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Article

Reducing Avoidable Deaths through Technology: Deployment of Persuasive Technology-Based Model in the Prevention and Control of Malaria in Nigeria

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Abstract: Malaria is one of the leading causes of illnesses and deaths in Africa at large and Nigeria in particular, especially amongst pregnant women and children under the age of five years. Our research revealed that though the government has deployed so many intervention systems to contend with this death-causing vector—the mosquitoes, malaria related deaths (MRDs) have continued to increase. This is because people have not sufficiently adopted those intervention systems to protect themselves. Further enquiries into the ineffective compliance of the people to the intervention systems revealed that the interventions are passive in nature. Based on these, we set up three measurable research outcomes to enable us to determine the appropriateness of persuasive technology in solving the malaria problem. We technically avoided a one-size-fits-all design approach and adopted Participatory System Design (PSD) and User-Centered Design (UCD) approaches in our system design methodologies. Well-structured questionnaires were used to extract information from the participants. The data obtained from the research survey was used in modeling the intervention system. The research was conducted in three phases: baseline, development and deployment of an intervention system—the Malaria Prevention and Control Support System (MPCSS), and an evaluation study to determine the performance of the intervention system. The research led to the following achievements: (1) encouraged an increase in the number of people who participated in malaria prevention and control activities by lowering the rate of malaria cases from 96.9% to 68.5% and increasing ownership of mosquito nets from 54% to 85.5%; (2) demonstrated that persuasive technology could be used to increase public awareness and knowledge of a given subject as noted in our evaluation result; and (3) demonstrated that persuasive technology is a veritable active intervention to combat malaria.

KEYWORDS: Persuasive Technology; Malaria Prevention and Control Support System (MPCSS); active intervention tool; Mosquitoes; Malaria Related Deaths (MRDs)

1.0 . INTRODUCTION

Malaria is one of the leading causes of illness and death, especially among children and pregnant women in Africa and particularly in Nigeria. The third Sustainable Development Goal (SDG) of the United Nations (UN) aims to ensure healthy lifestyles and promote wellbeing for all people of all ages, and its Target 3.3 calls for the eradication of hepatitis, water-borne diseases, and other infectious diseases by 2030. The WHO report of 2020 noted that out of 229 million global malaria cases in 87 malaria endemic countries, Africa region recorded 215 million cases which represented 94% of the overall estimated global cases with Nigeria topping the list of Africa malaria endemic with 23% (WHO, 2020; Ignatius & Ifeyinwa, 2021).

To curtail the scourge of malaria incidences, the World Health Organization (WHO) recommended that children and pregnant mothers living in malaria endemic regions

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must sleep under Mosquito Treated Bed-net (ITN), (WHO, 2019). This research further discovered that in response to the WHO recommendations, the Federal Government of Nigeria rolled out several malaria intervention programmes such as the RollBack Malaria (RBM) programme, free distribution of insecticide-treated nets (ITNs), distribution of free/subsidized Artemisinin Combination Therapy (ACT) drugs, inaugurations of Strategic Plan for Nigeria Against Malaria (NMSP), National Malaria Eradication Programme (NMEP) and introduction of monthly environmental clean-up exercises to minimize or probably eradicate the scourge of malaria in the country.

However, despite these initiatives by the concerned authority, malaria related deaths (MRDs) have continued on escalation, leaving one to question why.

This study revealed that these interventions are ineffective because they were passive. They are passive in the sense that they are used whenever individuals want. For example, if someone is unwell, he follows his medication routine rigorously until the pain subsides. He will either discontinue the medications or begin to miss the scheduled regiment. However, if someone is actively watching him, he will complete the remaining regiment as advised.

Secondly, Ogbaga *et al*., (2022) observed that the difficulty in controlling malaria in Africa is due to constant changes in mosquito genetic makeup, which provides it the ability to fight malaria medications, implying that prevention is much more important than cure since cure is no longer guaranteed.

Based on these findings, the government should incorporate active stimulating, monitoring, and reporting mechanisms into these interventions in order to track their progress and level of acceptance by the intended audience. Furthermore, given that human effort has not delivered the expected results, there is a need for technology adoption in providing a solution to this public health issue. The purpose of this study therefore is to ascertain the relevance of persuasive technology in addressing the challenges of malaria.

Malaria can also be controlled/eliminated using persuasive technology (PT) that employs appropriate Persuasive Strategies (PS) to stimulate the desired behavior on the target audience, as PT has been used to motivate desirable behaviors in other domains such as health and wellness, sustainable environment, dietary, fitness, and so on (Nkwo *et al*., 2019, Orji *et al*., 2013). Researchers and industry professionals have been interested in investigating how technology may be tailored to promote behavior change. Persuasive Technology, as defined by B. J. Fogg, is a computer system, device, or application that is purposefully designed to change the attitudes of a person or group of people in a predefined way, without coercion or deception (Fogg, 2003). Technology can never be neutral because through 'its consistent use, the user's attitude is influenced incrementally.

Research has further proved that mobile phone reminders, phone calls, and social media notifications can be used to motivate people to perform expected actions because mobile phone use is very prevalent among low-middle-income communities and any technology implemented through it will undoubtedly enjoy a high level of acceptance, provided it is sufficiently tailored to the target audience usage capacities (Ignatius *et al*., 2021; Nkwo & Orji., 2019).

2.0. STUDY SETTING

This research was carried out in Ebonyi State. Ebonyi State is a state in Nigeria's South-East region, consisting of 13 local government areas (LGAs) divided into three senatorial zones. The state's health-care delivery system is divided into three tiers, with primary health care at the bottom, followed by secondary and tertiary care. Three towns in each of these three senatorial zones are urban (Abakaliki, Onueke and Afikpo). Three local government areas (LGAs) were chosen at random from each senatorial zone for the study based on three inclusion criteria: the largest number of malaria-related deaths, proximity to a river, and availability of mobile phone network service.

3.0. STUDY DESIGN

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This research was conducted in 3 main stages and the methodology adopted at each stage are as follows:

i. Pre-evaluation stage to obtain our measurable outcome –Baseline study
ii. Implementation of the measurable outcomes in a developed interventions system that was used to plug-in the observations made in step 1.
iii. Evaluation stage that was used to evaluate the performances of the developed intervention system in-line with the measurable outcomes of the research.

4.0. MEASURABLE OUTCOMES OF THE RESEARCH

i. There should be increased adherence of people to positive malaria preventive measures such as (consistent sleeping under ITN, keeping clean environment, use of chemical mosquitoes repellents such as sheltox and net-proofing of doors and windows.)
ii. The number of persons who become ill of malaria should be reduced.
iii. Determine whether there is a connection between persuasive technology intervention systems and malaria prevention and control

5.0. RESEARCH METHOD

The study adopted multiple methodological approaches otherwise known as triangulation which included: 1) Survey, 2) Persuasive System Design (PSD) model and 3) Object-oriented Analysis and Design Methodology. This hybridized method was chosen to maximize the benefits of each component method in studying an existing system, identifying problem areas, and designing a better system for the future. Semi-structured survey questions were also utilized to learn more about the factors that influence positive health behaviors in relation to malaria prevention and control. Using a convenient sample technique, some pregnant women and nursing mothers were identified as the targeted audience from three local government areas. The instrument was administered orally and through self-administration.

Moreover, the survey questions focused on the gains, hindrances, and consequences of disregarding positive health behaviours, as well as social and cultural challenges to the adoption of appropriate malaria prevention and control measures, basic mobile technology knowledge and its relevance. The sample questions can be found at https://forms.gle/D1VsWi2W1AUG35AE8.

5.0. DATA COLLECTION AND ANALYSIS

This study was conducted between August 2021 to September, 2022 in multiple locations such as homes, village squares, schools, and healthcare centers. The age ranges of the participants were between 18 to 69 years. We present the demography of the participants in Table 1.

Table 1: Participants details.

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Sex	Parameters	No of Baseline	
Pregnancy status	pregnant	41	97
	Not Pregnant	56	
Age	18-29	40	98
	30-40	51	
	ABOVE 40	7	
Marital status	Married	80	98
	Single	18	
Married with children	Yes	67	94
	No	27	
Highest level of education	Primary	0	96
	Secondary	24	
	Tertiary	72	

5.1. Analysis of the Baseline Study Questionnaire

The participants were recruited and briefed after which questionnaire were administered to them to respond to. The questions contained in the survey were segmented into seven sections: the demographic section, the malariology section to ascertain their levels of knowledge about malaria preventions and control techniques, the environmental sustainability section which captured the kind of house they live and how they maintain it. This section was followed by another section known as technology usage knowledge which focused on determining the participants' proficiency with mobile phone technology. Furthermore, the motivation/action triggers section was used to elicit the elements that motivate/persuade individuals to take action. Motivating features included rewards/gifts, stroking, personalization, and customization, among others. Finally, we had a section where participants were asked to suggest possible technologies that they believe may be used to modify people's unfavorable attitudes/behavior toward malaria prevention and control.

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6.0 . RESULTS

6.1. Result of Baseline study

We have two results to present in this study based on the research design: baseline and evaluation study results. Meanwhile, 98 people took part in the baseline investigation, and 76 people took part in the evaluation. However, after the exclusion criteria, the participants were normalized to 76 for parity purpose. The baseline study uncovered that 96.9% of the respondents have been sick of malaria within the time of this research.

i. We also uncovered that 54% of the respondents have ITN and out of the 54%, only 52% of them sleeps inside the net.

ii. The study also uncovered that 87.5% of the respondents do not have nets on their doors and windows.

iii. Those who do not make use of their ITN have their various reasons as presented in this figure

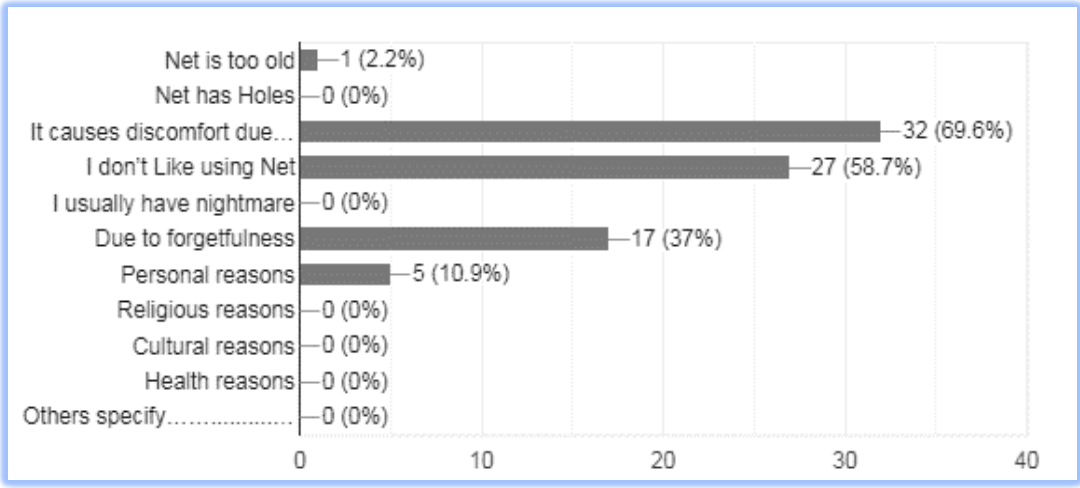

Figure 1: Reasons people avoid using their ITN.

iv. Some of the participants believed that malaria is a normal sickness. This opinion was shared by 78.6% of the respondents

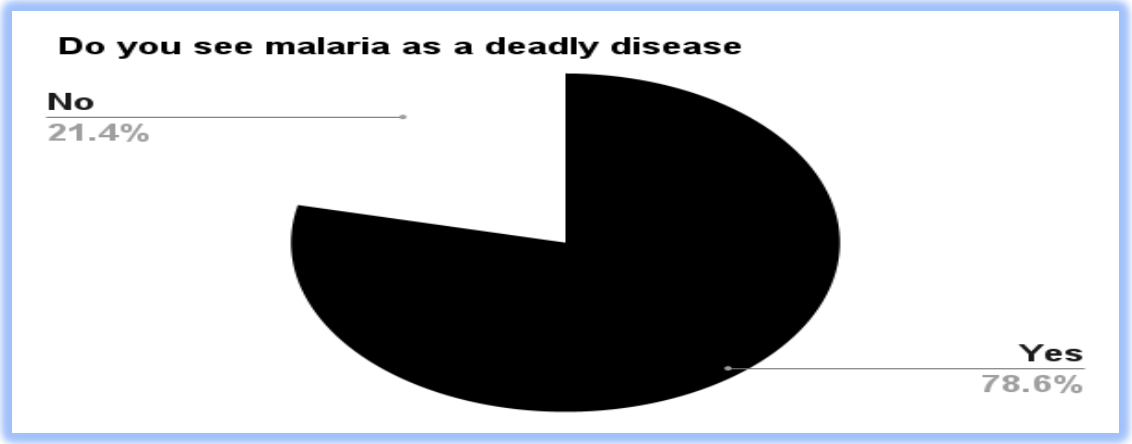

Figure 2: Peoples perception about malaria.

v. The research was able to ascertain the range of activities that motivates the participants as presented in this chat below with praises and social learning topping.

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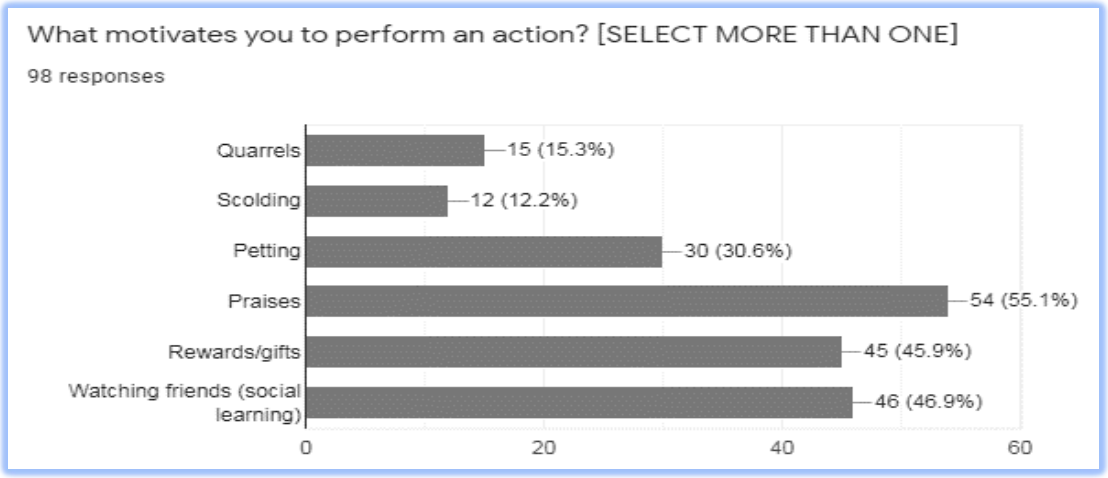

Figure 3: Motivational triggers of the people.

6.2. *Evaluation of our Intervention System*

Following the baseline, the analytical results were used to inform the design and development of our intervention system, "Malaria Prevention and Control Support System" (MPCSS). Particularly, items **iv** and **vi.** The performances of the model was validated with evaluation survey questions, which was distributed across the participating audience recruited during the baseline study. The evaluation was carried out after three months of constituent interactions with the participants. Some specialized message reminders, which focused on three major topics: malaria awareness, malaria dangers (severity and susceptibility), and preventative methods. These message reminders were utilized to stimulate/awaken their consciousness to have favorable attitudes regarding malaria prevention practices. A message table was created for this purpose. The assessment of user responses took place in the first week of September 2022. Their responses were examined and compared to the results of the baseline study. Seventy-six (76) people took part in the evaluation survey. We excluded 22 people from our baseline research respondent database who did not engage in the evaluation. This allowed us to have 76 participants for both the baseline and evaluation analyses.

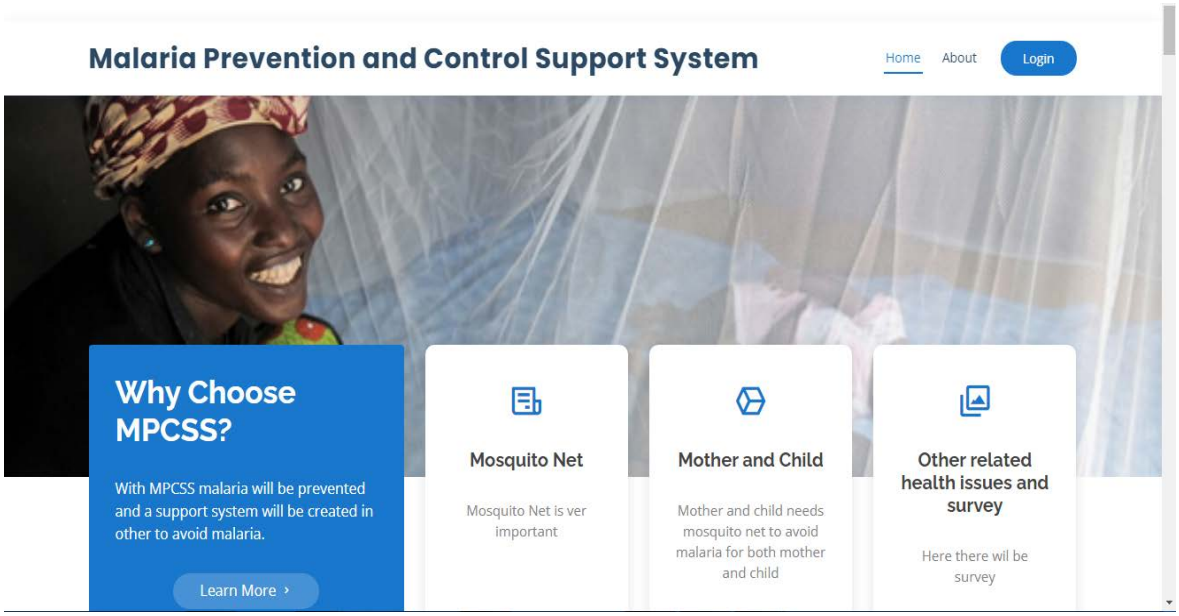

Figure 4: The index page of the MPCSS intervention

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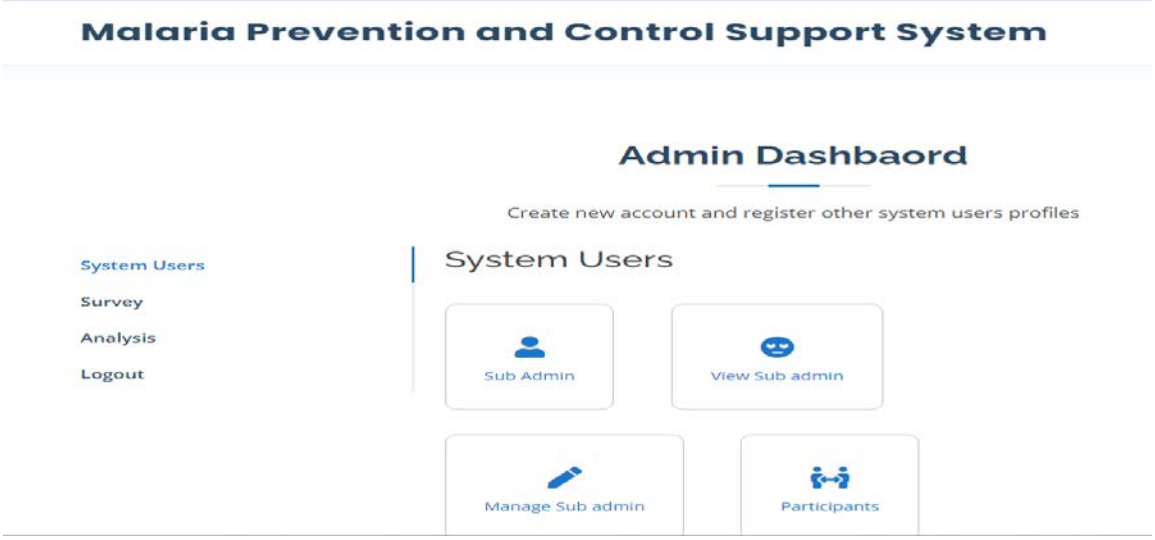

Figure 5: Admin panel of the intervention.

The intervention has the following features in the admin panel: survey, analysis, sub admins, manage sub admins, add participants, manage participants and results info-graphs.

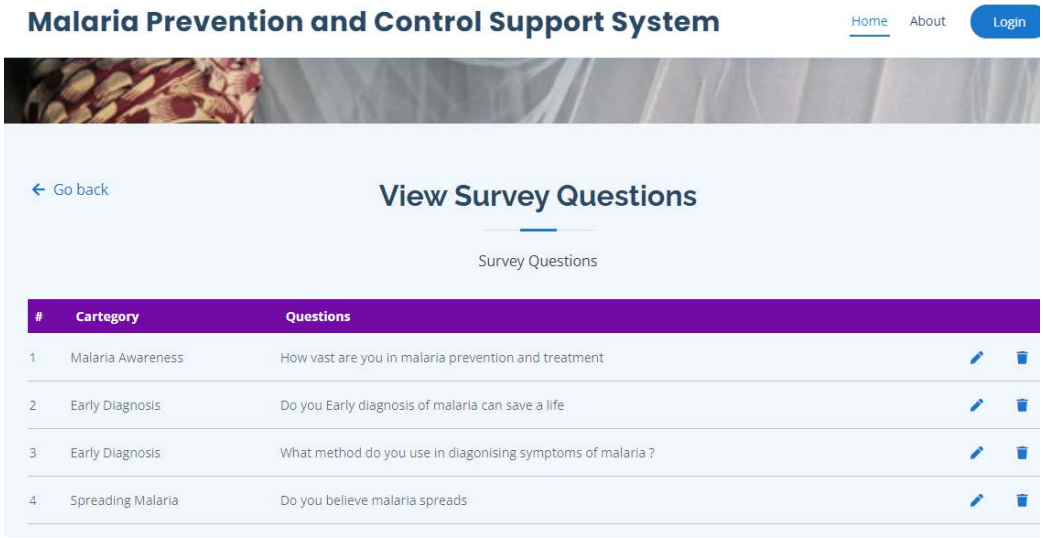

Figure 6: Sample survey question.

This interface contains sample of some of the tailored personalized messages that was sent to the target audience.

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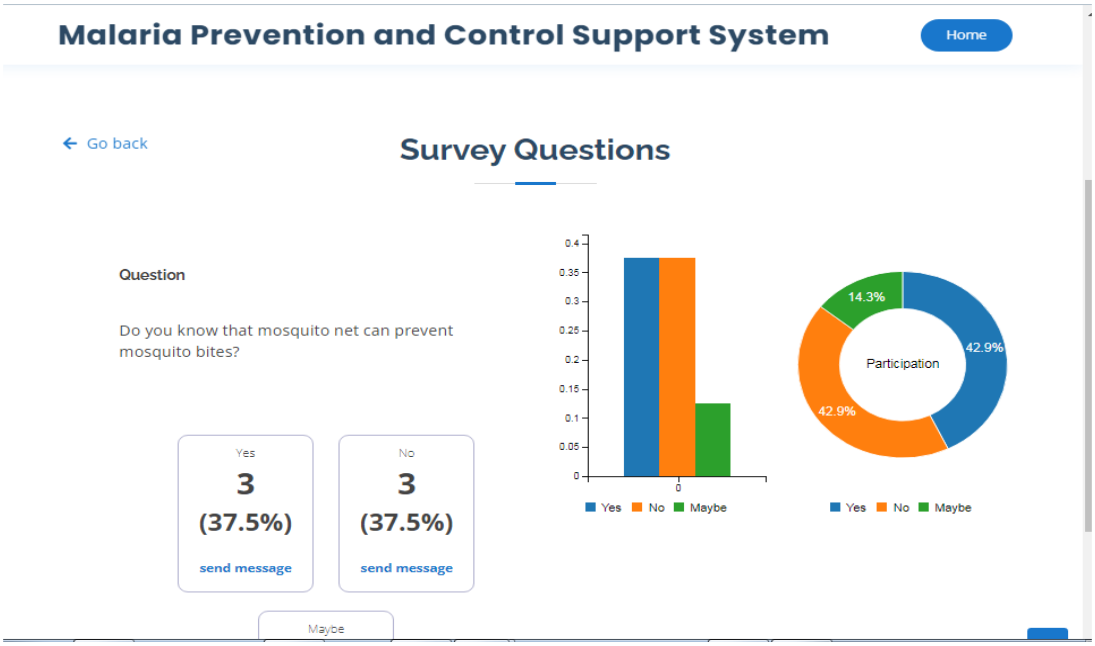

Figure 7: Sample result infograph of participants' feedback.

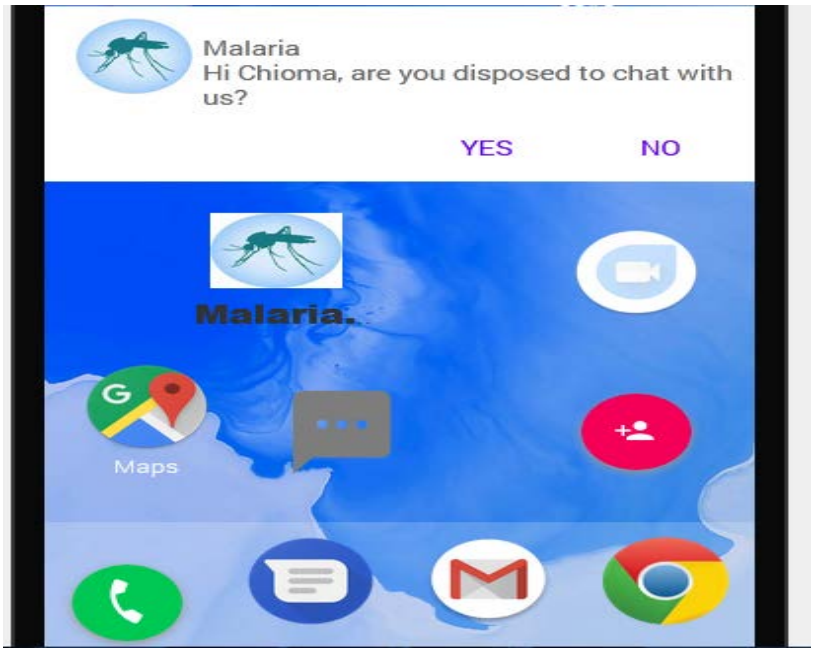

Figure 8: Sample of the persuasive text message received by the participants

However, the following results was obtained:

i. 68.% of the participants fell sick of malaria as against 96.9% that fell sick within the period of baseline

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ii. 85.5% of the participants now own ITN as against 54% recorded in the baseline

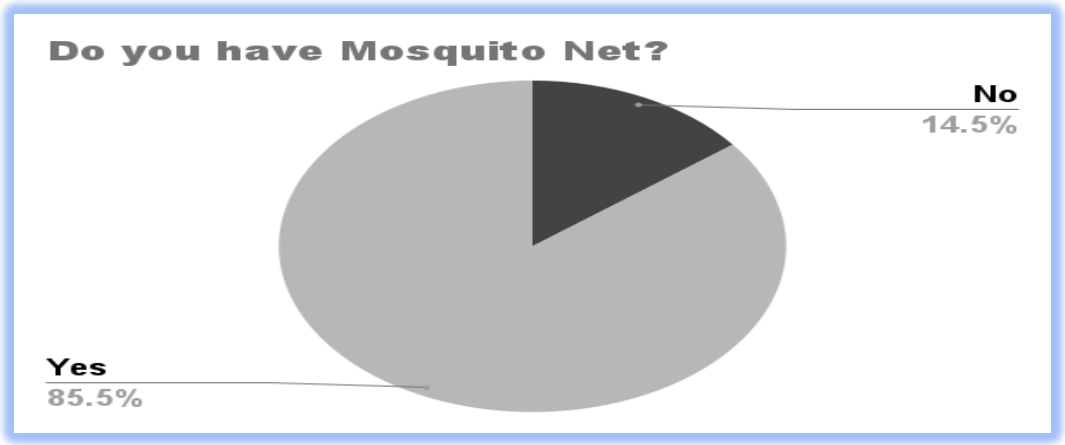

Figure 9: Ownership of mosquitoes net after deployment of our intervention.

iii. 84.2% of the participants now see malaria as a deadly sickness 78.6% recorded in baseline

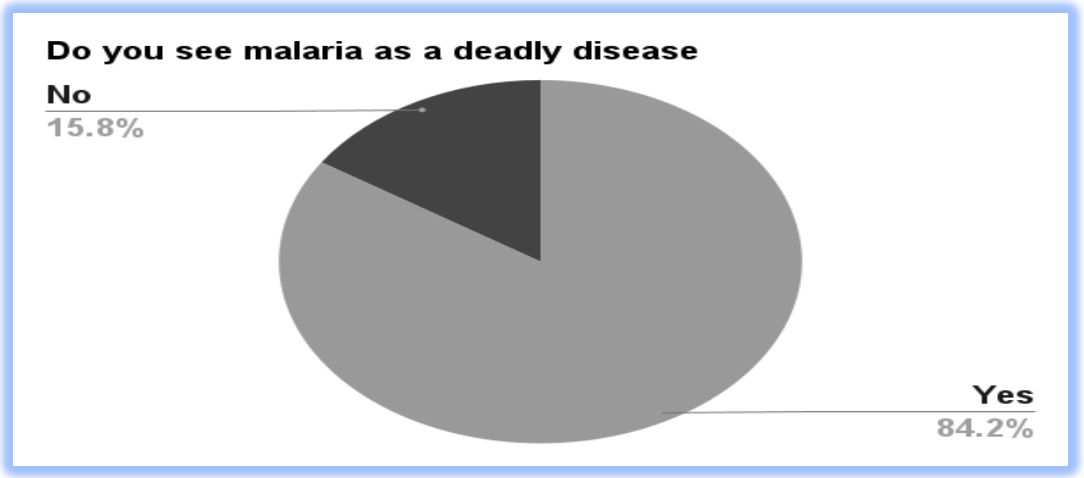

Figure 10: People's perception about malaria after deployment of our intervention.

iv. 97.4% net-proofed their doors and window against 87.5% recorded in the baseline.

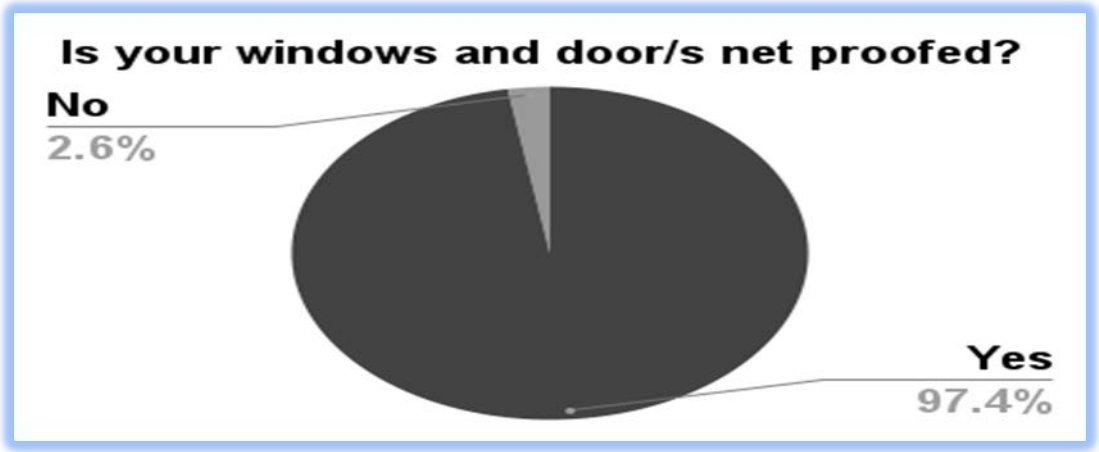

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Figure 11: Rate of Net-proofing of doors/windows after our intervention deployment.

v. Among the malaria control behaviours modeled in our intervention system which included use of insecticide spray, sleeping under the ITN, net-proofing of doors and windows, closing of door and windows on time and keeping the environment clean (see https://forms.gle/D1VsWi2W1AUG35AE8). Sleeping under the ITN was mostly influenced with 86.8% followed by keeping the environment clean

Table 2: Summary of result

Sex	Parameters	No of Baseline		No of evaluation		Excluded criteria	Evaluated
Pregı status	pregnant	41		34			
	Not Pregnant	56	**97**	37	**71**		
Age	18-29	40		30			
	30-40	51	**98**	38	**6**		
	ABOVE 40	7		8			
Marital status	Married	80		56			
	Single	18	**98**	20	**76**		
Married with children	Yes	67		58			
			94		**76**		
	No	27		18			
Highest level of education	Primary	0		2			
	Secondary	24	**96**	27	**76**		
	Tertiary	72		47			
Ownership of ITN	Yes	53	**98**	66	**76**		
	No	45		10			
Rate of Malaria sickness	Rarely	38		32			
			96		**76**		
	Occasionally	49		36			
	Always	9		8			
Do you see malaria as dangerous?	Yes	77		64			
			98		**76**		
	No	21		12			
Total		**98**		**76**		**22**	**76**

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7.0 . DISCUSSIONS

The discussion of our results shall be presented in accordance with the stated measurable outcomes of the research.

7.1. Measurable Outcome one:

A component of our baseline survey was used to identify the factors that discourage individuals from engaging in malaria prevention activities. Factors such as laziness, forgetfulness, loss of interest, and so on were discovered. These factors made it difficult for them to adopt government-provided free interventions such as Insecticide Treated Net (ITN), chemoprevention mechanisms such as (Sheltox, *ota pia-pia,* mosquito coil burning), and environmental cleanliness. The summary results obtained on the use of the aforementioned items in our baseline study are shown in the results section.

During our evaluation study, we assessed people's compliance with characteristics such as ITN ownership and use, chemical spray use, and environmental cleanliness. There was an increase in utilization, particularly in the ownership and use of ITN. (See **ii**) of the evaluation section's results. In allusion to the notion that mobile phone intervention can be used to motivate people to adhere to malaria prevention and control methods. Thus, the first measurable outcome sought to demonstrate that increased adherence of people to positive malaria preventive measures such as (consistent sleeping under ITN, keeping a clean environment, and using chemical repellents such as sheltox) can be achieved using a technology-based intervention system.

7.2. Measurable Outcome two

We included a portion in our baseline research to determine participant motivation/action triggers. In this section, we attempted to figure out what motivates people to do things even when they do not originally have the desire to do so. People's motivation triggers included quarrels, scolding, petting, praise, rewards/gifts, and watching a friend perform an action (social learning). The results obtained on these triggers can be seen in item **iv** of the baseline result section.

Secondly, we used these action triggers in our persuasion strategies while sending reminders to our participants. The reminders were tailored to fit within these motivating factors. These reminders were set to be delivered at a time that was convenient for them to check their phone. This resulted in a high level of adherence to the reminders. This was reflected in the number of people who were ill with malaria as a result of mosquito bites and their degree of awareness about mosquito management. Thus, our second measurable aim which was to determine whether the use of technology could reduce the number of times people became ill of malaria was achieved.

7.3. Measurable Outcome three

We used some questions in our baseline study survey to also determine the number of participants who have a mobile phone, the type of phone, what functions they can perform with the phone, the number of up-time and down-time of the phone, the amount of time they spend with their phone, and the time they are most available to attend to their mobile phones. This is done to ensure the participants' full engagement and compliance. The results of this were used to model our intervention system.

In our evaluation survey questionnaire, we tried to ascertain whether our intervention system have made any impact on the behaviours of our audience as regards their perception towards malaria. For instance, in our baseline study, 20% of the participants believed that malaria is a normal sickness and it cannot cause any harm to pregnant mothers and her child. So, in our evaluation survey, we tried to check this perception. The results as can be found in (result of evaluation study **iii**) our intervention system MPCSS has actually impacted on this negative perception of the people. Same thing was also done to ascertain the number of them who have net proofed their doors and windows.

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This alluded to the measurable outcome number three which sought to prove that there exist strong relationship between mobile phone-based intervention system and malaria preventive and control measures.

8.0 . CONCLUSION

In order to arrive at the set goal of this research as enumerated in the research outcomes, the researcher followed Fogg's postulate on the processes that PT designers should follow to design PT interventions. Fogg classified these processes into eight distinct steps (Fogg, 2009). This study was carried to arrive at a solution that could take care of the flaws observed in the existing systems, using the framework stated above.

Summarily therefore, this research was able to achieve the following based on the stated research outcomes:

Summarily therefore, this research was able to achieve the following based on the stated research outcomes:

i. Established that there is an increased number of adherence by the people to malaria prevention and control activities. This was reflected in the number of people that now own ITN and visits hospital for malaria treatment. This alluded to the fact that mobile phone intervention can be used to motivate increased adherence of people to engage in malaria prevention and control activities as can be seen in evaluation result (**i & ii**).
ii. Established that the application of persuasive technology could be used to reduce the number of times people fall sick of malaria by strictly adhering to the malaria prevention and control techniques through proper sensitization on the danger of malaria. This was demonstrated in our evaluation result (**iii**).
iii. Established that there is strong relationship between technology and malaria prevention and control. This alluded to the research outcome number three which sought to prove that there exist relationship between mobile phone-based intervention system and malaria preventive and control measures.
iv. We developed a mobile persuasive system (MPCSS) that was used to persuade people to adopt positive malaria prevention and control behaviours

Conclusively, this research targeted mainly the pregnant mothers and mothers with children within the age of five years. The reason for this group of people is because they are the worst affected. The mothers prepare the bed and it is expected that the reminders should help to remind them to setup their mosquito nets after preparing the bed for both the husband and the children. After all, it is the duty of the mothers to take care of their homes.

Finally, the Oinas-Kukkonen postulate on technology use, which was founded on empirical and conceptual analysis, stated that technology can never be neutral as it must use either direct or indirect routes to influence people however justifies this study. Persuasion must start small and then increment without being obtrusive (Oinas-Kukkonen *et al*., 2008).

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Availability of data and materials.

All data generated or analyzed during this study are included in this published article.

Supplementary information

The online version of this article (Figures/Tables) contains supplementary material, which is available to authorized users.

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