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*Full Length Research*

# Low awareness and misconceptions of immature mosquito stages hinders community participation in integrated vector management in Malindi, Kenya

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**ABSTRACT:** Understanding community perceptions of the significance, feasibility and utility of managing mosquito larvae and preventing breeding sites is important to developing strategies for improving implementation of larval control. The objective of this study was to explore community perceptions of mosquitoes and suggest ways of enhancing community based larval control. A cross sectional study was carried out in Malindi and Magarini sub counties in the coastal region of Kenya. Qualitative research methods were employed to collect data in four selected villages using participatory methodologies. The factors identified as hindering community participation in integrated vector management were inadequate knowledge about mosquito biology - lack of awareness of the fact that larvae represent the immature stages of adult mosquitoes responsible for transmission of malaria and other infectious diseases and consequently low community motivation to participate in larval control. The presence of mosquitoes in the area was associated with the presence of large natural water bodies such as river Sabaki and swamps. Participants did not know that small man-made water bodies were potential mosquito breeding places. Successful and sustainable community based larval source management will require innovative advocacy, communication and social mobilization activities explaining in a simple language understandable by the community, the mosquito biology, ecology and behaviour, taking into consideration community needs, knowledge and practices.

**Keywords:** Community, integrated vector management, Kenya, larvae, malaria, Malindi, vector borne diseases.

## INTRODUCTION

Vector-borne diseases account for more than 17% of all infectious diseases, causing more than 1 million deaths annually (WHO 2017a). Mosquitoes are responsible for transmitting diseases such as malaria, lymphatic filariasis and an array of arboviral infections. There is growing evidence documenting a substantial decline in malaria morbidity and mortality in several African countries, including Kenya (WHO 2017b, Okiro et al., 2007, O'Meara et al., 2008). However, the risk of emerging or re-emerging of other vector borne diseases such as dengue fever, rift valley fever and Chikungunya is eminent and the increasing number of outbreaks reported in the recent past is worrying (Weaver et al., 2018, Macharia et al., 2018). Additionally, vector control tools are facing challenges due to emergence of insecticide resistance in mosquitoes (Hemingway and Ranson, 2000; Hemingway et al., 2013; Lengeler 2004.). Moreover, the key malaria vector control tools (i.e. long-lasting impregnated nets (LLINs) and indoor residual spraying (IRS)) target indoor-resting and indoor-biting vectors (Pluess et al., 2010; Lengeler, 2004). In fact, there is evidence of limited impact on mosquitoes and of resurgence of clinical malaria in parts of sub-Saharan Africa (Mukonka et al., 2014; Zhou et al., 2011). Hence, there is need to include interventions that can tackle residual malaria transmission and also reduce disease risk from arbovirus infections.

Larval source management (LSM) has been shown in several studies in Africa to be effective in reducing the abundance of malaria mosquito larvae, adults and disease transmission (Imbahale et al., 2012; Githeko et al., 2006). Techniques used in LSM include environmental management, larviciding, biological control or combinations of these methods (WHO, 2013). LSM offers the dual benefits of reducing numbers of adult mosquitoes, both outdoor- and indoor-biting females (Fillinger and Lindsay, 2011) and, therefore, is a valuable strategy in tackling residual malaria transmission that is now the challenge in many parts of Africa. A recent Cochrane review by Tusting et al. (2013) recommended use of LSM alongside with LLINs and IRS, for reducing malaria morbidity in both urban and rural settings where a sufficient proportion of larval habitats can be targeted. Environmental and entomological skills can be taught to enhance community capability at the grassroots level (Mukabana et al., 2006). However, community education and participation which is an important component of Integrated Vector Management (IVM) is recognized to be vital to the effectiveness, affordability and sustainability of vector control (WHO, 2004). Despite this realization, community participation is only sporadically implemented in IVM or completely overlooked (WHO, 2004; Beier et al., 2008). The purpose of this study was therefore to explore community perceptions of mosquitoes and suggest ways of enhancing community participation in integrated vector management especially larval source management in Malindi, Kenya.

## MATERIALS AND METHODS

### Study area

The study was conducted in Malindi sub-county, Kilifi County of Coastal Kenya located at 3°13'4.76"S and 40°7'0.91"E. It is 120 kilometres northeast of Mombasa. The population of Malindi was 207,253 as of the 2009 census. The study villages included Jilore, Marekebuni, Malimo and Mikuyuni, which are situated between 40 and 60 kilometres west of the Indian Ocean in the Nyika plateau (Figure 1). The Nyika plateau is characterized by hot and dry climate for most of the year with low fertility brown sandy soils, low grassland and thorny bush. The annual rainfall is between 500 and 700 mm and the area is sparsely populated. Most of the people living in these villages (70%) belong to the Mijikenda ethnic group. The community derive their livelihoods mostly from subsistence farming, fishing and tourism. The villages are located on a flood plain characterised by swamps, shallow wells and streams. River Sabaki is the main source of water used for farming, for animals and domestic purposes. The area is also characterised by swamps. A detailed description of the study area has been provided previously (Muturi et al., 2006; Kibe et al., 2017; Mbogo et al., 2003). The main malaria vectors found in the area are *Anopheles gambiae senso stricto., Anopheles arabiensis, Anopheles merus* and *Anopheles funestus* (Mbogo et al., 2003). Man-made breeding sites have been estimated to be responsible for more than 90% of the mosquito populations (Keating et al., 2003). Despite a remarkable malaria reduction over the last two decades in the area (Mbogo et al., 2003), some these villages continue to report of malaria infections..

### Study design and population

The study employed a descriptive, cross sectional study design. Field data collection was carried out over a period of six months, between November 2013 and April 2014 with intervals of two weeks or one month to allow consolidation and synthesis of data. The study employed a mix of qualitative methodologies with group discussions and in-depth interviews as shown in Table 1.

Purposive and cluster sampling techniques were used to select the study participants. In the first instance, the 4 study villages were identified. Participants for the study were then purposively selected from these villages using pre-set criteria, namely age (18 to 70 years), gender, (50% representation of both genders in all age groups) and residency. A chart was developed showing the categories of individuals and the numbers required per age and sex. Selection criteria and the chart were shared with the area chiefs or assistant chiefs of the selected villages to guide in the identification and selection of the participants. The participants for in-depth interviews were chosen through a snow balling exercise which was based on their activities and involvement in community and malaria related activities. A total 129 participants took part in group discussions - 61 women and 68 men, and 8 in in-depth interviews.

### Composition and training of the study team

A team of eight (8) researchers conducted the study. They included the principal investigator (Kibe LW), Participatory Rural Appraisal expert (Gachigi JK) and six Field Assistants (FA) (3 males and 3 females). The FA were recruited based on at least secondary education attainment, previous experience working in the community and residency of Malindi. Before embarking on data collection, the research assistants received a three-days

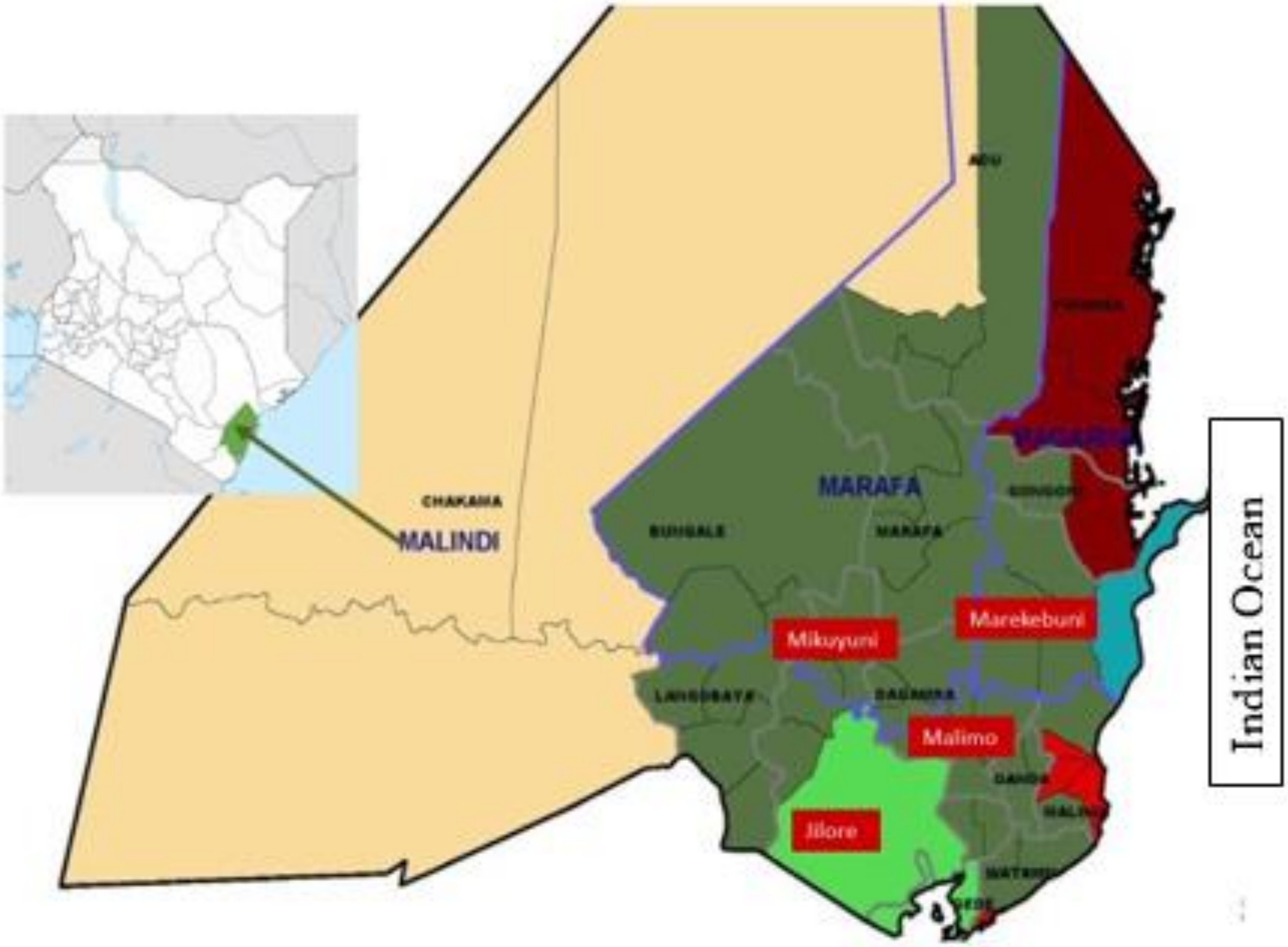


**Figure 1.** Map of the study area.

**Table 1.** Summary of methods, participants involved and outcomes.

| Method used & of persons involves | No. of participants / village | | | | Outcome from each tool |
|---|---|---|---|---|---|
| | Jilore | Malimo | Marekebuni | Mikuyuni | |
| Community malaria map | | | | | 4 |
| Male | 13 | 11 | 8 | 6 | |
| Female | 7 | 7 | 7 | 9 | |
| Total | 20 | 18 | 15 | 15 | |
| Focus Group Discussions | | | | | 8 |
| Male | 17 | 19 | 15 | 17 | |
| Female | 15 | 15 | 16 | 15 | |
| Total | 32 | 34 | 31 | 32 | |
| Transect mosquito walks | | | | | 8 |
| Male | 7 | 11 | 8 | 7 | |
| Female | 9 | 10 | 7 | 10 | |
| Total | 16 | 21 | 15 | 17 | |
| In-depth Interviews | 2 | 2 | 2 | 2 | 8 |

training which was organized as follows. Day one tackled the research tools used in the study, their application and use, communication skills, consenting process and recording responses. Day two had practical simulation exercises. Day three was pretesting, reviewing and adjusting of discussion guides and transect walk tool.

### Data collection methods

The data collection methods included community mosquito risk maps, transect mosquito walks, focus group discussions (FGDs) and in-depth interviews (IDI). All the data collection guides were developed and pre-tested. The outcome of the pre-test was used to re-define the questions in each guide. The guides were translated into the commonly spoken languages Giriama and Swahili and back translated in English. The guides focused around questions related to mosquito control, mosquito breeding sites, challenges in mosquito control interventions used and suggestions for improving existing tools. Data collection progressed from community mosquito risk maps, transect mosquito walks to FGD and IDI (Figure 2). This enabled the researchers to identify emerging themes and issues that required further probing.

#### *Community mosquito risk maps*

Community mosquito risk maps were used to identify and plot the areas that are perceived to be mosquito prone areas. This was done by identifying and plotting water bodies e.g swampy areas, location of houses and agricultural areas. Before starting the assignment, participants were taken through the process of drawing the risk map by the lead facilitator. When they had understood, the facilitator “handed over the stick” to the participants. Handing over the stick implies enabling people to control or manage a process on their own. Participants started by agreeing on the boundaries, both outer and inner boundaries of their village, roads and rivers. Plotted on the map were rivers, lakes, fish ponds, swamps and irrigation areas, farming areas, human settlement, public utility facilities such as chief camp, schools, dispensary among others. After completing the map where both men and women participants took part, the participants through the group leader discussed the outcome and lessons from the exercise. Later, the facilitators drew conclusions and lessons from the map. The process took about 6 hours.

#### *Transect mosquito walks*

A transect walks or “mosquito walks” as participants called them due to the nature of the activity were undertaken in each of the 4 villages. A pre-tested tally sheet was used to collect data on mosquito breeding habitats, type of habitats, presence or absence of larvae, economic activities around the habitat. Before embarking on the transect mosquito walks, the research team and the participants agreed on the foot paths and roads which represented a cross section of the village and those that had the likelihood of passing aside many larval habitats. They followed the footpaths recording the required information as per the tally sheet. They also took pictures to document the various habitats observed. In total, eight transect walks (two in each study village). Larval sampling was done to ascertain the presence or absence of larvae using the standard dipping method with a 350 ml mosquito dipper (Service, 1993b). Collected larvae were identified based on morphological characteristics and classified as anophelines and culicines. An entomologist of Kenya Medical Research Institute lead participants in larval sampling and identification.

#### *Focus group discussions (FGDs)*

FGDs were conducted in the community halls of the 4 selected study villages. The criteria were set to include women aged between 18 to 70 years of sound mind. They were mainly farmers and all residents of the study villages. In each village, two FGDs were conducted. The FGD comprised 6 to 9 participants. The discussions were facilitated by 2 experienced social science researchers, (male and female), a note taker and an observer. A total of eight focus group discussions were conducted, two in each of the study villages, involving 61 women and 68 men.

#### *In-depth interviews*

In-depth interviews (IDI) participants were selected using a snowballing technique. The interviewees included public health officials, entomologists, opinion leaders who included village elders and chiefs, community health workers and community volunteers. The interviews lasted about 60 to 90 minutes. A total of eight IDIs were conducted by an experienced social science researcher assisted by a note taker.

### Data management and analysis

Data were analyzed manually using thematic framework analysis. According to Braun and Clarke (2006), the thematic framework analysis has six main steps, namely familiarization of the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes and producing the report. For the sake of capitalizing on validity and reliability, all collected information in the field was given a code for confidentiality. The field notes were read regularly during and after discussions in order to confirm that all points discussed had been recorded accurately. The narratives were read

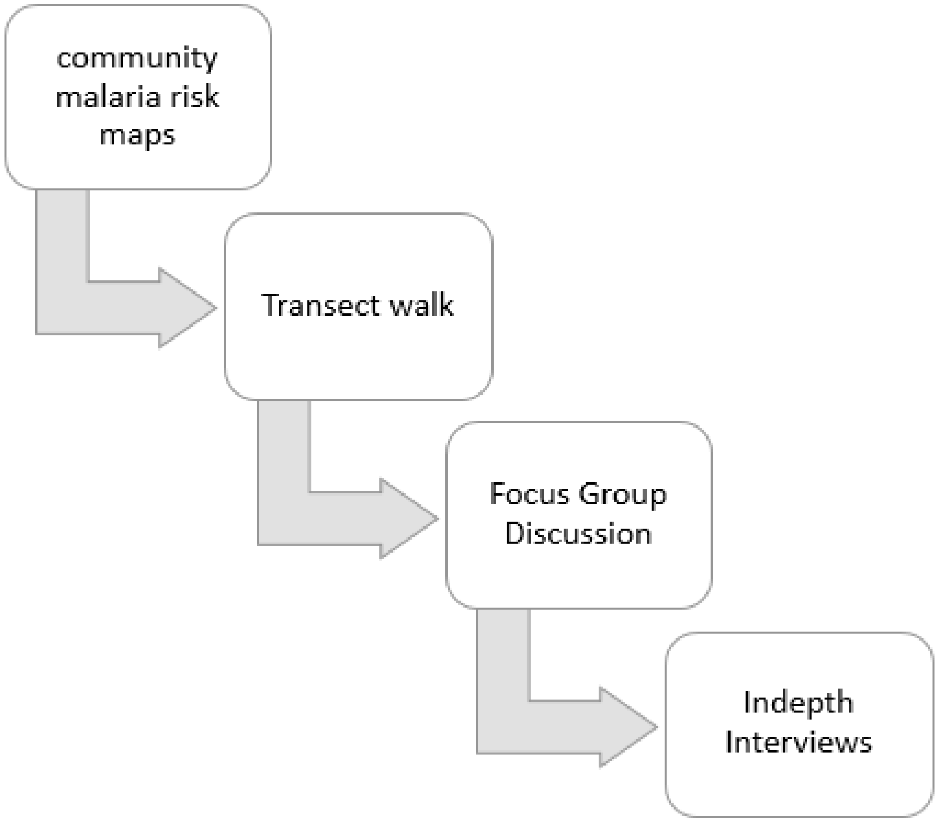


**Figure 2.** Illustration showing sequence of study method used.

and coded by two experienced researchers, themes were then compared, discussed and agreed upon together. Additionally, a statistical computer package, QSR NVIVO version10 was used for further analyses of the qualitative data.

### Ethical approval

Ethical clearance for the study was sought and obtained from the Ethical Review Committee of the Kenya Medical Research Institute and was assigned KEMRI ERC No: 2631. All participants were provided with information regarding the purpose of the discussions / interviews and verbal consent was sought before data collection. The reason for tape recording the discussions was explained and consent was sought before commencement of interviews. Permission was also sought from participants on the use of photographs during publication of the manuscript.

## RESULTS

Five themes emerged from the analysis of all data sets: (1) potential mosquito breeding sites (2) status of identified mosquito breeding habitats (3) knowledge of mosquito biology and misconceptions about mosquito larvae (4) human activities around the mosquito breeding places (5) challenges to effective utilization of mosquito control measures.

### Potential mosquito breeding sites

A total of 120 potential larval habitats were identified during the mosquito/transect walks in the 4 selected villages (Table 2). Of these, 82% were man-made with shallow wells accounting for 55.0%. The community mosquito maps drawn by participants across the four villages showed malaria areas located along River Sabaki and swampy places (Figure 3). Participants were however surprised to find many other mosquito breeding places (mainly man-made), during the “mosquito walk”, and which they did not know were also mosquito breeding sites. A participant commented during a “mosquito walk” in Mikuyuni, *“We have many of these shallow wells but I did not know they are also areas that mosquitoes breed in”*.

### Status of identified mosquito breeding habitats

Majority of the potential habitats identified were positive for mosquito larvae 61% (73 out of 120) as shown in Table 3.

**Table 2.** Number of main potential mosquito breeding sites in the 4 villages.

| Type of breeding habitat | Nature of breeding habitat | Number identified | % of the total |
|---|---|---|---|
| Shallow wells | Man-made | 66 | 55 |
| Stream pools | Natural | 15 | 13 |
| Road side drainage | Man-made | 13 | 11 |
| Swamps | Natural | 6 | 5 |
| Fish ponds | Man- made | 5 | 4 |
| Car-track | Man - made | 4 | 3 |
| Irrigation canal | Man-made | 4 | 3 |
| water tank | Man- made | 3 | 3 |
| Dam | Natural | 1 | 1 |
| Water trough | Man- made | 1 | 1 |
| Puddle | Man- made | 1 | 1 |
| Ditch | Man- made | 1 | 1 |
| Total | | 120 | 100 |


**Figure 3.** Map showing sketch map drawn by community.

Shallow wells and road side drainages were found frequently in all the study villages with 55% (36/66) of shallow wells identified found positive for mosquito larvae. The water bodies that were found positive had few human activities around them and in most instances, they were abandoned.

## Knowledge of mosquito biology and misconceptions about mosquito larvae

Participants' understanding of mosquito biology was low. Study participants were not able to give a clear description of the mosquito lifecycle. Most participants were well

**Table 3.** Number and status of habitats sampled per village.

| Village | Habitat type | No. of habitats | No. of habitats positive of larvae | % positive habitats |
|---|---|---|---|---|
| Mikuyuni | Shallow well | 34 | 15 | 44 |
| | Stream pool | 4 | 4 | 100 |
| | Roadside drainage | 1 | 1 | 100 |
| | Swamp | 3 | 2 | 67 |
| | Fish ponds | 0 | 0 | 0 |
| | Car-track | 0 | 0 | 0 |
| | Irrigation canal | 0 | 0 | 0 |
| | water tank | 0 | 0 | 0 |
| | Ditch | 1 | 1 | 0 |
| | Water trough | 0 | 0 | 0 |
| | Puddle | 0 | 0 | 0 |
| | Total | 43 | 23 | 53 |
| Malimo | Shallow well | 15 | 9 | 60 |
| | Stream pool | 6 | 5 | 83 |
| | Roadside drainage | 8 | 4 | 50 |
| | Swamp | 2 | 2 | 100 |
| | Fish ponds | 0 | 0 | 0 |
| | Car-track | 0 | 0 | 0 |
| | Irrigation canal | 4 | 4 | 100 |
| | water tank | 0 | 0 | 0 |
| | Ditch | 0 | 0 | 0 |
| | Water trough | 1 | 1 | 100 |
| | Puddle | 1 | 1 | 100 |
| | Dam | 0 | 0 | 0 |
| | Total | 37 | 26 | 70 |
| Marekebuni | Shallow well | 9 | 7 | 78 |
| | Stream pool | 5 | 1 | 20 |
| | Roadside drainage | 2 | 1 | 50 |
| | Swamps | 0 | 0 | 0 |
| | Fish ponds | 0 | 0 | 0 |
| | Car-track | 4 | 3 | 75 |
| | Irrigation canal | 0 | 0 | 0 |
| | Water tank | 1 | 1 | 100 |
| | Ditch | 0 | 0 | 0 |
| | Water trough | 0 | 0 | 0 |
| | Puddle | 0 | 0 | 0 |
| | Dam | 1 | 1 | 100 |
| | Total | 22 | 14 | 64 |
| Jilore | Shallow wells | 8 | 5 | 63 |
| | Stream pools | 0 | 0 | 0 |
| | Road side drainage | 2 | 1 | 50 |
| | Swamp | 1 | 1 | 100 |
| | Fish ponds | 5 | 1 | 20 |
| | Car-track | 0 | 0 | 0 |
| | Irrigation canal | 0 | 0 | 0 |
| | Water tank | 2 | 2 | 100 |
| | Ditch | 0 | 0 | 0 |
| | Water trough | 0 | 0 | 0 |
| | Puddle | 0 | 0 | 0 |
| | Dam | 0 | 0 | 0 |
| | Total | 18 | 10 | 56 |

conversant with adult mosquitoes which they said are found inside their houses, and on the surface of marshy waters. However, only a few of them 10% (4/40) could provide a clear description of mosquito larvae. Those who gave correct descriptions said they had participated in trainings and mosquito related activities organised by researchers from Kenya Medical Research Institute (KEMRI).

This is what a respondent at Marekebuni said: "*I cannot differentiate mosquito larvae from the eggs of frogs"* (FGD respondent, Marekebuni). When the correct description was given to them by the facilitators, participants said they always see them (larvae) in the water and they refer to them as "*worms*" but did not know they were immature stages of mosquitoes*. "I always see those worms in water but I did not know they are young ones of mosquitoes"* (FGD respondent, Malimo).

When asked, if there was any risk associated with those "*worms*", half of the participants (50%) said they are harmless and referred to them as *vilinda maji* (water guard) because they always see them in water and perceived them as guarding the water. About 40% said they consider them to be bacteria that transit typhoid and cholera and that they see them in water. They said whenever they see them, they boil the water before drinking it.

## Human activities around the mosquito breeding places

The main activity around the breeding places identified was agriculture. Most of the mosquito habitats (55%) were shallow wells that residents dug around the swamps, stream pools and dam. With no piped water in these villages, residents stated that they needed to dig shallow wells to get clean water as the water from the swamps or dam was dirty and contaminated (Figure 4). As affirmed by a respondent during a transect mosquito walk *"there is no piped water here. These shallow wells that you see are our source of water. We use the water for cooking, washing clothes, watering plants and for our cows and goats".*

## Challenges to effective utilization of mosquito control measures

Prompted on mosquito control measures, participants of focus group discussions were able to list the major available tools (Table 4). Specific challenges were also identified for each of the measures. Mosquito nets were recognized as the main control tool. In fact, in following the mass distribution campaign in 2015 and 2017 all households received a net for every two people (universal coverage). The other methods listed to protect themselves against mosquito bites were aerosols, repellents and the use of traditional herbs such as baobab fruit, *mvumbani.* Clearing bushes and keeping their compounds clean was mentioned as measures to keep mosquitoes away.

A

B

**Figure 4.** Pictures of shallow wells showing human activities around the habitats. (A) Swamp surrounded by shallow wells (both abandoned and in-use) and (B) Water cannel dotted with shallow wells.

However, environmental management was confused to mean sweeping the compound. Some participants stated that they remove trash from the compound not to control mosquitoes but to prevent cholera and keep off dangerous creatures like snakes from entering their houses. Regarding commercial mosquito repellents participants said they were not aware of this control method and a few who said they had heard about repellents said they were not available in the local shops and that they were expensive in Malindi town. Concerning traditional methods such as burning herbs, residents stated that their use had gone down due to the availability of mosquito nets.

## DISCUSSION

Community understanding and perceptions of mosquito biology and behaviour is important in designing effective

**Table 4.** Types of malaria prevention measures identified and challenges to their effective use.

| Control measures | Challenges to its effective use |
|---|---|
| Mosquito nets | Offers protection only when one sleeps under it; Nets were reported to be small and having a "*Vuvuzela shape" (they are circular shape with thin long upper side and a wider base* |
| Environmental management | Inadequate awareness and knowledge on the use of larval source management measures such as filling and draining potential mosquito breeding places; resources required to carry out environmental management |
| Traditional methods using smoking | Black soot on the building, less emphasis |
| Larval source management | Low awareness, no larvicide available for community use |
| Commercial Repellents | Method barely known to residents. Costly, available only in supermarkets and big shops in Malindi town. Not stocked in local / rural shops. |
| Aerosols | Costly, available in supermarkets and big shops in Malindi town. Not stocked in local / rural shops |

advocacy, communication and social mobilization strategies. In summary, findings from this study revealed major gaps in knowledge by residents on immature stages of mosquitoes, on potential mosquito breeding sites, on human activities creating mosquito breeding sites and on the proper utilization of existing control measures.

Most water bodies identified in Malindi provided conducive breeding places for mosquitoes (Table 3). Shallow wells were found to be the most productive habitats (55.0%) for mosquito larvae with more than half of them (54.5%) found positive. However, small man-made pools including shallow wells, drainage channels were not recognized as mosquito breeding habitats by participants. Similar findings in Western Kenya were reported that man-made pools, drainage channels and burrow pits were not perceived to be mosquito breeding sites (Imbahale et al., 2010). Despite this, man-made larval habitats in close vicinity to human habitation are known to play an important role in *Anopheles* proliferation (Girardin et al., 2004; Holstein and WHO, 1954; Minakawa et al., 2002; Mutuku et al., 2006b), especially during the dry season when supported by human activity (McCann et al., 2018).

Intrinsically, resident's demand for water in an area not served with piped water, dug shallow wells closer to permanent water bodies (Figure 4). As the water body retreats especially during the dry season, residents abandoned the old wells and dug new ones closer to the water bodies. This created conducive environments for mosquito breeding around these permanent habitats. Nevertheless, human activities such as digging mud for houses (Mutuku et al., 2006a ), brick making pits in Nyabondo (Imbahale et al., 2010), cement lined pits in Mbita (Opiyo et al., 2007) have been identified to be conducive breeding sites for mosquitoes. Notably, people choose to seek a livelihood in occupations that may increase their exposure to malaria but which are necessary to support their families (Moore et al., 2008). For effective and sustainable malaria prevention, the vital role of community participation and perception about the benefits of comprehensive malaria control as well as addressing community emerging attitudes on innovative malaria control tools should therefore be emphasized (Mboera et al., 2013). It is therefore important for residents to be informed of activities that expose them to risk of mosquito breeding. They should be guided on options that are available for preventing the risk. Such options could include filling or draining shallow wells as they dig new ones or reclaiming the land for potential agricultural uses. While larval source management may be advocated in such environment, as observed in this study, a thorough understanding on uses and importance of such potential breeding habitats to the residents is critical in making informed decisions.

The study also found a limited knowledge of immature stages of mosquitoes with varied understanding of what larval stages of mosquitoes represent, results that are similar to those obtained in Western Kenya by Mutuku et al. (2006a,b). In this study, mosquito larvae were perceived as both beneficial (a worm that guard water) and harmful (bacteria that transit cholera and typhoid fever). Such misconceptions, especially where larvae were perceived to be beneficial, served to promote mosquito breeding, since eliminating them would mean killing the "water guard". On the other hand, it became apparent that low understanding of what immature stages represent, explains low perception of risk of immature stages of mosquitoes by residents and therefore the participation of the residents in larval control would be low since individual awareness of risk prompts action according to Health Belief Model. Similarly, those who perceived larvae as causing typhoid and cholera could be true to the fact that contaminated water may contain larvae if it has stayed for longer periods like over five days. In an area that lacks piped water, hygiene standards are likely to be compromised and thus water borne diseases are likely to spread.

The findings explain why major challenges to community involvement in disease control including larval source reduction activities are educating people(Service, 1993a, Gubler and Clark, 1996). Motivating people to assume responsibility for their own health is important as it promotes adherence to interventions and treatments (Jones et al., 2018). It is therefore important that a holistic educational intervention approach is applied that embraces both the motivational model of stages of social change and the social ecological framework (Green and Kreuter, 2005) . The intervention framework will not only look at the individual knowledge, believes and attitudes but other factors that influences the individual (families and social networks; organizational and institutional levels) to action. It is therefore important to conduct a community situational analysis to understand community needs and opportunities for building on when packaging advocacy, communication and social mobilization strategies for larval source reduction activities.

## Conclusion

An individual exists in a social ecological system. Changing individual level behaviours in IVM especially larval control in a process of social change will require an enabling environment that will facilitate change and remove bottlenecks that inhibit change at the household, community, organization and policy levels. Importantly, IVM is embedded on the five principles (integrated approach, capacity building, collaboration with other sectors, evidence-based decision making and advocacy, social mobilization and legislation) that forms a framework for successful social action. A developmental approach will be required to facilitate provision of piped drinking water to residents in order to reduce wells dug for procuring water thus reducing the risk of malaria infections and other vector and water borne diseases.

## COMPETING INTERESTS

The authors declare that they have no competing interests.

## AUTHORS' CONTRIBUTION

LWK and CMM conceived and designed the study. LWK and JKG led the data collection with assistance from JM. LWK and JKG led the data analysis with input from JM, AK and AH. LWK drafted the manuscript and all the other authors participated in editing the manuscript and have read and approved the final manuscript submitted.

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