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Evaluating the knowledge, attitude, perception, and readiness of caregivers of under 5-year-old children to accept malaria vaccine in Nigeria

Purpose: The global burden of disease and mortality is greatly influenced by malaria, particularly in children. Nigeria alone accounts for about 25% of global malaria cases and fatalities. Despite efforts to control and eliminate malaria, conventional treatments have limitations, prompting the need for a vaccine. However, while efforts have focused on researching and developing malaria vaccines, less attention has been given to public acceptance and preparedness for vaccination.

Materials and Methods: The study employed a cross-sectional approach to assess the knowledge, perceptions, and readiness of caregivers towards the malaria vaccine. Data were collected through a physical and online survey among a representative sample of caregivers across the six geopolitical regions of Nigeria. The data was analyzed using principal component analysis and percentages.

Results: Out of 347 respondents, 180 (51%) men, 165 (46.6%) women, 2 (0.5%) transgender, 156 (45%) rural settlers, and 191 (55%) urban settlers were identified in this study. The study reported an overall acceptance rate of 78.4% and 21.6% resistance rate. The age group between 21–30 years recorded the highest 207 (59.6%). A significant number of participants, 252 (59.6%), held at least a higher or post-secondary certificate, out of which 193 (55.6%) demonstrated strong readiness to accept the malaria vaccine. The study showed that fear of adverse effects was the main reason for malaria vaccine resistance among caregivers.

Conclusion: This study's findings offer valuable insights into caregivers' knowledge about the malaria vaccine, highlighting the factors that impact the acceptance of the malaria vaccine.

Keywords: Malaria vaccines, Awareness, Perception

Introduction

Malaria is a severe public health concern in Nigeria, accounting for a high burden of disease and loss of life due to *Plasmodium* parasites transmitted to individuals through the bites of infected female *Anopheles* mosquitoes. According to World Health Organization (WHO) reports, there were 247 million cases of malaria in 2021, and malaria was responsible for 619,000 fatalities globally, with the WHO Sub-Saharan Africa area accounting for around 96% [1]. Nigeria has the largest malaria burden in Africa, with an estimated 95% of the population at risk of infection, and contributes a significant amount to the worldwide malaria burden, accounting for 23% of the 31.3% of all global malaria fatalities [1,2].

Plasmodium falciparum parasites have gained resistance to all antimalarials used on

a broad basis [3]. In Africa, less complicated malaria is managed using artemisinin-based combination therapy (ACT), of which artemether-lumefantrine is used as an essential medicine in Nigeria due to its efficacy in the treatment of malaria, but it is more expensive than earlier treatments, and recently, resistances have been reported [4]. Despite persistent initiatives to regulate and eradicate malaria, conventional treatments, including treated mosquito nets, indoor residual spraying, and ACT, have demonstrated limits in terms of long-term impact. Therefore, vaccines are an apparent strategy to prevent the spread of infectious diseases across the world. The importance of vaccinations has been shown effectively in the battle against numerous infectious illnesses, including polio, measles, diphtheria, tetanus, rabies, and smallpox [5]. In addition to the present initiatives, more financing for malaria vaccine research and development will be required to reach the WHO global technical strategy objectives [2] and the Sustainable Development Goal (target 3.3) [6]. As a result, the development and distribution of a malaria vaccine will constitute a key milestone towards the elimination and eradication of malaria by providing the necessary protection for those living with malaria or at risk of malaria.

The first malaria vaccine that has been proven to provide partial defense against *P. falciparum* which is the most frequent lethal malaria parasite worldwide is known by different names such as Mosquirix, RTS, S/AS01, or simply RTS,S [7-9]. The implementation of RTS,S malaria vaccine is encouraged to prevent *P. falciparum* malaria in pediatric populations residing in regions with moderately high transmission, according to WHO guidelines, within the framework of integrated strategies for malaria control. Subsequent to phase III effectiveness study across the borders of seven sub-Saharan African countries, the WHO licensed the RTS,S, malaria vaccine regime comprising of four doses for recommended usage in October 2021 [8,10]. The fourfold dosage regimen indicated a 25.9% effectiveness rate (95% confidence interval, 19.9 to 31.5) in a group of 6,537 infants aged 6–12 weeks and a 36.3% effectiveness rate (95% confidence interval, 31.8 to 40.5) in a trial group of 8,922 children aged 5–17 months diagnosed with clinical malaria. The initial three doses are administered via intramuscular route from 5–9 months of age, with the fourth dosage indicated around 15–18 months of age [10], all with the goal of reducing malaria morbidity and burden.

While the focus has primarily been on malaria vaccine research and development, less attention has been paid to public acceptance and the preparedness of caregivers to comply with

malaria immunizations. The degree of awareness as well as the population's opinions of the diseases in question impact compliance rates [11,12]. This study aims to fill this research gap by investigating the knowledge, perception, and awareness of malaria vaccines among caregivers living in Nigeria. Through a comprehensive survey and qualitative interviews, we seek to explore the factors influencing vaccine knowledge, assess the perception of malaria vaccines, and identify the level of awareness among caregivers and various population groups in Nigeria. The outcomes of this study will foster a deeper understanding of the sociocultural dynamics surrounding malaria vaccines and inform strategies for enhancing vaccine acceptance and uptake in the Nigerian context.

Materials and Methods

Study area

The study involved an online survey that spanned the six geopolitical zones of Nigeria (Fig. 1). Nigeria is a West African country that is bordered by Republics of Benin, Cameroun, Chad, and Niger. With around 199 million people, Nigeria is the world's most populous Black Country [12]. The rainy season and the dry season are the two seasons of Nigeria. While the dry season lasts from October to March, the rainy season lasts from April to September. Rainfall often increases in the southern region of the nation that is closer to the Atlantic Ocean, and gradually diminishes in the northern region that is closer to the Sahara Desert [13]. Even though English is the official language of Nigeria, the country has over 250 ethnic groups and 500 languages [14].

Sample size

The minimal sample size needed for this study was calculated using Fisher's formula for sample size determination in health studies [15].

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

Where N = minimum sample size, Z = standard normal distribution that corresponds to a 95% confidence interval, the value obtained from a normal distribution table is 1.96. P = 67.7% (proportion of respondents who were unwilling to accept malaria vaccine from a previous study) [16], q = 1 - p, and d = desired precision = 0.05. Thus, $N = (1.96)^2 \times 0.677 \times 0.323 / (0.05)^2 = 336$. However, we were able to document 347 responses at the end of the study.

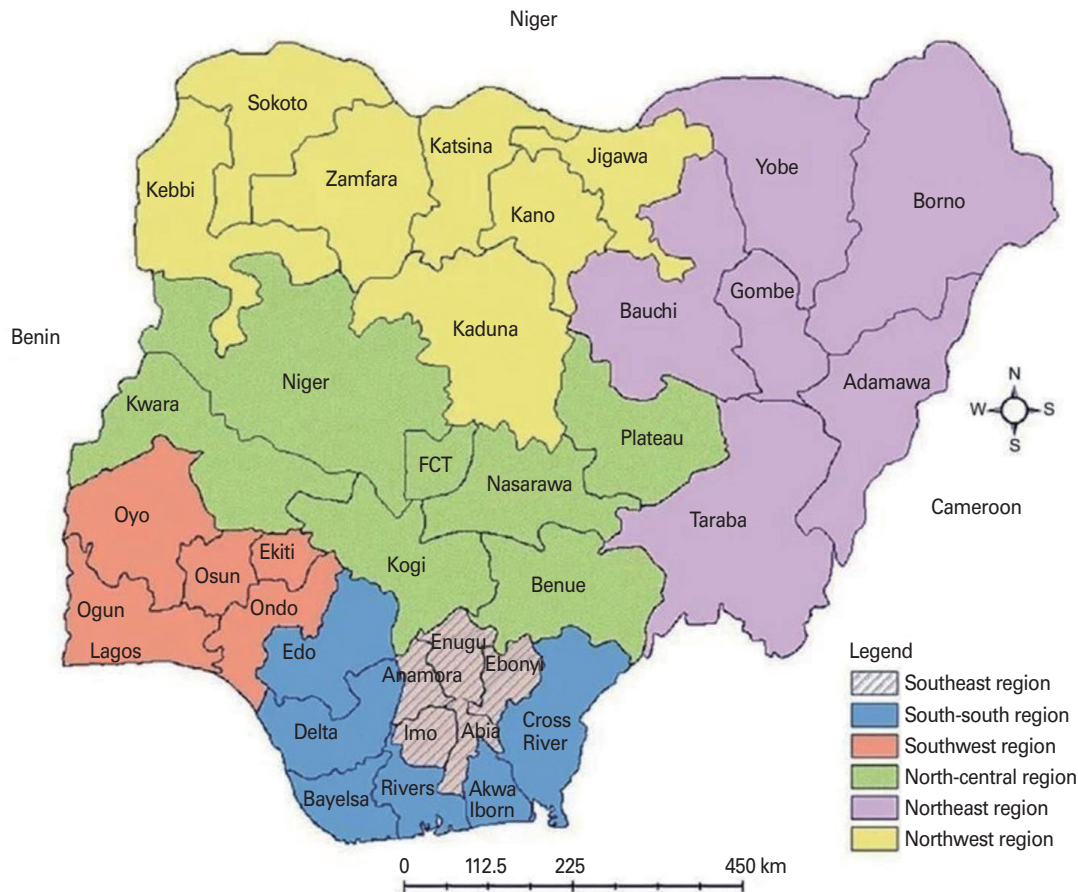


Fig. 1. Map showing the six geo-political zones of Nigeria.

Data collection

Cross-sectional physical and online survey was conducted from May 22 to 28, 2023. Method of simple random sampling as described by Stratton [17], was employed using a semi-structured questionnaire created with Google Forms (Google LLC, Mountain View, CA, USA; <https://docs.google.com/forms/>). The questions administered through the questionnaire were close-ended with a “yes,” “no,” or “not sure” responses. Responses like “no” and “not sure” were analyzed to determine hesitancy to the malaria vaccine. The authors of this research study were drawn from either the northern or southern parts of Nigeria in order to facilitate extensive distribution of the online questionnaire link across numerous social media platforms specific to each region. A physical survey was carried out in rural areas that do not have access to internet. For the physical survey, respondents were met in markets, family houses, hospitals, schools, and other physical places. The questionnaire for this study was designed to generate information about the demographic profile of the respondents, their general perception about malaria parasite infection, their knowledge and aware-

ness of the malaria vaccine, as well as their perception and acceptance of the vaccine. The information filled out by the respondents was directly stored in an online and retrievable single spreadsheet that was linked to the Google Forms. The privacy of each respondent was respected, and they were kept anonymous.

Caregivers consent to participate

The study was conducted in accordance with the Declaration of Helsinki. The design of this study was approved by the Ethics Committee of Specialist Hospital Yola, Adamawa State, Nigeria (Ref. ID: ADS/SHY/SUB/77/VOL.I), which served as the central location where the idea for the study was conceived. Furthermore, informed consent was obtained in written form and verbally from all caregivers who participated in this study.

Data analysis

The socio-demographic profile of the respondents was presented in the form of percentages and analyzed thereafter us-

ing principal component analysis (PCA). The PCA was done using GraphPad Prism ver. 9.5.0 (GraphPad Software, San Diego, CA, USA). Other information obtained from the study was presented in tables and graphs that were applicable and analyzed using descriptive statistics. Vaccine hesitancy for each category of a variable was calculated as (number of no responses+number of not sure responses)÷number of respondents in each category.

Results

Socio-demographic profile of the respondents

Table 1 display the frequency distribution of the caregivers’ socio-demographic profile, further analyzed and summarized by PCA (Fig. 2A–H). As can be observed, men made up

Table 1. Socio-demographic profile of the respondents (interviewees)

Characteristic	Category	Frequency (%)
Gender	Female	165 (47.6)
	Male	180 (51.9)
	Other	2 (0.5)
Age range (yr)	21–30	207 (59.7)
	31–40	98 (28.2)
	41–50	28 (8.1)
	≥50	14 (4.0)
	Educational level	Higher education
	Non-formal	52 (15.0)
	Primary	18 (5.2)
	Secondary	25 (7.2)
Geopolitical zone	Northeast	96 (27.7)
	North-central	64 (18.4)
	Northwest	108 (31.1)
	Southeast	31 (8.9)
	South-south	16 (4.6)
	Southwest	32 (9.3)
	Occupation	Business man/woman
	Civil servant	99 (28.5)
	Farmers	29 (8.4)
	Students	75 (21.6)
	Unemployed	48 (13.8)
Marital status	Divorced	1 (0.3)
	Married	134 (38.6)
	Single	198 (57.1)
	Widow	14 (4.0)
Settlement	Rural	156 (45.0)
	Urban	191 (55.0)
Point of collection	Online	148 (42.7)
	Physical	199 (57.3)

the greater percentage of the respondents, with 180 (51.9%), while women were represented by 165 caregivers (46.6%). Two transgender people (0.5%) were also interviewed in the study. In terms of age, the study observed that the majority of participants (207 [59.6%]) were young adults, specifically men and women aged between 21 and 30 years. A significant majority of the respondents, specifically 252 (72.6%), hold at least one of the higher or post-secondary certificates of learning conferred by the Nigerian tertiary institutions. Furthermore, each of the geopolitical zones has a fair representation of participants, with the Northwest accounting for more than 108 (31%) of the respondents.

With respect to occupation status, it was found that civil servants comprised the largest proportion, representing 28.5% of the overall participants. Conversely, farmers represented the smallest proportion, accounting for only 8.4% of the respondents. With respect to marital status, a significant majority of the respondents, specifically 198 individuals, representing 57.1%, were identified as unmarried or single. Regarding settlement patterns, no significant difference was observed in the proportion of respondents residing in rural areas (45%) compared to those residing in urban areas (55%). Furthermore, Fig. 3 showed that a higher percentage of the study’s responses were acquired through conducting online questionnaire, accounting for 199 responses (57.3%) of the total. In contrast, 148 responses (42.7%) were obtained from the physical survey.

Malaria vaccine resistance among caregivers of under-5 children in Nigeria

Table 2 displays the vaccine hesitancy among respondents that participated in the study. Respondents with higher educational qualifications (n=193) showed a strong readiness to embrace the malaria vaccine compared to other categories. However, the divorce category recorded the highest vaccine hesitancy of 100%, as the only respondent in that category decided not to use the vaccine when implemented. Similarly, primary school certificate holders showed the second highest vaccine hesitancy (38.9%), as documented in this study.

Respondents’ knowledge and awareness about the malaria vaccine

The majority of the respondents in each category have not heard about the new malaria vaccine. Similarly, they are also not aware that the Nigerian government has approved the vaccine for use and that the implementation of the vaccine starts in 2024 (Tables 3–5).

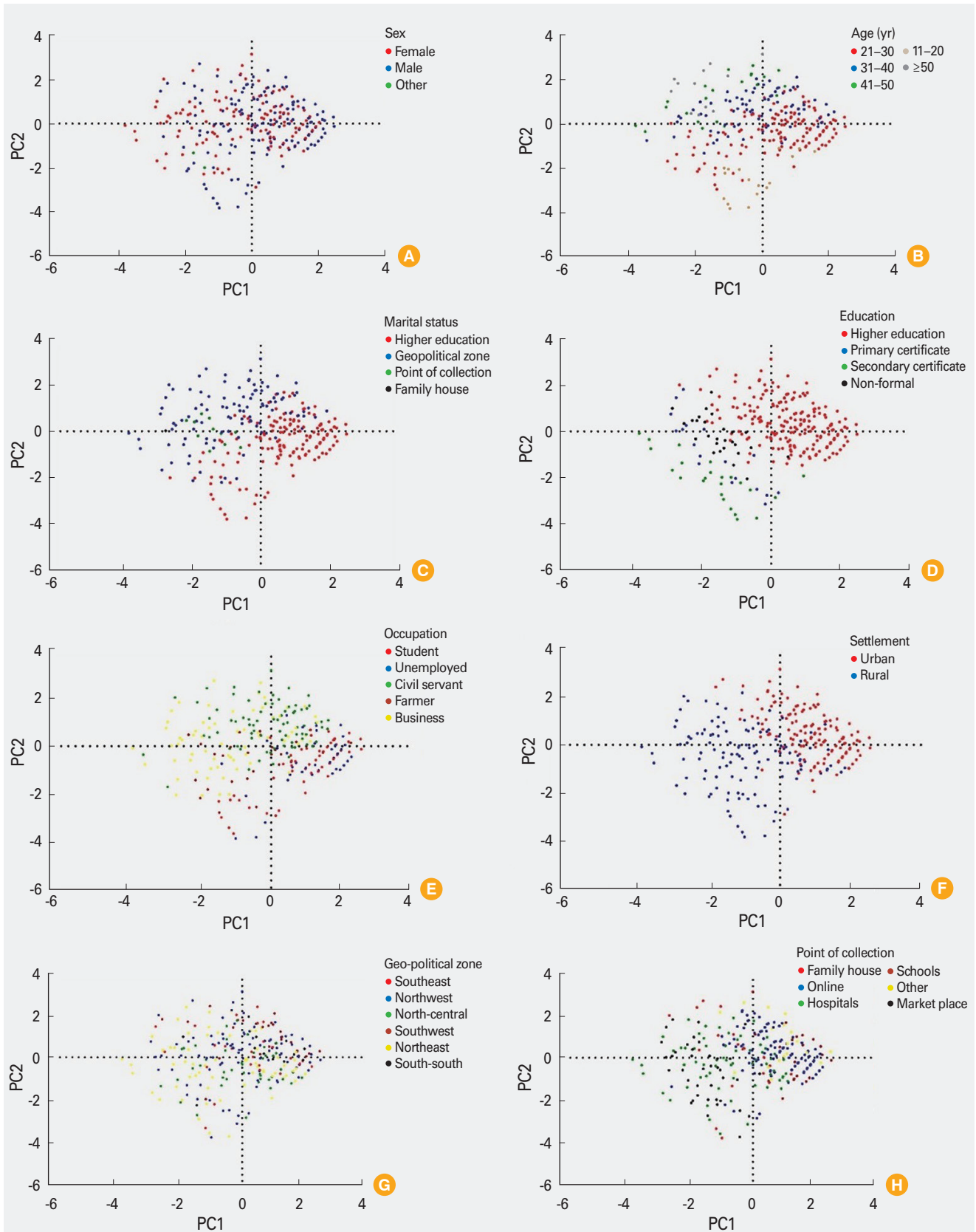


Fig. 2. Principal component (PC) analysis comparing gender (A), age (B), Marital status (C), educational level (D), occupation (E), settlement (F), and geopolitical zone (G) of the respondents, and point of collection of data (H).

Table 2. Willingness to accept the malaria vaccine among caregivers of under-5 children in Nigeria

Variable	No. of willingness			Hesitancy (%)
	Yes	No	Not sure	
Gender				
Male	149	10	21	17.2
Female	121	15	29	26.7
Other	2	-	-	0
Age range (yr)				
21–30	152	21	34	26.6
31–40	81	3	14	17.3
41–50	20	3	5	34.8
≥50	10	2	2	28.6
Educational status				
Higher education	198	12	42	21.4
Non-formal	41	4	7	21.2
Primary	11	6	1	38.9
Secondary	21	2	2	16.0
Geopolitical zone				
Northeast	80	4	12	16.7
North-central	53	3	8	17.2
Northwest	82	12	14	24.1
Southeast	22	1	8	29.0
South-south	13	1	2	18.8
Southwest	21	3	8	34.4
Occupation				
Businessmen/women	70	9	17	27.1
Civil servants	81	3	15	18.2
Farmers	24	2	3	17.2
Students	60	7	8	20.0
Unemployed	36	4	8	25.0
Marital status				
Divorce	-	1	-	100.0
Married	105	10	19	21.6
Single	156	12	30	21.2
Widow	10	1	3	28.6
Settlement				
Rural	120	16	20	23.1
Urban	150	8	33	21.5

Reasons for vaccine hesitancy cited by some of the respondents interviewed during the study

As demonstrated in Fig. 4, different caregivers cited different reasons for their hesitancy to take the vaccine. The majority were hesitant because they believed that the vaccine had potential side effects, while others explicitly stated the side effects they felt or heard that the vaccine had. Others did not give their personal reasons why they were hesitant to take the malaria vaccine when implemented by 2024.

Table 3. Respondents’ knowledge and awareness about the malaria vaccine

Variable	Knowledge: Q1. Have you heard about the new malaria vaccine?	
	Yes	No
Gender		
Male	63	117
Female	42	123
Other	-	2
Age range (yr)		
21–30	63	124
31–40	31	72
41–50	9	19
≥50	9	20
Educational status		
Higher education	87	164
Non-formal	8	44
Primary	2	16
Secondary	7	19
Geopolitical zone		
Northeast	26	69
North-central	20	44
Northwest	28	80
Southeast	16	15
South-south	5	11
Southwest	10	23
Settlement		
Rural	38	117
Urban	67	125

Q1: question 1 administered to the respondents.

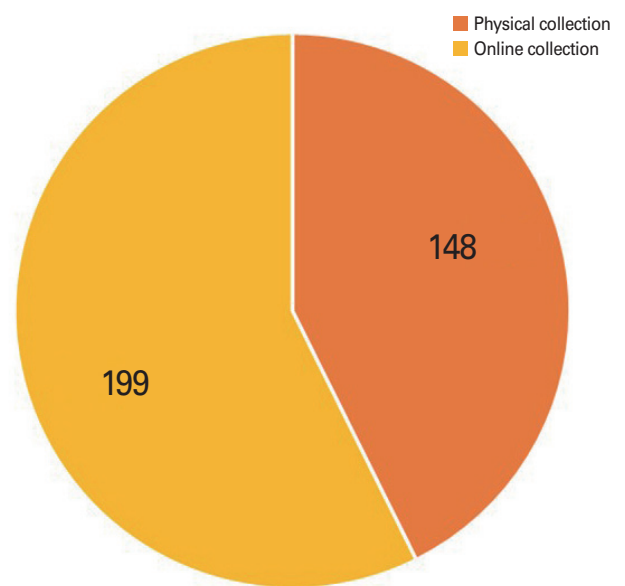


Fig. 3. Proportion of the number of virtual (online) and physical respondents in the study.

Table 4. Respondents’ knowledge and awareness about the malaria vaccine

Variable	Knowledge: Q2. Are you aware that the Nigerian government has approved the vaccine for use?	
	Yes	No
Gender		
Male	60	120
Female	39	126
Other	-	2
Age range (yr)		
21–30	55	132
31–40	30	73
41–50	4	34
≥50	8	21
Educational status		
Higher education	20	191
Non-formal	6	42
Primary	-	18
Secondary	2	24
Geopolitical zone		
Northeast	15	80
North-central	12	52
Northwest	25	83
Southeast	10	21
South-south	5	11
Southwest	10	23
Settlement		
Rural	16	139
Urban	60	132

Q2: question 2 administered to the respondents.

Table 5. Respondents’ knowledge and awareness about the malaria vaccine

Variable	Knowledge: Q3. Are you aware that the implementation of malaria vaccine in Nigeria starts by 2024?	
	Yes	No
Gender		
Male	28	153
Female	20	144
Other	-	2
Age range (yr)		
21–30	29	158
31–40	9	89
41–50	12	26
≥50	10	14
Educational status		
Higher education	39	212
Non-formal	3	49
Primary	1	18
Secondary	4	21
Geopolitical zone		
Northeast	18	77
North-central	7	56
Northwest	11	96
Southeast	5	26
South-south	4	15
Southwest	4	28
Settlement		
Rural	23	132
Urban	25	167

Q3: Question 3 administered to the respondents.

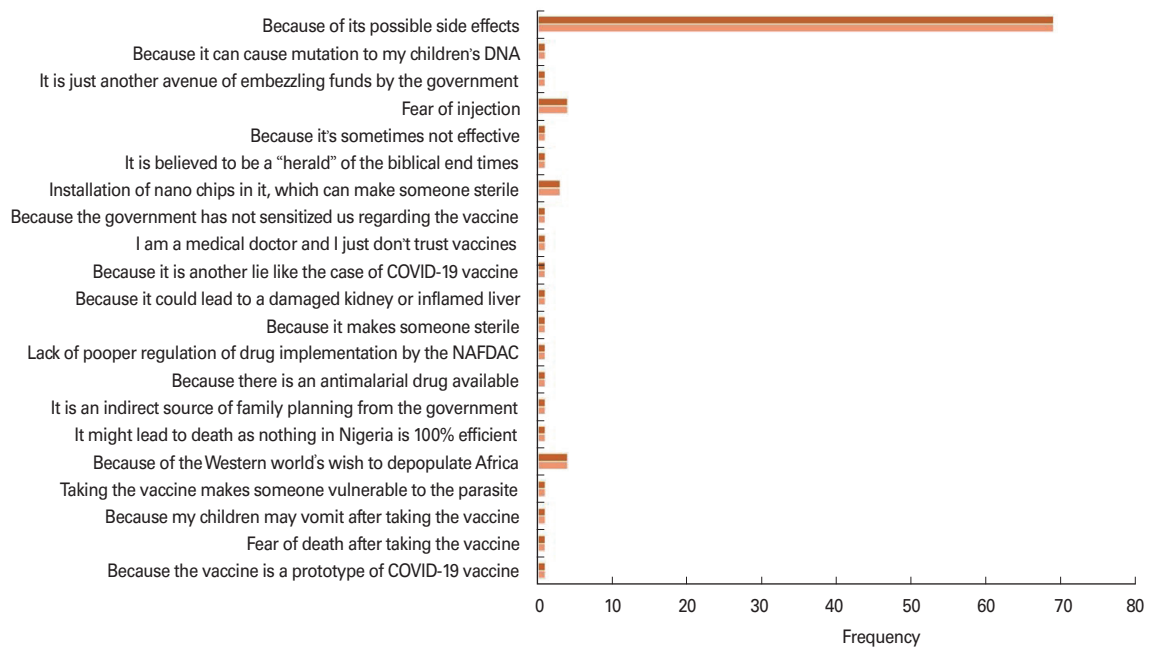


Fig. 4. Reasons for vaccine hesitancy cited by some of the respondents interviewed during the study. COVID-19, coronavirus disease 2019; NAFDAC, National Agency for Food and Drug Administration and Control.

Discussion

The introduction of new vaccines is often met with a range of reactions and concerns within communities. In Nigeria, where malaria is a significant public health issue, the acceptance or resistance to the malaria vaccine determines the success or failure of the vaccine to effectively eradicate this persistent disease [18]. The findings of this study showed that 271 out of 347 caregivers were eager to see the eradication of malaria in Nigeria, and so they willfully accept that they would allow their children to be part of the vaccination program once it kickstarts, as a result the study demonstrated an overall acceptance rate of 78.4%. However, some of the caregivers were only willing to accept the vaccine if there were no side effects, giving a resistance rate of 21.6%. This finding can be supported by the work of Ojaka et al. [19], which reveals that 88% of caregivers expressed acceptance regarding their children receiving the malaria vaccine in Kenya. However, the finding was in contrast with the study carried out in Ethiopia [16], which revealed a relatively low acceptance rate of 32.3%. The variation in findings may be attributed to the differences in survey design and data collection techniques. Also, research conducted at different points in time or under varying circumstances can generate different outcomes. Nonetheless, this study is unique because we employed both physical and online techniques to gather data in remote places (rural settlement) and developed areas (urban settlement) to ensure that we present an unbiased result.

This study assessed the reasons for vaccine resistance among 21.6% of the caregivers who bluntly rejected the malaria vaccine, and found that the main reason for vaccine hesitancy was because of the possible side effects of the vaccine. This finding concurred with the study conducted in Ethiopia by Asmare [16], in Tanzania by Mtenga et al. [20], and in Sierra Leone by McCoy et al. [21], which reported that caregivers will only agree to receive the vaccine once its safety and effectiveness have been guaranteed. Normally, the possible side effects of the malaria vaccine range from injection site reactions (mild to moderate pain, swelling, or redness of the injection site), high fever, headache, muscle ache, and fatigue [22]. However, there are fears that the malaria vaccine can come with more adverse effects, such as heart diseases, partial strokes, and induced infertility (population control), organ or system failures, and so forth [23]. These fears are being instigated by many factors, like the spread of inaccurate information, rumors, and conspiracy theories [23]. Another factor that instills fear in caregivers is a lack of trust in the healthcare system and government agencies in-

involved in vaccine distribution [24]. In Nigeria, where trust in government institutions and healthcare providers varies, a lack of confidence in the system can contribute to resistance to the acceptance of malaria vaccines [24]. Additionally, past experience with healthcare interventions, particularly in the context of clinical trials or public health campaigns, can influence attitudes toward the new malaria vaccine. Past experiences with previous vaccination program such as the coronavirus disease 2019, which resulted in several adverse effects on those who took the vaccine [25], and polio meningitis trials that led to the deaths of many children in Nigeria [26]. A study by Tabiri et al. [27] has shown that caregivers in Ghana, whose children had previously developed fever following a dose of vaccination, reported a reduced acceptance rate of the malaria vaccine. Furthermore, socio-economic factors can contribute to vaccine resistance. In Nigeria, where poverty and limited access to healthcare services are prevalent, individuals may prioritize immediate needs over preventive measures such as vaccinations [28]. Concerns about the cost of vaccine, transportation, and time off work for vaccination visits can act as barriers to malaria vaccine acceptance [29]. Therefore, to adequately tackle resistance against the malaria vaccine, a holistic strategy is required. This strategy should encompass community involvement, the spread of accurate information, the restoration of trust in the health care system, and making sure the vaccine is accessible and affordable. It is crucial to engage local leaders, healthcare experts, and community organizations in educational initiatives that aim to address concerns, debunk misconceptions, and highlight the advantages of vaccination for malaria prevention [30].

This study discovered that the majority of caregivers lacked knowledge and were unaware of the recently approved malaria vaccine. This finding was in contrast with the study conducted in Kwabre East Ghana (95.7%) [31] and India (82.2%) [32], which reported that caregivers had high knowledge on immunization. The lack of knowledge and awareness among caregivers can be linked to the following factors: first, limited access to healthcare services and insufficient healthcare infrastructure. In Nigeria, particularly in rural areas, access to health care facilities is often limited. This impedes the dissemination of information regarding the malaria vaccine. Second, low literacy rates, especially in rural areas, can be a significant barrier to understanding and spreading awareness about health-related topics, including the malaria vaccine. From the study, caregivers who had only primary school education demonstrated the highest resistance to the malaria

vaccine, indicating a hesitancy rate of 38.9%. This indicates that formal education has the tendency to have a positive impact on individuals' knowledge and behavior related to health. This finding was in concordance with the report carried out in Ashanti, Ghana, by Wemakor et al. [31].

Insufficient investments in comprehensive and targeted awareness campaigns about malaria vaccines can be another reason for the lack of knowledge [33]. Effective awareness campaigns require funding, coordination, and strategic planning, which might be lacking in some regions of Nigeria. Finally, with limited research and development [34], Nigeria, like many developing countries, is faced with great challenges in terms of research and development capacities, and the lack of local research studies and clinical trials related to malaria vaccines can limit the generation of knowledge and awareness about their effectiveness and safety. Overall, it is necessary to implement proactive community education and campaigns, adequate health care infrastructure funding, and valuable research for proper awareness and understanding of the malaria vaccine.

Furthermore, the findings of this study revealed that caregivers who were divorced exhibited the highest level of resistance, at 100%, towards the malaria vaccine. This outcome could potentially be attributed to the limited number of participants in this particular group. The widowed caregivers constituted the subsequent group within this category, displaying a relatively high resistance rate of 28.6%. Their resistance to the malaria vaccine might be associated with their apprehension of experiencing the loss of another family member. This finding is similar to the report of Kaur [35] who investigated parental concerns and anxiety regarding vaccinations.

According to geopolitical zones, this study revealed that the northeastern part of Nigeria had a relatively high acceptance rate and displayed the lowest hesitancy rate of 16.7%. The north-central region, on the other hand, had a resistance rate of 17.2%. Furthermore, the northwestern part of Nigeria demonstrated the highest acceptance rate and a comparatively low resistance rate of 24.1%. Conversely, the southwestern region had the highest hesitancy rate of 34.4%. The variations in hesitancy can be attributed to the differences in specific local or regional factors such as ongoing economic conditions, conflicts, or public health campaigns targeting a specific region. These factors can shape the perceptions and attitudes of caregivers and, as such, must have contributed to the variations in acceptance and resistance to the malaria vac-

cine in these regions [36,37].

Even though this study exhibits specific strengths, there are substantial gaps that must be acknowledged and taken into account when interpreting the findings of this study. First, due to the cross-sectional design of this study, which investigated vaccine resistance and its related factors concurrently, as a result, determining the actual connections between them is not feasible. Secondly, the size of our sample might not have been sufficient to identify the factors responsible for resistance to accepting the malaria vaccine among caregivers. Notwithstanding these limitations, we are confident that our study offers valuable insights into the perception, knowledge, awareness, and acceptance of the malaria vaccine among caregivers in Nigeria.

In conclusion, although the development of a malaria vaccine holds potential for combating this devastating disease (malaria infection), the resistance of caregivers towards the vaccine presents a notable hurdle. The findings of this study, despite revealing a high acceptance rate among caregivers, displayed significant resistance among caregivers towards accepting the vaccine, citing possible adverse side effects among other factors as the major cause of malaria vaccine hesitancy. Consequently, in order to ensure widespread vaccination and achieve effective malaria control in Nigeria, the government and healthcare professionals should employ effective targeted health communication, increase community engagement, and enhance healthcare infrastructure. Ultimately, progress can be made to overcome malaria vaccine resistance, and lives threatened by malaria can be protected.

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