HUMAN VACCINES & IMMUNOTHERAPEUTICS
2020, VOL. 16, NO. 3, 539–547
https://doi.org/10.1080/21645515.2019.1667728

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RESEARCH PAPER

Infant vaccination against malaria in Mozambique and in Togo: mapping parents' willingness to get their children vaccinated

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ABSTRACT

Background: Malaria is one of the most widespread and deadly diseases worldwide and large majority of malaria cases and deaths occurs in Africa. Efforts to develop an effective vaccine against malaria are underway and several vaccine prototypes are on different clinical trial phases.

Objective: As many sub-Saharan African countries have shown interest in introducing large-scale infant vaccination against malaria when a definitively approved vaccine will be available, the present study aimed at mapping Mozambican parents' willingness to get their children vaccinated and comparing the results with findings from a similar study we conducted in Togo (209 participants).

Methods: In Mozambique, 227 parents indicated their willingness to get their children vaccinated (using an 11-point scale) against malaria under different conditions varying as a function of the main constructs of health-protective theories: perceived risk of getting malaria, perceived severity of malaria, effectiveness of the vaccine, cost of the vaccine, and neighbors' attitude toward vaccination. The participant responses were subjected to cluster analysis, ANOVA and Ch^2 test.

Results: Six qualitatively different positions were found, which were labeled *Cost* (12%); *Neighbors, Risk, and Cost* (28%); *Treatment, Risk, and Cost* (10%); *Always Vaccinate* (7%); *Risk and Cost* (13%); and *Risk, Treatment, Effectiveness, and Cost* (22%). These positions were associated with participants' socio-demographic characteristics.

Conclusion: A similar variety of parental positions on malaria vaccination was found in Mozambique and in Togo, which suggests that malaria vaccination campaigns in sub-Saharan African countries must be tailored in design and implementation to match the diversity of parents' needs and views.

ARTICLE HISTORY
Received 29 June 2019
Revised 21 August 2019
Accepted 8 September 2019

KEYWORDS
Africa; infant; Mozambique; Togo; vaccine against malaria

Introduction

Malaria is one of the most widespread and deadly diseases worldwide (World Health Organization).[1] In 2016, there were an estimated 216 million cases of malaria and 445 000 deaths globally.[1] The large majority of malaria cases and deaths occurred in Africa, 90% and 91%, respectively.

Malaria is generally transmitted by the bite of a female mosquito (Anopheles) that is already infected with a protozoan parasite species belonging to the genus Plasmodium. To prevent infection by the parasite, it is necessary (a) to sleep under anti-mosquito nets, (b) to keep mosquitoes away from the indoors by spraying the inside walls with insecticides, and (c) to use preventive therapies (intermittent treatment) with anti-malarial drugs.[2] Despite the efforts to make all these preventive methods available in countries where the epidemic is widespread – for instance, in sub-Saharan countries – only 43% of households have sufficient nets, and even fewer people (2.9%) at risk of malaria are being protected by indoor insecticide spraying.[2]

The development of an effective malaria vaccine is, therefore, essential for mitigating the malaria pandemic.[3] At present, more than 20 vaccine candidates are being evaluated in clinical trials or are in advanced preclinical development.[3] Among the prototypes being tested, RTS,S/AS01 is the only vaccine that demonstrated a modest protective effect – up to 40% – against malaria among young children in a Phase 3 trial.[4] Since April 2019, the Phase 4 trial is underway to evaluate the effectiveness of the RTS,S/AS01 in routine childhood immunization in which at least 360 000 children (from 5 to 17 months) will be vaccinated in Ghana, Kenya, and Malawi.[5]

With the prospect of the availability of an infant vaccine against malaria and in light of the interest shown by many sub-Saharan African countries in introducing large-scale anti-malaria vaccination programs when a definitively approved vaccine will be available,[3] it is important to know to what extent parents are willing to vaccinate their children and under what conditions. The importance of this study is also linked to the fact that the resistance to routine children vaccination, associated with a scientifically unfounded discourse, has been growing in the last years in all parts of the world, negatively affecting the children immunization coverage in many Asian and African countries.[6,7] With regard to the classic vaccine routinely administrated to children (e.g. vaccine against measles, polio, diphtheria/pertussis/tetanus, rotavirus, tuberculosis, etc.), estimates from 2017 show that the Mozambican national immunization coverage range from

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70% to 90%, depending on the vaccine type.[7] These estimates indicated that Mozambique is doing better than some African countries such as Chad, Nigeria, Somalia, and South Sudan, and doing less than some other African countries such as Togo, Tanzania, Botswana, Senegal Ghana, Ivory Cost, etc.[8]

The current study

Previous studies conducted in Africa have shown that factors such as families' financial situations, communal values and social norms, as well as individuals' socio-demographic characteristics – including educational level and religious beliefs – affect many African parents' decisions regarding whether to vaccinate their children against diseases such as polio, measles, and tuberculosis.[9–11] Particularly, in collectivist societies such as those in sub-Saharan Africa, the social interdependency among community members has been shown to play a major role on parental health-care decision regarding their children in that the parents tend to attach importance to the attitudes/behaviors of the other community members and their leaders.[12]

Purpose

The purpose of the current study was to map parents' willingness to vaccinate their infants against malaria in Mozambique and to compare its findings with those of the similar study we conducted in Togo.[13] For the sake of comparison, the material used in the current study was the same as that employed in the study in Togo.

As matter of fact, the study we conducted in Togo, with 209 participants, found a diversity of positions regarding the willingness to vaccinate children against malaria, ranging from a willingness to vaccinate in all circumstances to a willingness to vaccinate with certain restrictions; no participant refused vaccination under any circumstance.[13]

Mozambique (located in Southern Africa sub-region) and Togo (located in West Africa sub-region) are culturally-speaking two very different countries, and their recent histories and socio-political backgrounds are also very different. Mozambique was a Portuguese colony while Togo was a French colony. The predominant religions practiced in Mozambique include Islam as well as Christianity and animism while in Togo they are only Christianity and animism.[14] After its independence in 1975, a civil war ravaged Mozambique; this led to its backwardness in terms of economic, health, and educational development as compared to Togo, which did not undergo a civil war.[1,15] For example, the socioeconomic situation is currently better in Togo than in Mozambique. In 2017, Mozambique's Human Development Index (HDI) was 0.437 and Mozambique ranked 180th out of 189 countries, whereas Togo's HDI was 0.503 and Togo ranked 165th. In 2017, the real GNI per capita in Mozambique was US$420, whereas it was US $670 in Togo.[16,17] The level of development of their national health systems and the extent of their national health coverage are also different: Patients' access to national health services is better in Togo than in Mozambique.[1] Thus, the results obtained in one part of Africa cannot be generalized to other parts of the continent. To draw general conclusions about the determinants likely to impact parents' willingness to vaccine their children against malaria in sub-Saharan Africa, it is important to carry out similar studies in different sub-regions of the continent and compare the results.

Research questions and hypotheses

Tree research questions were considered: Regarding the willingness to get their children vaccinated against malaria, will the Mozambican sample yield a diversity of positions as was the case with the Togolese sample? What will be the effects of the socio-demographic characteristics on the Mozambican participants' willingness to get their children vaccinate? What will be the main differences between the Mozambican study and the Togolese study? Our hypothesis was that five different positions, similar to the ones found in Togolese sample,[13] would be found: *Depends on neighbors' attitude, Depends only on cost, Depends on both cost and neighbors' attitude, Depends on treatment and cost*, and *Always vaccinate*. We were, however, open to other positions, given that Mozambique and Togo are culturally different countries (as we stressed in the introduction). We also expected that these positions would be related to demographic characteristics.

Methods

Settings

Mozambique has a population of 28.8 million (Instituto Nacional de Estatísticas).[18] The life expectancy is estimated at 50.3 years (INE 2018).[18] In 2017, there were 4,673,604 reported cases of malaria and 754 confirmed deaths related to malaria.[19] The infant (under 1-year-old) mortality rate is 53 deaths/1000 live births and the under 5-year-old mortality is 72.4 deaths/1000 live births.[20] In 2015, the percentage of deaths in children under five caused by malaria was 13%.[21]

Participants

Participants were unpaid volunteers recruited by ten students working as research assistants. These assistants went door to door in cities, towns, and villages in the three Mozambican provinces of Maputo, Gaza, and Inhambane looking for parents of 0–1-year-old children who would be willing to participate in the study. Of the 378 parents who qualified, 227 agreed to participate (120 mothers and 107 fathers). After signing an informed consent, an appointment for testing at the participant's home was set up. The data were collected from May to November 2018. Participants' demographic characteristics are shown in Table 1.

Material and design

First, it is important to note that the study was based on the supposition that a definitively approved malaria vaccine is available (which is currently not the case) and the purpose was to assess the parents' willingness to get their children vaccine in that situation.

The material was inspired by health-protective behavior theories,[22] and by previous studies conducted in an African

Table 1. Demographic characteristics of the sample. Composition of the clusters.

	Cluster							
Characteristic	C	NR&C	TR&C	AV	R&C	RTE&C	U	Total
Gender								
Males	14(13)	35(33)	15(14)	5(5)	13(12)	18(17)	7(6)	107
Females	14(12)	29(24)	7(6)	11(9)	16(13)	31(26)	12(10)	120
Age								
18–24 Years	4(8)	10(19)[ab]	8(16)	1(2)	9(18)	11(21)	8(16)[ab]	51
25–29 Years	10(16)	12(19)[cd]	5(8)	8(13)	9(15)	12(19)	6(10)	62
30–34 Years	10(18)	20(37)[ac]	4(7)	5(9)	5(9)	9(16)	2(4)[a]	55
35+ Years	4(7)	22(37)[bd]	5(9)	2(3)	6(10)	17(29)	3(5)[b]	59
Education								
< 13 years	27(20)[a]	38(28)	13(9)	1(1)[a]	20(15)	24(17)[a]	14(10)	137
> 12 Years	1(1)[a]	26(29)	9(10)	15(17)[a]	9(10)	25(28)[a]	5(5)	90
Socioeconomic Status								
Low	24(21)[ab]	19(17)[a]	17(15)	0(0)[a]	19(17)	20(18)	13(12)	112
Interm.	4(5)[a]	37(47)[ab]	3(4)	1(1)[b]	5(6)	25(32)[a]	4(5)	79
High	0(0)[b]	8(22)[b]	2(6)	15(42)[ab]	5(14)	4(11)[a]	2(5)	36
Religion								
Christian	12(10)[a]	24(20)[a]	13(11)	13(11)[a]	15(13)	34(29)[a]	7(6)	118
Muslim	3(6)[b]	22(46)[a]	4(8)	1(2)	5(11)	9(19)	4(8)	48
Animist	12(26)[ab]	12(26)	4(9)	0(0)[a]	8(17)	3(7)[a]	7(15)	46
Atheist	1(7)	6(40)	1(7)	2(13)	1(7)	3(20)	1(6)	15
Total	28	64	22	16	29	49	19	227

Figures in parentheses are percentages. Figures with the same superscript are significantly different, $p < .05$. C = Cost; NR&C = Neighbor, Risk, and Cost; TR&C = Treatment, Risk, and Cost; AV = Always Vaccine; R&C = Risk and Cost; RTE&C = Risk, Treatment, Effectiveness, and Cost; and U = Undetermined.

context.[23,24] The study material was written and discussed with participants in Portuguese, the official language in Mozambique. It consisted of 48 cards containing a vignette of a few lines, a question, and a response scale. Five factors – corresponding to each of the five main constructs of health-protective behavior theories – were systematically combined in these vignettes, including perceived susceptibility to malaria infection (1 chance in 10 vs. 1 chance in 50), perceived severity of malaria consequences (lethal because treatment is not available vs. curable owing to the availability of treatment), effectiveness of the vaccine (half vs. at least three out of four), cost of the vaccine (free, $10 US, or $20 US), and neighbors' attitude toward vaccination (encourage parents to do it vs. do not encourage parents to do it). Thus, these 48 conditions constituted a 2 x 2 x 2 × 3 x 2 within-subjects design.

In the vignettes, all the individuals were identified as a 10-month-old boy. The following is an example: "Baby Manito is 10 months old. He has a very small chance of getting malaria (about 2 chances out of 100) because he lives in a house where mosquito bites are rare. In the case of malaria, Baby Manito can be treated effectively with medication and he will regain good health. Mercier Pharmaceutical Laboratories has launched a vaccine to prevent malaria. This vaccine protects only half of the vaccinated children. This vaccine costs $10 US. Several parents in the neighborhood have already had their babies vaccinated and they encourage the parents of Baby Manito to do so as well. *If you were a parent of Baby Manito, what is the likelihood that you would get your baby vaccinated*?" Participants' willingness to vaccine their babies under each of the 48 conditions was assessed using an 11-point response scale, ranging from 0 ("certainly would not") to 10 ("certainly would").

Procedure

Ethics approval for the study was obtained from the Ethics Committee of the Eduardo Mondlane University (Mozambique). Informed consent was obtained from all participants and full anonymity was provided. The procedure was the one suggested by Anderson[25,26] . The site for processing was a quiet room in the participant's home. Testing was strictly individual. Participants were given a brief synopsis of the research methods and of the purpose of the study. They were also given instructions on how to use the response scales. They were allowed to ask questions and the researchers answered them in a way that was not suggestive of any particular response. Vignettes were randomly ordered for each participant. It usually took between 45 and 55 min to rate the 48 vignettes. Finally, participants answered additional questions about their age, gender, educational level (determined by years of schooling), socioeconomic status (determined by the family monthly incomes and the living area), and religion. No participant withdrew from the study after starting it.

Statistical analyses

To answer the first research question, a cluster analysis was performed on the whole set of raw data as recommended by Hoffmans and Mullet.[27] As at least five clusters were expected, a five-cluster solution was tested. As one resulting cluster was not easily interpretable, several alternative solutions were tested with cluster sizes of four, six, seven, and eight. The seven-cluster solution was retained because it produced the most meaningful findings. Separate ANOVAs were conducted on the data of each cluster, using a Risk x Severity x Effectiveness x Cost x Neighbors, 2 × 2 × 2 × 3 × 2 design. Owing to the great number of comparisons, the significance threshold was set at .001.

Cluster analysis is generally used to group participants into clusters as a function of the similarity of their profiles of ratings. When the K-means procedure is used, the number of clusters is set by the experimenter prior to the analysis as a function of what is known from previous analyses and a function of the hypotheses. When nothing is known about the number of clusters that can be identified, several cluster solutions are examined and the one that best explains participants' differences in ratings is retained. When a satisfactory cluster structure is found, each cluster is examined and named according to the factor (or the set of factors) having the main impact on the participants' ratings.

To answer the second research question, Chi^2 tests were performed to test the effects of demographic characteristics. To answer the third research question, an ANOVA including both the data from the Mozambican and the Togolese samples was conducted with a design of Country x Risk x Severity x Effectiveness x Cost x Neighbors, 2 × 2 × 2 × 3 × 2.

Results

The main patterns of data that correspond to each cluster are shown in Figures 1 and 2. The associations between the demographic characteristics of the sample and the clusters are shown in Table 1. The main results of the ANOVAs are shown in Table 2.

The first cluster (N = 28, 12%) was the expected *Cost* cluster. As shown in Figure 1 (top panels), ratings of willingness to vaccinate were considerably higher when the vaccine was free (M = 7.98) than when it was costly (M = 2.82) or very costly (M = 1.16). In addition, ratings were higher when the risk of getting infected was high (M = 4.55) than when it was low (M = 3.42). The ratings were very high (>8) for each of the nine scenarios in which the vaccine was free and the risk was high. Animists and participants with a lower educational level or a lower socioeconomic status were more often found in this cluster than Christians and those with a higher educational level or a higher socioeconomic status (SES).

The second cluster (N = 64, 28%) was reminiscent of the "neighbors and cost" cluster found in the previous study. As shown in Figure 1 (center panels), ratings of willingness to vaccinate were considerably higher when the neighbors' attitude was positive (M = 6.35) than when it was negative (M = 2.37) and when the vaccine was free (M = 5.28) than when it was expensive (M = 3.37). In addition, the effect of the cost was stronger when the neighbors' attitude was positive (7.64–4.94 = 2.70) than when it was negative (2.91–1.80 = 1.11). Also, ratings were higher when the risk of getting infected was high (M = 5.32) than when it was low (M = 3.40), and, to a lesser extent, when treatment was not available (M = 4.77) than when it was available (M = 3.94). This

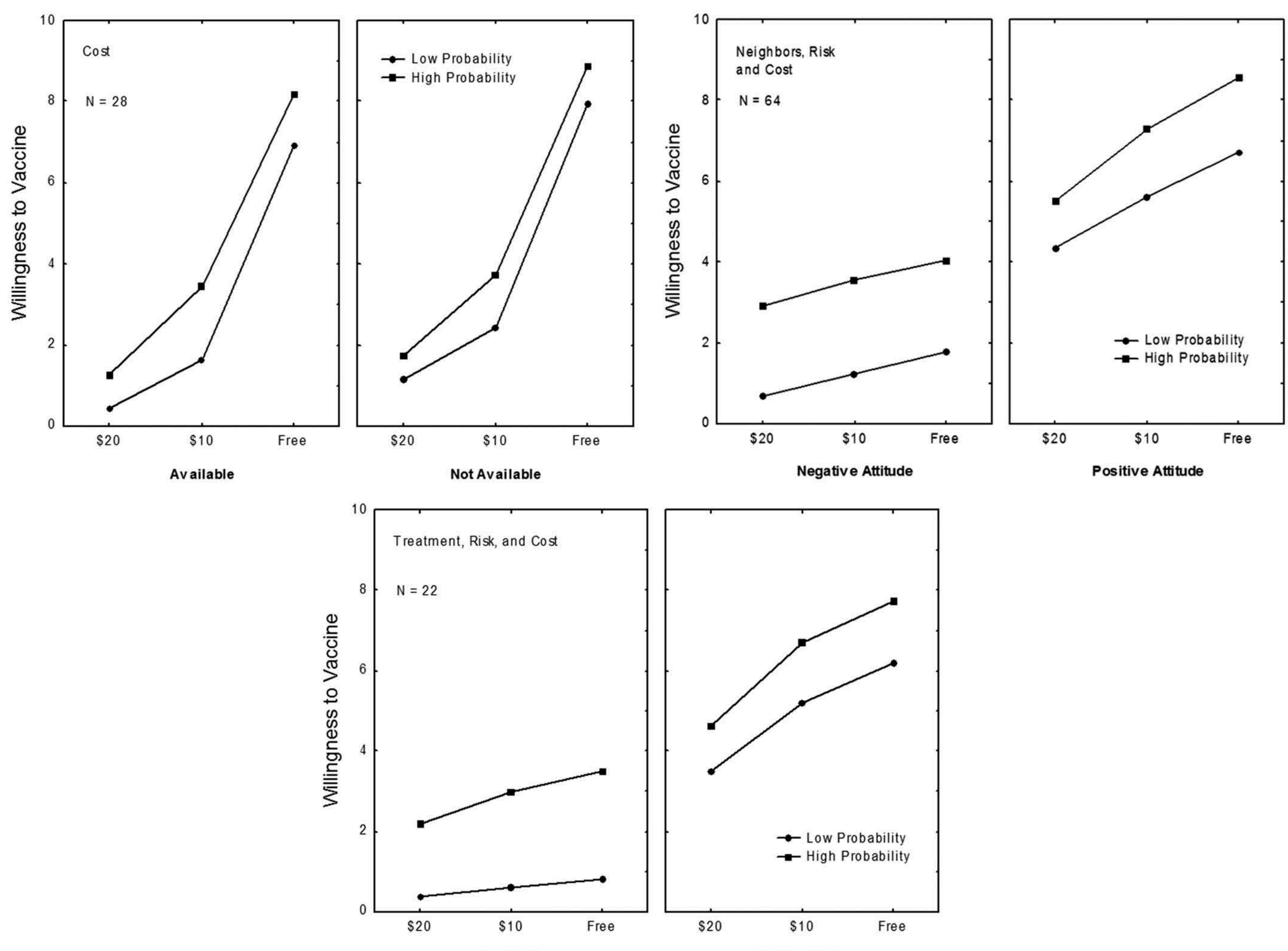

Figure 1. Patterns of results corresponding to the "Cost" cluster (upper row panels), "Neighbors, Risk, and Cost" cluster (center panels), and "Treatment, Risk, and Cost" cluster (lower row panels): In each panel, (a) the mean levels of willingness are on the y-axis, (b) the three levels of cost are on x-axis, and (c) the two curves correspond to the two levels of risk. The two panels correspond either to the two levels of availability of treatment or the two levels of neighbor's attitude.

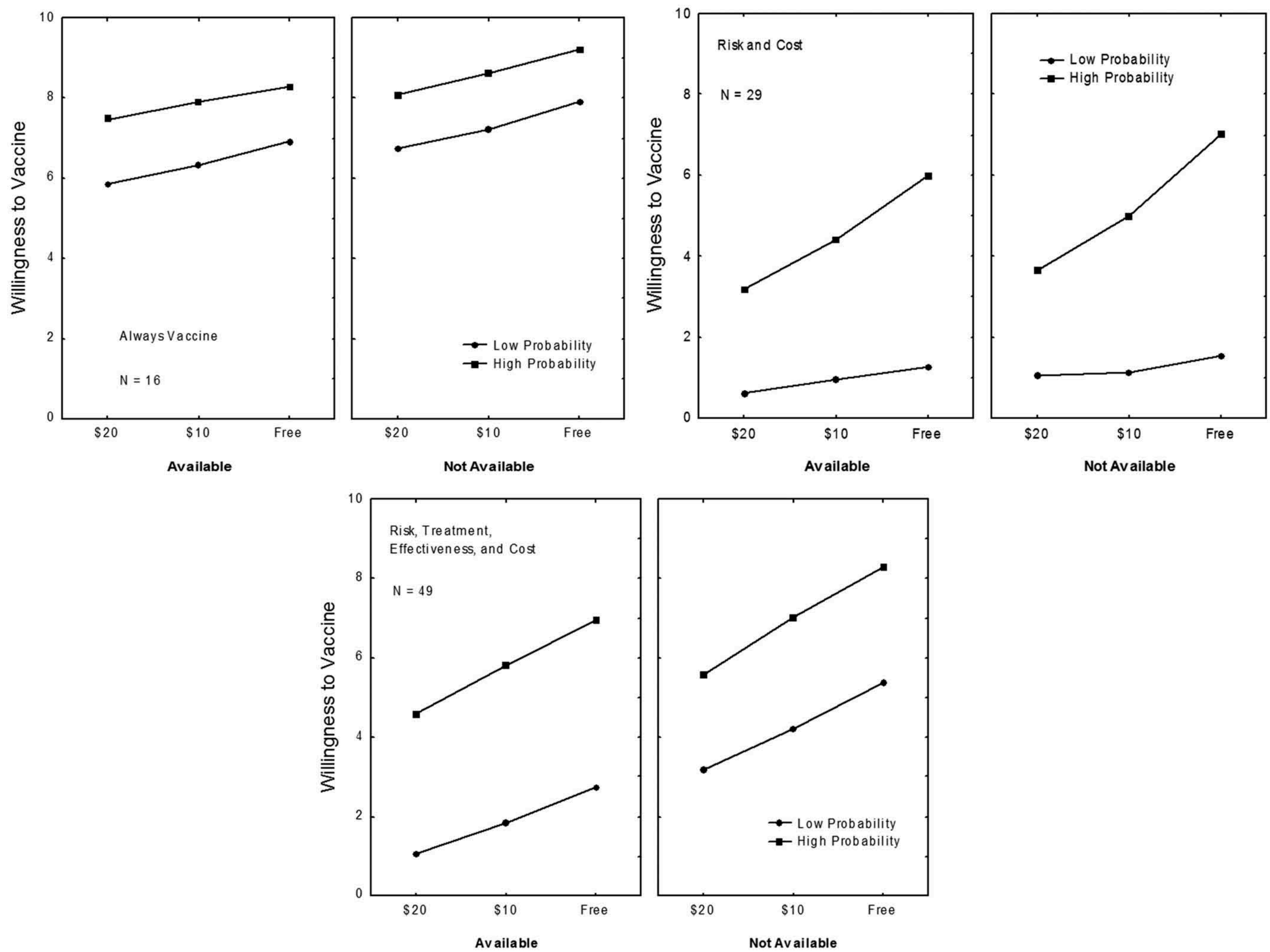

Figure 2. Patterns of results corresponding to the "Always Vaccine" cluster (upper row panels), "Risk and Cost" cluster (center panels), and "Risk, Treatment, Effectiveness, and Cost" cluster (lower row panels): In each panel, (a) the mean levels of willingness are on the y-axis, (b) the three levels of cost are on x-axis, and (c) the two curves correspond to the two levels of risk. The two panels correspond to the two levels of availability of treatment.

cluster was therefore named *Neighbors, Risk, and Cost.* The ratings were very high (>8) for each of the four scenarios in which the neighbors planned to vaccinate their children, the vaccine was free, and the risk was high. Muslims, older participants (30+ years), and those with an intermediate SES were more often found in this cluster than Christians, younger participants (18–29 years), and those with a lower SES.

The third cluster (N = 22, 10%) was reminiscent of the "treatment and cost" cluster found in the previous study. As shown in Figure 1 (bottom panels), the ratings of willingness to vaccinate were considerably higher when treatment was not available (M = 5.66) than when it was available (M = 1.74) and also higher when the vaccine was free (M = 4.56) than when it was expensive (M = 2.67). The effect of the cost was stronger when treatment was available (6.96–4.06 = 2.90) than when it was not (2.16–1.28 = 0.88). In addition, ratings were higher when the risk of getting infected was high (M = 4.62) than when it was low (M = 2.78). Ratings were, however, never very high. This cluster was called *Treatment, Risk, and Cost.*

The fourth cluster (N = 16, 7%) was the expected *Always vaccinate* cluster. As shown in Figure 2 (top panels), all ratings were high (M = 7.55). All effects were small although ratings were slightly higher when the risk was high (M = 8.27) rather than low (M = 6.84). For 17 scenarios, ratings were very high (>8). Christians and participants with a higher educational level or a higher SES were more often found in this cluster than animists and participants with a lower educational level or a lower SES.

The fifth cluster (N = 29, 13%) was called *Risk and Cost* because, as shown in Figure 2 (center panels), the ratings of willingness to vaccinate were higher when (a) the risk of getting infected was high (M = 6.38) rather than low (M = 3.07), and (b) the vaccine was free (M =5.84) rather than expensive (M = 3.60). In addition, the effect of the cost was stronger when the risk was high (6.51–3.43 = 3.08) than when it was low (1.39–0.84 = 0.55). As in the third cluster, ratings were never very high.

The sixth cluster (N = 49, 22%) was called *Risk, Treatment, Effectiveness, and Cost* because, as shown in Figure 2 (bottom panels), the ratings of willingness to vaccinate were higher when (a) the risk of getting infected was high (M = 6.38) rather than low (M = 3.07), (b) treatment was not available (M = 5.60) rather than available (M = 3.84), (c) the vaccine

Table 2. Main results of the ANOVAs.

Cluster and Factor	df	MS	F	p	η^2_p
Cost					
Risk (R)	1	425.25	89.56	.001	.77
Treatment (T)	1	145.36	77.95	.001	.74
Effectiveness (E)	1	33.44	56.37	.001	.68
Cost (C)	2	5 662.09	356.96	.001	.93
Neighbors (N)	1	13.36	23.63	.001	.47
Neighbors, Risk, and Cost					
Risk (R)	1	2 819.42	538.90	.001	.90
Treatment (T)	1	525.86	303.26	.001	.83
Effectiveness (E)	1	48.25	15.59	.001	.20
Cost (C)	2	936.80	275.64	.001	.81
Neighbors (N)	1	12 124.55	638.77	.001	.91
R x N	1	95.98	30.14	.001	.32
Treatment, Risk, and Cost					
Risk (R)	1	887.33	176.35	.001	.89
Treatment (T)	1	4 042.00	221.87	.001	.91
Effectiveness (E)	1	17.52	5.36	.03	.20
Cost (C)	2	323.73	177.15	.001	.89
Neighbors (N)	1	34.91	16.85	.001	.45
T x C	2	93.69	37.42	.001	.64
Always Vaccine					
Risk (R)	1	393.88	38.89	.001	.72
Treatment (T)	1	133.33	25.57	.001	.63
Effectiveness (E)	1	10.55	14.72	.005	.50
Cost (C)	2	70.78	14.46	.001	.49
Neighbors (N)	1	19.38	6.95	.05	.32
Risk and Cost					
Risk (R)	1	4 991.74	137.38	.001	.83
Treatment (T)	1	83.05	34.75	.001	.55
Effectiveness (E)	1	0.07	0.02	.88	.00
Cost (C)	2	386.88	37.35	.001	.57
Neighbors (N)	1	2.76	0.93	.34	.03
R x C	2	187.07	17.95	.001	.39
Risk, Treatment, Effectiveness, and Cost					
Risk (R)	1	6 417.19	357.27	.001	.88
Treatment (T)	1	1 823.57	328.51	.001	.87
Effectiveness (E)	1	1 210.02	50.12	.001	.51
Cost (C)	2	986.64	204.72	.001	.81
Neighbors (N)	1	171.44	49.15	.001	.51
R x T	1	213.72	24.74	.001	.34
Undetermined					
Risk (R)	1	141.32	16.28	.001	.47
Treatment (T)	1	157.50	13.05	.01	.42
Effectiveness (E)	1	4.92	3.24	.10	.15
Cost (C)	2	78.63	16.37	.001	.48
Neighbors (N)	1	4.35	2.77	.15	.13
Overall					
Risk (R)	1	13 430.38	562.41	.001	.71
Treatment (T)	1	4 355.57	264.18	.001	.54
Effectiveness (E)	1	604.76	59.80	.001	.21
Cost (C)	2	5 427.35	280.03	.001	.55
Neighbors (N)	1	4 905.54	122.64	.001	.35
R x T	1	132.38	32.79	.001	.13
R x P	2	105.87	31.32	.001	.12

was free (M = 5.84) rather than expensive (M = 3.60), and (d) effectiveness was high (M = 5.44) rather than low (M = 4.01). In addition, the effect of the availability of treatment was stronger when the risk of getting infected was low (4.25–1.89 = 2.36) than when it was high (6.95–5.80 = 1.15). Christians and participants with a higher educational level or an intermediate SES were more often found in this cluster than animists and participants with a lower educational level or a higher SES.

Finally, 19 participants (8%), ratings were centered on the middle of the response scale (M = 5.10). All factors had small effects. Ratings were only slightly higher when the vaccine was free (M = 5.55) than when the cost was $20 ($M$ = 4.55). This cluster was called *Undetermined*. Younger participants (18–24 years) were more often found in this cluster than older ones (>30 years).

An additional series of ANOVAs were conducted on the raw data with a design that included each time one demographic characteristic (e.g. gender or education) as a between-subject factor. Ratings from participants with higher education (M = 4.97) were higher than ratings from those with lower education (M = 4.10), $F(1, 225) = 30.74$, $p < .001$, $\eta^2_p = .12$. Cost had a stronger effect among participants with lower education (5.64–2.76 = 2.88) than among those with higher education (5.83–4.07 = 1.76), $F(2, 450) = 17.78$, $p < .001$, $\eta^2_p = .07$. Ratings from participants with higher SES (M = 5.77) were higher than ratings from those with lower SES (M = 3.92), $F(2, 224) = 41.82$, $p < .001$, $\eta^2_p = .27$. Cost had a stronger effect among participants with lower SES (5.53–2.52 = 3.01) than among those with higher SES (6.37–5.14 = 1.23), $F(4, 448) = 11.46$, $p < .001$, $\eta^2_p = .09$. Neighbors' attitude had a stronger effect among participants from intermediate SES (5.64–3.51 = 2.13) than among other participants (5.35–4.34 = 1.01), $F(2, 224) = 12.82$, $p < .001$, $\eta^2_p = .10$.

With regard to the differences between the two studies (the Mozambican study and the Togolese study), the comparison results showed that Togolese ratings were higher (M = 5.56) than Mozambican ratings (M =4.44), $F(1, 434) = 43.45$, $p < .001$, $\eta^2_p = .09$. According to the ANOVA conducted, the Country x Risk interaction was significant, $F(1, 434) = 285.44$, $p < .001$, $\eta^2_p = .40$. When risk was high, Mozambicans' and Togolese's ratings were similar (M = 5.55 and 5.73). When risk was low, Mozambicans' ratings (M = 3.33) were lower than Togolese's ratings (M =5.40). The Country x Cost interaction was also significant, $F(2, 868) = 54.13$, $p < .001$, $\eta^2_p = .11$. When the cost was high, Mozambicans' and Togolese's ratings were similar (M = 3.28 and 3.71). When the vaccine was free, Mozambicans' ratings (M = 5.71) were much lower than Togolese's ratings (M = 8.13). Finally the Country x Neighbors' Attitude interaction was significant, $F(1, 434) = 20.23$, $p < .001$, $\eta^2_p = .04$. The effect of neighbors' attitude was stronger among Mozambicans (5.11–3.77 = 1.34) than among Togolese (5.85–5.26 = 0.59).

Discussion

As expected, several qualitatively different positions were found, which were at least partly associated with socio-demographic characteristics. The first finding to highlight is the importance of cost, i.e. the affordability of the vaccine. For 12% of the participants, it was the main determinant of their willingness to get their infants vaccinated. For another 73%, the cost was one of the several factors that influenced their willingness. The role of cost and the fact that animists and participants with a lower educational level or SES were found in the *Cost* cluster more often than Christians and those with a higher educational level or SES were consistent with previous findings of the importance of socioeconomic factors in

African parents' decision-making about vaccinations for their children.[9,11]

The second important finding was that most parents' willingness to vaccinate was influenced by a variety of circumstances – not just costs, but also the risk of infection, availability of treatment, neighbor's attitude, or safety and effectiveness of the vaccine. These results are consistent with previous findings showing that people in Africa tend to shape their decision-making regarding vaccination in reference to the communal norms and social interdependency among community members, the perceived risks of contracting the disease, and the effectiveness of the vaccine.[10–12]

The third finding of importance is that only a small minority of parents (7%) seemed to be willing to get their infants vaccinated irrespective of the five circumstances modeled in the study. The members of this minority were likely to have a relatively high income and presumably to be less concerned by cost. They were also likely to be educated, which is consistent with findings of a large number of studies that the more a population is educated, the more it is able to understand the benefit of vaccination and therefore willing to accept it.[9]

Fourth, the factors not or little taken into account are noteworthy. The severity of malaria – whether the infant would recover or not – appeared to play no significant role in parent's ratings of their willingness to get their children vaccinated. The reason may be that malaria is so common that it was a part of the participants' daily experiences. In addition, in one cluster (22% of participants) the parents reported a willingness to get their children vaccinated even if the effectiveness of vaccine was 50%. This may be an important information since, in clinical trials, the initial vaccine effectiveness did not exceed 40%.[4,28]

Finally, no participant was unequivocally opposed to malaria vaccination. A small minority (8%), however, did express complete indetermination, i.e. their ratings were middle-of-road for all the scenarios, and none of the variables had any impact on these ratings.

Comparison of the results of the current study with the results of the Togolese study[13] shows similarities and differences. First, six positions were found in the Mozambican sample whereas five positions were found in the Togolese sample. However, it must be highlighted that both studies showed that the parents' positions regarding the willingness to vaccinate their children varied considerably, ranging from willingness to vaccinate irrespective of the circumstances to willingness to vaccinate only if a whole set of constraining circumstances was present.

Second, when the risk of getting infected was high, Mozambicans and Togolese did not differ in their willingness to vaccinate; when it was low, Togolese were more willing to get their children vaccinated than Mozambicans. When the cost of the vaccine was high, Mozambicans and Togolese did not differ in their willingness to vaccinate; but when the cost was low, Togolese were more willing to get their children vaccinated than Mozambicans. These differences in attitude may result, in part, from the higher childhood mortality from malaria in Togo (18% of deaths) than in Mozambique (13%).[21] They may be linked as well to the quality of the public health services offered in both countries and in people's confidence in a medical treatment that, like the malaria vaccine, is still being tested. Indeed, as a result of the long (1977–1992) and extremely violent civil war (a million dead) that followed the country's independence, Mozambique has lagged behind in terms of economic, educational, and health development compared to Togo.[15] A poorly educated population may have less confidence in a new medical treatment because it lacks knowledge linked to it and can be more vulnerable to adverse rumors. In addition, corruption in the public health-care services is omnipresent, and patients often have to bribe health practitioners, paying far more than the officially stipulated fees.[29] As a result, when they have a health problem, Mozambicans tend to resort to traditional medicine, which is much cheaper, going to the public health-care services only when they have a severe health problem and when it becomes clear that traditional medicine has failed. While Togo has also the same problems of economic, educational, and national health system shortcomings, it is clear from the United Nations reports that the situation in Mozambique is worse.[1,14,15]

Third, Mozambicans gave more importance to neighbors' behavior. As the situation regarding formal education is generally better in Togo than in Mozambique and the illiteracy rate is higher in Mozambique (50%) than in Togo (36%),[14] this difference might be explained by a tendency of less educated people to rely more on other community members to model their own behavior than do more educated people. Differences in socio-cultural norms and values may also explain this difference in attitude (e.g. conformism requirements), although evidence from comparative studies is not available to support this point/suggestion.

Overall, it appears to be easier to convince Togolese to vaccinate their children than to convince Mozambicans. For many Mozambicans, it is necessary, before deciding to accept, to be certain of not spending too much, to perceive a great risk, and to know the neighbors approve.

Limitations

First, the sample was of moderate size. A vignette technique is always costly in time, which prevented the use of large samples. Nevertheless, it is important to stress that all social and professional categories of the Mozambican population were present in the sample, which also comprised people living in rural areas. Second, many other factors not investigated in this study – including those operating at the level of the individual parent, such as trust in health-care providers – can potentially influence a parent's decision-making regarding vaccinating his or her child.[30] Third, although participants were presented with realistic scenarios, their behavior was not observed in real situations. The use of vignettes has, however, many advantages: (a) it makes possible the assessment of immediate reactions to a situation, (b) it standardizes the situations across participants, (c) it permits statistical analyses to examine how people weight and combine separate factors, and (d) it allows the characterization of qualitatively different patterns of responses. Despite its limitations, this study provides insights on how to tailor the promotion of infant vaccination against malaria in at least some sub-Saharan African countries.

Conclusion and implications

In summary, the current study conducted in Mozambique and the previous study carried out in Togo[13] indicate that parents' willingness to vaccine their infants against malaria is determined mainly by the vaccine cost. It is also determined by the attitude of the other members of the community where they are living, the perceived risk of getting the disease, and, to a lesser degree, the vaccine effectiveness. These circumstances suggest that the main emphasis of vaccination promotion efforts among parents in sub-Saharan Africa should be on (a) reducing financial barriers, (b) developing community-based vaccine promotion that is engaging and persuasive to people, involving influential community leaders (e.g. traditional and religious leaders) and local media, (c) promoting educational interventions addressing possible misconceptions about the consequences of malaria while explaining how a vaccine can reduce the disease severity, and (d) in each country where a large-scale vaccination program is to be implemented, identifying the determinants in each hesitant subgroup in order to tailor the intervention specifically to that subgroup.

Acknowledgments

The authors thank the students who worked as assistants to recruit participants and organize de testing sessions.

Disclosure of potential conflicts of interest

The authors report no conflict of interest. The authors certify that: (a) they have complied with American Medical Association Ethical Principles in the collection of the data, (b) the manuscript contains original work, and (c) the work is not simultaneously submitted for review elsewhere.

Funding

The authors received no financial support for the research.

Authors' contributions

The idea and contents of the article emerged from discussions among the authors, who have worked together in the previous research. Germano Vera Cruz and Amélie Humeau conducted the research on the ground and wrote the introduction and the discussion sections. Etienne Mullet conducted the statistical analysis and wrote the results section. Lonzozou Kpanake and Paul Sorum partially rewrote and reviewed the article. The authors are solely responsible for final content and interpretation. The authors received no financial support or other form of compensation related to the development of the manuscript.

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