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Knowledge and willingness towards malaria vaccines among caregivers in Dar es Salaam, Tanzania

Felista Mwingira[1,2*], Deokary Matiya[1,2] and Frank Chacky[3]

Abstract

Background Tanzania is a malaria-endemic country that relies solely on anti-malarial drugs and vector control measures, including insecticide-treated bed nets and indoor residual spraying. However, the growing resistance to these interventions threatens their effectiveness, highlighting the need for additional strategies to accelerate malaria eradication efforts. Currently, malaria vaccines have begun to roll out in endemic areas. However, hesitancy emanating from misinformation on vaccine efficacy and safety has been recorded in various parts of the world. In this context, this study investigated the knowledge and willingness of caregivers towards the malaria vaccine.

Methods This is a health facility-based cross-sectional survey conducted from September 2022 to March 2023. In total, 293 caregivers attending Ante-Natal Clinics (ANC) in selected health facilities in Dar es Salaam were recruited. A semi-structured questionnaire was used to collect caregivers' demographic information, knowledge of malaria, knowledge of malaria vaccines and willingness to receive malaria vaccines.

Results The respondents were predominantly women (97.3%) aged 18 to 52 years. Overall, 87.4% had knowledge of malaria disease, while 14% did not know how malaria is transmitted. Most respondents (86.3%) knew about malaria prevention/control methods. However, only 14.7% of the recruited caregivers were aware of the malaria vaccine. Of those exposed to vaccine messages, 67.4% were aware that the vaccine was for children under 5 years of age, while 53.5% knew that the vaccine was for pregnant women. Despite their low exposure, most respondents (92.8%) were willing to receive the malaria vaccine for their children under five years.

Conclusion Malaria knowledge and willingness to vaccinate against malaria was high among Tanzanian caregivers despite the low awareness of malaria vaccines. This suggests the need for targeted information, education and communication strategies (IECs) for communities to curb misconceptions and complement their high willingness to accept the malaria vaccine in Tanzania.

Keywords Malaria vaccine willingness, Perception, Malaria knowledge

Background

Malaria has remained a public health hurdle for more than a century since its discovery [1]. In 2021, more than 247 million people were infected with malaria, and approximately 619,000 people were killed globally, with 95% of the burden recorded in Africa with 65% of the burden occurring in children under 5 years of age [2]. Tanzania is among eight countries bearing more than 60% of the global malaria burden, and in 2022, an 8% prevalence

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of malaria was recorded in children under 5 years nationwide [3]. Since 2000, after countries renewed their efforts to control and eliminate malaria, the main strategies have been using effective malaria drugs and controlling mosquitoes with insecticide-treated bed nets (ITNs) and indoor spraying (IRS) [2]. These control strategies effectively reduced the malaria burden by 68% [4] in Africa by 2015; however, malaria control success has been slightly reversed, with cases and deaths increasing [5]. The development of resistance in malaria parasites and vectors to the chemical products used in their control might be the reason for the current reversal of success in malaria control [6]. These challenges facing current interventions have necessitated global malarial control stakeholders to rethink additional control strategies to be integrated with existing strategies to accelerate the pursuit of malaria eradication.

Vaccines, are among the most effective interventions for eradicating several deadly infectious diseases, are considered effective additional tools in the fight against malaria. There have been trials of approximately 17 malaria candidate vaccines, some in the pre-clinical stages and others in different phases of clinical trials [7]. The RTS, S/AS01 and R21/Matrix-M vaccines developed from the circumsporozoites protein have shown substantial efficacy and safety [8, 9]. These vaccines have been recommended by the World Health Organization (WHO) for use in under five-year-old children in malaria-endemic areas [10, 11].

The R21/Matrix-M vaccine is in phase 3 of clinical trials and has shown 75% efficacy against clinical malaria for 1 year of follow-up. This efficacy aligns with the WHO's goal of being very effective in malaria control and elimination [12]. Due to the high efficacy of the R21/Matrix-M vaccine in under-fives, two countries in Africa (Ghana and Nigeria) have approved it for use despite a phase 3 clinical trial [13]. On the other hand, four doses of RTS and the S/AS01 vaccine have gone through all phases of clinical trials and have shown approximately 40% efficacy in reducing clinical malaria and 30% efficacy in reducing severe malaria for five months to under-fives [11, 13]. Additionally, 40% of vaccine efficacy surpasses the efficacy of ITNs in malaria control. From 2019 to 2021, pilot roll-outs of this vaccine were conducted in three African countries: Ghana, Kenya and Malawi [13]. Moreover, in 2021, the WHO endorsed the RTS, S vaccine for broader roll-out in areas with moderate to high malaria transmission [14].

After the endorsement of the RTS, 'the S vaccine', WHO, GAVI and UNICEF have allocated 18 million doses of RTS, S to twelve countries in sub-Saharan Africa as the first wider roll-out of such a vaccine in mid-2023 [14]. If effectively utilized, this vaccine allocation will lead to groundbreaking breakthroughs in malaria eradication for under-fives living in endemic areas. However, there has been a growing tendency towards vaccine hesitancy, and if such a phenomenon is not addressed satisfactorily, the substantial benefit of the vaccine will not be realized [15]. During the outbreak of the COVID-19 pandemic, the vaccine hesitancy increased immensely due to misinformation on COVID-19 vaccine efficacy and safety [16]. For instance, UNICEF reported that the percentage of immunized children in some countries decreased to 44% during the COVID-19 pandemic [13]. Such misconceptions and hesitancy towards COVID-19 may also affect the acceptance of other vaccines, including malaria. Therefore, it is crucial to investigate the magnitude of malaria vaccine acceptance and address all community misconceptions before the vaccine roll-out.

In the coming years, Tanzania is preparing to receive and integrate the malaria vaccine into its Expanded Programme on Immunization (EPI) [17]. However, Tanzania experienced the highest degree of COVID-19 vaccine hesitancy until late 2022 [18, 19]. In particular, large cities were severely affected due to the rapid spread of misconceptions via media outlets, including social media. Therefore, it is vital to assess the acceptance of the coming malaria vaccine by children's caregivers and address the existing misconceptions before its integration into the EPI programme in the county. In that context, this study investigated the knowledge and willingness of malaria vaccine among caregivers in Dar es Salaam region.

Methods

Study area

The study was conducted in the Ubungo, Temeke, Ilala and Kinondoni Municipal Councils of the Dar es Salaam Region in Tanzania. Dar es Salaam is the largest city and economic hub of Tanzania. This region is located between 06° 48′ 58″ S and 39° 16′ 49″ E, along the coast of the Indian Ocean to the east and the Coast region to the north, west, and south. The city covers approximately 1493 km^2 and has an approximate population of 5.383 million [20]. Dar es Salaam has a hot and humid climate with,a long rainy period between March and May, and a short rainy period between November and December [21].

Study design

The study is a qualitative health facility-based cross-sectional study conducted among parents/caregivers attending antenatal clinics (ANCs) in selected health facilities. The study was conducted in the four municipalities of Dar es Salaam within the peak malaria transmission season between September 2022 and March 2023. Dar es Salaam region was purposefully chosen since it is an

economic hub with over 10% of the country's population. It also has characteristics of urban malaria with low but consistent transmission throughout the year due to both local and international influx of people. Participant selection was purposive and criterion-based.

Study population and eligibility

The study population consisted of male and female parents/caregivers attending a scheduled ANC appointment in selected health facilities in the Dar es Salaam region municipalities. The inclusion criteria were (i) consenting caregivers who were expectant and/or had children under 5 years and (ii) being present in the ANC on the day of the survey.

Sample size determination

The sample size for this study was estimated using the Leslie Kish Formula [22] for a cross-sectional study at a 95% confidence level (CI) and a 5% margin of error. The proportion of awareness of the malaria vaccine in Tanzania was 11.8% in 2015 [23]. Thus, the study assumed a twofold awareness level at 2023 and 10% for the anticipated non-response rate. This gives a minimum sample size of 298 respondents.

Data collection

The data were collected from the participants using a pretested semi-structured questionnaire with open- and closed-ended questions. The semi-structured questionnaire was loaded in the Android-based Open Data Kit (ODK) using the KoboCollect platform. Study enumerators were well-trained with qualified researchers who participated in the pretesting of data collection tools. Pretesting was conducted among 30 women attending ANC at one of the health centres in Dar es Salaam. Researchers and enumerators assessed the clarity of the questions, the time required to administer the questionnaire, and the validity and reliability of the tool. Feedback from the pretesting was used to adjust and improve the questionnaires.The semi-structured questionnaire gathered data on various topics, including socio-demographic details, knowledge of malaria disease, prevention methods, and symptoms. It also covered participants' knowledge and experience with childhood vaccinations, awareness of malaria vaccines, sources of information on malaria vaccines, and their willingness to accept malaria vaccines for their children.

Study variables

The primary outcome variable of the study was willingness to accept malaria vaccine, i.e., whether the parent/caregiver would allow/not allow the child/ren to be vaccinated once roll-out began in the country. Explanatory variables included awareness of malaria vaccines (*Have you ever seen/heard about malaria vaccine?*), the channels from which vaccine information was obtained (*where did you see/hear about malaria vaccine information?*), and knowledge of malaria, including malaria disease (*Have you ever seen/heard about malaria disease?)*, transmission (*How malaria is transmitted?*), symptoms (*Name the symptoms of malaria you know*) and control/prevention methods (*How can malaria be prevented?*). Additionally, the source of exposure to malaria messages was probed to determine the source of channeling malaria information (*where did you hear about malaria disease information?*). Other factors influencing willingness to vaccinate children included socio-demographic characteristics, such as age, sex, parent/caregiver level of education, occupation, history of EPI vaccination information.

Data analysis

Data analysis was performed using SPSS® version 27. Descriptive statistics summarized numeric and categorical variables, including frequencies, percentages, means, and standard deviations. The chi-square test was employed to compare proportions between different groups. The main outcome variables, such as willingness, awareness, and knowledge of malaria and malaria vaccines, were categorized as "yes" or "no." Other variables associated with awareness and knowledge of malaria and willingness of malaria vaccine which were analyzed included sex (male, female), age (18–25, 26–30, 31 +), education level (non-formal, primary, secondary, tertiary), occupation, and exposure to malaria treatment ("yes" or "no"). The significance level was $p = 0.05$ to identify meaningful differences between groups.

Ethical considerations

The institutional ethics and research approval number DUCE-EFMLD22161 was obtained from the Ethical Review Board of the University of Dar es Salaam. Research clearance was sought from the Dar es Salaam Regional Health Research Coordinator and each municipal council. At the municipal level, the research team sought permission from the people in charge of the health facilities. The team was introduced and worked under the patronage of the maternal and child health (MCH) care nurse. During the survey day, sensitization meetings were held with caregivers to elaborate on the research objectives. Privacy and confidentiality were observed throughout the study during the interviews. All participants provided informed consent before being enrolled in the survey. All personal records will be kept confidential. Participants were identified primarily by

their study number, and no individual names were used in any reports or publications resulting from the research.

Results

Socio-demographic characteristics

The study recruited 293 caregivers attending the ANC in selected health facilities in the Dar es Salaam region. This implies that the response rate of the study was greater than 98%. The mean age of the participants was 28.7 years, ranging from 18–52 years. Table 1 shows that the participants were predominantly women (97.3%) and married (75.5%). Most participants had secondary (45.2%) or primary education (44.2%). Slightly more than half of the participants were self-employed. Most parents/caregivers (52.2%) had between 2 and 3 children, 85.5% of whom had at least one child under the age of 5 (Table 1).

Table 1 Socio-demographic information of the respondents (N = 293)

Variable	Variable attribute	Frequency (%)
Age (Years)	18–25	102 (34.8)
	26–30	95 (32.4)
	31 +	96 (32.8)
	Total	293 (100)
Sex	Female	285 (97.3)
	Male	8 (2.7)
	Total	293 (100)
Marital status	Divorced	5 (1.7)
	Married	219 (75.5)
	Unmarried	64 (22.1)
	Widowed	2 (0.7)
	Total	290 (100)
Education	Non-formal education	3 (1.0)
	Primary education	129 (44.2)
	Secondary education	132 (45.2)
	Tertiary education	28 (9.6)
	Total	292 (100)
Employment	Civil servant	10 (3.4)
	Private sector	22 (7.5)
	Self-employed	148 (50.7)
	Unemployed	112 (38.4)
	Total	292 (100)
Total number of children	0—1	112 (38.2)
	2—3	153 (52.2)
	3—4	28 (9.6)
	Total	293 (100)
Total number of children Under 5 years	1	242 (85.5)
	2	39 (13.8)
	3	2 (0.7)
	Total	283 (100)
Municipal Council	Ilala	47 (16.0)
	Kinondoni	65 (22.2)
	Temeke	63 (21.5)
	Ubungo	118 (40.3)
	Total	293 (100)
Ward	Mbezi	38 (13.0)
	Ilala	47 (15.7)
	Kizuiani	63 (21.5)
	Mwananyamala	65 (22.2)
	Sinza	74 (25.3)
	Other	7 (2.2)
	Total	293 (100)

General knowledge of malaria

Overall, 87.4% (256/293) of respondents were aware of malaria disease ($\chi^2 = 163.6$, $p < 0.0001$). More than half of the participants (58%) correctly identified that only some mosquitoes transmit malaria. However, 28% incorrectly believed that all mosquitoes transmit the disease, and 14% were unsure about how malaria is transmitted.

The results revealed a significant association between caregivers' age and awareness of malaria ($\chi^2 = 5.9$, $p = 0.05$), with younger caregivers (18–25) being less aware of the disease compared to older caregivers (26 years and above). However, the study found no significant differences in malaria awareness based on caregivers' education levels, occupations, or number of children (Table 2).

Most participants (86.3%, 253/293) demonstrated a significantly high knowledge of at least one malaria control and prevention method ($\chi^2 = 30.1$, $p = 0.0001$). A significantly higher proportion of caregivers (71.7%, $\chi^2 = 285.2$, $p = 0.0001$) mentioned only a few malaria prevention methods, specifically between 1 and 3, compared to 12% who identified an adequate number, mentioning between 4 and 6 prevention methods. However, only 2.7% of caregivers were able to mention more than seven control/prevention methods.

Unlike other methods, insecticide-treated nets (ITNs) were the most cited method for preventing malaria (Fig. 1). Additionally, ITNs were the most preferred control/prevention methods by 79%, ($\chi^2 = 391.3$, $p < 0.0001$) of the caregivers, followed by untreated mosquito bed nets (2.4%) and other methods (5.2%), such as repellents, aerosols spraying, window screens and environmental modification. On the other hand, a greater proportion of older caregivers above 31 years knew about malaria prevention than younger caregivers, although the difference was not statistically significant (Table 2). Additionally, knowledge of malaria prevention was greater among caregivers with tertiary education than among those with primary or secondary education. In contrast, unemployed caregivers had the lowest knowledge of malaria

Table 2 Malaria knowledge among respondents

Variable	Variable attribute	No n (%)	Yes n (%)	Statistics
Awareness of malaria as a disease				
Age (Years)	18–25	19 (18.6)	83 (81.4)	$\chi^2 = 5.9$, p = 0.052
	26–30	11 (11.6)	85 (88.4)	
	31 +	7 (7.3)	89 (88.4)	
Education	Non-formal education	0 (0.0)	3 (100)	$\chi^2 = 6.2$, p = 0.184
	Primary education	21 (16.3)	108 (83.7)	
	Secondary education	16 (12.1)	116 (87.9)	
	Tertiary education	0 (0.0)	28 (100)	
Occupation	Civil servant	0 (0.0)	10 (100)	$\chi^2 = 3.2$, p = 0.522
	Private sector	2 (9.1)	20 (90.9)	
	Self-employed	17 (11.5)	131 (88.5)	
	Unemployed	18 (16.1)	94 (83.9)	
Number of children	0–1	18 (16.1)	94(83.9)	$\chi^2 = 3.4$, p = 0.184
	2–3	18 (11.8)	135 (88.2)	
	3–4	1 (3.6)	27 (96.4)	
Knowledge of malaria prevention				
Age (Years)	18–25	21 (20.6)	81 (76.4)	$\chi^2 = 7.9$, p = 0.094
	26–30	11 (11.6)	84 (88.4)	
	31 +	8 (8.3)	88 (91.7)	
Education	Non-formal education	0 (0.0)	3 (100)	$\chi^2 = 7.2$, p = 0.52
	Primary education	23 (17.8)	106 (82.2)	
	Secondary education	17 (12.9)	115 (87.1)	
	Tertiary education	0 (0.0)	28 (100)	
Occupation	Civil servant	0 (0.0)	10 (100)	$\chi^2 = 8.4$, p = 0.398
	Private sector	2 (9.1)	20 (90.9)	
	Self-employed	17 (11.5)	131 (88.5)	
	Unemployed	21(18.8)	91(81.2)	
Number of children	0–1	20 (17.9)	92 (82.1)	$\chi^2 = 4.7$, p = 0.323
	2–3	19 (12.4)	134 (87.6)	
	3–4	1 (3.6)	27 (96.4)	
Exposure to malaria messages				
Age	18—25	34 (33.3)	68 (66.7)	$\chi^2 = 3.2$, p = 0.198
	26—30	21 (22.1)	74 (77.9)	
	31 +	25 (26)	71 (74)	
Education	Non-formal education	2 (66.7)	1(33.3)	$\chi^2 = 7.5$, p = 0.114
	Primary education	43 (33.3)	86 (66.7)	
	Secondary education	29 (22)	103 (78)	
	Tertiary education	6 (21.4)	22 (78.6)	
Occupation	Civil servant	0 (0.0)	10 (100)	$\chi^2 = 9.8$, p = 0.044
	Private sector	3 (13.6)	19 (86.4)	
	Self-employed	40 (27)	108 (73)	
	Unemployed	36 (32.1)	76 (67.9)	

prevention. The majority of caregivers with more children knew about malaria prevention methods compared to those with fewer number of children or expectant mothers (Table 2). Although not statistically significant, exposure to malaria knowledge was associated with age, where older caregivers (> 31 years) were more exposed to malaria messages than their younger counterparts. Similarly, caregivers with non-formal and primary education

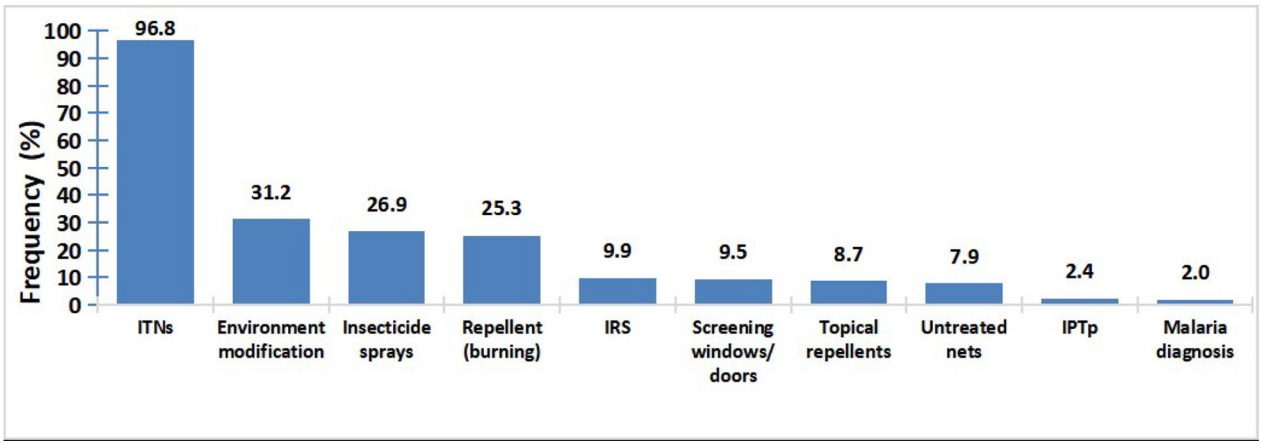

Fig. 1 Malaria prevention methods among care givers

levels were less likely to be exposed to malaria messages than those with higher education level. The unemployed caregivers were less likely to be exposed to malaria messages than self-employed individuals, private sector employees, and civil servants, although the results were not statistically significant (Table 2).

Overall, 76.1% (223/293) of caregivers were able to accurately identify at least one malaria symptom ($\chi^2 = 79.9$, $p < 0.0001$). Among these, 32.4% mentioned one symptom, 27.6% mentioned two, and only 12.6% identified three symptoms. The number of caregivers who mentioned three symptoms was significantly lower than those who mentioned one or two symptoms ($\chi^2 = 81.6$, $p < 0.0001$). Only a small proportion, 3.4%, could correctly name four common malaria symptoms. Fever was the most frequently mentioned symptom (93.7%), followed by headache (44.8%) and vomiting (39.5%) ($\chi^2 = 151.3$, $p < 0.0001$) (Fig. 2).

In addition, television (67.0%), health facilities (55.0%), and radio (48.0%) were the most commonly cited sources of malaria information among caregivers, compared to social media (14.0%) and newspapers/magazines (3.8%) ($\chi^2 = 157.6$, $p < 0.0001$). This suggests that most caregivers receive their information primarily through television and health facilities.

General awareness of all available vaccines for different diseases

Generally, the majority of respondents (96.2%) ($\chi^2 = 150.6$, $p < 0.0001$) had vaccinated their children within the EPI

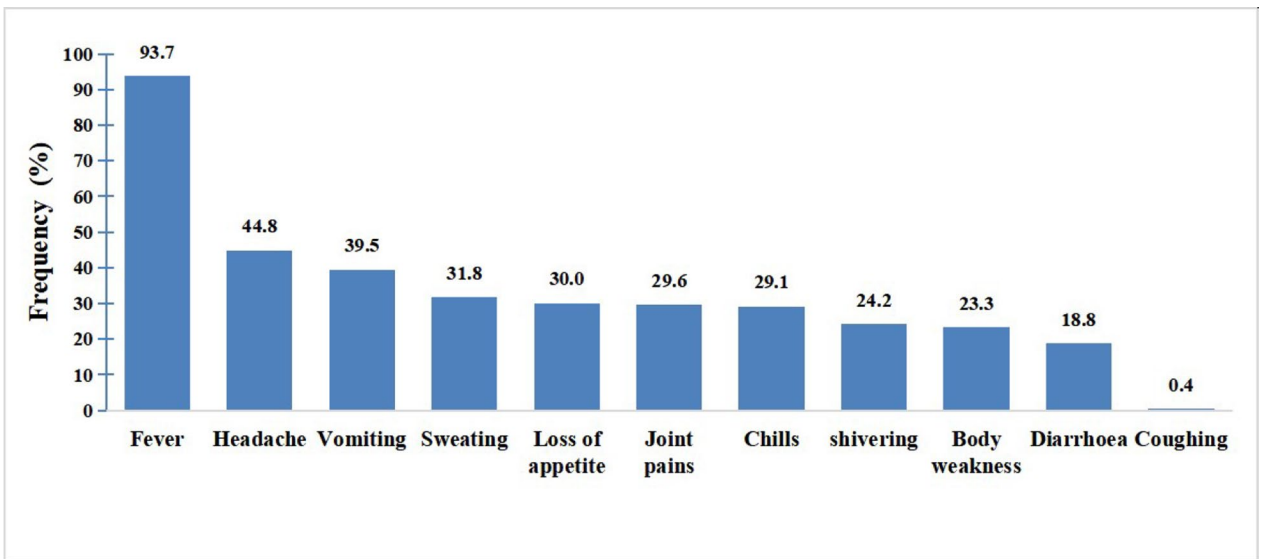

Fig. 2 Malaria symptoms

immunization programme with other vaccines, including BCG, tetanus, and diphtheria. Most participants (95.6%) ($\chi^2=143.3$, $p<0.0001$) reported no adverse effects of previous vaccines on their children. However, a few caregivers reported minor effects of vaccines, ranging from blood clots in the area of injection (0.3%), boils at the site of injection (0.3%), persistence of flu (0.3%), swelling of the area of infection (0.7%), and high fever (2%).

Awareness towards the malaria vaccine

Only 14.7% of respondents were aware of malaria vaccine ($\chi^2=146.3$, $p<0.0001$), indicating that most caregivers (85.3%) had not received any information about it. Health facilities (47.6%) and television (45.2%) were the most common sources of receiving malaria vaccine information ($\chi^2=21.1$, $p<0.0001$) (Fig. 3). Of those exposed to vaccine messages, 67.4% correctly identified the malaria vaccine is intended for children under 5 years, while 53.5% mistakenly thought malaria vaccine is for pregnant women. Children under 5 years and pregnant women represented a significantly higher proportion compared to other groups: non-pregnant women (20.0%), older people (9.3%), young people (7.3%), and children over 5 years (2.3%) ($\chi^2=45.6$, $p<0.0001$).

The study revealed a weak association between caregivers' age, education, occupation, and awareness of the malaria vaccine. Awareness of the vaccine slightly increased with age, with the older age group (34 + years) having a higher awareness (17.7%) than the youngest group aged 18–25 years, (11.8%), though this was not statistically significant ($\chi^2=1.4$, $p=0.498$). Caregivers with no formal or primary education (0–10%) had a similar level of awareness compared to those with secondary (17%) or higher education (21%) ($\chi^2=4.01$, $p=0.405$). Additionally, unemployed caregivers (10%) were less aware of the vaccine compared to self-employed (13%) and civil servant caregivers (30%), though the difference was not statistically significant ($\chi^2=4.1$, $p=0.399$) (Table 3).

Willingness towards the malaria vaccine

The study shows that most caregivers (92.8%) were willing to vaccinate their children under 5 years old against malaria, with the result being highly significant ($\chi^2=215$, $p<0.0001$). However, 7.2% were hesitant due to concerns of lack of information (4.1%), possible side effects (2%), doubts about the vaccine's effectiveness (0.3%), and fears of poisoning (0.3%). Among those who were initially unwilling, nearly all (95.2%) were willing to accept the vaccine if provided with accurate information ($\chi^2=17.2$, $p<0.0001$), however, 4.8% remained hesitant even after being sensitized.

Across age groups, willingness was high (88–93%), with no significant difference between age groups ($\chi^2=0.98$, $p=0.613$), although the youngest caregivers aged 18–25 were slightly less willing. Caregivers with formal education (92.2–93.2%) were less willing to vaccinate their children compared to those with no formal education (100%), but this difference was not statistically significant ($\chi^2=0.4$, $p=0.983$). Similarly, unemployed caregivers (94.6%) were more willing than employed caregivers (80–93.2%), though this was also not significant ($\chi^2=4.5$,

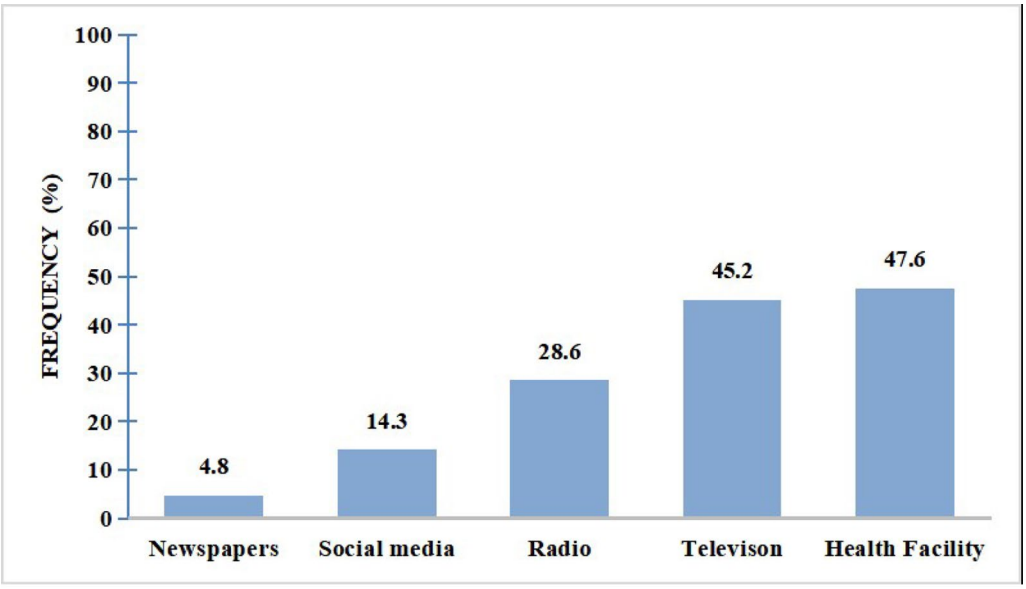

Fig. 3 Source of information about malaria vaccine

Table 3 Factors associated with awareness and willingness towards malaria vaccine

Variable	Variable attribute	No n(%)	Yes n(%)	Statistics
Awareness of the malaria vaccine				
Age	18–25	90 (88.2)	12 (11.8)	$\chi^2 = 1.4$, p = 0.498
	26–30	81 (85.3)	14 (14.7)	
	31 +	79 (82.3)	17 (17.7)	
Education	Non-formal education	3 (100)	0 (0.0)	$\chi^2 = 4.01$, p = 0.405
	Primary education	115 (89.1)	14 (10.9)	
	Secondary education	109 (82.6)	23 (17.4)	
	Tertiary education	22 (78.6)	6 (21.4)	
Occupation	Civil servant	7 (70)	3 (30)	$\chi^2 = 4.1$, p = 0.399
	Private sector	19 (86.4)	3 (13.6)	
	Self-employed	123 (83.1)	25 (16.9)	
	Unemployed	100 (89.3)	12 (10.7)	
Willingness to accept malaria vaccine				
Age	18–25	9 (8.8)	93 (91.2)	$\chi^2 = 0.98$, p = 0.613
	26–30	7 (7.4)	88 (92.6)	
	31 +	5 (7.4)	91 (92.6)	
Education	Non-formal education	0 (0.0)	3 (100)	$\chi^2 = 0.4$, p = 0.983
	Primary education	10 (7.8)	119 (92.2)	
	Secondary education	9 (6.8)	123 (93.2)	
	Tertiary education	2 (7.1)	26 (92.9)	
Occupation	Civil servant	2 (20)	8 (80)	$\chi^2 = 4.5$, p = 0.34
	Private sector	3 (13.6)	19 (86.4)	
	Self employed	10 (6.8)	138 (93.2)	
	Unemployed	6 (5.4)	106 (94.6)	
No. of children	0–1	10 (8.9)	102 (91.1)	$\chi^2 = 0.9$, p = 0.637
	2–3	9 (5.9)	144 (94.1)	
	3–4	2(7.1)	26 (92.9)	

p = 0.34). Caregivers with two or more children were more willing to vaccinate compared to those expecting or with only one child, but the difference was not significant ($\chi^2 = 0.9$, p = 0.637). In summary, there is broad support for the malaria vaccine, with most hesitancy linked to lack of information. Providing accurate details could significantly increase acceptance.

Discussion

The current study assessed the willingness of caregivers in the municipalities of the Dar es Salaam region in Tanzania to receive the malaria vaccine. This study aimed to inform policy with evidence-based information on the best strategies to engage the community and improve the use of novel malaria interventions, particularly the new malaria vaccine in Tanzania. The study population group comprised more females than males. This was expected due to the lagging attendance of male caregivers/parents in the ANC clinic for several reasons outlined elsewhere [24].

Awareness of malaria

According to the current study, awareness of malaria infection was high among caregivers, for whom 8 out of 10 knew about malaria infection. These results reflect the high the malaria burden in most parts of the country. Similar high awareness were recorded in other studies conducted in Tanzanian settings, including the Coast region [25], Eastern [26] Central region [27] and Northwest and Southern regions of Tanzania [28, 29]. Despite a substantial proportion of caregivers being aware of transmission of malaria, misconceptions about disease transmission were recorded. Approximately one-third of respondents knew that all mosquitoes species transmit malaria and approximately 2 of 10 did not know how malaria is transmitted. Such a lack of knowledge may impede malaria control efforts in the country. Such misconceptions have also been recorded among communities in Tanzania and Nigeria [28, 30], pregnant women in Uganda [31] and caregivers of children in Sierra Leone and Ethiopia [32, 33].

Age was significantly associated with malaria awareness, with younger caregivers being less aware than older caregivers. This may be due to older caregivers having more exposure to malaria information from previous ANC attendance than younger caregivers [34]. Generally, knowledge of malaria prevention was high among older caregivers, those employed, those with tertiary education and those with children. However, three-quarters of the respondents could mention at least three malaria prevention methods, while only less than 3% could mention seven or more malaria prevention methods. This indicates that despite their awareness of malaria, the majority of caregivers are unaware of the variety of methods for the prevention and control of malaria. This may slow down the pace towards the set goal of malaria elimination in the country. Insecticide-treated bed nets (ITNs) were the predominant method of malaria control among the participants.

Awareness and willingness to accept malaria vaccine

The study reported insufficient awareness of the malaria vaccine within the surveyed community, where only 1 in 10 caregivers were aware of the malaria vaccine. These results mirror those obtained 10 years ago in mainland Tanzania and Isles, where an equally lower proportion of respondents (11.8%) were aware of the malaria vaccine. In particular, the current results on awareness in the Dar es Salaam region mirror those of a previous study by Romore et al. [23], which revealed it as one of the regions with low awareness of the malaria vaccine in Tanzania despite being the most populated region harboring approximately 10% of the country's population. These findings are similar to those in other malaria endemic areas where inadequate awareness of the malaria vaccine was recorded among communities in Southwest Ethiopia (18%) [37], healthcare workers (48.9%) [38, 39], the community (48%) [39] and caregivers of children under 5 years of age (40%) [38, 39] in Nigeria. The low awareness of the malaria vaccine among the surveyed caregivers in malaria-endemic settings is alarming, even more so among health actors and communities at large, particularly now that the vaccine has been launched and is being implemented in other malaria-endemic countries, including Malawi, Kenya and Ghana, since 2021 [5, 40]. This calls for deliberate efforts to design and implement appropriate advocacy strategies within the population on the benefits of the malaria vaccine.

Misconception regarding the target group for the vaccine was recorded among the respondents, where the majority mentioned pregnant women, elderly people and children over 5 years old, as the potential vaccine recipients. Such misconceptions were also recorded among respondents in Mozambique [41]. Additionally, various perceptions were identified among the respondents in the current study, including that the probable side effects of the vaccine could be poisonous and that the vaccine is not helpful. These perceptions were also identified in some parts of Tanzania [28] and elsewhere [42]. These perceptions linger among the respondents mainly due to a lack of appropriate information on the malaria vaccine [13]. Such misconception may contribute to poor acceptance of the vaccine since the uptake of any intervention in a community is determined by its perceived effectiveness and relevance. Thus, it is paramount to design appropriate information, education and communication strategies (IECs) that are inclusive and tailored to remove misconceptions about the malaria vaccine within the local community.

Despite low malaria vaccine awareness, caregivers' willingness to vaccinate their children when roll-out begins was high (92.8%). This information aligns with a study by Romore et al., where many Tanzanian community members were willing to vaccinate their under-five children against malaria in mainland Tanzania and the Isles [23]. The current study also revealed that even a small proportion of respondents unwilling to vaccinate their children against malaria were inclined to agree upon being well sensitized. This is unsurprising as Tanzania is among the countries with high coverage of the Expanded Programme for Immunization (EPI) [35]. This was evident in the current study findings, where more than 96% of the participants reported vaccinating their children with the recommended vaccines and receiving no serious adverse effects. These findings imply that their acceptance and understanding of routine childhood vaccines reflect a positive inclination toward future vaccines against malaria [36].

Factors associated with knowledge and willingness to accept the malaria vaccine

In the current study, age, sex, occupation and education of the caregivers were not significantly associated with knowledge or willingness to receive the malaria vaccine. However, younger, unemployed caregivers with non-formal education did not know about the malaria vaccine compared to their counterparts. This is contrary to studies performed elsewhere where education level, family size and other factors, such as religion, income and family size, were associated with vaccine acceptance [38, 43, 44].

The current study's strengths lie in the fact that a large sample size was recruited with a high representation of caregivers' age, sex, education level and occupation in the Dar es Salaam region. Awareness of malaria disease, transmission and prevention methods were assessed along with the caregivers' knowledge of

the existing immunization programme and their willingness to receive the future malaria vaccine. Despite these strengths, the current study had a few setbacks, including the probing of willingness to vaccinate with a product yet to be implemented in the country. This may lead to unreliable responses among respondents. Additionally, due to financial and time constraints, the study sampled Dar es Salaam from all 26 regions of mainland Tanzania; thus, caution should be taken when generalizing the results to Tanzania. Based on the study findings, key stakeholders should advocate for policy improvements by promoting malaria vaccine awareness campaigns, incorporating the malaria vaccine into the EPI immunization programme, providing training for health workers, collaborating with local media and community members, and monitoring the roll out and impact of the vaccine within the community.

Conclusion

Knowledge of malaria disease and malaria prevention methods was high among the caregivers. Caregivers were also highly exposed to malaria messages through various channels, primarily television and health facilities. However, awareness of the malaria vaccine was low among the surveyed respondents, calling for targeted messages and education on the malaria vaccine, particularly for younger caregivers and those with low literacy and non-formal education. In contrast, the caregivers were highly willing to accept future malaria vaccination. This study provides information for policy actors to plan for future malaria vaccines should they be deployed in Tanzania.

Abbreviations

ANC	Antenatal clinics
EPI	Expanded programme for immunization
GAVI	Global alliance for vaccines and immunization
IEC	Information, education and communication
IRS	Indoor residual sprays
ITN	Insecticide-treated bed net
MCH	Maternal and child health
WHO	World Health Organization

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Author contributions

FM conceptualized and designed the study, participated in the field work, and drafted the manuscript. DJ participated in the field work and data analysis, literature search, and review and editing of the manuscript. FC designed the study, coordinated the fieldwork, participated in data management/analysis and contributed to the writing of the manuscript. All the authors have read and approved the final manuscript.

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Availability of data and materials

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the University of Dar es Salaam Ethical Review Board with approval number DUCE-EFMLD22161. Informed written consent was obtained from each respondent before being included as a study participant.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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