake ($F = 122.42; p < 0.001$). 80.0% of mothers expressing an intention to vaccinate their child actually did so, versus only 9.4% among those with no such intention, showing a direct influence. Regarding the determinants favorable to vaccination intention, all modalities presented as multiple-choice options and tested were significantly associated with vaccine uptake, with p -values of 0.000, indicating very strong statistical significance. Leading these, health professionals' recommendations (88.1%) and fam-

ily/friends' opinions (87.9%) emerged as the strongest drivers. These were followed by quality of reception (87.5%), clear information (72.7%), vaccine accessibility (72.7%), and financial support or free vaccine provision (57.1%) (**Table 5**).

Table 5. Association between social norms, community influences, and malaria vaccine uptake among children aged 6 to 18 months in the Allada-Toffo-Zè health zone, 2025.

Variables	Yes n (%)	No n (%)	Total n (%)	Rao-Scott F (p)
Perceived community endorsement of the MV				
A great deal	177 (94.7)	10 (5.3)	187 (31.0)	F = 29.05; <i>p</i> < 0.001
A lot	165 (85.5)	28 (14.5)	193 (32.0)	
Moderately	24 (61.5)	15 (38.5)	39 (6.5)	
A little	6 (40.0)	9 (60.0)	15 (2.5)	
Not at all	4 (80.0)	1 (20.0)	5 (0.8)	
Doesn't know	62 (37.6)	103 (62.4)	165 (27.3)	
Community exposure to discussions about the MV				
No	317 (67.6)	152 (32.4)	469 (77.6)	F = 21.71; <i>p</i> < 0.001
Yes	121 (89.6)	14 (10.4)	135 (22.4)	
Favorable opinion of close family/friends on the MV				
No	7 (25.0)	21 (75.0)	28 (4.6)	F = 36.20; <i>p</i> < 0.001
Yes	431 (74.8)	145 (25.2)	576 (95.4)	
Mother's decision-making autonomy				
Yes	321 (73.6)	115 (26.4)	436 (72.2)	F = 0.41; <i>p</i> = 0.524
No	117 (69.6)	51 (30.4)	168 (27.8)	
Person granting permission when autonomy is absent (n = 168)				
Mother (of the respondent)	57 (83.8)	11 (16.2)	68 (40.5)	F = 6.68; <i>p</i> = 0.015
Head of household	60 (60.0)	40 (40.0)	100 (59.5)	
Perceived equal access to MV information (men/women)				
Yes	294 (77.8)	84 (22.2)	378 (62.6)	F = 5.20; <i>p</i> = 0.029
No	144 (63.7)	82 (36.3)	226 (37.4)	
Intention to have the child vaccinated against malaria				
No	6 (9.4)	58 (90.6)	64 (10.6)	F = 122.42; <i>p</i> < 0.001
Yes	432 (80.0)	108 (20.0)	540 (89.4)	

3.6. Practical Issues Related to Vaccination and Malaria Vaccine Uptake

The uptake rate reached 92.6% among mothers rating financial access to the vaccine as very easy, versus 78.0% among those rating it as easy (F = 2.60; $p = 0.043$). Ease of access to vaccination services was likewise associated with uptake (F =

2.72; $p = 0.043$). Mothers rating access as very easy had an uptake rate of 89.3%, versus 59.1% among those rating access as not easy at all. In addition, availability of transportation to the vaccination center was not significantly associated with uptake ($F = 2.36$; $p = 0.134$), although the uptake rate was slightly higher among mothers with access to transportation (81.7%) than among those without (70.5%). Evaluation of the quality of services provided at vaccination centers was likewise associated with uptake ($F = 4.45$; $p = 0.005$). The uptake rate was 85.1% among mothers rating services as very good and 74.3% among those rating them as good. Evaluation of the quality of reception was also significantly associated with MV uptake ($F = 5.73$; $p < 0.001$). Mothers who rated reception as very good had an uptake rate of 87.8%, versus 72.4% among those rating it as fairly good and only 50.0% among those rating it as poor. Having received advice or information from a health worker regarding the malaria vaccine was strongly associated with uptake ($F = 38.70$; $p < 0.001$). Among mothers who had received information or advice about the MV, 89.0% had their child vaccinated, versus only 57.5% among those who received no information (**Table 6**).

Table 6. Association between practical issues related to access to vaccination services and malaria vaccine uptake among children aged 6 to 18 months in the Allada-Toffo-Zè health zone, 2025.

Variables	Yes n (%)	No n (%)	Total n (%)	Rao-Scott F (p)
Perceived financial ease of obtaining the MV				
Very easy	25 (92.6)	2 (7.4)	27 (4.5)	F = 2.60; <i>p</i> = 0.043
Easy	78 (78.0)	22 (22.0)	100 (16.6)	
Moderately easy	260 (71.4)	104 (28.6)	364 (60.3)	
Not very easy	60 (71.4)	24 (28.6)	84 (13.9)	
Not easy at all	15 (51.7)	14 (48.3)	29 (4.8)	
Ease of access to vaccination services				
Very easy	25 (89.3)	3 (10.7)	28 (4.6)	F = 2.72; <i>p</i> = 0.043
Easy	147 (65.6)	77 (34.4)	224 (37.1)	
Moderately easy	187 (77.6)	54 (22.4)	241 (39.9)	
Not very easy	66 (74.2)	23 (25.8)	89 (14.7)	
Not easy at all	13 (59.1)	9 (40.9)	22 (3.6)	
Distance to the health center				
Less than 5 km	329 (70.3)	139 (29.7)	468 (77.5)	F = 2.78; <i>p</i> = 0.105
5 km or more	109 (80.1)	27 (19.9)	136 (22.5)	
Availability of transportation to the vaccination center				
No	349 (70.5)	146 (29.5)	495 (82.0)	F = 2.36; <i>p</i> = 0.134
Yes	89 (81.7)	20 (18.3)	109 (18.0)	

Continued

Evaluation of service quality at the vaccination center				
Very good	40 (85.1)	7 (14.9)	47 (7.8)	F = 4.45; <i>p</i> = 0.005
Good	352 (74.3)	122 (25.7)	474 (78.5)	
Average	41 (58.6)	29 (41.4)	70 (11.6)	
Poor	5 (41.7)	7 (58.3)	12 (2.0)	
Very poor	0 (0.0)	1 (100.0)	1 (0.2)	
Overall evaluation of reception quality				
Very good	115 (87.8)	16 (12.2)	131 (21.7)	F = 5.73; <i>p</i> = 0.001
Fairly good	268 (72.4)	102 (27.6)	370 (61.3)	
Moderately good	36 (51.4)	34 (48.6)	70 (11.6)	
Poor	5 (50.0)	5 (50.0)	10 (1.7)	
Very poor	0 (0.0)	1 (100.0)	1 (0.2)	
Doesn't know/no opinion	14 (63.6)	8 (36.4)	22 (3.6)	
Received advice/information from a health worker about the MV				
No	181 (57.5)	134 (42.5)	315 (52.2)	F = 38.70; <i>p</i> < 0.001
Yes	257 (88.9)	32 (11.1)	289 (47.8)	

3.7. Multivariable Analysis of Factors Associated with Malaria Vaccine Uptake

Mothers who reported an intention to have their child vaccinated had approximately 6.6 times higher odds of uptake than those without this intention (aOR = 6.69; 95% CI: [2.18 - 20.54]; *p* = 0.002). Compared with mothers holding an unfavorable perception (not very effective, not effective at all) of MV effectiveness, those holding a favorable perception (very effective, moderately effective) had more than 9 times higher odds of having their child vaccinated (aOR = 9.46 [2.92 - 30.62]; *p* = 0.001). Mothers perceiving strong (a great deal, a lot) community endorsement of the MV had more than 2.6 times higher odds of vaccine uptake (aOR = 2.62; 95% CI: [1.37 - 5.00]; *p* = 0.006) than mothers of children perceiving low endorsement (moderately, a little, not at all) or who did not know how to assess it.

A favorable opinion of close parents or friends regarding the child's vaccination was associated with an uptake probability multiplied by nearly 4 (aOR = 3.84; 95% CI: [1.63 - 9.04]; *p* = 0.004) (**Table 7**).

4. Discussion

The MV uptake rate (up to date for age) in our study population at the time of the survey was 72.6%, which falls within the range reported by other African studies. It is thus comparable to that observed by Abiache *et al.* [12] in Cameroon, where 72.0% of vaccinated children had completed the recommended schedule,

Table 7. Factors independently associated with malaria vaccine uptake.

Variables	Yes n (%)	No n (%)	Crude OR [95% CI]	Adjusted - simple design OR [95% CI]	Adjusted - cluster design OR [95% CI]	p (cluster design)
Intention to vaccinate the child						
No	6 (9.4)	58 (90.6)	1	1	1	--
Yes	432 (80.0)	108 (20.0)	38.67 [16.26 - 91.97]	6.69 [2.32 - 19.31]	6.69 [2.18 - 20.54]	0.002
Perceived effectiveness of the MV						
Not favorable/DK	42 (23.9)	134 (76.1)	1	1	1	--
Favorable	396 (92.5)	32 (7.5)	39.48 [23.95 - 65.09]	9.46 [4.52 - 19.79]	9.46 [2.92 - 30.62]	0.001
Community endorsement of the MV						
Low/DK	96 (42.9)	128 (57.1)	1	1	1	--
High	342 (90.0)	38 (10.0)	12.00 [7.83 - 18.39]	2.62 [1.45 - 4.75]	2.62 [1.37 - 5.00]	0.006
Awareness of MV existence						
No	50 (31.1)	111 (68.9)	1	1	1	--
Yes	388 (87.6)	55 (12.4)	15.66 [10.11 - 24.25]	1.89 [0.90 - 3.94]	1.89 [0.69 - 5.18]	0.205
Distance to the health center						
Less than 5 km	329 (70.3)	139 (29.7)	1	1	1	--
5 km or more	109 (80.1)	27 (19.9)	1.71 [1.07 - 2.72]	1.78 [0.85 - 3.73]	1.78 [0.56 - 5.67]	0.312
Health worker advice						
No	181 (57.5)	134 (42.5)	1	1	1	--
Yes	257 (88.9)	32 (11.1)	5.95 [3.87 - 9.14]	1.67 [0.91 - 3.07]	1.67 [0.77 - 3.62]	0.185
Favorable opinion of parents/friends						
No	7 (25.0)	21 (75.0)	1	1	1	--
Yes	431 (74.8)	145 (25.2)	8.92 [3.71 - 21.41]	3.84 [0.91 - 16.21]	3.84 [1.63 - 9.04]	0.004
Equal access to information						
No	144 (63.7)	82 (36.3)	1	1	1	--
Yes	294 (77.8)	84 (22.2)	1.99 [1.39 - 2.87]	1.57 [0.88 - 2.79]	1.57 [0.80 - 3.08]	0.181
Perceived malaria risk in the child						
Low/DK	16 (43.2)	21 (56.8)	1	1	1	--
Moderate	22 (71.0)	9 (29.0)	3.21 [1.17 - 8.83]	2.14 [0.47 - 9.70]	2.14 [0.65 - 7.03]	0.197
High	293 (72.7)	110 (27.3)	3.50 [1.76 - 6.94]	1.80 [0.63 - 5.12]	1.80 [0.56 - 5.80]	0.310
Very high	107 (80.5)	26 (19.5)	5.40 [2.48 - 11.77]	1.05 [0.31 - 3.59]	1.05 [0.30 - 3.66]	0.932
Trust in the MV						
Not favorable	405 (71.7)	160 (28.3)	1	1	1	--
Favorable	33 (84.6)	6 (15.4)	2.17 [0.89 - 5.29]	0.86 [0.24 - 3.10]	0.86 [0.22 - 3.39]	0.819

Continued

Quality of reception						
Poor/DK	323 (68.3)	150 (31.7)	1	1	1	--
Good	115 (87.8)	16 (12.2)	3.34 [1.91 - 5.83]	1.62 [0.71 - 3.71]	1.62 [0.74 - 3.53]	0.210
Availability of transportation						
No	349 (70.5)	146 (29.5)	1	1	1	--
Yes	89 (81.7)	20 (18.3)	1.86 [1.10 - 3.14]	1.17 [0.53 - 2.59]	1.17 [0.49 - 2.82]	0.712
Perceived financial ease						
Not easy	335 (70.2)	142 (29.8)	1	1	1	--
Easy	103 (81.1)	24 (18.9)	1.82 [1.12 - 2.96]	0.92 [0.43 - 1.97]	0.92 [0.46 - 1.84]	0.846

but remains lower than the coverage reported by Tabiri *et al.* [13] in Ghana, where uptake of the first MV dose reached 94.1%. Our result, however, exceeds that of Simbeye *et al.* [14] in Malawi, where coverage declined progressively from 90.5% at the first dose to only 41.2% at the fourth dose, illustrating marked vaccine attrition over the course of the schedule; this may be explained by the fact that, in our study, our coverage figure corresponds to an average taking all doses into account.

The intention to have the child vaccinated emerged as one of the factors most strongly associated with MV uptake (aOR = 6.69; 95% CI: [2.18 - 20.54]; $p = 0.002$). There is thus a favorable vaccination intention within the population, but a gap is observed between this intention to vaccinate (89.4%) and actual uptake (72.6%), which is in line with the conclusions of Mathebula *et al.* [4] in South Africa, who identified a genuine “intention-behaviour gap” among caregivers who were motivated but faced structural and logistical constraints limiting the translation of their intention into action. This intention-behavior gap shows that barriers to vaccination lie not only at the level of ideological adherence to the vaccine, but more so in the pivotal zone separating motivation from the concrete act of vaccination. Our findings thus reinforce the idea that improving vaccination coverage requires acting as a priority on operational barriers as well, rather than solely on raising caregiver—or, in our case, maternal—awareness about vaccination.

Regarding perceived MV effectiveness, our result (aOR = 9.46; 95% CI: [2.92 - 30.62]; $p = 0.001$) is consistent with data reported in Ghana by Kwadzokpui and Ablordey in 2025, where belief in complete vaccine protection multiplied the odds of RTS,S acceptance by nearly five (crude OR = 4.68; [95% CI: 1.27 - 17.33]; $p = 0.023$), and subjects who believed the vaccine offered complete protection against malaria had a markedly higher acceptance rate (96.8%) than those who did not (86.7%) [15]. This association between favorable perception of effectiveness and vaccine adoption is, however, not consistently found in the 2023 study by Röbl *et al.*, who showed that in Guinea and Sierra Leone, acceptance depended more on geographic access, socioeconomic level, and prior preventive behaviors than on perceived effectiveness itself [16]. These divergent findings suggest that the influ-

ence of perceived effectiveness on vaccine adoption is not uniform, but likely depends on the sociocultural context and the degree of community ownership of the vaccination program.

Mothers perceiving strong (a great deal, a lot) community endorsement of the MV had more than 2.6 times higher odds of vaccine uptake (aOR = 2.62; 95% CI: [1.37 - 5.00]; $p = 0.006$). This positive association is consistent with observations made in Ghana by Kwadzokpui and Ablordey in 2025 [15], where family and peer influence was a significant determinant of vaccination completeness (aOR = 2.09). This relationship is not, however, univocal: in a study conducted in Nigeria by Sulaiman *et al.* [17], dominant community representations were marked by misinformation (notably rumors of infertility), and a decrease in vaccine adherence of 20 to 30% was observed instead. These studies reveal that the intensity of community endorsement influences vaccine uptake, but that the content (favorable or unfavorable) of the dominant social norms within the community is a factor to be taken into account, underscoring the importance of community mobilization efforts targeted at the quality of information circulating locally.

The positive influence of close social circles is likewise consistent with the previously cited work of Kwadzokpui and Ablordey [15], where family and peer influence was a significant determinant of vaccination completeness through booster doses (aOR = 2.09), as well as with a study conducted by Adamu *et al.* in Gombe State, Nigeria, in 2025, where 67.2% of caregivers reported that family, friends, and religious leaders influenced their decision to vaccinate [18]. These converging findings confirm the weight of one's close social circle (family and friends) as a robust, independent determinant of MV uptake in our sample. Health worker advice, although strongly associated with uptake in bivariate analysis (**Table 6**), no longer retained an independent association once the other variables were accounted for in our adjusted model, suggesting that it may act through indirect pathways, notably by reinforcing perceived vaccine effectiveness, itself one of the determinants most strongly associated with uptake in our study. This finding argues for communication strategies that combine an active role for health workers as trusted sources of information on MV effectiveness, with mobilization of mothers' close social networks as complementary vectors of vaccine adherence.

5. Study Limitations

Owing to its cross-sectional design, this study cannot establish causality between the factors studied and MV uptake, and certain self-reported variables (intention, risk perception, trust) remain exposed to social desirability and recall bias, although vaccination status was verified against the vaccination record to limit this risk for the dependent variable. The post hoc grouping of certain risk-perception categories, necessitated by small cell counts, may have slightly reduced the precision of this measure. Finally, conducting the study in a single pilot health zone limits the generalizability of the findings to Benin as a whole, particularly to areas without the MV or with different sociodemographic profiles.

6. Conclusion

This study shows that adoption of the malaria vaccine at its introduction in the ATZ health zone is generally satisfactory. Our findings call for strengthening health workers' interpersonal communication regarding the MV, particularly the content of the message (existence, importance, effectiveness, safety of the MV, and its complementary role in the fight against malaria); revising communication on the MV vaccination schedule to account for pre-existing habits; and improving vaccination services (services located closer to the population, with sufficient qualified staff providing quality care, good reception, and adequate technical resources).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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