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Malaria prevention and treatment using educational animations: A case study in Kakamega County, Kenya

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ABSTRACT

Despite worldwide efforts to prevent malaria, the disease continues to take its strongest toll in sub-Saharan Africa. Kenya is no exception, with millions of cases and thousands of deaths reported annually. This pilot study looks at knowledge on malaria prevention and treatment among peri-urban communities in Western Kenya. Through a study on the use of animated videos as an informal educational tool, we examine baseline knowledge, sources of knowledge, and learning gains on a range of knowledge points on malaria prevention and treatment. The study has three significant findings: 1) participants in this study had relatively high levels of knowledge on malaria before the video intervention, 2) although the trend was an increase of correct answers post-animation viewing for all questions, and in some cases this went to 100% correct answers, the pre-knowledge levels were high enough for most questions that statistical significance was only detected in one question, and 3) we detected a significant correlation between Internet usage and baseline knowledge on malaria among the mostly literate sample population. These findings suggest that in heavily sensitized populations, for a particular topic, educational animations can be used to 'top off' knowledge on a given topic. Findings from this study can guide future malaria prevention and education efforts in Kenya and other developing nations.

Keywords*: malaria, Internet access, education, learning, Western Kenya*

INTRODUCTION

According to the World Health Organization (WHO), learning via electronic technology and media should not only provide access to information on disease prevention and health promotion but also engage these topics in a way that allows for the enjoyment of learning in its recipients (World Health Organization, 2017). We would add that in an era of ever-growing Internet connectivity and mobile phone use across the developing world, digital and Internet access is not only rapidly gaining ground as a major source of information, including around issues of health and disease prevention but also may already be a necessity.

In this regard, Information Communication Technologies (ICTs) have the potential to meet WHO's mandate and both to inform and delight knowledge recipients with respect to good practices

around health issues such as the prevention and reduction of diseases like malaria. While ICTs include a broad spectrum of communication devices, electronic or otherwise, ICT informational strategies involve (1) the deployment of cost-effective and accessible communication hardware, e.g., cell phones, projectors, and other audio-visual equipment, to disseminate, share, and enable the use of (2) geographically and contextually relevant informational or educational content in local settings. This combination of communication and relevant content is especially important for medical applications, such as disease prevention or reduction, since these goals require that accurately conveyed information becomes actionable tasks for affected populations.

For malaria, this task is urgent, as it threatens the lives of 3.2 billion people globally and leads to over one million deaths annually. The World Health Organization (2013) estimates that in 2012 there were 627,000 deaths from malaria worldwide, 90% in sub-Saharan Africa. Twenty-first global efforts to eradicate malaria were first articulated in the Millennium Development Goals (MDGs) of 2000 and now again more recently in 2015 through the Sustainable Development Goals (SDGS). According to the World Health Organization, malaria accounted for an estimated 13% of children's deaths globally in 2010, and 21% in sub-Saharan Africa (World Health Organization, 2016). Africans living in rural areas are most likely to suffer from malaria due to a combination of factors including poor living conditions, limited access to information that can help improve their livelihoods, and limited access to health care, among others (Gallup and Sachs, 2001). Some cultural beliefs may also interfere with the spread and acceptance of scientific knowledge about malaria and other diseases. However, while social and cultural myths may account for the gap between awareness of modern disease prevention measures and health seeking behavior (Feyisetan et al., 1997; Campbell, 2014), several other factors more strongly influence the practice of malaria prevention, including a lack of access to information and limited access to preventative tools such as mosquito bed-nets or mosquito repellants.

Identifying and analyzing the sources of health information that people rely on for information gathering and sharing is crucial for healthcare providers, policy makers, and other interested groups working with communities when developing educational programs that could lead to behavior change and improved disease prevention. Additionally, using animated videos translated into dialectically local languages and shared through mobile phones have the potential to bring awareness, change perceptions, increase knowledge, and improve social mobilization around the prevention of diseases like malaria (Sharples et al., 2009; Aranda-Jan et al., 2014.)

RESEARCH QUESTIONS

This study seeks to answer the following research questions:

- What are the levels and detail of knowledge on malaria among rural communities in Western Kenya?

- How do the variables of education and Internet access correspond to knowledge on malaria prevention and treatment?

RESEARCH METHOD

Significance of the Study

This study measures participant knowledge around malaria prevention and treatment in three peri-urban/rural communities in Western Kenya. ICT deployment of educational animated video

material on malaria prevention was chosen for this area due to both the widespread impact of malaria in Kenya locally and generally and the large number of people who have access to cell phones.

Annually, Kenya has 6.7 million new clinical cases of malaria and 4,000 deaths from the disease, with many of these cases reported in western Kenya (Centers for Disease Control, 2015). Malaria infection rates are particularly high during the heavy rainfall season that runs from April to July; those most highly affected by malaria are children and pregnant mothers (Centers for Disease Control, 2015). The Kenya Medical Research Institute reports that malaria is the main cause of death (20%) for Kenyan children younger than five years old (NMCP, 2016).

As part of existing malaria prevention efforts in Kenya, insecticide-treated nets (ITNs) are distributed free of charge in the same manner that vaccines are provided to many developing countries, based on the belief that bed-nets provide important community-level effects in addition to personal protection. The CDC also documented that the Kenyan government and social marketing organizations are working on increasing availability of nets and re-treatment kits, and novel distribution mechanisms that link insecticide-treated bed-nets to national immunization days. All these innovative measures are being explored to prevent and eradicate malaria.

This strategy, however, is not without its problems. The nets are at times used for purposes other than preventing malaria. Atieli et al. (2011) carried out an empirical study to find out the utilization of ITNs in Western Kenya. Their findings show that there exists a gap between ITN ownership and usage and that the nets are used more during the high transmission season. Atieli et al. (2011) also noted that other factors that affect the use of ITNs ranged from the education level to significantly high numbers of mosquitoes and low indoor temperatures. Additionally, Atieli et al. (2011) found that education level and knowledge about malaria transmission impacted the usage of ITNs. When compared to households with no education, households with at least one member having primary or secondary education had significantly higher ITN ownership. Households with higher levels of formal education also reported higher levels of knowledge about malaria.

For ICT devices, in Kenya these include the Internet, regular mobile phones, and smart phones (Wyche, 2015). In 2012, 11.5% of Kenyans had Internet access at home, and 32.1% used the Internet (World Bank, 2015). According to the Communication Authority of Kenya (CAK), most smartphones are sold in the capital city of Nairobi and account for 42% of the mobile phone sales in the country. As of 2016 the number of registered mobile subscriptions amounted to 38.5 million countrywide while the mobile penetration countrywide was at 87.3% (Communication Authority of Kenya, 2016), up from 71% in 2012 (World Bank, 2015).

Not only subscription numbers but the range of cell phone usage as an ICT device has increased dramatically in Kenya. For example, Kenyans are using cell phones to address existing problems in international development, for mobile banking, social organizing, and social learning (Komen, 2014, Sanya, 2013, Mas and Radcliffe, 2010). Di Castri (2013) indicates that over 18 million Kenyans use cell phones for mobile banking. More broadly, a study of African youth and health information seeking behavior shows that one-third of those surveyed with access to the Internet used the Internet as an ICT device for searching for information on HIV and AIDS; two-thirds reported that if Internet access were free, then they would search for information on HIV/AIDS (Okonofua and Olagbuji, 2014). Likewise, a 2012 study on cancer patients in Kenya found that while most patients did not have access to the Internet, those who did reported using the Internet to educate themselves on their disease and treatment (Kivuti-Bitok et al., 2012).

Design

The purpose of this pilot study is to examine knowledge around malaria treatment and prevention among participants in selected communities in western Kenya. As part of a larger series of studies by Scientific Animations without Borders (SAWBO) into the use of animated videos as an informal educational tool (Bello-Bravo and Baoua, 2012; Bello-Bravo et al., 2013; Bello-Bravo et al., 2011), here we looked both at formal education levels and Internet access as types of informal education to test whether a correlation exists between these two variables and knowledge on malaria prevention and treatment. While much of SAWBO's research on the use of these technologies has focused to date on learning gains among a target population, i.e., how much information people retain, especially where health factors are involved (Bello-Bravo et al., 2013), this paper focuses on a sample population with an initially already relatively high baseline knowledge on malaria. Therefore, while the study used a pre-/post-test design to measure knowledge both before and after an animated educational video intervention on malaria prevention and treatment, the analysis in this paper does not only focus on learning gains, but as well on the baseline knowledge itself and potential explanations for the levels of knowledge on malaria among the sample population.

The animated video used as an intervention in this study addressed various knowledge points around four, linearly presented malaria topics. First, the video explained what malaria was. Second, it stated the symptoms of malaria. Third, it suggested ways that any individual experiencing these symptoms could identify and go to locations for treatment. And fourth, it provided recommendations for ways to avoid malaria inside and outside of one's home.

Study Area and Sample

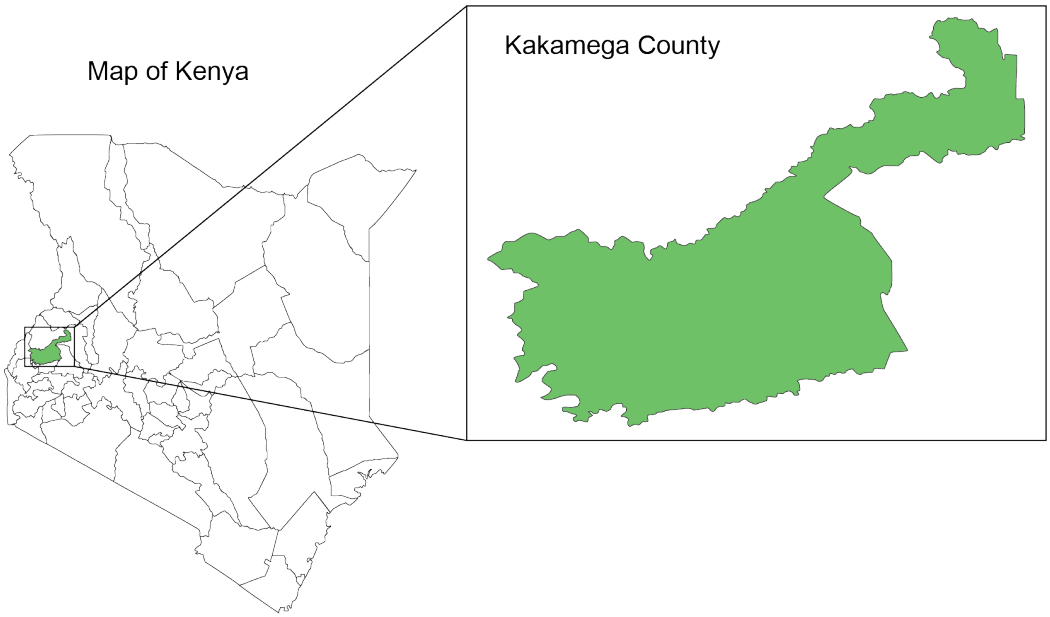

Figure 1: *Kakamega County in Western Kenya*

Data collection for this study was conducted in April 2015 among a broad sample of 75 participants from three villages, Munyanya, Sichilai and Shikhambi, situated in the peri-urban and rural areas of Kakamega town in Kakamega County, Western Kenya. Kakamega County is a

county in the Western Province of Kenya. It has a total population of 1.9 million, and covers an area of 3,244.9 km^2. The population density is 515 individuals per km^2 with 57% of the population living below the poverty line. Kakamega County is Kenya's second most populous county after Nairobi (Kakamega County, 2016). The area is tropical with a high average rainfall (1250–1750 mm per annum) and a temperature range of 10.3–30.8°C with an average of 20.5°C. Kakamega Forest National Reserve, with the only tropical rainforest in Kenya, is located in Kakamega County.

***Table 1**: Participant Demographic Data*

Parameter	# of Responses (out of 75)	Percentage
Age		
…….18-29	13	17.3%
…….30-50	55	73.3%
…….51-70	7	9.3%
Gender		
…….Male	45	60.0%
…….Female	30	40.0%
Education		
…….None	2	2.7%
…….Adult Education	0	0.0%
…….Primary School	8	10.7%
…….Secondary School	23	30.7%
…….Vocational School	33	44.0%
…….University/College	9	12.0%
Marital Status		
…….Single	14	18.7%
…….Divorced	1	1.3%
…….Widowed	4	5.3%
…….Separated	2	2.7%
…….Married (Monogamous)	52	69.3%
…….Married (Polygamous)	2	2.7%
Occupation*		
…….Farmer	12	16.0%
…….Housewife	11	14.7%
…….Mechanic	1	1.3%
…….Mason	1	1.3%
…….Businessman	12	16.00%
…….Student	2	2.7%
…….Accountant	1	1.3%
…….Teacher	2	2.7%
…….Shopkeeper	1	1.3%
…….Handyman	1	1.3%
…….Other	31	41.3%

*Not all participants answered this question

Health care infrastructure in Kakamega County is limited with a total of 55 health facilities (12 hospitals, 15 health centers, 20 dispensaries and 8 clinics). Furthermore, medical services in the county are inaccessible to the majority of the people due to high costs, inadequate or poorly equipped health facilities, staff shortages, and a lack of maintenance of the health facilities. In Kenya, the average distance to a health facility is 10km in rural areas and 500m in urban areas. The doctor patient ratio of 1:14,246 indicates an extreme medical personnel shortage.

The study's 75 participants were selected from the three communities on a volunteer basis. Efforts were made to recruit a representative sample from the local population in terms of age, gender, marital status, education, and occupation (see Table 1 for a breakdown of the demographics of the participants).

In general, a high percentage of the participants (89%) were more than thirty years old, more than half were men (60%), and more than half were married (72%) monogamously or polygamously. The majority (86%) had had some degree of formal education through at least part of secondary school or vocational training. Occupations reported by participants included laborers (farmers, housewives, mechanics, masons, handymen), white collar workers (accountants, teachers, students), and entrepreneurs (businessmen, shopkeepers). Participants spoke several languages including English, Kiswahili, Luhya, Luo, Kalenjin; all spoke English, a majority also spoke Kiswahili and Luhya. As such, the research questionnaires did not need to be translated from English and communications between the researchers and participants were conducted in English to maintain consistency across all study participants. For participants not able to read, uncomfortable with reading in English, the researcher would read the questionnaire to them and record their responses.

Research Instrument

Structured questionnaires were administered to the participants. Participants were told about the goal of the survey and were offered an opportunity to consent or decline to participate in the research. After consenting, participants completed a pre-assessment questionnaire that evaluated their existing knowledge on malaria treatment and prevention. Secondly, they watched the malaria treatment and prevention video animations on cell phones. Lastly, they completed the post-assessment.

Data collection was based on an in-depth, structured questionnaire completed by all participants in the study. The instrument had 44 questions and followed a pre-existing survey that has been validated. The survey instrument is divided into three sections: section A included demographic information as well as questions on participants' profession, educational background, and access and use of technology. Section B included questions about the knowledge points for the four topics described in the video above. Sections A and B were completed before the video intervention. After the participants viewed the video, they completed Section C of the survey, which includes a post-test on the questions from Section B, and an additional two questions querying the participant's rating of the usefulness of the video animation as a teaching and learning tool and asking for suggestions on issues, subject matters, or topics that they would want to see covered in future video animations.

Data Collection and Analysis

The survey data was compiled, descriptive statistics calculated, and the data analyzed using SPSS software. Pre- and post-data on the same points of knowledge were compared to assess learning gains from watching the malaria prevention video using a Chi-squared analysis. Learning gains were calculated for each knowledge point (corresponding to a survey question). In SPSS,

the correlation significance bivariate test was used to determine how variables such as age, gender, education level, and Internet access relate to participants' calculated learning gains as well as reported knowledge on various aspects of malaria treatment and prevention.

FINDINGS

Overall, we found that the participants in this study initially had relatively high levels of knowledge on malaria prior to the video intervention; differences in pre- versus post-intervention surveys scores measured minimal learning gains, although the trend was for a positive increase in correctly answered questions. The significant finding from this study comes from an analysis of the relationship between the variables of education level and Internet access, and pre-existing knowledge on malaria among the study participants. We discuss this below.

Comparing Pre-Test and Post-Test Knowledge on Malaria

Table 2: *Pre- and Post-Test Knowledge Gains*

Knowledge Point	Response	Scores (n=75)		
		Pre-Test	Post-Test	±Gain (%)
• Malaria Symptoms	*Strongly/Agree*	74 (98.7%)	75 (100.0%)	+1 (1.3%)
• Malaria Transmission	*Strongly/Agree*	72 (96.0%)	73 (97.3%)	+1 (1.3%)
• Treatment & Prevention	*Yes*	73 (97.3%)	74 (98.7%)	+1 (1.4%)
• Nests where mosquitoes multiply	*Yes to All Options*	58 (77.3%)	74 (98.7%)	+16 (21.4%)*
• Sanitizing homes	*Strongly/Agree*	70 (93.3%)	72 (96.0%)	+2 (2.7%)
• Malaria victims visiting health care centers	*Strongly/Agree*	74 (98.7%)	75 (100%)	+1 (1.3%)
• Household members working together to fight malaria	*Strongly/Agree*	71 (94.7%)	75 (100%)	+4 (5.3%)
• Importance of sharing malaria information	*Strongly/Agree*	67 (89.3%)	69 (92.0%)	+2 (2.7%)
• Treat mosquito nets with insecticides	*Strongly/Agree*	73 (97.3%)	75 (100%)	+2 (2.7%)
• Sources of information & resources about malaria	*Yes to All Options*	54 (72.0%)	58 (77.3%)	+4 (5.3%)

*Significantly different ($p<0.05$).

Table 2 summarizes test responses on participant pre- and post-intervention knowledge for malaria. Questions tested included knowledge on symptoms, transmission, treatment & prevention, conducive conditions for mosquito breeding, home sanitization with mosquito-repellent insecticides, the use of sanitized mosquito nets, the three main sources available for the treatment of malaria (i.e., clinics, hospitals, and doctors), and the importance or urgency of sharing information about malaria treatment and prevention. While there was an upward shift after watching the animated video in the number of respondents who agreed or strongly agreed with most of the statements, with one exception (discussed below), this study measured no significant learning gains among the participants. This is not unexpected given that the pre-

intervention survey measured high levels of preexisting knowledge about malaria prior to the animated video intervention.

Nests Where Mosquitoes Multiply

With regard to the *nests where mosquitoes multiply* knowledge point, a significant learning gain ($p<0.05$) was measured. Pre-test responses correctly identifying *all* of the locations conducive to mosquito breeding were initially the second-lowest overall (77.3%). Participants were often unfamiliar with common places that mosquitoes can breed near a home. For example, many of the participants came from households that did not have houses with gutters, as places that therefore can collect water and breed mosquitoes; participants in houses that *did* have gutters were not aware that dirty gutters make good breeding grounds for mosquitoes. Post-test scores measured amongst the highest overall (98.7%).

Sharing Malaria Information

With regard to *sharing malaria information* knowledge point, participants indicated interest in sharing the animated video information with others both by word of mouth and by downloading the videos to digital devices (G. Akolo, 2017, pers. comm., 17 February). Given that the videos are designed as ICT interventions, less than three minutes long and readily downloadable to low-end cell phones, this affords people access to the videos and makes them readily shareable without consuming too much time or data. In particular, re-sharing the videos to others on cell phones helps further disseminate its educational to non-literate, or non-dominant-language literate, members of the community as well as with those without Internet access (Bello-Bravo, Olana and Pittendrigh, 2015) . This resonates with Kratzke et al. (2013), who demonstrated how mobile phones, text use, and the Internet can assist in closing the gap for access to health information when working with populations in rural areas.

Source of Information & Resources about Malaria

With regard to the *sources of information & resources about malaria* item, while a majority of the participants indicated on the pre-test that they knew to seek information on malaria from clinics, hospitals, and doctors, this knowledge point had the lowest pre-test (72.0%) *and* post-test (77.3%) percentage of correct responses. An answer was deemed correct if all three locations, i.e., clinics, doctors, and hospitals, were selected. The general consistency of pre-test and post-test answers suggests that while participants initially had some (only partial, incorrect) knowledge of one or two of the locations for malaria treatment or (correct) knowledge of all three locations, during the post-test the number of known (correct or incorrect) number of locations remained generally unchanged.

In addition to the three locations tested on the survey, participants also indicated that they access information about malaria on the Internet and other media platforms, as well as from friends, family members, tribal chiefs, and neighbors. Another source of local information reported by the participants is the chief's *baraza*, a monthly meeting held by the chief, in his capacity as a government official at the local level, where information on policy, education, social, and development issues are discussed. While these additional sources of information are not locations for the *treatment* of malaria systems, they do represent nodes where increasing community knowledge about available treatment means and facilities can occur.

Access to Technology, Formal Education, and Knowledge on Malaria

Given that the participants identified Internet use as a means for finding information about malaria, and in light of the growing body of literature on the general use of the Internet to access health information (Cline and Haynes, 2001; Kivuti-Bitok et al., 2012; Okonofua and Olagbuji, 2014), we analyzed the data to investigate whether Internet access was a factor contributing to the participants baseline knowledge of malaria prevention and treatment. While education has long been positively correlated with health outcomes generally (Cutler and Lleras-Muney, 2006; Groot and van den Brink, 2006; World Health Organization, 1969), the utility of the Internet in an 'educational' sense remains a fertile and open question (Bello-Bravo et al., 2013).

We anticipated that access to technology (limited in this study to mobile phones, laptop or desktop computers, and tablets) would increase participant opportunities to obtain health information in general, including around malaria treatment and prevention. In this study, access to technology was defined as *owning, having the ability to use or the possibility of sharing or borrowing from another person, or paying for access (e.g., via internet cafes) for one of the above technologies, including the possibility and the ability to browse the Internet*. In this study, 69 (92.0%) of the participants reported having, or having access to, smart phones to reach the Internet; several had more than one means for accessing the Internet (see Table 3).

Having access to technology, however, does not necessarily imply use of that technology. While two participants did not answer the question about frequency of Internet access, 56 (74.7%) reported accessing the Internet at some point over the course of a year, while 17 (22.7%) reported never accessing the Internet (see Table 3).

Table 3*: Digital Technology Access & Use*

	# of Responses (out of 75)	Percentage
Internet Technology*		
…….Internet Access	56	74.7%
…….Mobile Phones	69	92.0%
…….Computer (Laptop/Desktop)	10	13.3%
…….Tablet	7	9.3%
*Some participants reported having more than one device		
Estimated Frequency of Internet Use		
…….Never	17	22.7%
…….Daily	41	54.7%
…….Weekly	10	13.3%
…….Monthly	3	4.0%
…….A Few Times Per Year	2	2.7%
…….Once Per Year	0	0.0%
…….No Response	2	2.7%

Mobile phones provided the most common and basic access technology for Internet use, with computers or tablets generally providing an access redundancy. While none of the respondents reported having a fixed Internet connection at home, most could access the Internet via smart phones. In Kenya, service providers have made special prepaid Internet access plans available that allow even low-income customers to periodically access the Internet. The least expensive

packages cost approximately $0.05 (G. Akolo, 2017, pers. comm., 17 February). This resonates with other findings that mobile phones are the most reliably prevalent form of technological access to the Internet in Africa (Kenny, 2000; Oyelaran-Oyeyinka and Adeya, 2004), with use still rapidly increasing (Hampshire et al., 2015; Porter et al., 2016).

However, that Clouse et al. (2015) can report high cell phone ownership but low Internet usage for a high health-risk population strongly suggests the need to utilize the widespread availability of cell phones to increase knowledge-access on the Internet. Their finding also resonates with the findings here as well. While seventeen participants reported no ability to access the Internet, an additional ten reported that they never did despite having access. So, as in Clouse et al. (2015), access *capacity* is in place but is not being utilized. This creates both a gap and an opportunity for reaching more people with Internet-based health interventions, if we can understand why respondents with Internet access do not avail themselves of it, or only infrequently access it.

To further investigate the potential relationships between the participants' formal education levels and Internet access with their baseline/pre-intervention knowledge of malaria, we ran Pearson Correlation Significance (2-tailed) bivariate tests in SPSS to see if there were any believably non-random correlations. We ran the tests on the variables of age, gender, education level and Internet access to test each of these variables with measured pre-intervention knowledge on the various aspects of malaria. The correlation significance tests showed no correlation between age and any of the knowledge points or between gender and pre-intervention knowledge. However, when looking at education and Internet access, moderate positive correlations were found for three pre-intervention knowledge points ($p<0.05$ for all points): malaria transmission ($r=0.27$; $n=73$; $p=0.02$ and $r=0.34$; $n=75$; $p=0.002$ for education and Internet access, respectively); visiting health care centers ($r=0.23$ $n=73$; $p=0.049$ and $r=0.26$ $n=75$; $p=0.021$ respectively); and use of bed-nets ($r=0.24$ $n=75$; $p=0.03$ and $r=0.38$; $n=75$; $p=0.001$, respectively).

That the significant correlation coefficients for Internet access across these three knowledge points ($r=0.34$, $r=0.38$, and $r=0.26$) was consistently higher than those for formal education ($r=0.27$, $r=0.23$, and $r=0.24$) is interesting and suggests that Internet access *may have potentially more influence on knowledge of malaria prevention and treatment than formal education among literate populations*.

DISCUSSION

Based on the findings above, participants had relatively high initial levels of knowledge on malaria prior to the video intervention; as such, the measured pre- versus post- intervention scores suggested minimal learning gains. While his invites the question why a relatively good grasp of knowledge about malaria transmission and prevention does not necessarily translate into disease prevention practice, the increasing use mobile phones and smartphones technology to access information indicates that ICT interventions like the one described here can help to provide the needed information to change behavior toward disease prevention.

The fact that the participants generally had high levels of knowledge on malaria before the video intervention echo studies by other infectious disease scholars looking at communities with high malaria prevalence rates. In a study on malaria-related knowledge gaps among lay community members on Rusinga Island in western Kenya, Juma (2009) found that community members had a good understanding of malaria but also had large knowledge gaps. Firstly, they understood that insecticide-treated bed-nets were the most effective means for preventing malaria. Secondly, they also knew that hygiene around homes as well as destroying mosquito vectors and their breeding sites prevented malaria. Likewise, these residents were also able to identify stagnant water as

places suitable for mosquitoes to lay eggs. Rusinga residents also understood correctly that the female *Anopheles* mosquitos were the source of the Plasmodium parasites that caused malaria; they could not, however, explain how the parasite enters the body.

In general, the residents knew about malaria transmission by mosquito vectors but had a low understanding of the interaction between the parasite and the vector (Juma, 2009; Opiyo et al., 2007). Furthermore, Juma (2009) found that the population did not understand or had significant knowledge gaps about what caused malaria. Some thought it was caused by taking a cold bath, eating cold or raw food, drinking unboiled water, or exposure to the cold due to a change of weather. Another critical knowledge gap among the residents of Rusinga Island was that they did not consider pregnant mothers at high risk for suffering from malaria; they only considered children to be vulnerable to the disease, which has also been noted in research elsewhere in Africa (Korenromp et al., 2003). However, Schantz-Dunn and Nour (2009) demonstrated that pregnant women infected with malaria are three times more likely to suffer from other severe disease compared to their non-pregnant counterparts.

In terms of disease treatment, Juma (2009) found that only 10% of the residents studied considered seeking a medical checkup if they felt ill. Another 10% reported that they would buy drugs from local pharmacists or vendors. Due to a general lack of access to healthcare facilities, individuals tended to revert to self-treatment, i.e., the use of herbal medicines or anti-malarial drugs purchased without a prescription, and tended only to visit the health center or hospital after the illness had failed to respond (Juma, 2009; Opiyo et al., 2007).Countervailing this, the SAWBO video discusses the symptoms of malaria and emphasizes that those with symptoms of malaria should go to the nearest medical facility for treatment, when available. Juma (2009) advises that future programs should not overlook the impact of community beliefs, attitudes and practices on acquisition, transmission, treatment and control of the disease. Negative attitudes and practices, as well as land use and management practices that create mosquito breeding sites, have been found to enhance transmission and decrease the effectiveness of control efforts, (World Health Organization, 1969; Juma, 2009; Ruebush et al., 1995).

Most generally, scholars of malaria treatment have argued that residents in rural western Kenya are generally well informed about the symptoms and prevention of malaria but that when it comes to treatment they could benefit from more information, including the correct dosage of anti-malarial medications, better healthcare facilities, and future group-partnerships that can provide such information (Ruebush et al., 1995).

Bed-Net Use

In line with recommendations from the World Health Organization, the SAWBO video not only underscores good malaria prevention and treatment practices, such as the use of insecticidal bed-nets, but also the use of instructive and enjoyable methods, i.e., animated videos (Bello-Bravo and Baoua, 2012; Bello-Bravo et al., 2013; Bello-Bravo et al., 2011). Studies done by various scholars on the use of bed-nets in Western Kenya have found that bed-net use for children under five years old was low even when the parent or caregiver knew that malaria was transmitted by mosquitoes (Hamel et al., 2001). In Ghana, De La Cruz et al. (2006) indicated that greater knowledge about malaria does not translate into improved bed-net use. Whereas Ghanaians had a relatively good level of correct knowledge on malaria prevention, they did not practice it due to alternative beliefs and attitudes about the cause of malaria; specifically, their beliefs and attitudes do not align with scientific knowledge and therefore inhibit best practices.

Similarly, Monroe et al. (2015) also found that participants knew that bed-nets were effective in the prevention of mosquito stings and malaria but what they practiced was different; the team observed that the use of nets and other personal prevention measures was low. They also

reported that households do not have enough nets, with a ratio of access being one net for every 3.5 people instead of the required one for every two recommended by WHO as the standard for universal coverage. Even for households with enough nets, usage remained low. The researchers observed unused nets hanging over sleeping spaces but with the sides raised. Others remained in sealed packages; still others were used as bedding. The community under study preferred to use the nets during the rainy season when it was cooler and complained that during the dry season the rooms were hot, with the use of nets making them feel hot or suffocated.

Our research echoes the above findings in that we found that knowledge of malaria transmission and infection does not necessarily lead to prevention practices.

Residual Transmission

The most common malaria transmission interventions involve the use of insecticidal nets and spraying indoors. Nonetheless, mosquitoes can transmit malaria in the early morning or during evenings, particularly at times when one does not wear long-sleeved clothes or trousers. Malaria scholars term this higher-risk period *residual transmission*. According to Killeen (2014), residual malaria transmission represents forms of transmission that can persist even after achieving otherwise full coverage through an effective use of insecticidal nets and spraying indoors. For instance, malaria prevalence rates remain high after the rainy season due to increased standing water as breeding sites for the mosquito vectors; these sites include puddles, tree holes, even cattle hoof prints. Vector population and density increases during this season lead to increased (residual) transmission. The increased rainfall also causes increased humidity, which contributes to higher mosquito survival rates.

Killeen (2014) noted that there are many novel or improved vector control strategies to address residual transmission: (1) enhance control of adult vectors that enter houses to feed and/or rest by killing, repelling, or excluding them; (2) kill or repel adult mosquitoes when they attack people outdoors; (3) kill adult mosquitoes when they attack livestock; (4) kill adult mosquitoes when they feed upon sugar or; (5) kill immature mosquitoes in aquatic habitats. Residual malaria transmission may account for the finding that even those with high levels of knowledge on malaria have been unable to prevent the spread of the disease in their communities.

CONCLUSION AND RECOMMENDATIONS

This study suggests two directions for further, future research and practice into the area of malaria, and disease prevention, in general: 1) the power of the Internet as a source of health information and tool for health education amongst literate populations, and 2) the potential of animated videos and mobile phone technology to encourage both literate and illiterate populations to put disease prevention and treatment knowledge into practice.

The sample population in this case study was mostly literate, with some education and some access to technology. The findings indicate a significant correlation not only between education level and knowledge about malaria but also Internet use and knowledge about malaria. In fact, the correlation significance was stronger for Internet use, which points to the increased use of the Internet by average citizens as a means for obtaining information on health issues like malaria prevention and treatment. Kivuti-Bitok et al. (2012), extrapolating from the increased use of the Internet to access medical information in recently industrialized nations like Malaysia and South Korea, predict a similar trend would be seen developing nations. Our findings suggest this is the case in Kenya.

Although the sample in this case study reported high initial levels of knowledge on malaria prevention and thus little significant learning gains, it is still important to note that there was a shift in knowledge after watching the animated video. Participants who seemed to be unsure about certain facts during the pre-test tended to show a positive shift in knowledge about those aspects of malaria prevention in the post-test. At the same time, the knowledge point that did show statistically significant learning gains point to a need to disseminate better information about breeding sites for the mosquito larvae in common household locations around houses, like gutters, puddles, and the like. Intervening at the mosquito larval stage is easier and potentially more effective than at later stages. How to more frequently or reliably translate this from knowledge into practice also remains to be explored.

Also, it may prove advantageous to conduct studies on homogenous groups, e.g., on only farmers or women, or simply the most affected demographic for a given health-related or agricultural intervention, since specific differences may exist within those groups with respect to finding a relevant means for implementing learning gains, especially around the time-based process of learned behavioral change (Prochaska and Velicer, 1997). The participants' emphasis on information about malaria gleaned from the chief's *baraza* as well suggests a future direction for research into how traditional forms of knowledge dissemination interact with or can serve complementarily to the increasingly more prevalent access to digital information.

Overall, this study contributes to an understanding of malaria knowledge sources and disease prevention in light of the role of ICT animated videos as a tool for enhancing malaria prevention and treatment education if not health-related topics generally. Given that mobile phones appear to be the most accessible means of ICT access for Kenyans, short, downloadable animated videos pertaining to health-related topics are well-positioned to disseminate and enhance disease prevention and treatment educational efforts. Future studies might further focus on still other means or ICT devices to assess informal education channels like the Internet, including increased access to Web searches for malaria or other health issues along with ways of sharing of that information via digital devices. In line with the WHO's avowed goals, we hope that this study, while focused on a small sample from Kakamega County, Kenya, can serve as a basis for facilitating the on-going effort to eradicate malaria in Kenya, other African nations, and around the world.

Ethical Approval

Ethical approval was obtained from University of Illinois Urbana-Champaign (UIUC) IRB Review Committee. All work for this project was performed while all of the co-authors were (or are) at UIUC.

Consent

Each participant gave consent to willingly and voluntary participate in this research.

Conflict of Interest

The authors declare that they do not have any conflict of interest with respect to the research in this paper.

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