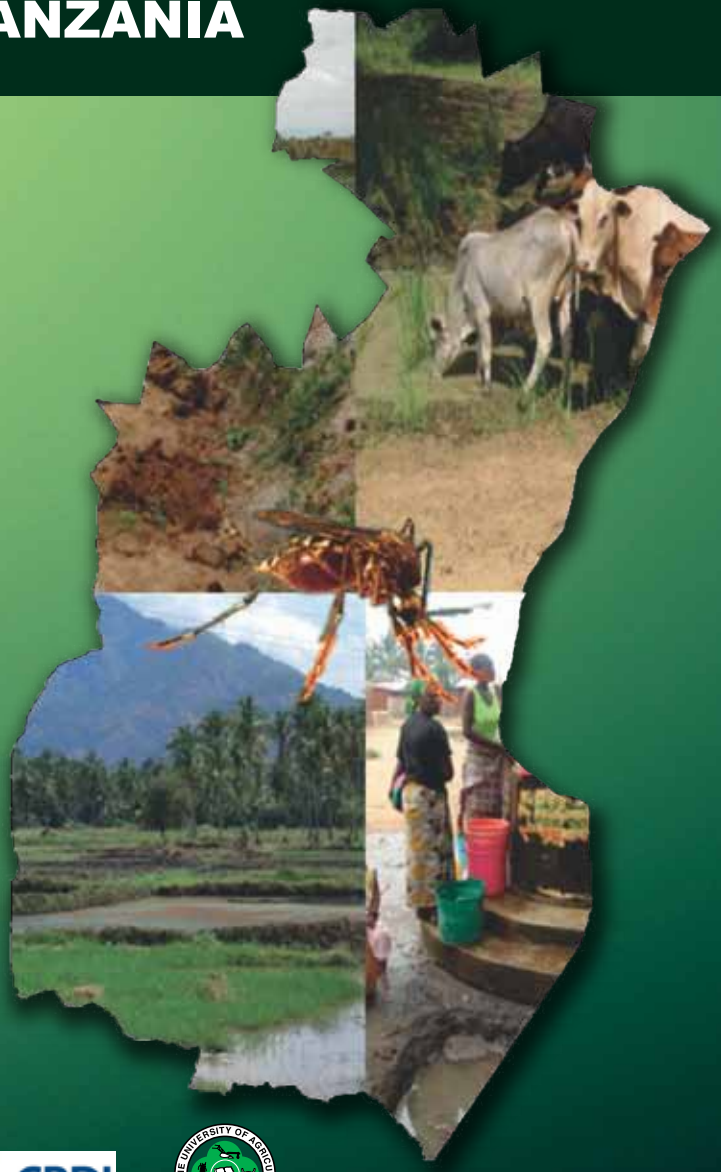
Integrated Research Partnerships for Malaria Control
through an Ecohealth Approach in Africa

MALARIA, ECOSYSTEMS AND LIVELIHOODS IN KILOSA DISTRICT, CENTRAL TANZANIA



September 2013

NATIONAL INSTITUTE FOR MEDICAL RESEARCH

IDRC CRDI

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ISBN 978-9987-9143-2-6

Recommended Citation: Mboera, L.E.G., Mlozi, M.R.S., Rumisha, S.F., Bwana, V.M., Malima, R.C., Shayo, E.H., Mayala, B.K., Mlacha, T. & Nguruwe, R. (2013) Malaria, Ecosystems and Livelihoods in Kilosa District, Central Tanzania. National Institute for Medical Research, Dar es Salaam, Tanzania

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Executive Summary

Background and objectives

Malaria is the single most important and widespread mosquito-borne disease in the world. The disease is endemic in most parts of Tanzania, and remains as a major cause of morbidity and mortality both in rural and urban areas. Complex health problems such as malaria are difficult to solve without understanding ecosystems and livelihoods contexts. The main objective of this study was to investigate the relationships between malaria, ecosystems and livelihoods in Tanzania. This study aimed to address the following specific objectives: (i) to consolidate knowledge on malaria burden and transmission intensity in selected study areas; (ii) to determine the level and form of stakeholder engagement and integration of factors related to community-based livelihoods, ecosystems, and health services in national malaria control policy formulation, in order to identify priority research and policy issues; (iii) to assess the strengths and weakness of the health services delivery that influence malaria control; (iv) to develop appropriate communication strategies and tools for results-sharing and utilisation with target communities in improving malaria control strategies; and (v) to enhance research capacity of the collaborating institutions and their boundary and strategic partners working on malaria in Sub-Saharan Africa. The study was carried out in Kilosa Districts and involved the villages of Tindiga, Malui, Twatwatwa, Mbwade and Kimamba.

Malaria burden and transmission intensity

Malaria prevalence surveys were carried out in the villages of Tindiga and Malui (rice agro-ecosystem), Twatwatwa and Mbwade (savannah ecosystems characterised by pastoralism) and Kimamba (savannah ecosystem characterised by mixed livelihoods). Schoolchildren were screened for malaria infection using both microscopy and malaria rapid diagnostic test (mRDT). Malaria mosquito collections using CDC light traps were done in the same villages. A total of 1,318 school children aged 4–16 years were involved. The overall prevalence of Plasmodium falciparum malaria infection was 8.5% by mRDT and 3.5% by microscopy. Children in rice farming community were at a higher risk of malaria infection. Children living in areas with health care facilities had a low risk of malaria infection by 45%. Children over 8 years old were at a higher risk of acquiring malaria infection than younger children. Anaemia was most prevalent among children in the pastoral communities.

A total of 936 female mosquitoes were collected in 15 houses. Some 46.9% were malaria mosquitoes (Anopheles gambiae = 28.6%; Anopheles funestus = 18.3%). The largest proportion of the malaria mosquitoes was collected in the rice irrigation ecosystem than in the savannah ecosystem. On average an individual human received 43.91 Anopheles bites per night. Human biting rate per person per night for the two malaria mosquitoes was highest in Malui (46.01) and lowest in Twatwatwa (1.67).

Anthropogenic drivers of ecosystem associated with malaria transmission

The objective was to assess the land use patterns and other anthropogenic activities associated with malaria mosquito productivity in Kilosa District. Mosquito larvae and pupae were collected using a standard dipper from all potential mosquito breeding sites in Kimamba. Heads of households were interviewed using a face-to-face questionnaire to explore their knowledge, perception and practices as regards to malaria mosquito productivity. A total of 211 potential anopheline mosquito breeding sites were identified. Bricks making, farming practices, discarded containers were the major mosquito breeding sites. Man-made habitats accounted for 86.2% of all potential breeding sites. The majority (85.2%) of the man-made habitats were associated with livelihood practices. Brick making borrow pits accounted for 30% of all potential mosquito breeding sites. A total of 399 people (mean age= 39.7) were interviewed. There was low knowledge among the community on potential mosquito breeding sites.

Knowledge, practices and social determinants of malaria

This study aimed to determine knowledge, practices and social determinants of malaria among rural farming communities in Tindiga, Malui, Mbwade and Twatwatwa. In each village, heads of households were interviewed using a structured questionnaire. A total of 471 households were interviewed. Overall, less than a quarter (23.5%) of the respondents had high knowledge on malaria disease and its control. Over half (56%) of the respondents could not associate any livelihood practice with mosquito productivity or malaria transmission. Of the 2606 individuals recorded in the households, 702 (26.94%) were reported to have had fever in the previous three months. Fever cases were significantly higher in households headed by non-educated respondents (31.2%) than in educated ones (21.5%). Women experienced significantly more episodes of fever than men (p-<0.001). Over half (56.4%) of the febrile cases lasted for more than 3 days. Crop farming communities claimed to experience longer periods of febrile illness than the pastoral communities (p=0.051). The duration of illness among women was shorter than among men (p=0.04). More than three quarters (79%) of the respondents believed that the fever was due to malaria. The proportion of those who mentioned that the fever was due to malaria was significantly higher among the pastoral community (81.7%) than crop farming community (76.1%) (p=0.038). Among those mentioned to have experienced fever, 30% were diagnosed with their blood sample taken and most of the diagnoses were done at the health facilities (96.2%). Non-educated individuals reported to be diagnosed and treated more at health facilities than the educated ones. Seeking of treatment for fever significantly differed between crop community and pastoral community (p=0.051). Smaller households were frequently seeking care for cases of fever/malaria than larger households. Blood test for malaria parasite confirmation was frequently done by those with joint pains (p<0.01). More than 82% of the respondents used medication to treat fever. Only 37.5% of the respondents used medication within 24hrs from the onset of fever. The most common antimalarial drug used by the respondents was artemether-lumefantrine (ALu) (61.3%). More than 56% of the respondents reported availability of antimalarial drugs in the facilities during their visits. Over half (54%) of the respondents were satisfied with the service provided at the nearest health facility. In

conclusion, malaria knowledge is low among farming community of central Tanzania. Appropriate public health promotion should be designed to show the links of livelihoods and malaria transmission among rural communities.

Malaria, climate change and food security

This study was carried out to explore rural community's knowledge, perceptions, and practices regarding farming practices, climate change, food security, and malaria. The majority (73%) reported that most people get sick from malaria during the rainy season. Half of the respondents felt malaria has decreased in their village during the last 10 years. Only a quarter of the respondents understood the term "Mabadiliko ya tabia nchi" (climate change). Climatic parameters that influence mosquito abundance were rainfall (35.8%), temperature (11.3%) and relative humidity (2.0%). Some 62% believed that the temperature has increased in the last 10 years. The majority (86%) of the respondents reported to rely on weather pattern to determine planting time for their crops. Only about half the respondents thought the weather forecast provided by the meteorological agency is useful to help determine planting time. Three quarters reported that they do not have sufficient production from their own farms to guarantee food security for the whole year. Seventy-three percent reported a food shortage experience in their households in the last five years. About half said they most often experience food shortage during the rainy season, which is the peak of malaria transmission.

Accessibility, availability and utilisation of interventions among pregnant women

The objective of this study was to determine factors affecting accessibility, availability and utilisation of malaria interventions among pregnant women. A total of 310 women (mean age=30±9.6 years) who had been pregnant during the past five years were involved. Most of them (74.8%) were married or living with partners. Over 94% of the women had attained primary school education. Those educated had lower proportion of having more than 3 under fives (p-value 0.014). Most (71.4%) women had medium knowledge of malaria. Only 8% of the women had good knowledge of malaria in pregnancy. A significant proportion (35% of women did not know the reasons for taking sulfadoxine-pyrimethamine (SP) during pregnancy. Some 45.8% did not know the effect of malaria in pregnancy. Over 97% of the women were able to consult health facilities when suffered from malaria. Almost all women (98%) had a mosquito net. All women attended the ANC during their last pregnancy. However, only 45% attended three times and 41% over 3 times. The coverage of IPTp2 was only 41.3%. Timing for first dose of SP for IPTp was 1-3 month (28.4%) and 4-6 months (36.8%). Over three quarters of women (78.06%) were provided with SP under supervision of the health provider. The knowledge that SP treats malaria was associated to decrease intake of 2 doses of SP during pregnancy. In conclusion, most pregnant women in Kilosa district have low knowledge on malaria in pregnancy and coverage of IPT2 was low.

Malaria surveillance and use of evidence in health planning and decision making

The disease surveillance system in relation with malaria was assessed at facility and district levels to identify key barriers, constraints, priority actions for surveillance strengthening; and to explore the use of evidence in t health planning and decision making. The study involved health facility workers and district health management teams. A total of 17 health workers were interviewed. Of the 17 informants, 15 were familiar with disease surveillance. A good number (8/17) had received training during the previous two years. Most of the health facilities (14/15) faced difficulties in submitting reports due to lack of resources and feedback from the district authority. Nine of the facilities were reported to perform minimal data analysis. Analysis of malaria data was reported in only 9/17 facilities. Challenges in diseases surveillance included unavailability of compilation books, lack of computers, poor data storage capacity, poor recording, lack of adequate skills for data analysis and increased workloads of staff.

Inter-sectoral approach in malaria control in Tanzania

This part of the study explored stakeholders' opinions as regards to different sectoral activities that contribute to malaria transmission and control. It also explored the likelihood that cross-sectoral approach in malaria control in Tanzania will be adopted in the future. This study involved participatory discussions with Kilosa District Council officials from various sectors and national level stakeholders from all key sectors. The sectors involved were health, agriculture, environment, livestock, fisheries, education, works, irrigation, water resources, land development, forestry, and community development. At the district level, the sectoral activities that were identified to contribute to malaria transmission included: irrigation, clearing of forests, fishing, pastoralism, water resource management, road and house construction, drainage systems, and farming systems. The district representatives admitted that to some extent intersectoral collaboration exist though not specifically for malaria control. Lack of budget was the reason for a weak intersectoral collaboration. Specific inter-sectoral strategies were proposed to respond to gaps identified in the research findings and issues raised from the group discussions. The respondents, research and district representatives agreed that malaria is contributed to a greater extent by ecosystems and human activities so it is the responsibility of all sectors to work together to address the health problem. At the national level, 26 senior officials from the production, economic, social and cross-cutting sectors were involved. Sectoral activities that contribute to malaria transmission were identified to include road/house construction, irrigation agriculture, mining, water resource management, disposal of waste, road maintenance and fishing. Slightly less than half of the respondents admitted that their organizations had been involved in malaria control activities including training and advocacy activities. About half of the respondents mentioned that their sectors have made some contributions to make in malaria and other disease control strategies. All supported the need for stronger inter-sectoral collaboration in malaria control.

Participatory knowledge translation

This section described the activities that were carried out by the project in sharing research findings through various mechanisms at community, district, regional, national and international levels. At the district level, the concept, objectives and activities of the research were shared between various stakeholders through an inception workshop. Throughout the implementation of the project, research findings were shared through feedback meetings, workshops and scientific conferences. At community, district, regional and national levels, an eco-health approach was used to bring together key stakeholders in malaria, ecosystems, livelihoods and health systems, to share the research findings and identify gaps and solutions in malaria control. The participatory approach in knowledge translation provided a unique opportunity for participants to provide answers and solutions to some of the gaps identified. The participatory knowledge translation process identified limitations to the common interpretations of knowledge translation principles and highlighted the characteristics of collaborative research initiatives that are of greatest importance to key actors.

Conclusion

Broadly, the main livelihoods of the people in Tanzania are driven by water and land resources management. Socio-economic and cultural factors and practices were identified to play important role in malaria transmission, acquisition and control. The studies identified the following practices that contributed to increased mosquito biting among the communities: (i) Night outdoor community activities, including temporal shifting to farm, expose farmers to mosquito bites; and (ii) Poor housing structures among pastoralists allow easy entry of malaria mosquitoes. Rice agro-ecosystem was characterized by higher mosquito abundance and higher malaria prevalence. Dry savannah inhabited by pastoral communities was characterized by moderate malaria transmission, poor food security and high burden of anaemia among children. Mixed farming was characterized by lowest malaria prevalence but high levels of anthropogenic activities that create potential mosquito breeding sites.

In terms of the health system, the findings indicate that there are frequent shortage of antimalarial drugs, lack of diagnostic services and poor malaria case management. There is inadequate professional health workforce who is inequitably distributed. Reporting of epidemiological data from lower to higher levels is poor, incomplete and not timely. Only a minimal data analysis is done at facility and district levels for planning in relation to malaria control. Knowledge on disease surveillance among district and facility level workers is poor. Coverage of IPTp2 is low. There are no specific organized outdoor malaria interventions targeting and crop farmers and pastoralists to complement indoor malaria strategies. Although the integrated vector management approach is recommended by the National Malaria Strategic Plan, environmental management has received low attention. Moreover, livelihoods and ecosystem health are not included in the National Malaria Control Policies. The current malaria control strategy is strong in terms of public-private partnership, but weak in intersectoral collaboration.

In conclusion, the studies have clearly shown that water and land resource management are important drivers of rural community livelihood systems. These findings suggest that malaria control programmes must account for the livelihoods and ecosystems contexts in which they are implemented. It is also critical to strengthen community capacity in water and land resource management strategies to prevent negative impact on health and ecosystem.

Recommendations

There is need to advocate for use of insecticide treated mosquito nets, mosquito repellents during night activities. The use of repellents and long sleeved clothing while carrying out farming activities at night is recommended. Appropriate environmental management to minimize and eliminate potential mosquito breeding sites should be recommended. Efforts should be made to improve communication strategies on malaria prevention and control to strengthen the local knowledge on malaria and its prevention. Malaria being a problem that cuts across different sectors – an intersectoral malaria approach is recommended.

Muhtasari

Utangulizi and madhumuni ya utafiti

Malaria ni ugonjwa unaoambukizwa na mbu ni moja ya magojwa muhimu sana nchini Tanzania. Pamoja na juhudi kubwa za kutokomeza malaria, ugonjwa huo umeendelea kuathiri jamii ya Watanzania kwa kiwango kikubwa. Ukubwa wa tatizo la malaria unachangiwa na tabia za binadamu, uwezo wa kiuchumi, mazingira, udhaifu wa huduma za afya, ufinyu wa bajeti, kutokuwa na utawala bora na uwajibikaji. Kuna uhusiano mkubwa kati ya mazingira, shughuli za kiuchumi na maambukizi ya malaria katika nchi nyingi za Afrika. Hivyo ni muhimu kufanya tafiti kuoanisha uhusiano huo katika mapana yake ili kuweza kubuni njia bora za kupambana na hatimaye kutokomeza malaria.

Malengo ya utafiti huu ni kuchunguza na kuoanisha uhusiano kati ya malaria, shughuli za kiuchumi, mazingira na mifumo ya utoaji huduma za afya katika Wilaya ya Kilosa, Tanzania. Utafiti ulilenga maeneo yafuatayo: (i) Kiwango cha maambukizi ya malaria kwa watoto na mbu; (ii) Ufahamu wa jamii kuhusu malaria – ugonjwa, maambukizi, tiba na kinga; (iii) Upatikanaji na utumiaji wa huduma za malaria kwa wanawake wajawazito; (iv) Mabadiliko ya tabia nchi, usalama wa chakula na malaria; na (v) Ushirikishwaji wa sekta mbalimbali katika kuthibiti malaria nchini Tanzania. Utafiti ulihusisha vijiji vitano vya Tindiga na Malui (jamii ya wakulima wa mpunga), Twatwatwa na Mbwade (jamii ya wafugaji) na Kimamba (shughuli mbalimbali).

Kiwango cha maambukizi malaria katika jamii na mbu

Jumla ya watoto 1318 (umri= miaka 4-16) walifanyiwa uchunguzi wa maambukizi ya vimelea vya malaria kwa kutumia kipimo cha haraka na hadubini. Takwimu za umri, jinsi, joto la mwili, uzito, urefu, na matumizi ya chandarua zilikusanywa. Uchunguzi ulifanywa kuwepo kwa bandama iliyovimba upungufu wa damu kwa watoto wote. Asilimia 8.5% ya watoto walikuwa na maambukizi ya vimelea vya malaria kwa kutumia kipimo cha haraka wakati 3.5% waligundulika kuambukizwa malaria kwa kutumia hadubini. Kiwango cha malaria kilikuwa kigodo kwa watoto waliotoka vijiji vyenye vituo vya huduma ya afya. Kiwango kikubwa cha maambukizi ya malaria kilikuwa katika vijiji vya Malui na Tindiga (jamii ya wakulima wa mpunga). Kwa wastani 22.7% ya watoto wote walikuwa na upungufu wa damu. Upungufu wa damu uliathiri asilimia kubwa (40.2%) ya watoto wa Twatwatwa (jamii ya wafugaji). Idadi kubwa ya watoto (83.2%) wanatumia vyandarua.

Jumla ya mbu jike 936 walikamatwa katika nyumba 15 kwa siku tatu. Asilimia 46.9% ya mbu wote walikuwa ni wa malaria (Anopheles gambiae = 28.6%; Anopheles funestus = 18.3%). Jamii nyingine za mbu zilichangia 22.8%. Asilimia kubwa ya mbu wa malaria (62.8%) ilikamatwa Malui na asilimia ndogo (2.3%) Twatwatwa. Kwa wastani, mbu wa malaria 44 walikuwa na fursa ya kumuuma mtu mmoja katika usiku mmoja.

Shughuli za kibinadamu na mifumo ya ekolojia inayochangia maambukizi ya malaria

Utafiti ulifanywa kuainisha shughuli za kibinadamu na mifumo ya ekolojia inayochangia mazalio ya mbu katika eneo la Kimamba. Zoezi hili litumia vifaa vya kitaalamu vya kuchotea maji na kuchunguza hatua mbalimbali za maisha ya mbu. Viluwiluwi na mabuu ya mbu yalichotwa kutoka katika maji na kufanyiwa uchunguzi wa kina. Wakuu wa kaya walihojiwa kuhusu uelewa wao wa shughuli za kibinadamu zinazochangia mazalio ya mbu. Jumla ya mazalio 211 ya mbu wa malaria yalitambuliwa katika eneo la utafiti. Mashimo ya kutengenezea wa matofali ya udongo, mashimo ya maji taka na vyombo vilivyotupwa hovyo vilichangia kwa kiasi kikubwa uwepo wa mazalio ya mbu. Asilimia kubwa ya mazalio ya mbu (86.2%) yalitokana na shughuli za kibinadamu. Mazalio haya yalihusishwa kwa kiwango kikubwa (85%) na shughuli za kujipatia kipato kama kilimo, biashara na ujenzi wa nyumba. Utengenezaji wa matofali ya udongo ulichangia kuwepo kwa mazalio ya mbu kwa asilimia thelathini (30%). Jumla ya watu 399 (umri = miaka 39.7) walihojiwa na uelewa wao kuhusu mazalio ya mbu ulikuwa ni mdogo.

Uelewa na mtizamo wa jamii kuhusu malaria

Jumla ya kaya 471 (zenye wanakaya 2606) zilishiriki katika utafiti huu. Kwa wastani, ni asilimia 23.5 tu ya wahojiwa walikuwa na ufahamu wa kutosha kuhusu malaria na mbinu za kudhibiti ugonjwa huo. Zaidi ya nusu (56%) ya wahojiwa hawakuweza kuhusisha shughuli zao za kiuchumi na mazalio ya mbu au maambukizi ya malaria. Kati ya wanakaya 2606 ambao taarifa zao zilkusanywa, 702 (26.94%) waliripoti kuwa waliugua homa katika kipindi cha miezi mitatu iliyotangualia. Matukio mengi ya homa yalikuwa katika kaya zilizokuwa na mkuu wa kaya aliye na elimu (31.2%) kuliko mkuu wa kazi asiye na elimu (21.5%). Wanawake walipatwa na matukio mengi ya homa kuliko wanaume (p-<0.001). Zaidi ya nusu (56.4%) ya matukio ya homa yalidumu kwa takribani siku 3. Jamii ya wakulima wa mpunga walilalamika kuugua homa kwa muda mrefu kuliko jamii ya wafugaji (p=0.051). The duration of illness among women was shorter than among men (p=0.04). Zaidi ya robo-tabu (79%) ya wahojiwa waliamini homa zilikuwa zimesababishwa na malaria. Wahojiwa waliohusisha matukio mengi ya homa na malaria walikuwa ni jamii ya wafugaji (81.7%) kuliko wakulima wa vipando (76.1%) (p=0.038). Kati ya waliotaja kupata matukio ya homa, 30% ya matukio hayo yalithibitishwa na kipimo cha maabara. Sehemu kuwa ya wahojiwa wasiokuwa na elimu walitafuta tiba kutoka vituo vya kutoa huduma za afya kuliko wale waliokuwa na elimu. Kaya zilizokuwa na watu wachache ndizo zilizokuwa mara nyingi zikitafuta tiba kwa matukio ya homa. Mara nyingi waliofanyiwa vipimo vya malaria ni wale waliolalamika kuwa na maumivu ya viungo (p<0.01). Asilimia 82% ya wahojiwa walitumia dawa kutibu homa. Hata hivyo, ni 37.5% tu ya wahojiwa walikiri kutafuta tiba ndani ya muda wa saa 24 tangu kutokea kwa dalili za homa. ALu ndio dawa iliyotumiwa na wahojiwa wengi zaidi (61.3%). Matumizi ya vyandarua vilivyosindikwa viuatilifu yalitajwa kama njia bora ya kujikinga na malaria. Zaidi ya nusu ya wahojiwa (56%) hawakuweza kuhusisha shughuli za kilimo na ongezeko la mbu au malaria.

Mabadiliko ya tabia nchi, usalama wa chakula na malaria

Sehemu hii ya utafiti ilikusudia kudodosa kuhusu uelewa na shughuli za watu wa Kilosa kuhusu uhusiano wa malaria na mabadiliko ya tabia nchi na usalama wa chakula. Robo tatu (73%) ya wahojiwa walisema wanapata matukio mengi ya malaria wakati wa kipindi cha mvua za masika. Nusu ya wahojiwa walikiri kupungua kwa matukio ya malaria katika kaya zao katika kipindi cha miaka 10 iliyopita. Theluthi moja (35.8%) walihusisha mvua na ongezeko ya mbu wakati 11.3% walihusia ongezeko la joto na 2.0% ongezeko la unyeunyevu na ongezeko la mbu. Ni robo (25%) tu ya wahojiwa walikuwa na uelewa kuhusu mabadiliko ya tabia nchi. Hata hivyo wengi walikubali kuwa nyakati za majira ya mvua zimebadilika na hazitabiriki. Asilimia 62 waliamini kuwa kiwango cha joto kimeongezeka katika miaka 10 iliyopita. Asilimia 50% ya wahojiwa walikiri kuwa utabiri wa hali ya una manufaa katika kupanga shughuli zao za kilimo. Robo-tatu ya wahojiwa walisema hawana mavuno ya kutosha kuwahakikishia usalama wa chakula kwa mwaka mzima. Idadi hiyo hiyo ilitoa taarifa kuwa na upungufu wa chakula katika kaya zao. Nusu ya wahojiwa walisema upungufu wa chakula ni mkubwa wakati wa masika – msimu wenye matukio mengi ya malaria.

Upatikanaji na utumiaji wa huduma za malaria kwa wanawake wajawazito

Utafiti huu ulichunguza vikwazo katika upatikanaji na utumiaji wa huduma za malaria kwa wanawake wajawazito na wale wenye watoto wenye umri chini ya miaka mitano walishirikishwa katika utafiti huu. Jumla ya wanawake 310 walishiriki; wengi wao (74.8%) walikuwa kwenye ndoa. Asilimia 92 walikuwa na elimu ya msingi. Kulikuwa na uhusiano mkubwa kati ya elimu na idadi ya watoto. Waliokuwa na elimu walikuwa na watoto wachache. Mmoja kati ya wanawake watano walikuwa na ufahamu mdogo kuhusu malaria. Walio wengi (71.4%) walikuwa na ufahamu wa wastani. Ni asilimia 8 tu waliokuwa na ufahamu mkubwa kuhusu malaria. Zaidi ya theluthi moja ya wanawake hawakujua sababu za kutakiwa kumeza SP wakati wa ujauzito. Zaidi ya 97% walikiri hutafuta huduma ya malaria kutoka kwenye vituo vya huduma za afya. Karibu wahojiwa wote (98%) walikuwa na vyandarua vilivyosindikwa viuatilifu. Wanawake wote walihudhuria kliniki angalao mara moja katika ujauzito uliopita. Hata hivyo, ni 45% ndiyo walihudhuria mara tatu na 41% walihudhuria zaidi ya mara 3. Matumizi ya dozi mbili za SP yalitajwa na 41.3% ya wanawake wote. Wanawake 28.4% walisema kipindi cha kupata dozi ya kwanza ya SP ni miezi mitatu ya kwanza ya ujauzito na asilimia 36.8% walisema ni kipindi cha pili cha ujauzito (mwezi 4-6). Zaidi ya robo tabu (78.1%) ya wanawake wote walimeza SP chini ya uangalizi wa mtoa huduma.

Mfumo wa taarifa za malaria na matumizi ya takwimu katika kupanga mipango na utoaji wa maamuzi

Tathmini ilifanywa kwenye mfumo wa taarifa za magonjwa katika ngazi ya wilaya na vituo vya kutolea huduma za afya. Lengo lilikuwa ni kuanisha vikwazo na vipa umbele katika kuimarisha ufumo huo wa taarifa; hususan, tathmini ilifanywa kuthibitisha matumizi ya takwimu katika kupanga mipango na kutoa maamuzi katika ngazi za kituo na wilaya. Jumla ya watumishi 17 wa vituo vya kutolea huduma za afya walihojiwa. Kati ya hao 15 walikuwa na uelewa kuhusu mfumo wa ufuatiliaji wa takwimu za magonjwa. Nusu ya wahojiwa (8/17)

waliwahi kupata mafunzo katika eneo hilo hilo katika kipindi cha 2010-2012. Idadi kubwa ya vituo (14/15) zilikumbana na changamoto mbalimbali katika uwasilishaji wa taarifa za kila juma/ mwezi kwenda Wilayani. Baadhi ya changamoto katika mfumo wa taarifa ni kukosekana kwa vitabu vya taarifa, kukosekana kwa ngamizi, uhifazi hafifu wa takwimu, uingizaji wa takimwu katika vitabu; kutokuwa na weledi katika uchanganuzi wa takwimu na kuongezeka kwa majukumu ya wahudumu. Wengi wa waliohojiwa walikiri kuwa ni mara chache takwimu zinatumika katika kufanya makisio ya mahitaji ya dawa. Kwa ujumla mfumo wa taarifa za malaria katika vituo vya huduma za afya na wilaya ni mbovu na matumizi ya takwimu ni nadra.

Ushirikishwaji wa sekta mbalimbali katika kuthibiti malaria nchini Tanzania

Katika utafiti huu wadau mbalimbali walishirikishwa kabla, wakati wa utafiti na baada ya utafiti. Warsha za uzinduzi wa mradi zilifanyika katika ngazi ya kimataifa, kitaifa na wilaya. Mrejesho wa matokeo nao ulishirikisha ngazi zote – kijiji, wilaya na taifa. Katika majadiliano yaliyoambatana na mrejesho, swala la ushirikishwaji wa sekta mbali mbali katika kudhibiti malaria liliibuliwa na wadau mbali mbali. Kutokana na dhana hiyo, utafiti ulifanywa kupata maoni ya wadau mbalimbali kuhusu malaria, shughuli za kiuchumi na maendeleo na haja ya ushirikiswaji wa sekta mbalimbali katika kudhibiti malaria. Washiriki walikuwa wakuu wa Idara mbalimbali katika Halmashauri ya Wilaya Kilosa na Maofisa waandamizi kutoka Wizara mbalimbali za serikali, taasisi za uma na asasi zisizo za kiserikali.

Katika ngazi ya wilaya, idara zilizoshiri ni pamoja na afya, kilimo, mazingira, mifugo, uvuvi, ujenzi, elimu, maji na umwagiliaji, maendeleo ya jamii, ardhi na misitu. Maeneo ya majadiliano yalilenga kuanisha mambo makuu matatu: (i) shughuli za kisekta zinazochangia maambukizi ya malaria na magonjwa mengine; (ii) ushirikishwaji wa sekta mbalimbali katika mapambano dhidi ya malaria; na (iii) juhudi, changamoto na fursa zilizopo katika ushirikishwaji wa sekta mbalimbali katika kudhibiti malaria. Katika ngazi ya Wilaya shughuli zinazochangia ongezeko la malaria ni pamoja na: kilimo cha uwagiliaji, uchomaji wa misitu, uvuvi, ufugaji wa kuhamahama, hifadhi za maji, ujenzi wa barabara na nyumba, utengenezaji wa matofali ya udongo, ukosefu wa mifereji ya kuondoa maji yaliyotuama, na mifumo mbalimbali ya kilimo. Washiriki walikiri kuwa ushirikishwaji wa sekta mbalimbali katika kudhibiti malaria upo kwa kiasi kidogo. Na hili linachangiwa kwa kukosa mwongozo na rasilimali za kutosha. Wote walikubaliana kuwa katika siku zijazo, kuna haja ya kuwa na mfumo rasmi wa ushirikishwaji wa sekta mbalimbali katika udhibiti wa malaria na magonjwa mengine.

Katika ngazi ya taifa, washiriki walikuwa 26 na walitoka Wizara za Fedha, Elimu na Mafunzo ya Ufundi, Kilimo na Usalama wa Chakula, Maendeleo ya Mifugo na Uvuvi, Nishati na Madini, Afya na Ustawi wa Jamii, Maji, Maendeleo ya Jamii, Ujenzi na Usafirishaji. Wengine walitoka Tume ya Rais ya Mipango, Ofisi ya Makamu wa Rais (Mazingira), Chuo Kikuu cha Sayansi ya Tiba Muhimbili, Asasi isiyo ya Serikali na Taasisi ya Taifa ya Utafiti wa Magonjwa ya Binadamu. Shughuli za kisekta zinazochangia maambukizi ya malaria zilianishwa kuwa ni ujenzi (barabara, nyumba), kilimo na umwagiliaji, uchimbaji wa madini, miradi ya maji, ukosefu wa ukarabati wa barabara kwa wakati, ujenzi wa vyoo vya mashimo, mabwawa ya

samaki, na utupaji holela wa takataka. Washiriki wote walikubaliana kuwa ushirikishwaji wa sekta katika udhibiti wa magonjwa mbalimbali, hususani, malaria.

Hitimisho

Utafiti umeonesha kuwa kwa kiwango kikubwa shughuli za kiuchumi kwa watu wengi waishio vijijini zinatoka na matumizi ya rasilimali maji na ardhi. Shughuli za kibinadamu na utafutaji kipato zimeanishwa kuchangia kwa kiwango kikubwa maambukizi na udhbiti wa malaria. Kuna baadhi ya shughuli ambazo humweka mtu katika mazingira hatarishi ya kuambukizwa malaria, nazo ni pamoja na (i) uhamiaji wa kwenda shambani nyakati za usiku kulinda mazao yasishambuliwe na wanyama waharibifu; (ii) kuishi katika nyumba zisizo na ubora zinazoruhusu mbu kuingia ndani kwa urahisisi.

Katika eneo la utafiti mifumo ya ekolojia iliyokuwepo ni pamoja na kilimo cha umwagiliaji, nyanda za nyasi za malisho ya mifugo. Maeneo ya kilimo cha mpunga yalikuwa na mbu wengi na maambukizi ya kiwango cha juu. Maeneo ya ekoljia ya mbuga yalikuwa maambukizi ya wastani lakini yenye tatizo kubwa la upungufu wa damu kwa watoto.

Matokeo yanaonesha kuwa kuna upungufu rasilimali watu, upungufu wa muda mrefu wa dawa za malaria, uwezo mdogo wa kimaabara, na matibabu yasiyozingatia ubora. Ukusanyaaji, uwasilishaji, uchanganuzi na matumizi ya takwimu ni wa kiwango cha chini. Kiwango cha matumizi ya SP kwa wanawake wajawazito ni kidogo. Hakuna nyezo maalumu za kuzuai maambukizi ya malaria kwa Jamii ya wafugaji wanaohamahama. Ingawaje mpango mkakati wa taifa ni kudhibiti malaria kwa kushirikisha mbinu mbalimbali, mbinu zinazolenga kutunza mazingira na kuangamiza viluwiluwi hazijapewi kipa umbele. Licha ya hilo, swala la shughuli za kiuchumi katika kuchangia maambukizi ya malaria halijatiliwa mkazo unaostahili. Zaidi ya hayo, mkakati wa ushirikishwaji wa sekta mbalimbali katikakupambana na malaria haujapewa msukumo unaostahili.

Ni dhahiri kuwa matumizi ya rasilimali maji na ardhi yanachochea sana ongezeko la maambukizi ya malaria nchini na hasa maeneo ya vijijini. Matokeo ya utafiti huu yanathibitisha kuwa mapambano dhidi ya malaria ni lazima yajumuishe mifumo ya ekolojia na shughuli za kiuchumi za jamii husika. Ni vyema basi jamii ikaongezewa uwezo wa kusimamia vizuri matumizi ya rasilimali maji na adhi kuepuka madhara ya kiafya na mazingira yanayoambatana na matumizi mabaya ya rasilimali hizi.

Mapendekezo

Ipo haja ya kuielimisha jamii kuhusu matumizi bora ya vyandarua na mbinu nyingine ya vyandarua katika kuzuia maambukizi ya malaria. Matumizi ya vifukuza mbu na uvaaji wa mashati ya mikono mirefu na suruali nyakati za usiku ni muhimu katika kuzuia kuumwa na mbu. Utunzaji wa mazingira ni muhimu pia kuzuia kuongezeka kwa mazalio ya mbu. Ipo haja ya kuongeza juhudi katika kuboresha elimu ya afya kwa jamii kuhusu mbinu sahihi za kupambana na malaria. Mikakati wa kudhibiti malaria ni lazima ikazingatia umuhimu wa kutumia mbinu shirikishi na siyo kutegemea matumizi ya vyandarua na upulizaji wa viuatilifu

katika nyumba peke yake. Kwa kuwa malaria ni swala mtambuka, basi ushirikishwaji wa sekta mbalimbali katika vita dhidi ya malaria ni muhimu.

Chapter 1: Introduction

Background

Malaria is the single most important and widespread mosquito-borne disease in the world. It is endemic throughout the tropical and sub-tropical regions (Su et al., 2004). According to the World Health Organization report, the ongoing transmission continues to affect 99 countries and territories around the world (WHO, 2015). Globally, there are about 219 million people who suffer from malaria each year, ranging from 154 million to 289 million; causing on average 600,000 deaths annually, mostly (85%) among children under 5 years of age (Murray et al., 2012; WHO, 2012). Malaria is endemic in most parts of Tanzania, and remains as a major cause of morbidity and mortality both in rural and urban areas. In decreasing order of prevalence, the common species of Plasmodium affecting humans in Tanzania are P. falciparum, P. malariae, P. ovale and P. vivax (Mboera, 2000). P. falciparum is the most serious and the cause of severe complicated malaria. Malaria risk in Tanzania is heterogeneous (Clyde, 1967; Bousema et al., 2010; Mboera et al., 2010, 2011) with malaria prevalence rates, parasite densities and entomological inoculation rates varying from one area and season to another (Mnzava, 1991). Such a distribution is determined in part by climatic, ecological and topographic factors which determine the distribution patterns of the vectors (Mnzava, 1991).

There is a bidirectional link between health and the ecosystems, livelihoods factors. Environmental changes, especially those brought about by agricultural, water development and construction projects, often lead to changes in the ecology of malaria vectors. Agriculture, which accounts for the occupation of the majority of rural people in Tanzania, and as food source for its urban populous, is closely tied to human malaria (Mboera et al., 2007). Good health affects agriculture by boosting people's capacity for work and thus increasing agricultural productivity. On the other hand, unintended side effects associated with certain agricultural systems may increase human exposure to vectors of malaria (Ijumba & Lindsay, 2001; Mboera et al., 2007a). In agricultural communities, poor health directly reduces income and productivity, further decreasing people's ability to address poor health and inhibiting economic development more severely, while in the population at large, malnutrition and disease patterns influence market demand for agricultural products (Hawkes & Ruel, 2006)). Malaria is therefore, an important disease that illustrates the interactions between livelihoods, ecosystems and health systems. Examining malaria in the livelihood and ecological context is therefore important because the two factors present not only opportunities for improving health but also risks to malaria. It is important therefore, to examine the links within a broad framework that considers the different pathways, given the multiplicity of interactions that can produce unexpected outcomes and trade-offs.

Delivering public health services requires functional and effective health systems including capable innovative health leadership, qualified healthcare providers, effective human resource systems, reliable data, adequate physical infrastructure, and many other critical inputs (Anyangwe & Mtonga, 2007). To be effective, intervention tools need to be usable within the available health system framework and implemented appropriately so that the

end user is able to benefit from them. A considerable body of research evidence pinpoints weak health systems as critical barrier to improved health across Africa (Anyangwe & Mtonga, 2007). Likewise, Tanzania is faced with a number of problems due to limited financial, infrastructure and human resource base. Weak and dysfunctional health systems are considered to be the major reasons for many effective low-cost health interventions to remain underutilized while people continue to suffer and die in the midst of existing opportunities. A weak health system is an important challenge to the implementation of malaria interventions in Tanzania (Makundi et al., 2007). In many cases, the failure to deliver affordable and effective interventions to predictable, preventable and treatable diseases like malaria is a major weakness in the health systems of many developing countries. Health systems research can help identify best practices and prioritize areas that need strengthening (De Savigny & Adam, 2009). While health systems in general have received worldwide attention, little has been done to strengthen facility and district health systems in Tanzania.

Accurate epidemiological data are essential for adequate malaria control. These data have to be obtained by surveillance. The problem is that in many malaria endemic regions, the surveillance systems are not functioning properly. Surveillance requires impact indicators, based on standardised case definitions on morbidity and mortality. Definitions will vary, depending on diagnostic capabilities at different levels of the health care system, and most importantly, whether the case is defined with the aid of microscopic diagnosis, rapid diagnostic test or not. Adequate case definition serves to provide indicators of malaria epidemiology, which can be used for needs assessment, situation analysis and to evaluate the effectiveness of the malaria control programmes. They also serve to guide and adapt control activities. The effectiveness of a health information system at the district and facility levels depends on the ability of staff to utilise the information properly. The world Health Organization has recognised that health information system plays a pivotal role at the interface between disease control programmes and health sector reforms (AbouZahr & Boerma, 2005). A functioning surveillance system is of paramount in monitoring and evaluating a malaria control programme (Mboera et al., 2007b).

The fact that there are linkages between environment, livelihoods and health poses an opportunity for the various sectors to work together to help solve each other's problems. However, in many countries, getting practitioners and policymakers in the different sectors to work together is still a nightmare. Usually, government ministries and agencies are organized strictly along sectoral lines; and instead of collaborating, they most often find themselves competing over resources. Establishing multi-sectoral linkages is important to facilitate joint efforts to tackle the problems at the community level because at that level, development problems are often perceived holistically. In addition to formal collaborations, informal networks in the form of friendly relationships among researchers and decision makers are as important in linking research and policy, and effecting policy change, as formal structures. In Tanzania such systems are exceedingly fragile, with the infrastructure for collaboration and coordination often weak. There is major disconnect between the health care systems and other sector systems within the policy arena, which needs

urgent redressing if successful health delivery system is to be realized (Mlozi et al., 2006). Institutional linkage is expected to stimulate system changes by enabling cross-sectoral health leadership team to develop and launch innovation initiatives that integrate pivotal health system opportunities or address the bottlenecks.

This study envisaged to support the international and national initiatives in strengthening health, livelihoods and ecosystems linkages - from knowledge generation to action. The study aimed at bringing together scientific, technical and socio-economic information on environment and malaria linkages, and transfers that knowledge to inform decision-making at the local, district, national and regional levels. There is urgent need to strengthen national and district capacities for effective programme implementation and innovative modifications to cope up with the changing malaria epidemiological patterns and the scaling up of interventions that are currently being instituted.

Malaria and livelihoods in Sub-Saharan Africa

Crop production

In Sub-Saharan Africa, malaria is predominantly a rural disease where agriculture forms the backbone of the economy. Crop production, either for self-subsistence or for cash, is the main economic activity in rural Sub-Saharan Africa. Besides their importance as food source, crop production systems, especially, where irrigation is the practice, may provide suitable microhabitats for malaria mosquitoes (Mboera et al., 2010a). Development of crop irrigation schemes in Africa is becoming increasingly important because of the great aspects for economic development and self-sufficiency in food production to feed the hungry growing populations. However, agricultural development projects affect the environment, which in turn affects human health (Mutero et al., 2006). The establishment and operation of water resource development projects transform ecosystems and can substantially change the nature of malaria risk proximal to their location (Keiser et al., 2005; Mboera et al., 2010a).

Rice, sugarcane, wheat, cotton and vegetables are the major crops under irrigation in Africa. Of these, rice is considered to pose the greatest danger to health as it is grown in flooded conditions which provide ideal breeding sites for malaria mosquitoes (Ijumba & Lindsay, 2001; Ijumba et al., 2002; Mboera et al., 2009; 2010a,b). High yielding varieties of rice have high water requirements since they are very sensitive to water shortages and generally need more water after transplanting than traditional varieties. These flooded paddies provide ideal breeding sites for An. gambiae complex. These vectors are pioneer species, which rapidly colonise recently flooded fields, although they decline in abundance as the rice grows and begins to cover the water surface (Ijumba, 1997; Ijumba & Lindsay, 2001).

There are contradictory evidences as to the impact of rice irrigation on malaria burden in Africa. Although irrigation of rice has always been blamed for aggravating malaria situations in local communities, findings from some studies do not seem to support these allegations. In a study in Mali, Sissoko et al. (2004) observed that malaria parasite prevalence varied according to season and agricultural zone. Overall malaria prevalence was higher in

villages without irrigated agriculture than in the irrigated rice growing villages. In Tanzania improved socioeconomic status due to rice growing has been found to lead to reduced malaria prevalence, in spite of increased mosquito populations among villages adjacent to flooded rice fields (Ijumba, 1997). Similarly, studies in a rice irrigation scheme in Kenya have shown that malaria prevalence is lower in irrigated villages, in this case apparently because the predominant mosquito species preferred to feed on cattle rather than on people (Mutero et al., 2006). This situation is explained by a number of reasons including the widespread use of mosquito nets and antimalarial drugs and on the general improved livelihood. As residents of the irrigation scheme become wealthier due to income generated from agricultural production, some of it becomes diverted to health.

A number of Sub-Saharan African countries engage in sugarcane cultivation, which is used, mainly as raw materials in the local sugar industry. Sugarcane is propagated vegetatively and is grown in small patches by traditional farmers all over Africa. Although sugarcane requires irrigation for optimal growth, the plant is very susceptible to water logging and therefore needs efficient drainage. In the context of malaria transmission, only irrigated large-scale sugarcane is important. Usually, sugarcane irrigation does not support large expanses of water surfaces, and hence little contribution to mosquito breeding sites, hence malaria transmission. Lower malaria prevalence among the communities in sugarcane plantation has been reported in northern (Ijumba, 1997) and central Tanzania (Mboera et al., 2010b).

In Africa, data on the impact of crops other than rice and sugarcane on malaria burden are limited. An increase malaria transmission has been reported to be associated with the agricultural development in the Gezira-Managil cotton irrigation scheme in Sudan. The expansion and intensification of the irrigation programme was implicated to have created new mosquito habitats leading to serious malaria outbreaks (Oomen et al., 1988). Irrigated, open-spaced, commercial vegetable production has also been associated with malaria in urban areas of Accra, Ghana (Klinkenberg et al. (2005). The authors also found An. gambiae breeding in irrigation water in urban agricultural sites and resting at higher densities in houses in urban agricultural communities. Studies on the impact of maize on malaria are quite few. A study in Ethiopia established that a shift to maize farming from more traditional crops, such as barley, and sorghum was responsible for a 9.5-fold increase in malaria transmission (Kabende et al., 2005). This increase in transmission was explained to be due to maize pollen. It has been described that the force of transmission of malaria in sub-Saharan Africa might be reduced if maize plantings were excluded from the immediate vicinity of homes or, perhaps, if pollen of such maize were to express entomotoxins (Ye-Ebiyo et al., 20030).

Agricultural interventions are available to control the spread of malaria. Available techniques include filling and draining small water bodies, environmental modifications, and alternate wetting and drying of rice fields (intermittent irrigation). Intermittent irrigation in African rice fields has been shown to significantly reduce the density of malaria vectors by curtailing their larval development, while still maintaining yields, saving water, and reducing methane

emissions (Mutero et al., 2006). However, addressing the adverse impact of agricultural water projects on both malaria and the environment is a challenge. Communities as well as the agricultural and irrigation sectors tend to focus on economic benefits, paying inadequate attention to assessing public health and environmental impact. Agricultural projects tend to be planned and managed in isolation from other aspects of development at the local, district, and even national level. Moreover, the successful implementation of measures to minimise such impacts is constrained by paucity of information, technical reasons, and limitations in human, financial and institutional capacity.

Livestock production systems

The livestock production systems which ought to have been at a sustainable equilibrium in harmony with the environment can no longer cope due to growing human populations and increased demand for both animal and crop products (Gerber et al., 2007). Livestock production may specifically contribute to land degradation, the decline and pollution of water resources, the emission of greenhouse gases and the erosion of biodiversity (Oldeman et al., 1991). However, with good management, livestock production can make a positive contribution to the natural resource base by enhancing soil quality, increasing plant and animal biodiversity and substituting for scarce, non-renewable resources such as fossil fuels. The challenge is to identify policies and technologies which mitigate any negative environmental impact but which, at the same time, satisfy the considerable demand for livestock products (Gerber et al., 2007).

Among the other possible good use of livestock is for them to serve as alternative sources of blood meal for malaria and other vectors in what is known as zooprophylaxis (Saul, 2003). However, there is a lot of concern about the practice since some studies have shown that the presence of cattle may instead increase malaria prevalence a phenomenon known as zoopotentiation (Sota & Mogi, 1989) by attracting mosquitoes to the general proximity (Schultz 1989; Hewitt et al. 1994). In Ethiopia, a study by Seyoum et al. (2002) indicated that the presence of cattle in homesteads tends to increase the man biting rate of An. arabiensis while cattle keeping in separate cattle sheds outside of the human dwellings tends to reduce the man biting rate of An. arabiensis and malaria transmission. According to Saul (2003), beside the number and relative attraction rate of vectors to animals, the key factor in determining the magnitude of zooprophylaxis is the rate at which vectors die while searching for a blood meal. The two phenomena deserve further investigation in areas where there is livestock keeping. There is another issue pertaining to the pattern of utilisation of malaria intervention tools among the pastoralists and the farmers which shall also be assessed in this study.

Malaria and fishing

Fishing is one of the major occupations for a large proportion of the population in Tanzania. Sea, river and lake fishing are common in the country. Along the shores of Lake Victoria, traditional fishing and fishery activities constitute an important source of livelihood (Omwega et al., 2006). The industry greatly contributes to the development, acts as a source of

employment, provides food and is a strong base for food security, and serves as the major means of income generation.

Cases of malaria have oftentimes been associated with people working in the shipping and fishing industries, even when they are natives of places with no local transmission of malaria (Scerbaviciene & Pilipavicius, 1999). In Mali, more adult mosquitoes and more productive mosquito larval habitats were found in fishing hamlets during the dry season and these were responsible for seeding neighbouring areas with mosquitoes at the start of the rainy season (Sogoba et al., 2007). Studies in Mali have confirmed active migration of malaria vectors from fishing to non-fishing villages (Baber et al., 2010). In Entebbe, Uganda, a high prevalence of malaria has been reported among pregnant women including those residents in the fishing communities (Woodburn et al., 2009). Indeed, fishing has been documented to facilitate outdoor exposure of individuals to malaria vectors in India (Barai et al., 1982) and in the Brazilian Amazon (Ianelli et al., 1998; Ribeiro Sá et al., 2003). A study in Senegal established that the probability of dying at ages 1-4 years was 50% higher among children living in traditional homes, as is common place is fishing villages, than among those in modern homes as well as among children whose fathers' were engaged in farming, livestock and fishing (Goldberg & M'Bodji, 1988).

Settlements among fishing communities are either temporary or permanent shelters. The former tend to be short-term or transitory whilst the latter are of a more established or fixed character. This difference is reflected in the kind of building materials that residents have used to construct their shelters, shops, and kiosks. Most often fisher folks live in poor housing structures of simple mud-and-wattle unit with a grass- or reed-thatched roof (Omwega et al., 2006). Such environmental conditions expose individuals to mosquito bites, and hence malaria infections.

Marshes, papyrus swamps, and pools of stagnant water that are a common features around fishing villages and camps offer ideal breeding habitats for mosquitoes; and the fact that many people sleep in makeshift shelters or in other quarters that afford little protection against being bitten by them, together with all the time spent on or near the water during hours of darkness, means that the possibility of exposure to malaria is maximized. Malaria has been reported as one of the occupational hazards of Lake Victoria fishing life *(http://www.fao.org/docrep/006/AD150E/AD150E01.htm)*.

Rationale and objectives of the study

Complex health problems such as malaria are difficult to solve without understanding ecosystems and livelihoods contexts. It has already been recognised that socio-economic and environmental factors affect health, exposure to illness, risk for illness-producing behaviours, and the household response to the respective health problem. A new approach to human health therefore, constitutes a bridge among public health, a strategy for integrated management of the environment and an ecosystem approach to promoting human health. The ecosystem approach to human health offers an unequalled opportunity to promote human health through an enlightened approach to management of

the ecosystem. Ecosystem management relates to natural and environmental resources, but also must take into account the many human components, and the socio-economic and cultural factors relevant to the living environment. The ecosystem approach to human health is also dependent on a participatory and transdisciplinary research methodology that remains sensitive to the needs and aspirations of different social groups, including the differences between genders. This means, the ecosystem approaches to human health promotes a holistic view of human health, livelihood and environmental sustainability (http://www.idrc.ca/ecohealth).

In the context of ecosystems, health is a positive characteristic of human communities. It implies both the availability of and accessibility to resources. Specific positive outcomes include food security, good nutrition, low levels of disease, reproductive capacity, a sense of well-being, and access to knowledge (Waltner-Toews & Kay, 2002). This means, health is a social construct negotiated in the context of a better understanding of the constraints and opportunities provided by the ecosystems of which people are integral parts. Despite this understanding, for a number of years, conventional malaria research has tended to choose specific outcomes and view them as the result of a linear chain of events. It is envisaged that a more complex and realistic view requires identification of certain kinds of livelihood factors, which, although are possible determinants of malaria transmission, also generate money to improve the well being of the population. Considering this view, resolution of health-related issues, requires going beyond traditional health sector concerns and paying attention to the ecological and socio-economic context.
Malaria represents a complex, multi-dimensional health problem with a host of interacting variables ranging from the parasite, mosquito vector, human host, health-delivery systems to land use and climate change. A sound understanding of the nature and dynamics of certain ecosystem variables and their relationship to malaria transmission is a necessary step in identifying and addressing interventions that may reduce malaria while increasing agricultural productivity. Detailed field based research will be needed to further quantify the relationships.

Because of the unique nature of the malaria situation as a result of micro-epidemiological and ecological factors, and the virulence of mosquitoes and parasites, innovative approaches to the problem are necessary. It is important that researchers, policy makers and malaria control implementers initiate new solutions appropriate for specific situations. This is because, it has been established that no single approach to malaria control will be successful across the countries. Therefore multiple strategies, appropriate to socio-culturally and ecologically unique settings, must be implemented in an integrated approach. This project focused on providing solutions that will reduce malaria, resulting in improved health and well-being, increased productivity and poverty alleviation in Tanzania.

The main objective was to investigate the relationships between malaria, livelihoods, and ecosystem and health systems in Kenya, Rwanda, Tanzania and Uganda so as to strengthen the capacity to carry out integrated malaria research in an eco-health approach. This project aims to address the following specific objectives: (i) To determine the level and

form of stakeholder engagement and integration of factors related to community-based livelihoods, ecosystems, and health services in national malaria control policy formulation, in order to identify priority research and policy issues; (ii) To consolidate knowledge on malaria burden and transmission intensity in selected study areas; (iii) to assess the strengths and weakness of the health services delivery, livelihoods and ecosystems that influence malaria control; (iv) to develop appropriate communication strategies and tools for results-sharing and utilisation with target communities in improving malaria control strategies; and (v) to enhance research capacity of the collaborating institutions and their boundary and strategic partners working on malaria in the partner states and elsewhere in Sub-Saharan Africa.

Chapter 2: Malaria, ecosystems and nomadic pastoralism in Sub-Saharan Africa: a review

Abstract: Pastoralism is a free-range livestock production system, practised in all dry regions of Sub-Saharan Africa (SSA). In some communities it is the main source of food security and income. The ways of life of the pastoralists make them prone to a number of communicable diseases including malaria. However, most of the current malaria control strategies, rarely address this group of the population. The objective of this review was to analyse the interaction of nomadic pastoralism, ecosystem and livelihoods on malaria burden and control in SSA. Desk reviews of publications and technical reports on pastoralism and malaria in SSA were done. Both published and unpublished literature on pastoralism was carried out. The Internet search was conducted using specific search items including, livestock, pastoralism, nomads, livelihoods, and malaria. Generally, pastoralism is common in arid and semi-arid areas where malaria is of seasonal and low transmission. However, pastoral communities do move between areas of high and low malaria transmission. In these areas livestock may bring malaria into an area where it has been reduced, or in an area where transmission is low and make it a serious disease. In some parts of Sub-Sahara Africa, malaria prevalence among pastoral communities appears to be higher than among crop farming communities. In other areas, the opposite has been reported. Ruminant hoof prints have been reported as important aquatic habitats for Anopheles gambiae. However, keeping cattle has also been found to be of beneficial (zooprophylaxis) in malaria prevention in some parts of the world. The introduction of cattle in areas that livestock keeping was not practised has been associated with the decline in malaria transmission indices. On the other hand, malaria epidemics have been reported in areas where large heads of cattle have been moved out. Although cow dung has been implicated to support breeding of malaria mosquitoes, in some places, burning of cow dung has been reported to repel mosquitoes, and provide protection. In conclusion, malaria is a major public health problem among pastoral communities in SSA. However, pastoralism may play a bi-directional role of either bringing in or out malaria from one place to another. It was realised in this review that little is documented of the appropriate utilisation pattern of malaria intervention tools among pastoral communities. Studies on malaria and pastoralism need to be undertaken to further establish interactions that would allow the design of appropriate malaria interventions and policy implications.

Keywords: nomads, pastoralism, malaria, ecosystem, interventions, Sub-Saharan Africa

Nomadic pastoralism in Sub-Saharan Africa

Nomadic pastoralists are geographically and socially marginalized groups, inhabiting the arid and semi-arid areas unsuitable for crop agriculture. Pastoralists are people who primarily depend on livestock keeping for their living. In Africa, they inhabit those parts of the region where the potential for crop production is limited due to little rainfall, or limited natural resources. In order for them to optimally exploit the meagre and seasonally limited

resources many pastoralists are nomadic or semi-nomadic. Nomadic pastoral communities in these areas have over the years depended on livestock production for livelihoods. In particular, such communities keep various types of cattle, camels, donkeys, sheep and goats. Livestock has traditionally served as sources of food (especially milk), income (from surplus sales), stored wealth (Barrett & Swallow, 2006a, b) and manure. In addition, livestock are used for transport, clothing, and as the basis for traditional customs and respect (Zinsstag et al., 2006). The low output (due to use of local varieties and breeds) result in low production surpluses, and hence low or non-participation in commodity markets. The challenges posed by the harsh environmental factors in the arid and semi-arid areas of Africa are causing significant changes in people's livelihood strategies. Hence, forcing the pastoralists to engage in more or less continual movement of family groups with their domesticated animals, or in a semi-nomadic lifestyle alternating between a settled or permanent household made of either tents made of skins, felt, or palm leaf mats, occupied during the rainy season (Zinsstag et al., 2006).

Nomadic pastoralist groups are livestock-centred, seasonally mobile, well adapted to harsh terrain and extreme climates, tolerant of ill health, family and social network-oriented, and independent. However, in many countries, nomadic people lag behind settled people in education and access to public services (Zinsstag et al., 2006). The health status of nomadic communities is usually poor, and the range of infectious diseases prevalent in nomadic populations may vary with region, but tends to include both zoonotic and non-zoonotic infections (Schelling et al. 2005a). Several zoonotic diseases appear to occur with increased frequency because of the close contacts between humans and their domesticated animals (Schelling et al. 2003).

One of the major challenges for the control of communicable diseases in rural Africa is to ensure health interventions that are accessible to all irrespective of their life style (Okeibunor et al., 2013). The nomadic way of life makes access to health care facilities in villages difficult, as groups with animals have to avoid areas with crops, and visits to markets often exclude the most vulnerable – women and children. The instability of large numbers of the African pastoralists is the major problem in malaria eradication (Prothera, 1961). Through these movements people infected with malaria may be introduced in malaria clean areas and will maintain a reservoir of malaria parasites (Prothera, 1961).

This paper, therefore, examines the interactions between pastoralism and malaria in SSA. It then assesses the burden of malaria among pastoralists and explores their knowledge, attitudes, practices toward malaria disease and its control. The current malaria interventions are discussed in the context of their applicability among pastoral communities. Further, this chapter assesses pastoralist livelihoods and interactions with malaria so as to provide research-based evidence that is critical to influence public policy, improve the welfare of the pastoralists to better conserve their environments in which they live.

This review was carried out to address the interactions between pastoral livelihoods, ecosystem and malaria burden and control strategies among the pastoralists in SSA. A

systematic search of the literature was conducted using PubMed and other electronic databases and manual searches to locate peer-reviewed studies published. For the review, searches of peer reviewed journals, unpublished documents and grey literature on pastoralism and malaria was conducted. The internet search was conducted using specific search items including livestock, pastoralism, nomad, malaria, and mosquitoes. A total of 57 published journal articles and 12 government and non-government organization technical reports were reviewed and their excerpts included in this paper.

Pastoral ecosystems

Pastoralism is a free-range livestock production system. In a number of literatures, nomads and pastoralists are considered to be the same. However, Brieger (2011) classify nomads as hunters, collectors and pastoralists, while Sheik-Mohamed and Velema (1999) define pastoralists as those who migrate periodically with their herds to maximally exploit scarce resources (pasture, water), which they need for their animals and themselves, and which they are dispersed in time and space. Pastoralism is practised in all parts of Africa's arid and semi-arid regions. Pastoralists can further be categorised into (i) trans-humans (nomadic groups migrating regularly between two grazing areas along well-defined routes); and (ii) pastoralists migrating along conventional routes but also moving into different areas each year and semi-pastoralists with semi-sedentary residences and mobility patterns (Sheik-Mohamed & Velema, 1999).

There is no reliable information available on the number of pastoralists worldwide. According to one estimate, there are around 17.3 million pastoralists in Africa, 3.4 million in the Middle East and South Asia and no more than 2 million in Central Asia (Sandford, 1983). Sixty percent of the world's nomadic populations live in Africa. Statistics from African Union show that there are 268 million pastoralists in Africa (AU, 2010). They live and move on 43% of Africa's land mass and contribute 10-44% of the Gross Domestic Product in the countries they live in. In Tanzania, the population of pastoralists is estimated at 3 to 5 per cent of the total population.

Pastoral communities inhabit over 21 countries on the African continent, ranging from the Sahelian West, the rangelands of Eastern Africa and the Horn, to the nomadic populations of Southern Africa. They are concentrated in some of the most arid regions of the continent, which necessitate semi- or wholly-nomadic livestock grazing. Two of the most well-known nomadic groups in Africa are both pastoralists: the Fulani who may be found from Chad to Senegal and the Maasai who live primarily in Tanzania and Kenya. The Maasai are supposed to constitute one of the largest pastoral groups in East Africa. Eastern Africa has numerous pastoral groups in a broad geographical band that stretches from the Kenya-Somalia border northwards into Ethiopia; and northwest to encompass regions of Uganda, Sudan, the Democratic Republic of the Congo and the Central African Republic.

Pastoral systems contribute significantly to national and regional economies, with many countries exporting meat and other livestock products. Pastoralism has immense potential for reducing poverty, generating economic growth, managing the environment, promoting

sustainable development and building climate resilience (AU, 2010). Among many pastoral communities, the number of livestock determines the level of household wealth. Pastoralism is the finely-honed, symbiotic relationship between local ecology, domesticated livestock and people, in resource-scarce regions – often at the threshold of human survival.

Pastoralism is complex; it seeks to maintain a balance between water, pastures, livestock and people, in uncertain and variable environments, where alternative land uses are risky. The changes in weather patterns have resulted in frequent severe droughts and floods in the semi arid habitats of pastoralists. These shocks have resulted in frequent famines among the pastoral communities forcing many hitherto pure pastoralists to seek alternative strategies of coping with the climate induced shocks. One of the coping strategies taking root among such communities is the transition to crop farming, especially along the rivers. Yet, in some countries, constant movements of pastoral communities to other areas searching for water and green pasture have been a common coping strategy (Campbell, 1978; Aklilu & Wekesa, 2002).

The most common coping strategies of pastoral livelihoods in response to drought are long distance movement of livestock including crossing of boundaries to other regions, opening of dry season grazing areas, importation of feed and increased selling of livestock, as well as search for alternative sources of food and cash (Barton et al., 2001; Pratt, 2001). When grazing reserves are exhausted longer distances are covered by a few male herders with selected livestock in search of forage and water. In addition, among the pastoral communities, the most common strategies in response to drought induced reduced access to food and markets are(i): Selling of animals and purchase of food items (cereals) to preserve as emergency food and to eat at once; (ii) Slaughtering of few animals to preserve as dried meat; (iii) Rationing of food and water .

The livestock production systems which ought to have been at a sustainable equilibrium in harmony with the environment can no longer cope due to climate change, growing human populations and increased demand for both animal and crop products (de Haan et al., 2002). The way livestock are kept and milk and meat are produced will be a key factor in the future health of the SSA population since crop and livestock production systems are some of the main users of the natural resource base (de Haan et al., 2002). Livestock production may specifically contribute to land degradation, the decline and pollution of water resources, the emission of greenhouse gases and the erosion of biodiversity (Oldeman et al., 1991). However, with good management, livestock production can make a positive contribution to the natural resource base by enhancing soil quality, increasing plant and animal biodiversity and substituting for scarce, non-renewable resources such as fossil fuels. The challenge is thus to identify policies and technologies which mitigate any negative environmental impact but which, at the same time, satisfy the considerable demand for livestock products (de Haan et al., 2002).

Pastoralists have come under pressure worldwide due to a variety of circumstances that include population growth, environmental degradation, epidemics, and unsound

development and trade policies. It has been reported that human migration was responsible for the malaria epidemics in the district (Alilio et al., 1995). Such movements were initiated mainly by tribal conflicts and fighting between the Maasai and minority tribes; movements were caused by other epidemics, such as meningitis and dysentery; and search for green pastures.

Establishment of national parks and encroachment of agriculture on their grazing territories and the privatization of former communally owned land is undermining the existence of pastoralists in East Africa. There are many instances where pastoralists are suddenly prevented from using their traditional pastures, because these are declared nature protection areas or national wildlife parks (Köhler-Rollefson, 1992; Husain et al., 1999). In Tanzania, the Maasai have been evacuated from the Serengeti Plains but have been given joint use of the Ngorongoro Conservation Area (McCabe et al., 1997).

Malaria burden among pastoral communities

Several studies have documented that the health and disease profile of pastoralists differ from the settled populations among whom they move (Sheik-Mohamed & Velema, 1999; Schelling et al, 2005b). Statistics indicate that, the diseases and health conditions in mobile populations do not differ substantially from those of sedentary populations, but pastoralists suffer higher infant mortality, maternal mortality, and under-five mortality rates (Chabasse et al., 1985; Brainard, 1986). Pastoralist groups may be more frequently affected by water-borne diseases as they consume surface water more often than settled groups (Bonfiglioli, 1990), and can be susceptible to zoonotic diseases due to their association with animals and consumption of poorly treated animal products (Smith et al., 1979; Schelling et al., 2003). In addition, mobility and dispersion can influence the spread of disease (Loutan & Paillard, 1992) and therefore enhance risk for mobile populations.

Historically, such population movements have contributed to the spread of infectious diseases (Prothero, 1977). Failure to consider this factor contributed to failure of malaria eradication campaigns in the 1950s and 1960s (Bruce-Chwart, 1968); and should also be considered today when scaling up malaria interventions in SSA. The movement of infected people from areas where malaria was still endemic to areas where the disease had been eradicated led to resurgence of the disease (Martens & Hall, 2000). This promotes the idea that population movement can precipitate or increase malaria transmission in other ways. As people move, they can increase their risk for acquiring the disease through deforestation and irrigation systems (Martens & Hall, 2000). Such activities can create more favourable habitats for Anopheles mosquitoes. Population movements to and from malarious areas are of epidemiological importance. People who move can be categorized as either active transmitters or passive acquirers (Prothero, 1977). Active transmitters harbour the parasite and transmit the disease when they move to areas of low or sporadic transmission. Passive acquirers are exposed to the disease through movement from one environment to another; they may have low-level immunity or may be non-immune, which increases their risk of diseases (Martens & Hall, 2000). Population movement is increasingly implicated in the spread of antimalarial drug resistance (Rajagopalan et al., 1986). Identifying and

understanding the factors that influence population movements can improve prevention measures and malaria control programmes (Martens & Hall, 2000).

Statistics on the burden of malaria among pastoral community are scarce. For instance, results of a study conducted among the pastoralists in northern Tanzania found that the prevalence of malaria ranged from 12-42% among the Iraq, Gorowa, Mbugwe, Maasai and Barbaig (Mboera et al., 1996). Malaria in these tribes was found to be the number one cause of morbidity and mortality in the districts. In a recent study (Chapter 3), low malaria prevalence was observed among nomadic pastoralists than in the rice-farming communities in Kilosa district of central Tanzania. In another study in northern Tanzania, cattle kraals, which are usually built close to houses, were found to be the most preferred resting place for Anopheles gambiae s.l. (Mboera et al., 1996). In a study in Somalia, the highest malaria prevalence was recorded among the pastoralists and agro-pastoralist communities and the lowest among the riverine communities (Noor et al., 2008). In a study among the nomadic Fulani of north-eastern Nigeria, Gundiri et al. (2007) reported a high prevalence of malaria with only a small proportion of the population using mosquito nets. The high prevalence of malaria among the nomads was associated with their low knowledge of prevention and treatment. Bolaji et al. (2010) reported similar higher malaria prevalence among the nomadic Fulani of Osun State, Nigeria.

In a study carried out among pastoral community in Ngorongoro district in Tanzania, malaria prevalence was found to range from 3.6 to 25.9% (Mboera et al., 2005). Recently, a study done among the pastoral communities in Babati in northern Tanzania (Mwanziva et al., 2010), and Kilosa in central Tanzania (Mboera et al., 2013), found a high prevalence of anaemia in children. On the other hand, the prevalence of malaria in these communities was relatively low compared to that of crop farming communities. However, the contribution of malaria to the prevalence of anaemia was considered insignificant. Socio-economic and cultural factors were considered important factors that could lead to high anaemia prevalence rates among the pastoral communities (Mwanziva et al., 2010).

Previous studies in West Africa have shown that, in spite of similar exposure to malaria and comparable use of protective measures, the Fulani group was less affected by malaria disease than the Dogon ethnic group. The Fulani are nomadic, partly settled pastoralists and the Dogon are ethnic group with a long tradition of sedentary farming (Bereczky et al., 2006). On the horn of Africa, a study in Somali among the nomads and semi-nomads people showed that the prevalence rates of seropositivity for malarial antibodies (Plasmodium falciparum) were higher in the older age group (both males (42.3%) and females (31.2%) of semi-nomads than in children (25%), while among adult nomads the prevalence was 41.9%. These findings suggest that these infections possibly occur at a relatively constant rate and may not necessarily be associated with clinically apparent illness (Ilard et al., 1987).

It has been found that the variation in malaria prevalence among nomadic groups is related to the type of livestock they maintain (Schelling et al., 2005b). Pastoralists staying in dry

environments experience very low prevalence of clinical malaria and their exposure to malaria infection is for the most part limited to the wet season. Those staying close to more humid environments that favour mosquito vectors (e.g. the Fulani around Lake Chad) experience higher clinical malaria frequen¬cies during the dry season. This experience points out to the important epidemi¬ological variations among nomadic pastoralists. Some spend most of their time in drier and epidemic-prone malaria zones, while others move into areas of more stable endemicity in order to find water for their cattle. Another important epidemiological variation is the apparently higher levels of malaria immunity among the nomadic pastoralists compared with nearby settled populations.

Malaria epidemics among pastoralists

Malaria epidemics have been common in areas occupied by nomadic and agro-pastoralists in northern Tanzania. Affected districts included Ngorongoro, Mbulu, Hanang and Babati districts (Mboera & Kitua, 2001). Population migration among the Maasai of Ngorongoro district is common. Such movements are usually initiated by three factors: (i) tribal conflicts and fighting between the Maasai and minority tribes forcing people to flee their villages; (ii) movements caused by other epidemics, particularly meningitis and dysentery, which have often caused some communities to run away from their homes; and (iii) search for greener pastures during the dry season entails movement with animals to malaria endemic areas around lakes and rivers within and outside the district (Alilio et al., 1995). The tendency of male pastoralists to visit malaria endemic areas to graze animals or to attend cattle auction markets is common among the pastoralists of northern Tanzania. In a study carried out in Ngorongoro District in 1995 by Alilio et al. (1995) found that factors that explained the increase of malaria morbidities and mortalities in the district included lack of protective measures against mosquitoes, lack of sufficient knowledge about causes, and mode of transmission of malaria. Yet, others were quality of treatment provided in the rural health units, lack of sufficient drug supply, and the change in the health seeking behaviour of the population and human and animal migrations. Most often, nomadic pastoralists live in temporary shelters, with the majority living in mud and grass thatched huts (Mboera et al., 2005). Usually, housing tends to be basic, leading to close human-vector contact. Moreover, housing is often near water bodies, such as rivers, to facilitate water collection and watering their animals, which increases the exposure of humans to mosquitoes.

Movement of non-immune populations from non-malarious areas into endemic areas has also been an important factor in epidemic development in other parts of Africa (Kloos, 1990; Woube, 1997). During the mid 1980s, mass exodus of cattle was the predisposing factor to the outbreaks of malaria in Dodoma in central Tanzania. On the other hand, heavy mortalities of cattle due to East Coast fever were the factor that influenced a malaria outbreak in the Mkomazi Valley during the early 1970s. During this outbreak, it was the absence of livestock in the area that diverted malaria vectors to human hosts and hence increased the risk of malaria transmission (White & Muniss, 1970).

Knowledge, attitude and practices of malaria among the nomadic pastoralists

Changes in livelihoods and the agro-ecosystem might influence in one way or another malaria transmission intensity pattern to a surrounding community. In Uganda, the government persuaded nomadic pastoralists to practice permanent ranching or dairy farming. After some years these communities complained of an increase in morbidity and mortality due to malaria among children because of changes in livestock-management practices. This was caused by restructuring of the land to households (to minimize movement of pastoralists); shifting from pastoralism to sedentary agro-pastoralism; and in decreasing distance between human dwellings and animal housing (Okello-Onen et al., 2012). It was hypothesized that reductions in the size of the cattle herds, and housing of cattle in sheds, favoured increased human–vector contact with the most likely, zoophilic malaria vectors. As a result, the mosquitoes fed more on people than on cattle, and this greatly increased malaria transmission.

An understanding of the febrile illness experience of nomadic community is necessary for developing an appropriate strategy for extending malaria intervention services to them. In a study in West Africa, Akogun et al. (2012) reported that, the Nomadic Fulani regarded pabboje (a type of "fever") that is distinct from other fevers because it "comes today, goes tomorrow, returns the next day") as their commonest health problem. Pabboje is associated with early rains, ripening corn and brightly coloured flora. When compared to the urban populations, the rural communities were poorly served by the health system, but in comparison with nomads, the gap between nomads and the rural settled communities is even wider (Sheik-Mohammed & Velema, 1999). Most often the formal health system appears ill-adapted for extending services to constantly mobile communities of nomads, and local authorities often disregard the existence of nomads when it comes to health service delivery (Okogun et al., 2012).

Although disproportionately more exposed to infectious diseases such as malaria, nomads remain isolated from the ongoing malaria management campaigns (Omar & Omer, 1999).

In Nigeria, Akogun et al. (2012) concluded that access to these services remain a challenge to the nomadic population despite the current government's efforts which included distribution and promotion of insecticide treated nets (ITN) usage, use of simple diagnostic tools, and behaviour change communication. Yet, others were appropriate chemotherapy, intermittent preventive treatment and community management of febrile illnesses. One of the major health issues in Africa is how beliefs about health and illness are used in health care delivery since the concept of illness is informed by cultural identity (Gordon, 2000). For example the Fulani express the sense of difference between them and other groups through the manner in which they acknowledge illness. Being Fulani means perseverance, strength of character, discipline and providing leadership over others. The lack of understanding of their cultural experiences with malaria is a hindrance to integrating them into the malaria control programme. In Ethiopia, Nigatu et al. (2009) study among the pastoralist communities at Afar Region showed that, the proportion of community members who correctly identified the transmission methods of malaria was 61.5% and knowledge

of communities on the signs of malaria was 88.4%, while, knowledge on the prevention methods of malaria was around 67.5%.

In Simanjiro District in northern Tanzania, Malisa & Ndukai (2009) found that, most (75%) of the pastoralists were informed that mosquitoes transmit malaria, while the remaining quarter reserved a considerable doubt on the link between mosquitoes and malaria. Also, 65% of the respondents were aware of the use of insecticide treated nets (ITNs). However, the coverage of insecticide treated mosquito net was only 5%. Affordability, unavailability and gender inequality were identified to be the major factors associated with the low ITN coverage (Malisa & Ndukai, 2009).

A study among pastoralists of Ngorongoro district in northern Tanzania, malaria was considered as the important health problem by the majority of the respondents (Mboera et al., 2005). The knowledge of transmission and symptoms of malaria among this community was high living in an area that had experienced frequent malaria epidemics. Although the majority of the respondents were seeking care from conventional health care facilities, traditional healers were also frequently contacted for treatment of malaria. Endukushi and Enekidong'o were considered as the most potent herbs used as antimalarials in the district (Mboera et al., 2005).

Although cow dung has been implicated to support breeding of malaria, in some places, burning of cow dung has been reported to repel mosquitoes, and provide protection (Alaii et al., 2003; Sabin et al., 2010). In some areas, the increased malaria prevalence was also attributed to a decline in the use of cultural and traditional preventive measures such as burning cow dung and using herbs to treat malaria, which led clinical malaria to be much more apparent in the population (Okello-Onen et al., 2012).

Malaria control in the context of nomadic pastoralism

Malaria control among the nomadic populations has always posed serious logistic difficulties. Insecticide treated tents have been employed in the control of malaria among the Afghanistan nomadic refugee in Pakistani. In Pakistan, Bouma et al. (1996) showed that permethrin-treated tents were a safe and culturally acceptable intervention for nomadic Afghan refugees. However, no further investigation of the intervention has been carried out to verify its applicability in different nomadic situations.

The current promotion of insecticide-treated net (ITN) usage and prompt treatment of malaria has left the nomadic populations behind. It has been shown that a method of surrounding livestock sheds with insecticide-treated nets may cut the number of disease transmitting insects by 90% in western Kenya *(http://farmbizafrica.com/index.php/)*. With the nets however, only the exact necessary amount of the chemical is sprayed in the nets and constantly released over time - minimizing the risk that insects will develop resistance to the insecticides. In a study among nomadic Fulani communities in north-eastern Nigeria, Okugun et al. (2012) found that when nomads are empowered they appropriately manage malaria using community-directed intervention strategy – in both the use of antimalarial and

insecticide treated mosquito nets.

Zooprophylaxis

Cattle have been used to serve as alternative sources of blood meal for malaria and other vectors in what is known as zooprophylaxis (WHO, 1993). Zooprophylaxis is a malaria prevention technique involving the use of animals for diversion of blood-seeking mosquitoes away from humans. The technique is most promising in regions where the dominant mosquito species, such as Anopheles arabiensis, prefers to feed on animals instead of humans; prefers to rest outdoors instead of indoors; and is sufficiently dominant relative to other local species (Mathys, 2010). Zooprophylaxis has been advocated as one of the malaria control strategies. However, there is a concern about the practice since some studies have shown that the presence of cattle may instead increase malaria prevalence, a phenomenon known as zoopotentiation (Bouma & Rowland, 1995; Sota & Mogi, 1989) by attracting mosquitoes to the people in proximity (Schultz, 1989; Hewitt et al., 1994). A study from an Afghan refugee camp reported a 38% increase in human biting in the presence of a single cow and 50% in the presence of two goats (Jamal, 2011). The two phenomena deserve further investigation in areas where there is livestock keeping and different species of malaria vectors. In a study in north-western Nigeria (Akogun et al., 2012) found that women and children usually sleep inside the tents while the men sleep outside, unprotected from mosquito bites. Their children sleep among the animals to "prevent mosquito bites".

Insecticide zooprophylaxis involves treating livestock with insecticide in order to kill malaria vectors upon feeding (Habtewold et al., 2004; Kawaguchi et al., 2004; Kaburi et al., 2009). This is relatively cost effective and recommended method in the control of malaria in complex emergencies (Sota & Mogi, 1989). Zooprophylaxis has been shown to be very effective in Afghan refugee camps where cattle treated four times annually with deltamethrin reduced the incidence of Plasmodium falciparum malaria by 56% in the refugee camp. This method is cheap and easy to apply, costing only 20% of the cost of indoor residual spraying (Jamal, 2011). The same method has also been successful in Kenya in conjunction with insecticide treated nets distribution (Kaburi et al., 2009). In Uganda, Okello-Onen et al. (2012) found that Anopheles arabiensis, which is widely known to be zoophilic and opportunistic in its feeding behaviour, was absent from the study area, possibly because these mosquitoes were inhibited by the intensive application of synthetic pyrethroids on cattle to control ticks and tsetse flies. However, this method of vector control requires the dominant vector species to display zoophilic behaviour as anthropophilic vectors will ignore livestock and feed upon humans. Compliance by livestock owners may be low if appropriate education of the benefits is not clearly conveyed.

The World Health Organization has recommended the use of cattle as a protective measure against malaria since 1982 (Bøgh et al. "Zooprophylaxis" 593). However, it is only during the last two decades that the potential of zooprophylaxis for malaria prevention in sub-Saharan Africa has been revisited. So far, three categories of zooprophylaxis have been described: (i) passive zooprophylaxis - refers to the natural prophylactic effect of cattle or other livestock in the community; (ii) active zooprophylaxis denotes a deliberate attempt

to introduce animals as a means of vector control (Bøgh et al. 2001); and (iii) insecticide zooprophylaxis, or "cattle sponging," – refers to a method by which insecticide is applied to domestic livestock, using a sponge or animal dip (Habtewold et al., 2004; Kawaguchi et al., 2004; Kaburi et al., 2009)

Research on zooprophylaxis in Africa has been documented in both East and West Africa. The first zooprophylaxis study in Africa was carried out by Bøgh et al. (2001) in the Gambia. In East Africa, the potential for zooprophylaxis as an intervention in areas where An. arabiensis dominates has been studied by Mahande et al. (2007a,b) in Tanzania, Muriu et al. (2008) in Kenya, Tirados et al. (2006) in Ethiopia and Noor et al., (2008) in Somalia.

A study by Noor et al. (2008) in south-central Somalia, an area of generally low malaria transmission reported the overall use of nets and parasite prevalence to be 12.4% and 15.7% respectively among the three livelihood groups (riverine, pastoralists and agro-pastoralists). Mosquito net use was significantly higher among the riverine communities (20.9%) compared to the pastoralists (8.6%) or agro-pastoralists 12.6%). Also, the overall protective effectiveness of mosquito nets was 54% after adjusting for livelihood, sex, and age.

Observations made in a study in northern Tanzania indicate that the nomadic community is relatively illiterate, has poor knowledge on malaria prevention techniques, consult traditional healers more often and travel long distance to seek treatment for malaria (Mboera et al., 2005). Nomadics are generally always on the move with limited access to health care service (Brieger, 2011). Most often they use herbs to treat malaria or go to medical shops when they have serious malaria symptoms like body pains.

Implications for malaria control to the nomadic pastoralists

Health care services have to be accessible to nomadic pastoralists and must be tailored to the local combinations of patterns of mobility, morbidity, environmental and socio-cultural factors (Aagaard-Hansen et al., 2010). However, there are a number of challenges of health care provision that nomadic pastoralists face (Imperato, 1974; Sheik-Mohamed & Velema, 1999; Schelling et al. 2005a). As stated by Aagaard-Hansen et al. (2009), the improved systems for forecasting and surveillance of population segments at risk of exposure to new diseases owing to migration would be an advantage for public health planning and management. Movement of nomadic pastoral populations is highly relevant to malaria burden, either leading to exposure of vulnerable, migrating populations to new risks or leading to introduction of pathogens into new areas. Delivery of health systems and initiatives to nomadic populations is difficult. This has traditionally been considered as a choice between either mobile clinics or fixed health centres placed in strategic towns. The latter approach can work well with seasonally active nomads, who will be sedentary at certain times of the year.

Identification and better understanding of potential risk factors for malaria are important for targeted and cost-effective health interventions. Housing conditions have been suggested

as one of the potential risk factors (Ye et al., 2006). The majority of the nomadic pastoralists live in houses poorly constructed - built of poles-and-mud walls, and thatched with soil mixed with cow dung and grasses. Living in poorly constructed houses allows mosquito entry increasing the exposure to mosquito bites. A number of studies have already shown that the design of a house significantly affects the incidence of malaria infection (Gamage-Mendis et al., 1991, Ghebreyesus et al., 2000; Lindsay et al., 2003; Konradsen et al., 2003). In a recent study in north-western Burkina Faso, the prevalence of malaria was high among children living in mud roofed houses than in iron corrugated sheets houses (Ye et al., 2006). It is important that house characteristics are taken into consideration when designing health interventions against malaria among the nomadic pastoralists

Conclusion

Complex health problems such as malaria are difficult to solve without understanding livelihoods and environmental contexts. It has already been recognized that socio-economic and environmental factors affect health, exposure to illness, risk for illness-producing behaviours, and the household response to the respective health problems. The modelling of human health was initially highlighted by the experience of the biomedical world and the spread of infectious diseases. Yet the world is subject to the influences of many complex factors, including livelihoods, ecosystems and health systems that can undermine the health of human beings and that cannot be controlled by a biomedical approach alone.

A new approach to human health constitutes a bridge among public health, a strategy for integrated management of the environment and an ecohealth approach to promoting human health. The ecohealth approach to human health offers unequivocal opportunity to promote both human and animal health as well as environmental health. Ecosystem management relates to natural and environmental resources, but also take into account the many human components including the socio-economic and cultural factors, among many others, relevant to the living environment. Malaria represents a complex, multi-dimensional health problem with a host of interacting variables ranging from the parasite, mosquito vector, human host, livelihoods, local health-delivery systems to land use and climate change. A sound understanding of the nature and dynamics of these ecosystem variables and their relationship to malaria transmission is a necessary step in identifying and addressing malaria interventions for its reduction among the rural communities to increase agricultural productivity.

Making reference to nomadic pastoralists, malaria is clearly a disease on the move. The challenge to local health services is to make malaria prevention and treatment services easily accessible along migration routes and near migrant settlements (Brieger, 2011). As Brieger (2011) puts it, we may not expect to stop human migrations, but hopefully we can prevent the movement of malaria along with them. It seems appropriate to pay specific attention to health care for nomadic pastoralists who use ecosystems that could hardly be habitable or productive without livestock. It is important to note that nomadic pastoral systems are under tremendous pressure and for several years have started to undergo social and economic transformation.

To reach equity effectively, a healthcare strategy and policy for nomadic pastoralists needs to be integrated into the national health policies with specific adaptations and decentralized decision-making (Tanner, 2005). Health and social service policy again should be elements of an overall framework for the sustainable use of semiarid areas. There is a need to better understand nomads' health and their demographic parameters, as well as the requirement for evidence of cost-effective interventions among nomadic pastoralists. With respect to pastoral systems, intervention strategies to support pastoralists should be geared towards building capacity among pastoral communities, through enhancing pastoralists' access to appropriate intervention packages.

Chapter 3: Prevalence of malaria in relation to livelihoods in Kilosa District

Abstract: Human activities, behaviour and socio-economic factors including living conditions have been described to provide risk to malaria as a result of an increased exposure to the disease. The objective of this study was to investigate the relationships between malaria, livelihoods, and ecosystem in a rural district of central Tanzania. This study was conducted in Tindiga and Malui (rice farming community), Twatwatwa and Mbwade (pastoral community) and Kimamba B (mixed livelihoods) villages. Health care facilities were available at Tindiga, Kimamba and Twatwatwa. Schoolchildren were screened for malaria infection using both microscopy (thick blood smear) and malaria rapid diagnostic test (mRDT). Demographic data including age, sex, place of residence and use of a mosquito net were collected. A total of 1318 school children aged 9 years (range=4–16 years) were involved. Two thirds (62.3%) of the children were from villages with a health facility. The overall prevalence of Plasmodium falciparum malaria infection was 8.5% by mRDT and 3.5% by microscopy. Children from mixed livelihoods village had the lowest prevalence of malaria. A significant high risk of malaria was observed among children in rice farming communities. Children living in areas with health care facilities had a low odd of malaria infection by 45% (OR: 0.55; 95% CI. 0.35, 0.86). Children over 8 years old were at a higher risk of acquiring malaria infection than younger children. Only six (0.47%) of the children had an enlarged spleen. The average prevalence of anaemia was 22.7%, with the highest rate (mean=26.9%) observed among children in the pastoral communities. In conclusion, malaria prevalence in Kilosa District is low. However, there are significant variations in the risk of acquiring malaria infection between children from different ecosystems and livelihoods and between those from villages with and without health care facilities. The study has clearly shown that water and land resource management are important drivers of rural community livelihood systems and malaria burden. These findings suggest that malaria control programmes must account for the livelihoods and ecosystems contexts in which they are implemented. It is also critical to strengthen community capacity in water and land resource management strategies to prevent negative impact on health and ecosystem.

Keywords: malaria infection, children, livelihoods, rice farming, pastoralism, Tanzania

Introduction

Malaria is the single most important and widespread mosquito-borne disease in the world. It is endemic throughout the tropical and sub-tropical regions (Suh et al., 2004) affecting about 219 million (range=154-289 million) people annually. The disease causes on average 600,000 deaths annually, mostly (85%) among children under 5 years of age (Murray et al., 2012; WHO, 2012). Malaria is endemic in most parts of Tanzania, and remains as a major cause of morbidity and mortality both in rural and urban areas. Recent statistics indicate that malaria mortality and morbidity in Tanzania have declined in recent years (Mboera

et al., 2013). The national parasitaemia rates have declined from 17.7% in 2008 to 9.2% in 2012, with major regional differences and difference between the poor and the best-off persisting (THMIS (2012). Geita, Kigoma, Mwanza, and Mara regions in the Lake and Western zones, Morogoro and Pwani in the Eastern zone, and Lindi, Mtwara and Ruvuma in the Southern zone still have higher prevalence than elsewhere (THMIS, 2013). Data from health facility are also suggestive of a reduction in malaria morbidity and mortality (Mboera et al., 2013).

Malaria represents a complex, multi-dimensional health problem with a host of interacting variables ranging from the parasite, mosquito vector, human host, local health-delivery systems to land use and climate change. It has been established that human activities, behaviour and living conditions provide risk to malaria as a result of an increased exposure to the disease. Social and environmental determinants of health include income, employment, access to food and social capital, and exposure to disease agents (Marmot, 2005; de Bartolome & Vosti, 1995). In many regions of Tanzania there are significant variations in malaria transmission intensities and prevalence associated with variations in topography (Mnzava, 1991), ecological systems (Ijumba, 1997; Mboera et al., 2010; 2011) and economic status (THMIS, 2013). Thus, complex health problems such as malaria are difficult to solve without understanding livelihoods and ecosystems contexts.

It has already been recognised that socio-economic and environmental factors affect health, exposure to illness, risk for illness-producing behaviours, and the household response to the respective health problem. A sound understanding of the nature and dynamics of certain ecosystem and livelihoods variables and their relationship to malaria transmission is a necessary step in identifying and addressing interventions that may reduce malaria while increasing agricultural productivity. The main objective of this study was to determine the relationships between malaria, livelihoods, and ecosystem in a rural district of central Tanzania.

Materials and Methods

Study sites

The study was carried out in Kilosa District (22017'-32049'E and 90127'-903339'N), situated in central Tanzania at about 300km west of Dar es Salaam. The district has a total surface area of about 14,400 km2 and a population of 489,513 people living in 105,635 households with an average household size of 4.6 people. The district has a climate that belongs to the tropical savannah that is very much regulated by the seasonal movements of the Inter-tropical Convergence Zone. The rainfall regime in the district is closely related to elevation with the direction of slope having a secondary effect. The rainfall has a characteristic monomodal pattern; the rains begin in October with a peak in April and continue till May. The mean annual temperature for Kilosa is 25oC (mean annual maximum=30oC; mean minimum= 19oC).

Geomorphologically the district is characterised by mountains, hills, and foot slopes of

mountains, undulating plains with broad valley bottoms and alluvial plains comprising the floodplains. In the district seven broad land cover types are recognised which include forest, woodland, bushland, grassland, cultivated land, water bodies and urban land. Natural forests are situated in higher landscapes at the catchments areas which are sources of most of the rivers in the district. The district consists of high mountain range and a wide alluvial plain in a general southwest-northeast direction. There are relatively dense river networks in the district. In terms of river systems, the Kilosa District can be divided into the following five areas: (i) Kimamba-Wami system; (ii) Mkondoa-Mkata-Wami system; (iii) Miyombo-Mkata system; (iv) Chali-Great Ruaha system and; (v) Ruhembe-Great Ruaha system. Permanent and seasonal swamps are found in the Mkata alluvial plain. Both rivers and swamps are important habitats for fish and many inundated areas are used for growing paddy. Water bodies are also important watering point for livestock.

Kilosa District is one of the leading agricultural production areas in Tanzania. Agriculture is the main activity of most people in the district and is characterized by predominance of smallholder and estate farms. The main land uses in the district can be categorised into public land use type which constitute crop agriculture and free-range livestock production system. The main crops produced are maize, rice, sorghum, beans, cassava, sweet potatoes, cotton, sunflower, sesame and sisal. Most of these crops are grown under labour intensive smallholder system and the use of hand tools is common, except for the sisal crop which is grown under estate plantation system.

The district is comprised of over 30 small and medium irrigation schemes. The main crops produced under irrigation include maize, rice, beans, onions, tomatoes and vegetables. Rice is the most important crop grown and marketed food crop under irrigation. The crops are mainly grown on the valley bottoms of the undulating plains and on the alluvial plains. Smallholder farmers are mainly concentrating on the alluvial plain where the soils are fertile and easily workable. Other farms under irrigated agriculture include Kilombero Sugar Company using sprinkler irrigation; Msimba seed farm using surface and sprinkler irrigation; Kilangali Rice Seed Farm using surface irrigation and Ilonga Research Institute drip and sprinkler irrigation. Livestock grazing is an important land use in the district. Zebu cattle, goats and sheep do graze in some parts of the Mkata alluvial plain mainly dominated by acacia bushland and bushed grassland. Extensive grazing by the Maasai pastoralists is also found in the open “Miombo” woodland of the undulating plains.

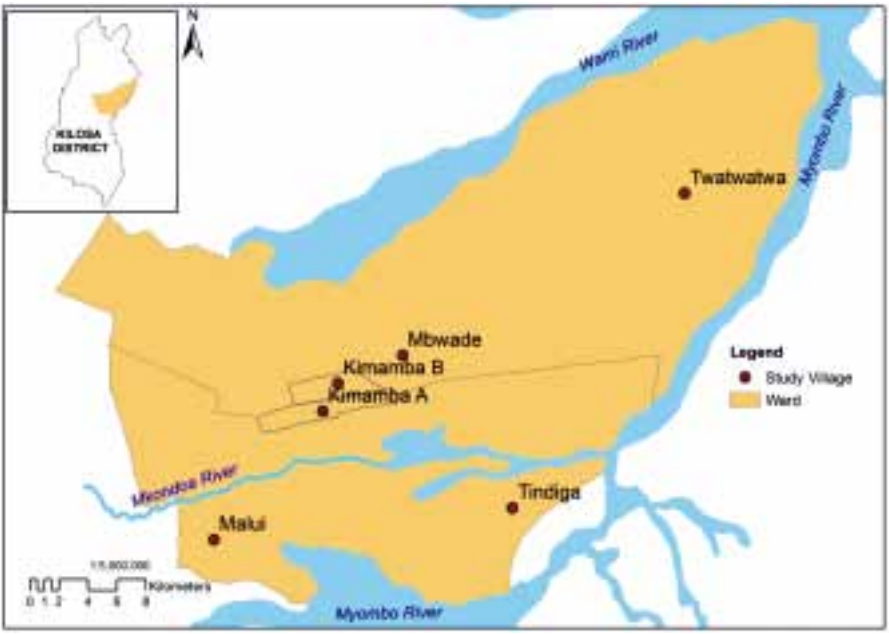

Figure 1: Study villages in Kilosa District, central Tanzania

Kilosa is an area with holoendemic malaria transmission with seasonal peaks (Eriksen et al., 2004; Makundi et al., 2006). The hydrological conditions and land-use patterns of the district provide opportunities for the proposed study. This study was conducted in 5 villages (Figure 1). The villages were Tindiga, Malui, Kimamba, Twatwatwa and Mbwade. Tindiga and Malui in the south-eastern part of the district are characterised by swampy flatland wetlands lying on the Kilangali alluvial basin. Most of the communities in Tindiga and Malui are small-scale farmers of rice using the traditional ground flooding irrigation practice. Kimamba is a growing township characterised by mixed livelihoods including crop cultivation, brick making and petty businesses. Kimamba is a large growing township marked with non-farm activities characterised by trade activities as well as providing casual labour to the large sisal estate in the nearby. Mbwade and Twatwata are located in the north-eastern part of the district. The villages are characterised by savannah type of vegetation, with most of the areas covered with short grass, trees and shrubs that provide a wide range of pasture for livestock grazing. The villages are inhabited mainly by the Maasai pastoralists keeping cattle, sheep and goats. Health facilities are present in Tindiga (health centre), Kimamba (health centre) and Twatwatwa (dispensary).

Data collection

Each individual child was screened for the presence of malaria parasites using both microscopy (thick blood smear) and SB-Bioline® (SD Bioline Malaria Ag. Pf/Pan test kits Device, Gewerbestrasse, Switzerland) after blood was collected by finger prick. The screening was done on malaria asymptomatic children at their own respective primary

schools. In each school, meetings were held with teachers to explain the objective and methodology of the survey before the tests were performed. Each child was examined for spleen enlargement and body temperature was taken. Schoolchildren were interviewed with the assistance of the schoolteachers regarding recent history of fever and any drug taken. Weight and height for each child were measured. Demographic data such as age, sex, place of residence and use of a mosquito net were recorded.

The blood smears were stained with Giemsa and were examined with a binocular microscope with an oil immersion lens to quantify the parasitaemia. Parasitaemia was measured counting the number of asexual parasites against the number of leukocytes in the blood film, based on a putative count of 8000 leukocytes per microlitre. The number of asexual parasites was counted against 200 leukocytes using a hand tally counter. A slide was considered negative if no parasite were seen after scanning 200 fields. The blood films were examined by experienced microscopists without reference to the results of the RDT.

Data analysis

All data were entered and verified in Microsoft Excel and analysed using STATA statistical analysis software package version 9 (Stata Corp., College Station, TX, USA, 2003). Simple associations were tested using Chi-square test; t-test and proportional test were applicable. Regression model was fitted to assess risk of malaria infection in the district considering all possible relevant factors. Effect was considered at 5% level of significance.

The mRDT sensitivity was estimated as true positives/ (true positives + false negatives), specificity as true negatives/ (true negatives + false positives), positive predictive value as true positives/ (true positives + false positives), negative predictive value as true negatives/ (true negatives + false negatives) and the positive likelihood ratio as sensitivity/ (100 – specificity). Inter-observer variability was assessed by Kappa values with < 0.40 indicating poor to fair agreement, 0.40–0.60 moderate agreement, 0.60–0.80 substantial agreement and > 0.80 almost perfect agreement between assessors.

Ethical considerations

This study received an ethical clearance from the Medical Research Coordinating Committee of the National Institute for Medical Research. Before the survey began, the objectives, methods and benefits of the study were explained to the district authority, school teachers and parents in a meeting convened by the village leaders. An oral assent was asked from each child enrolled in the study. Authorisation to conduct the survey in schools was obtained from the District Executive Director of Mvomero District. Any child found to be infected with malaria was given treatment according to National Guidelines on Malaria Treatment.

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Results

Demographic characteristics

A total of 1,318 school children, with mean age (SD) of 8.9±2.3 years were involved. Of the children, females accounted for 53.87%, while males accounted for 46.13% (Table 1). Two thirds (62.3%) of the children lived in areas with health facilities.

Table 1: Demographic characteristics for the children in Kilosa District

Variable		Kimamba	Malui	Mbwade	Tindiga	Twatwatwa	Total
Sex	Female	156 (51.65)	155 (60.07)	125 (52.3)	135 (54)	139 (51.67)	710 (53.87)
	Male	146 (48.34)	103 (39.92)	114 (47.7)	115 (46)	130 (48.33)	608 (46.13)
Mean age in years (SD)		7.6 (1.6)	9.8 (2.5)	9.9 (2.6)	8.3 (1.8)	9.6 (1.9)	8.9 (2.3)
Age groups (in years)	4-7	133 (44.04)	48 (18.6)	55 (23.01)	91 (36.4)	38 (14.13)	365 (27.69)
	8-12	166 (54.97)	164 (63.57)	146 (61.09)	155 (62)	216 (80.3)	847 (64.26)
	13-16	3 (0.99)	46 (17.83)	38 (15.9)	4 (1.6)	15 (5.58)	106 (8.04)

Prevalence of malaria

The overall prevalence of malaria infection was 8.5% by mRDT and 3.5% by microscopy (Table 2). Plasmodium falciparum was the only malaria parasite species (100%). The highest malaria prevalence was observed in Malui and Tindiga villages. Children from mixed livelihoods in Kimamba had lowest prevalence of malaria infection. Only three (0.23%) children were found with gametocytes (Tindiga= 1,

Malui =1 and Twatwatwa =1). Six (0.47%) of the children had an enlarged spleen. In all the five villages, higher malaria prevalence was detected by the use of mRDTs.

Table 2: Prevalence of malaria infection by livelihoods and village in Kilosa district

Type of livelihood	Village	No. screened	RDT N (%)	Microscopy N (%)	Spleen N (%)	Anaemia (%)	Net use (%)
Rice farming	Tindiga	250	35 (14.0)	22 (8.80)	4 (1.6)	24.4	83.2
	Malui	258	58 (22.5)	20 (7.75)	2 (0.79)	19.4	86.2
Pastoralism	Twatwatwa	269	6 (2.23)	2 (0.74)	0 (0)	38.7	75.6
	Mbwade	239	9 (3.77)	2 (0.84)	0 (0)	15.1	80.7
Mixed livelihoods	Kimamba	302	4 (1.32)	0 (0)	0 (0)	13.6	90.3
	Total	1318	112(8.5)	46 (3.5)	6 (0.47)	22.2	83.2

The prevalence of malaria infection by microscopy was 2.4 lower than that found using mRDT. About 33.9% and over 99% of the screened individuals were detected with and without malaria infection by both tests, respectively. However, among the 46 individuals who were tested positive by microscopy, 17.4% were found negative by mRDT (Table 3). The mRDT specificity and sensitivity were 94.18% and 82.61%, respectively.

Table 3: Sensitivity and Specificity of mRDT on malaria diagnosis

Measure	Definition	Estimate	95% CI
Sensitivity	Pr (+|D)	82.61%	[80.56%, 84.65%]
Specificity	Pr (-|~D)	94.18%	[92.92%, 95.45%]
Positive predictive value	Pr (D|+)	33.93%	[31.37%, 36.48%]
Negative predictive value	Pr (~D|-)	99.34%	[98.90%,99.77%]
Prevalence	Pr (D)	3.49%	[2.5%, 4.48%]

The area under a receiver operating characteristic (ROC) curve was 0.88. Sensitivity and specificity are plotted against different probability cutoff to assess performance of the test (Figure 2).

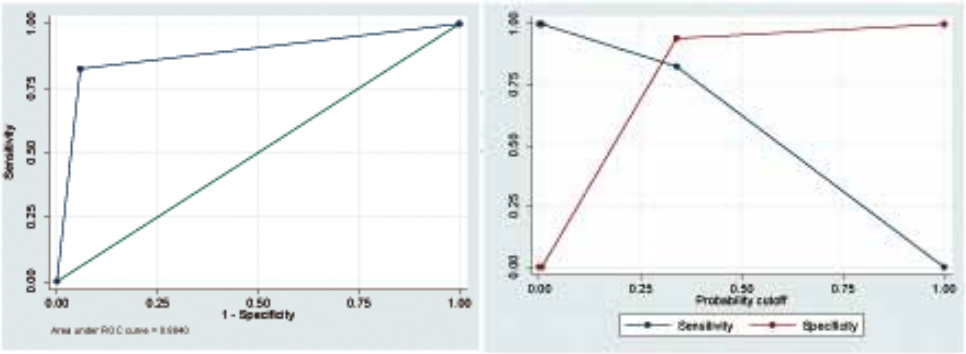

Figure 2: Assessment of the performance of mRDT in detecting malaria infection

Overall, the use of mosquito nets was very high in all villages (75.6-90.3%). All children with enlarged spleen were from rice farming villages. Anaemia prevalence in the District was 22.7% with the highest prevalence observed in the pastoral communities (Figure 3). Amongst those found with malaria using mRDT only 34% were found with malaria using microscopy.

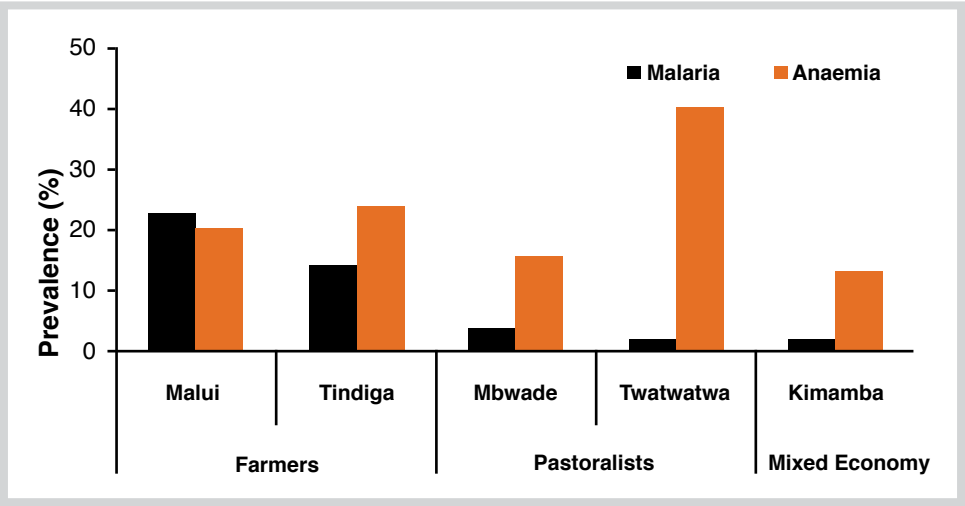

Figure 3: Pattern of malaria and anaemia prevalence in different livelihood systems in Kilosa, Tanzania

Attributes of risk of malaria infection

A multivariate regression model was fitted to assess factors related to the prevalence of malaria in Kilosa. No significance difference in malaria prevalence was observed between sex, net use or age. However a reduction on the odd of acquiring malaria infection was observed for those who were using mosquito nets. Children over 8 years old were observed to be at higher risks of acquiring malaria infection as compared to the younger children. A significant high risk of malaria was observed among children from the rice farming communities of Tindiga and Malui (Table 4).

Table 4: Odd ratio (OR) of malaria prevalence in relation to sex, age, livelihood and presence of a health facility in Kilosa.

Variable	OR	[95% CI]	P-value
Sex (Male=1)	1.35	0.89, 2.05	0.15
Net use (Yes=1)	0.63	0.37, 1.05	0.07
Age (reference: 13-16yrs)			
4-7 yrs	0.99	0.61, 1.62	0.975
8-12yrs	1.47	0.69, 3.13	0.315
Livelihood (reference: rice farming community)			
Pastoral community	0.13	0.07, 0.23	<0.001
Mixed livelihood	0.089	0.03, 0.25	<0.001
Presence of health facility (HF available=1)			
Health facility present	0.55	0.35,0.86	0.01

Presence of health facility showed an effect on the risk of malaria infection. Those living in areas with health care facilities had low odd of malaria infection by 45% (OR: 0.55; 95% CI. 0.35, 0.86) (Figure 4). Comparing between Tindiga and Malui which are both rice farming villages, the prevalence of malaria was 38.5% higher in Malui than in Tindiga.

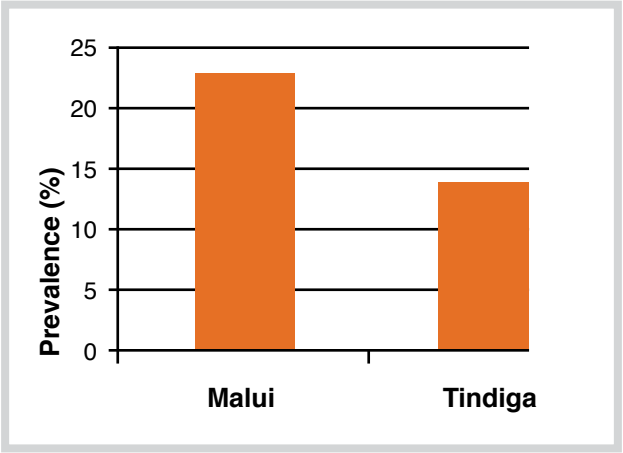

Figure 4: Malaria prevalence in rice farming villages of Malui and Tindiga

Discussion

The overall malaria prevalence in Kilosa is lower than the regional average of 13% (THMIS, 2013). The variation between villages is likely to have been attributed to the ecological and socio-economic factors. The highest malaria prevalence was observed among children in rice farming communities of Malui and Tindiga. Our results also indicate significant variations in the level of parasitaemia even between different villages within the rice-irrigation agrosystem. The variations in malaria prevalence in our study are likely to be due to different levels of malaria transmission and the socio-economic activities of the respective communities. Various studies have already shown that malaria transmission risk varies even on the smallest scale (Ye et al., 2006; Wang et al., 2006). Higher malaria prevalence among rice irrigation systems have been reported elsewhere in Sub-Saharan Africa (Mboera et al., 2011; Coosemans, 1985). Flooded paddy fields are known to provide ideal breeding sites for An. gambiae (Carnevale et al., 1999) and hence increase the annual duration of transmission (Ijumba & Lindsay, 2001). Children from mixed livelihoods in Kimamba had lowest prevalence of malaria infection. Kimamba is characterised by dry savannah vegetation with minimum potential breeding sites. Similar findings have been reported from a study in Mvomero district in Tanzania where the prevalence of malaria in savannah villages was relatively lower than in the rice-irrigation villages (Mboera et al., 2011a).

The prevalence of malaria varied strongly with age groups. Malaria prevalence was highest among the >8 years old children than among the younger children. The fact that malaria prevalence was higher among children living in villages without health facilities confirms previous findings elsewhere in Tanzania. Malaria prevalence and malaria treatment seeking behaviour have been reported to be relatively low among Tanzanian communities living close to health care facilities than among those living far away (Mboera et al., 2006, 2008). It is likely that individuals who live closer to the health facilities have better access to health care services than those living far from facilities.

Anaemia prevalence in the district was 22.7% with the highest prevalence among children in the pastoral communities. The prevalence in this study was lower than in a neighbouring district of Mvomero (61.9%). In this study anaemia was more prevalent among pastoral community than in the rice farming communities. A similar picture has been observed in Mvomero district (Mboera et al., 2011). Anaemia is a major health problem in Tanzania, especially among children (Schellenberg et al., 2003). In this study, anaemia was most prevalent among communities with low malaria prevalence. This suggests that the anaemia in the pastoral communities was most likely to be the result of dietary deficiency or parasitic infections other than malaria. Discussion with a number of local leaders among the pastoralists revealed that when grazing reserves are exhausted, pastoralists move longer distances with selected livestock in search of forage and water, leaving behind children and old persons with inadequate food reserve. Usually, those left behind suffer from shortage of food and malnutrition. In a nation-wide survey in 2004/2005, the most common cause of anaemia among children in Tanzania was identified to be nutritional anaemia resulting from inadequate dietary intake of nutrients (TDHS, 2005).

In this study, strong effect of the ecosystem, livelihoods and health systems on malaria was observed. This suggests that malaria is attributed to ecological and human socio-economic factors. Rice farming communities were at higher risk of malaria as a result of their routine farm activities that involves irrigation that supports mosquito productivity. Moreover, farm activities expose the community to mosquito bites and hence malaria transmission. Farm activities include planting and weeding during the rainy season and once the rice begins to grow, warding off wild birds and wild animals, which continue throughout the ripening stage. In addition, the agricultural calendar necessitates the adults to move back and forth between the villages and the paddy fields or sometimes even migrate temporarily to the fields, often with families without mosquito prevention tools.

Despite that low prevalence of malaria in Kilosa, there are variations in terms of risk between communities with livelihoods practices. Such variations are likely to be attributed to different malaria transmission levels and socio-economic factors. The variability of the levels of parasitaemia by age and livelihoods illustrates the existing of different micro-ecological zones. It is therefore important, that malaria control measures are designed taking into consideration the specific local needs. An inter-sectoral approach is recommended to address both rural agricultural related livelihoods and malaria transmission.

Chapter 4: Mosquito abundance and infectivity in Kilosa District

Abstract: There are spatial and temporal variations in the mosquito population, biting rate and malaria transmission intensity between geographical areas and between ecological systems. Such variations are clear even between relatively close villages. This study was carried out to determine the spatial variations in malaria transmission in five villages representing different livelihoods activities in Kilosa District in central Tanzania. This cross-sectional study involved five villages namely Tindiga and Malui (rice irrigation ecosystem), Twatwatwa, Mbwade (dry savannah ecosystem) and Kimamba B (savannah ecosystem). A total of 936 female mosquitoes were collected in 15 houses. Some 46.9% were malaria mosquitoes (Anopheles arabiensis = 28.6%; Anopheles funestus = 18.3%). Culex quinquefasciatus accounted for 30.3% of the total population. The largest proportion of the malaria mosquitoes (62.8%) was collected in Malui and the smallest proportion (2.3%) in Twatwatwa. Both the abundance and house density of the anopheles mosquito in this study was low. However, malaria mosquito accounted for about half of the total mosquito caught host-seeking indoors. Some 58.6% of the malaria mosquitoes were collected from the two rice-farming villages. Two-thirds of the malaria mosquitoes were collected in Malui (rice agro-ecosystem) and the lowest number Twatwatwa (dry savannah ecosystem). On average, 17.87 Anopheles mosquitoes were collected per village per day. Human biting rate per person per night for the two malaria mosquitoes was highest in Malui (46.01) and lowest in Twatwatwa (1.67). The variation in the abundance of anopheles mosquitoes was observed between villages and between different ecosystems. In the current study the parity of the anopheles mosquitoes was low. None of the anopheles mosquito in the current study was infected with malaria parasites. The low mosquito densities observed in the area are likely to be due to several factors including trapping technique and mosquito behaviours. The absence of sporozoite in the current study is likely to be attributed to the low mosquito abundance most probably a result of high mosquito coverage in the district. A more intensive longitudinal study is recommended to establish spatial and temporal malaria transmission intensity in the area.

Keywords: malaria, Anopheles arabiensis, An. funestus, mosquito abundance, ecosystem, Tanzania

Introduction

In Tanzania malaria is mainly transmitted by Anopheles gambiae, An. arabiensis and An. funestus (White, 1974). Other important vectors include An. merus (Mnzava, 1991; Kigadye, 2006), An. rivulorum and An. marshallii (Wilkes et al., 1996; Malima, 1999; Magesa et al., 1991). Anopheles gambiae s.l. represents more than half of the malaria vectors in the country with variation in density between villages, ecological systems and between seasons (Mboera et al., 1997).

Malaria transmissions in most areas of Tanzania have been generalized by zone, region or district (Clyde, 1967). However, it has been observed in that there are variations in anopheline mosquito composition and malaria transmission in localised areas, within districts and even within villages (Ijumba & Lindsay, 2002; Appawu et al., 2004; Mboera et al., 2007). Craig et al. (1999) and Hay et al. (2000) have demonstrated the existence of important small-scale local variations in the malaria transmission and endemicity across Africa as a whole. These variations are likely to be contributed by differences in micro-ecological and socio-economic factors including the heterogeneities in vector density, survival of the mosquitoes, vector host contact, and innate feeding preference of vectors (Smith et al., 1995; Bogh et al., 2001).

Generally, malaria transmission in Tanzania has been described to be highest in rice irrigation ecosystems than in any other ecosystems (Ijumba, 1997; Mboera et al., 2010). It has been shown that the human biting rate is highest shortly after the mosquito densities peak, near breeding sites where adult mosquitoes emerge, and around the edges of areas where humans are aggregated (Smith et al., 2005). These sources of spatial and temporal heterogeneity in the distribution of mosquito populations are associated with the variability in the human biting rate, the proportion of mosquitoes that are infectious, and in the risk of human infection (Smith et al., 2005).

Similar to mosquito density, the annual entomological inoculation rates (EIR) estimates in Tanzania display marked temporal and spatial variations, with likelihood of communities in irrigation ecosystems experiencing the highest EIR throughout the year (Mboera et al., 2010; Imbahale et al., 2012). It has already been observed that irrigated cultivation enhances population development of many malaria mosquito species and has been associated with high malaria transmission in sub-Saharan Africa (Dossou-Yovo et al., 1994; Briët et al., 2003). The variation in EIR between ecosystems may be explained by differences in the ecological settings, and more specifically the availability of favourable breeding sites (Dossou-Yovo et al., 1994; Appawu et al., 2004; Mboera et al., 2010).

In Tanzania, variations in mosquito density and entomological inoculation rate due to agroecological zones have been reported by Ijumba & Lindsay (2002) in northern Tanzania and Mboera et al. (2007b; 2011) in central Tanzania. In Tanzania, Ijumba and Lindsay (2001) observed that the potential risk of malaria due to An. arabiensis and An. funestus was four-fold higher in rice field villages than in sugarcane or savannah villages nearby. In central Tanzania, Mboera et al. (2011) reported that the mean annual inoculation rate for An. gambiae s.l. was significantly higher in traditional flooding irrigation than in other agro-ecosystems. The two studies in Tanzania and others elsewhere in Sub-Saharan Africa, therefore, demonstrate the need to generate spatial and temporal data on transmission intensity on smaller scales taking into consideration ecosystems. The assessment of indices relating to malaria transmission is central to its control through quantifying the potential risk of infection and elucidating the patterns of disease transmission (Githeko et al., 1993). This study therefore, was carried out determine the spatial variations in malaria transmission in five villages representing different ecosystems and livelihoods activities in Kilosa District in

central Tanzania.

Materials and Methods

Study area

This cross-sectional study was carried out in Kilosa District and involved five villages namely Tindiga and Malui (rice irrigation ecosystem), Twatwatwa, Mbwade (dry savannah ecosystem) and Kimamba B (wet savannah ecosystem). The area is has been described in Chapter 3. Tindiga and Malui are villages characterized by rice farming livelihoods, Twatwatwa and Mbwade by pastoral communities while Kimamba is mixed livelihoods.

Mosquito collection, identification and processing

Adult mosquitoes were sampled in three houses in each of the five villages for three days consecutively in May 2012. Mosquito collections were done using Centers for Disease Control (CDC) light traps (J.W. Hock Ltd, Gainesville, Florida, United States of America). For operation, each light trap was hung at the top of the foot-end of the bed with an adult person sleeping under untreated mosquito net (Mboera et al., 1998). The light traps were set at 18.00h and collected the following morning at 6.00h. Inquiries were made as to whether the trap fan and light had both worked all night, and catches from faulty traps were discounted.

Collected mosquitoes were kept in cool boxes and brought to a field laboratory for identification and further processing. At the field laboratory, mosquitoes were anaesthetised, sorted, identified morphologically to species (Gillies & De Meillon, 1968; Gillies & Coetzee, 1987) and counted. Parity of female An. funestus and An. gambiae s.l. from a sample of unfed mosquitoes were determined using the conventional technique as described by Detinova (1962). The presence of malaria sporozoites in the salivary glands was determined by examining the salivary glands under microscope. A proportion of each catch of An. gambiae s.l. was kept dry on silica gel in 0.5ml polypropylene tubes for later genotyping using polymerase chain reaction (PCR) techniques.

An. gambiae s.l. molecular identification was carried out according to the standard PCR method (Scott et al., 1993). Five oligonucleotide primers, GA, ME, AR, QD and UN designed from the DNA sequences of the intergenic spacer region of complex ribosomal DNA (rDNA) were used to amplify species-specific DNA sequences. The UN-primer is universal and anneals to the same position on the rDNA sequences of all five species, the GA anneals specifically to Anopheles gambiae s.s., the ME anneals to either Anopheles merus or Anopheles melas, AR to Anopheles arabiensis and the QD to Anopheles quadriannulatus. The PCR reaction mix of 25 µl contained 1 X PCR buffer (constituents), 200 µM of each of the deoxyribonucleotide triphosphates (dNTPs), 20 µM of oligonucleotide primers, 0.125 units of Taq Polymerase enzyme (Sigma, USA) and 0.5 µl of the extracted genomic DNA. Sterile double distilled water was added to make up the volume to 25 µl. The reaction mix was spun down briefly at 14,000 rpm and overlaid with mineral oil to avoid evaporation and refluxing during thermo-cycling.

The amplification reactions were carried out using PTC 100 thermal cycler (MJ Research Inc., USA) and the cycling parameters were as follows: 3 minutes at 94°C (initial denaturation), followed by 35 cycles with denaturation at 94°C for 30 seconds, annealing at 50°C for 30 seconds and extension at 72°C for 60 seconds and ended with a final cycle at 94°C for 30 seconds, annealing at 50°C for 30s and extension at 72°C for 10 minutes. For each reaction, a positive control containing 0.5 µl of PCR products of An. gambiae s.s. as template DNA and a negative control that contained no DNA template were included.

The amplified products were analyzed by agarose gel electrophoresis. Ten micro-litres of each PCR product were added to 1µl of 10x Orange-G loading dye and electrophoresed in 2% agarose gel stained with 0.5 µg/ml of ethidium bromide. The electrophoresis was run in 1X Tris acetate-EDTA (TAE) buffer at 100V for one hour and were visualized and photographed over a UVP dual intensity trans-illuminator at short wavelength using a digital camera fitted with an orange filter and a hood. The amplified PCR product was identified to the sibling species on the basis of the diagnostic band size determined by comparison with the mobility of a standard 100bp DNA ladder (Sigma, USA).

Indices of malaria transmission and data analysis

Data were entered in Epi Info database version 6 (Centres for Disease Control and Prevention, Atlanta, GA, U.S.A) and then transferred to STATA version 6 statistical package (Stata Corp 2001) for further analysis. The parity rates were determined as the proportion of Anopheles found to be parous. The human biting rates were calculated as the number of Anopheles biting per person per night using the formula by Lines et al. (1991). Converting the trap catches to estimates of bites per person gave estimates of the human biting rate as:

Whereby HBR= VD x 1.5/trap

HBR= human biting rate

VD = total mosquito density from light trap catches per number of traps installed

Ethical consideration

The Medical Research Coordination Committee of the National Institute for Medical Research granted ethical clearance for the study. Permission to enter into houses was obtained from heads of the respective households after explaining the objective of the study.

Results

A total of 936 female mosquitoes were collected in 15 houses. Some 46.9% were malaria mosquitoes (Anopheles gambiae = 28.6%; Anopheles funestus = 18.3%). Culex quinquefasciatus accounted for 30.3% of the total population. Other mosquito species accounted for 22.8%. The largest proportion of the malaria mosquitoes (62.8%) was collected in Malui and the smallest proportion (2.3%) Twatwatwa (Table 1). A total of 148 (55% of total collections) morphologically identified An. gambiae s.l. were further subjected for PCR analysis for speciation and all of them were genotyped as An. arabiensis.

Table 1: Mosquito composition and abundance per village in Kilosa District

Village	Anopheles gambiae s.l.	Anopheles funestus	Culex quinquefasciatus	Other species	Total (%)
Kimamba	18	2	99	2	121 (12.9)
Malui	157	119	16	162	454 (48.5)
Tindiga	58	43	24	43	168 (17.9)
Mbwade	25	7	7	6	45 (4.8)
Twatwatwa	10	0	138	0	148 (15.8)
Total (%)	268 (28.6)	171 (18.3)	284 (30.3)	213 (22.8)	936

On average, 17.9 Anopheles mosquitoes were collected per village per day (Kimamba=3; Malui=26; Tindiga = 6; Mbwade= 3; Twatwatwa=1). Human biting rate for An. gambiae s.l. (26.8) was higher than that for An. funestus (17.1). On average an individual human received 43.9 Anopheles bites per night. The human biting rate per person per night for the two malaria mosquitoes was highest in Malui (46.0) and lowest in Twatwatwa (1.7) (Table 2).

Table 2: Number of Anopheles mosquitoes collected, mean per house and human biting rate (HBR) per person per night

Village	Anopheles gambiae			Anopheles funestus			An. gambiae+An. funestus		
	Total	Mean	HBR	Total collection	Mean	HBR	Total	Mean	HBR
Kimamba	18	2	3.0	2	0.2	0.3	20	2.2	3.3
Malui	157	17.4	26.2	119	13.2	19.8	276	30.7	46.0
Tindiga	58	6.4	9.7	43	4.8	7.2	101	11.2	16.8
Mbwade	25	2.8	4.2	7	0.8	1.2	32	3.6	5.3
Twatwatwa	10	1.1	1.7	0	0	0	10	1.1	1.7
Total (%)	268	17.9	26.8	171	11.4	17.1	439	29.3	43.9

The overall parity rate for An. gambiae s.l. and An. funestus were 72.1% and 42.6%, respectively (Table 3). A total of 62 and 54 An. gambiae s.l. and An. funestus, respectively, were examined for presence of malaria sporozoites by salivary gland microscopy. None of the mosquitoes was infected.

Table 3: Parity rates of Anopheles gambiae and An. funestus by village in Kilosa

Village	*Anopheles gambiae* s.l.		*An. funestus*	
	Total dissected	Parity (%)	Total dissected	Parity (%)
Kimamba	1	0/1	2	2/2
Malui	50	38/50	24	14/24
Mbwade	14	10/14	5	4/5

Tindiga	16	10/16	19	13/19
Twatwatwa	5	4/5	4	3/4
Total	86	62/86 (72.1%)	54	23/54 (42.6

Parity % = Number Parous/Total number dissected x100

Discussion

Both the abundance and house density of the anopheles mosquito in this study was low. However, malaria mosquito accounted for about half of the total mosquito caught host-seeking indoors. Some 58.6% of the malaria mosquitoes were collected from the two rice-farming villages. Two-thirds of the malaria mosquitoes were collected in Malui and the lowest number in Twatwatwa. The variation in the abundance of anopheles mosquitoes was observed between villages and between different ecosystems. Interestingly, Culex quinquefasciatus accounted for the largest proportion of mosquito species in the rural village of Twatwatwa. This is fast a growing villages and the large number of Cx quinquefasciatus is likely to be attributed by the large number of pit latrines in the village.

In the current study, small number of An. gambiae s.l. and An. funestus were collected although the trapping technique used have proved exceptionally useful for catching endophilic malaria vectors in Tanzania (Mboera et al., 1998). The observation that all samples of An. gambiae s.l. were genotyped as An. arabiensis conforms to the previous geographical distribution of An. gambiae sibling species across Tanzania (White 1974; Mnzava & Kilama 1986). On the other hand, the ongoing climatic changes across Africa favours the environmental variables which support very much the distribution of An. arabiensis which from historical perspectives exhibits greater ecological flexibility than other members of the An. gambiae complex.

The findings of the current study in Kilosa differ slightly with those reported in 2008 when malaria mosquitoes (An. gambiae and An. funestus) accounted for the lowest proportion (2.5%) of the indoor mosquitoes (Mboera et al., 2008). In the 2008 study, Culex quinquefasciatus accounted for 96.8% of the mosquito populations. The previous study involved villages of Peapea, Mbwade, Kivungu, Kigunga, Malangali and Tindiga (Mboera et al., 2008). While the current study was carried out during the peak rainy season (May 2012), the previous study was carried out during before the long rainy season (January 2008). The parity rates of the anopheles mosquitoes found in the current study were similar to those reported in the previous study (Mboera et al., 2008). In the previous study, the parity rate for An. gambiae was 61.3% whereas for An. funestus it was 40.9%. In both two studies, none of the anopheles mosquitoes was infected with malaria parasites.

Despite the low number and absence of sporozoite infected Anopheles mosquitoes in Kilosa district, malaria infection with varying prevalence was observed among schoolchildren during a survey carried out during the same period of time (Chapter 3). Malui and Tindinga

which had the largest proportions of malaria mosquitoes also had the highest prevalence of malaria infection. Previous studies have indicated a higher endemicity of malaria in the district (Eriksen et al., 2004; Makundi et al., 2006; Uddenfeldt Wort et al. 2006). Generally An. arabiensis and An. funestus are less susceptible to infection with Plasmodium species compared to An. gambiae s.s (White et al 1972; Magesa et al, 1991; Mboera & Magesa, 2001). Unlike other sibling species a blood seeking An. arabiensis has the ability for locating its hosts even in outdoors thereby dominating the outdoor malaria transmissions if human hosts spend more time outside their households (Govella & Ferguson 2012). Therefore there could be a possibility that most transmission in Kilosa district are by the outdoors host seeking mosquitoes (exophagic) which rest outdoor after feeding (exophilic).

On average an individual human received about 44 bites of malaria mosquito bite each night. Human biting rate per person per night for the two malaria mosquitoes was highest in among rice farming community than pastoral community. Despite the low number and absence of sporozoite infected Anopheles mosquitoes in Kilosa districts, malaria infection with varying prevalence was observed among school children (Chapter 3). Malui and Tindinga which had the largest proportions of malaria mosquitoes also had the highest malaria infection prevalence. Previous studies have indicated a higher endemicity of malaria in the district (Makundi et al., 2006; Uddenfeldt Wort et al., 2006). The low mosquito densities and absence of sporozoite in the current study is likely to be a result of high mosquito net coverage in the district (Chapter 6). A more intensive longitudinal study is recommended to establish malaria transmission intensity in the area.

Chapter 5: Anthropogenic drivers of ecosystem associated with malaria transmission in Kilosa District

Abstract: Malaria continues to be an important vector-borne disease and a leading cause of morbidity and mortality in Africa. Environmental changes, either natural or through human activities change the manner in which malaria vectors breed, develop and transmit diseases. The objective of this study was to assess the land use patterns and other anthropogenic activities associated with malaria mosquito productivity in Kilosa District in central Tanzania. Mosquito larvae and pupae were searched using a standard dipper in all potential mosquito breeding sites in Kimamba are of Kilosa District. Mosquito larvae and pupae were collected and identified to genus level. Heads of households were interviewed using a face-to-face questionnaire to explore their knowledge, perception and practices as regards to malaria mosquito productivity in their areas. A total of 211 potential anopheline mosquito breeding sites were identified. Bricks making, farming practices and various discarded containers were the major mosquito breeding sites. Man-made habitats accounted for 86.18% of all potential breeding sites. The majority (85.25%) of the man-made habitats were associated with livelihood practices. Brick making borrow pits accounted for 30% of all potential anopheles mosquito breeding sites. A total of 399 people (mean age= 39.7 years; SD=15.2) were interviewed. There was low knowledge among the community on potential mosquito breeding sites. Only 1.5% and 0.25% knew that farming systems and other human activities, respectively, were contributing to mosquito productivity in their village. In conclusion, human activities are responsible for the majority of potential mosquito breeding sites in the study area. Inter-sectoral efforts are required to mitigate human activities that are responsible for increasing mosquito productivity in order to reduce malaria transmission. In addition, appropriate public education on environmental management is required in controlling mosquito productivity.

Keywords: malaria, anthropogenic factors, livelihoods, mosquito productivity, Tanzania

Introduction

It has been documented that since about 250 BC, human modification of African environments has created increasingly favourable breeding conditions for Anopheles gambiae (Mac Cormack, 1984). Natural and man-made environmental changes affect the way in which mosquitoes develop and transmit disease (Imbahale, 2009). Land-use changes and deforestation, human settlement, commercial development, construction of houses and roads, water control systems (dams, canals, irrigation schemes) are known to lead to the creation of conducive breeding grounds for malaria vectors (Hunter et al., 1982; Khaemba et al., 1994; Patz et al., 2000; Norris, 2004; Imbahale, 2009). Land use including agricultural changes create numerous water bodies exposed to the sun, providing ideal conditions for mosquito proliferation and increased malaria transmission (Lindblade et al., 2002; Briet et al., 2003).

The increased agricultural activities due to high demand for food caused by growing population have resulted into expansion of malaria areas in several African countries (Lepers et al., 2005; Imbahale, 2009) including Tanzania (Ijumba et al., 2001; Mboera et al., 2007, 2009, 2010, 2011). Agricultural water resource development, deforestation due to agriculture, logging, and fuel wood, wetland cultivation, creation of urban market gardens, and land-use changes for agricultural purposes expand habitats for malaria vectors (Keiser et al., 2005; Patz et al., 2004; Yasuoka & Levins, 2007; Imbahale, 2009). In many parts of East Africa, increased population pressure has led to changing land use practices, such as the clearance of natural swamps, massive deforestation and cultivation of crops in the valley bottoms (Minakawa et al., 2002; 2005; Munga et al., 2006; Imbahale, 2009). In Uganda, replacement of natural swamp vegetation with agricultural crops led to increased temperatures, which may be responsible for elevated malaria transmission risk in cultivated areas (Lindblade et al., 2000). In a study in western Kenya, man-made larval habitats accounted for the majority of the source of malaria vectors during the dry season (Carlon et al., 2004; Imbahale, 2009).

Much of the malaria is therefore, man-made where the breeding habitats of vector mosquitoes are created through human activities. Forest clearance for cultivation has been associated with invasion of malaria vectors such as Anopheles gambiae s.s. (Walsh et al., 1993; Martens, 1998; Molyneux, 1998; Patz et al., 2000; Grillet, 2000). In Uganda clearance of papyrus swamps at the bottom of highland valleys has created suitable conditions for An. gambiae and An. funestus (Steyn, 1946). Anthropogenic factors are responsible for altering malaria transmission dynamics by increasing the emergence of efficient vectors and by increasing contact between man and vector (Deressa et al., 2006; Imbahale, 2009).

Human activities associated with settlement, agriculture, or other environmental alterations, including road or dam construction have been described to create favourable larval habitats for malaria mosquitoes (Kitron & Spielman, 1989). However, in Tanzania, very little is known about anthropogenic activities that contribute highly to mosquito productivity. It is therefore not surprising that the main malaria vector control is exclusively targeting adult mosquitoes and dependent on use of insecticide treated nets and indoor residual spraying. It is important to identify habitats that produce adult vectors and contribute to malaria transmission in a specific area and during specific period of the year. One additional mosquito control would be through larval source management as mosquitoes spend a proportion of their life in the aquatic state. By identifying habitats that generate adult vectors larval source management might be targeted at these sites (Gu & Novak, 2005; Mutuku et al., 2006). The objectives of this study were to assess land use patterns and other anthropogenic activities associated with malaria mosquito productivity and determine community knowledge, and practice that play a role on malaria transmissions in Kilosa District of central Tanzania.

Materials and Methods

Study area

The study was carried out in Kilosa District (5°55' -7°53' S; 36°30' - 37°30 E), located in central Tanzania about 300km west of Dar es Salaam, and about 70km from Morogoro

town. The district has a total surface area of about 14,400 km2 and a population of 489,513 people living in 105,635 households with an average household size of 4.6 people (District socio-economic profile, 2010). Kimamba is located at about 21 km from Kilosa District capital and 59 km from Morogoro Regional capital. The village has a total population of 7810 whereby 4102 are women and 3708 are men (Village Government Report, 2010). Large part of Kimamba village is occupied by sisal plantations.

Kimamba is in the lowland and flatland area characterized by few valleys and hills. The vegetation cover consists of bushes, short grasses and scattered trees. The inhabitants cultivate mainly maize and rice. The area is characterized by large sisal estates (Skutali, Mauzi) and New Kimamba Fibres Estate. Only a small proportion is left for settlement and house construction. Hiring of land for crop production such as maize and rice is common. A number of inhabitants are employees and labourers in the sisal estates.

Mapping of study areas

The locations of the land use patterns and sub-villages were geo-referenced using a hand held Global Positioning System (GPS) receiver. The coordinates (latitudes, longitudes, altitudes) of the variables were imported into GIS databases in which they were converted into a point map by ArcGIS software. The study area was confined into Kimamba "A" and "B" with five sub-villages namely Posta, Uhindini, Skutali, Mkwajuni and Sokomsuya (Figure 1).

All sites with standing water within Kimamba were evaluated by standard dipping for presence of Anopheles mosquito larvae. The study was carried out in November 2011 before the beginning of the short rainy season which normally starts in November through December followed by long rains from mid-February through April.Standing water bodies were identified with the assistance of community members who were asked to search and identify all existing mosquito breeding sites in their respective villages. The villages were divided into five zones according to number of sub-villages and the number and diversity of mosquito breeding sites. Once identified, habitats were evaluated for presence of mosquito larvae using standard dippers. Dipping was performed around the perimeter of the habitat, with three dips performed at approximately one meter intervals.

All aquatic habitats were mapped in the study areas. These habitats were grouped per habitat type as natural water bodies, man-made water bodies, puddles, open drains and burrow pits. Puddles were temporary collections of water in the valley bottoms that formed after rainfall; open drains were open narrow drainages connecting to the main stream or disconnected ditches to lower water table and burrow pits were excavations intentionally made by people to meet a specific purpose like brick/sand-pits. Habitats were sampled daily from 07:00hr to 10:00hr. Contents collected in the dipper were emptied on a white tray to enhance visibility and counting of the sampled organisms. Immature mosquitoes were counted separately for early (1st and 2nd) and late (3rd and 4th) instars larvae of culicines and anophelines, and pupae (all species combined since they cannot be identified morphologically in the field). The following information was collected and recorded for each

habitat at the time of sampling: (i) study site name; (ii) presence or absence of water; (iii) length and width (cm) of water surface sampled; (iv) water depth; (v) water flow (slow, fast or stagnant).

Study subjects and sample collection

Heads of household (men and women) were selected for interview. Purposive sampling was employed in selecting key informants while random sampling was used to select the head of households from all sub-villages within the study area. Face-to-face interviews were conducted to eight key informants including district and village government officials, and key persons. These interviews assessed malaria knowledge, prevention, and treatment, land use, anthropogenic activities, and environmental management for malaria control. Key informants including civil servants, workers with non-governmental organization, and religious leaders were also interviewed.

Data analysis

Data was entered and processed using STATA software version 10 and MS Excel. The results are presented in terms of tables, graphs, and percentages. The abundance of immature mosquito stages was calculated as the number of individuals per square meter per habitat.

Ethical considerations

This study received an ethical clearance from the Medical Research Coordinating Committee of the National Institute for Medical Research. The objectives, methods and benefits of the study were explained to villagers through their village leaders. Before any larval sampling was initiated, verbal consent to access compounds and farms was obtained from both administrative officials and residents during local village meetings in all study sites. All interviewee provided informed verbal consent before the interview.

Results

Diversity of mosquito breeding sites in Kimamba village

The most common mosquito breeding sites were brick making pools (29.9%), wells (10.9%), broken pots (10.4%) and hoof prints (10.4%) (Table 1). Over a quarter (28.04%) of the wet mosquito breeding sites identified contained immature mosquitoes stages. There were variations in the type and number of breeding sites in the study area (Table 1). Most (83) of the potential breeding sites were identified in Skutali sub-village. Only a few (4) potential mosquito breeding sites were identified in Sokomsuya. Of a total 211 potential breeding sites, a total of 82 (38.9%) had water and 129 (61.1%) were wet.

Table 1: Types of mosquito breeding sites by sub-village in Kimamba

Habitat type	Total	%
Bricks making pools	63	29.85
Wells	23	10.9
Broken pots	22	10.4
Hoof prints	22	10.4
Tins	19	9.0
Coconut shells	17	8.1
Ditches	12	5.7
Broken buckets	7	3.3
Water containers	7	3.3
Broken Drums	4	1.9
Tyre marks	4	1.9
Concrete holes	4	1.9
Tyres	2	0.9
Banana leaves	2	0.9
Swamps, Streams, Water hole	3	1.5
Total	**211**	**100**

Of the 211 breeding sites, 201 (95.3%) were man-made. Of these, 77.7% were linked to livelihood practices such as farming, business and house construction. Of the breeding sites associated with livelihoods, 6 (3.7%) were linked to farm activities while 78 (47.6%) to house construction. The remaining proportion was linked to other livelihoods activities.

Plate 1: Man-made ditch (A) and mosquito pupae collected from the ditch (B)

Socio-demographic characteristics

A total of 399 heads of household were interviewed, of these, 74.2% were females and 25.8% were males. The mean age was 39.7 (SD= 15.2) years. Majority (50.1%) of the

respondents were aged 18-35 years, followed by 36-55 years (30.8%) and the remaining (>56 years) accounted for 19.1% of the respondents. About one-third (32.3%) of the respondents were illiterate. The main economic activity carried by the vast majority of the respondents (91.2%) was crop production. Married respondents accounted for 69.9% of the individuals interviewed (Table 3).

Table 3: Socio-demographic characteristics of respondents in Kimamba village

Variable	Response	No. Respondents	% respondents
Marital status	Single	41	10.3
	Married	279	69.9
	Widow/widower	35	8.8
	Divorced/separated	28	7.0
	Living together	16	4.0
Level of education	None	129	32.3
	Primary	249	62.4
	Secondary	19	4.8
	Post secondary	2	0.5
Main occupation	Crop production	364	91.2
	Pastoralism	1	0.3
	Mixed farming	1	0.3
	Business	15	3.8
	Employee	5	1.3
	Other*	13	3.3

Others* = housewife, mechanic, carpenter, food vendor, technician

Land use patterns

A total of 113 (28.3%) of the respondents reported to own land. Over two-thirds of the respondents (71.7%) had no land of their own. The largest proportion of land in Kimamba was under large-scale sisal estates with only a small percentage left for settlement and peasantry activities (Figure 2).

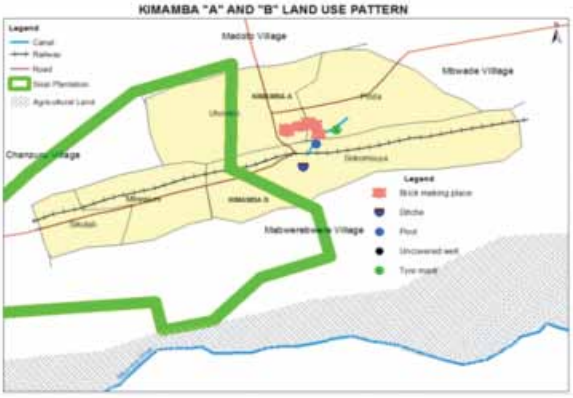

Figure 2: Distribution of types of land use in Kimamba

Agriculture was the main economic activity and most of people were involved in food crop production. The major food crops grown in the area were rice, maize, beans, cassava and bananas. The majority (97.5%) of the respondents were engaged in crop production of maize and rice, mostly outside the study village. Only a small proportion (1.25%) of the respondents was engaged in livestock keeping. Brick making for commercial purposes and house construction were the occupation for 0.5% of the respondents (Plate 1).

Plate 1: Brick making (A) and brick making hollows within a house compound (B)

Assessment of the houses showed that houses were poorly built, some unfinished and with wide eaves. Size of houses in Kimamba villages was observed to vary from large (23.6%), medium (44.4%) and small (32.1%). Most of them had walls made of poles and mud (7.0%), sun-dried bricks (5.8%), baked bricks (53.1%), concrete bricks (15.1%) and other materials (18.65%). The floors of the houses were made of cement (41.6%), dust (57.4%), tiles (0.50%), wood (0.3%) and concrete (0.3%). There were houses with no windows (27.8%), without shutters (12.0%), window with wooden shutters (10.5%), with glass shutters (0.50%), with mosquito gauze (38.9%), window with mosquito gauze and shutters (5.5%) and others (4.8%). Most of the houses had roofs made of iron sheets (88.2%), mud (1.8%) grasses (9.5%) and others (0.5%).

It was observed that farms in Kimamba were located far away from the households (4-18km). Less than half (42.9%; N=171) of the respondents reported to wake up at 5am for various activities including farming and businesses. Some of the respondents tend to stay overnight in their farms – mainly to reduce travel times to and from farms (16.3%), protecting crops from grazing domestic (10.0%), wild animals (11.0%) or vermin (9.8%). The proportion of those who stayed in the farm overnight differed between activities (farm preparation =7.5%; planting =8.1%; weeding =13.2%; harvesting =51.2%). The majority of the respondents (77.7%) claimed to take mosquito nets to the farm to protect themselves against mosquito bites.

Table 4: Respondent's opinion on factors that influence mosquito productivity and malaria seasons

Variable	Responses	No. of respondents	% of respondents
Factors influencing the presence of mosquitoes	Amount of rainfall	143	35.84
	Amount of stagnant water	231	57.89
	Farming method	6	1.5
	Unclean environment	171	42.86
	Temperature	45	11.28
	Humidity	8	2.01
	Other	87	21.8
	Do not know	5	1.25
Mosquito breeding areas	Stagnant water	231	57.89
	Plant with large leaves/sisal	29	7.07
	Bushes	30	7.51
	Other	4	1
Season with high incidence of malaria	Long rains	259	64.91
	Short rains	34	8.52
	Dry season	69	17.29
	Throughout	21	5.26
	Do not know	16	4.01

The presence of mosquitoes around household described to be influenced by various factors including amount of rains (35.8%), amount of stagnant water (57.9%) and unclean environment (42.9%). Other factors included temperature, humidity and farming methods. The majority (85.2%) of the respondents agreed that reducing mosquito population could help reduce malaria. A few (10.3%) did not agree while 4.5% did not know. Human activities that were mostly associated with mosquito productivity were agricultural practices (72.6%), bricks making (27.7%) and unclean environment (8.8%). Agricultural practices such as vegetable gardening, maize cultivation, rice cultivation and irrigation were mentioned as the main practices associated with mosquito productivity. Two thirds (64.9%) of the respondents mentioned that most people get malaria more frequently during the long rains. Only 17.3% of the respondents mentioned dry season to be the season when most people suffer from malaria. Other responses were short rains (8.5%) and throughout a year (5.3%). Some 4.0% respondents could not associate any season with most malaria incidences. While knowledge that link between mosquitoes and malaria was relatively high among respondents, knowledge related specifically to mosquito ecology and breeding sites was generally lower. A total of 231 (57.9%) of respondents mentioned stagnant water as the main breeding sites. Others mentioned tall grasses/sisal (7.1%) and bushes (7.5%) (Table 4).

Discussion

Land is a basic natural resource for economic development and a platform for various socio-economic activities including agriculture, water control systems and house and road construction. Land-use is a critical factor in natural and human-managed production systems, influencing the level of natural capital, social and economic development. The effects of land use change by humans have long been recognized as a factor in the exacerbation of water related diseases (Hunter et al., 1994). Changes in land-use can be placed onto several broad and overlapping categories including water retention systems, deforestation, agricultural development, canal irrigation and urbanization. In addition to these alterations human behavior associated with landscape modifications may contribute significantly to vector and disease transmission (Douglas, 2004).

The results of this study indicate that rural communities in Kimamba have low knowledge on mosquito productivity and that potential mosquito breeding habitats are poorly known by the community. Human interaction, modification and manipulation of environment is poorly associated with creation of mosquito breeding sites. However, about three quarters of the respondents could associate agricultural activities with high malaria transmission. Infact, human activities, including agriculture, was recognized as one of the reasons for increased incidence of malaria in the area. Despite the fact that brick making was contributing to about a third of the potential mosquito breeding sites, only a few respondents could associate brick making with malaria transmission. This was also true with discarded water containers, broken ports, coconut shells and broken buckets.

Studies elsewhere in Tanzania have shown that ther is a direct association between agricultural practices and malaria (Ijumba et al., 2001; Mboera et al., 2009, 2010, 2011). The influence of agricultural systems on health is particularly notable via the intermediary process of environmental change. Agricultural production systems including farming practices, type of crop, location of farms, and farming technologies are likely to result into environmental changes that create suitable ecological conditions for the breeding and survival of the anopheline mosquitoes (Asenso-Okyere et al., 2009).

With the current deforestation in many places in Tanzania, brick-making is becoming an important alternative material in house construction. It is also becoming an important economic activity for a number of communities in many areas of the country. Brick making result in the increase of borrow pits that support mosquito breeding. Like in Kimamba, it has been observed in Kenya that brick making is predominantly a dry season activity (Carlson et al., 2004). The stages used in the brick making process are excavations, fermentation, moulding, drying and kilning. During the moulding stage, water is brought into the brick pits and mixed with soil. Once the pits are abandoned during after kilning stage, the pit accumulates rain water and ground water thus, providing potential mosquito breeding sites. Since brick-making is done mostly during the dry season, it may aid in maintaining mosquito populations year round (Carlson et al., 2004). Land use and human modification of the natural environment continues to create habitats in which mosquitoes thrive if unabated with an enormous potential to negatively affect public health (Douglas, 2004). Contemporary

deforestation appears to be associated with the expansion of mosquito distributions and the increase in malaria transmission (Douglas, 2004).

Malaria control through environmental management is hampered by the community' poor knowledge on the mosquito ecology and livelihood activities which creates mosquito breeding grounds. Like in our current study, a study in western Kenya showed that only a few respondents recognised that the major breeding sites for malaria mosquitoes were those that they create themselves in their immediate vicinity (Imbahale, 2009). Similar to the findnigs in western Kenya, communities in Kimamba had knowledge that elimination of stagnant water is an important malaria control tool. However, there were no activities geared towards implementation of larval source management. In this regards, it is important to strengthen public health education, appropriate environmental management and agricultural practices to minimize mosquito productivity. It is important that environmental management including installing and maintaining drains, removing pools of stagnant water, managing vegetation, intermittent irrigation, and altering rivers to create more fast flowing water (Keiser ***et al*** 2005) should be emphasised.

Environmental management as a strategy in malaria control has received little attention in Tanzania. The World Health Organization defines environmental management as the planning, organisation, carrying out and monitoring of activities for the modification and/or manipulation of environmental factors or their interaction with man with a view to preventing or minimizing vector propagation and reducing man-vector pathogens (WHO, 2002). Despite of being safe to humans, it is environmentally sound, relatively cost-effective, locally available and sustainable in comparison to chemical tools. Studies in Ethiopia have already shown that reduction of mosquito breeding grounds through environmental management significantly reduce mosquito abundance (Yohannes et al., 2005). Environmental modification aims to create a permanent or long-lasting effect on land, water or vegetation to reduce vector habitat. Environmental management in the control of malaria mosquito has been successfully implemented in large scale interventions in Zambia and elsewhere (see Utzinger et al., 2000). In Zambia, for example, draining wetlands by the creation of ditches or drains, land levelling, filling depressions or covering water tanks and stagnant water were among the approaches applied to prevent, eliminate or reduce the vector habitat (PAN, 2010).

In a recent systematic review, Tusting et al. (2013) have shown that larval source management (LSM) – a control method that targets mosquito larvae and pupae as they mature in standing water could be an important supplementary measure in the fight against malaria. LSM is a method that targets immature mosquitoes, found in standing water, before the females develop into flying adults that are capable of transmitting malaria. This is done by permanently removing standing water, for example by draining or filling land; making temporary changes to mosquito habitats to disrupt breeding, for example by clearing drains to make the water flow; or larviciding using either chemicals or biological larvicides to standing water to kill larvae. The potential breeding sites observed in Kimamba are mostly confined to specific areas and LSM could therefore be particularly effective even

in rural areas with obvious breeding sites like small streams or swamps, abandoned brick making pits, streams and irrigation ditches where mosquitoes breed.

The findings of current study indicate that economic development programmes designed to improve health may simply contribute to increased malaria transmission. A research and development strategy to promote sustainable health must therefore incorporate multiple scales, multiple perspectives, and high degrees of uncertainty (Waltner-Toews, 2001). An ecosystem approach is therefore important to address complex health problem such as malaria while maintaining a health environment. The key to disease control is developing an understanding of the contribution of human landscape modification to malaria transmission and how a balance may be achieved between human development, public health, and responsible land use. For this to be effective, an inter-sectoral approach is an important step to consider.

In conclusion, the findings from this study show that the productivity of malaria vectors from different habitat types are highly heterogeneous and that man-made breeding sites outweigh natural breeding sites. With foresight and planning, most of these systems can be appropriately managed to control mosquito populations and malaria transmission. Therefore, we recommend the need to strengthen public health education, community empowerment and appropriate environmental management to minimize mosquito productivity in the area.

Chapter 6: Knowledge, practices and social determinants of malaria among crop farmers and pastoralists in Kilosa district Tanzania

Abstract: Malaria has remained an important public health problem in Africa. The success of malaria control programmes rely heavily on community perceptions and practices as regards to transmission, treatment and prevention. The objective of this study was to determine knowledge, practices and social determinants of malaria among rural farming communities of Kilosa District in central Tanzania. The study was carried out during May 2012 and involved villages of Tindiga, Malui (rice farming community), Mbwade and Twatwatwa (pastoral community). In each village, heads of households were interviewed using a structured questionnaire. A total of 471 households were interviewed. Overall, less than a quarter (23.5%) of the respondents had high knowledge on malaria disease and its control. Over half (56%) of the respondents could not associate any livelihood practice and mosquito productivity or malaria transmission. However, rice farming community associated crop irrigation and mosquito productivity than the pastoral community. Of the 2606 individuals recorded in the households, 702 (26.94%) were reported to have had fever in the previous three months. Fever cases were significantly higher in households headed by non-educated respondents (31.2%) than in educated ones (21.5%). Women experienced significantly more episodes of fever than men (p-<0.001). A larger proportion (56.4%) of cases of fever was reported to last for more than 3 days. Crop farming communities claimed to experience longer periods of fever illness than the pastoral communities (p=0.051). The duration of illness among women was shorter than among men (p=0.04). More than three quarters (79%) of the respondents believed that the fever was due to malaria. The proportion of those who mentioned that the fever was due to malaria was significantly higher among the pastoral community (81.7%) than among the crop farming community (76.1%) (p=0.038). Among those mentioned to have experienced fever, 30% were diagnosed with their blood sample taken and most of the diagnoses were done at the health facilities (96.2%). Non-educated individuals reported to be diagnosed and treated more at health facilities than the educated ones. Seeking of treatment for fever significantly differed between crop community and pastoral community (p=0.051). Smaller households were frequently seeking care for cases of fever/malaria than larger households. Blood test for malaria parasite confirmation was frequently done by those with joint pains (p <0.01). More than 82% of the respondents used medication to treat fever. Only 37.5% of the respondents used medication within 24hrs from the onset of fever. The most common antimalarial drug used by the respondents was artemether-lumefantrine (ALu) (61.3%). More than 56% of the respondents reported availability of antimalarial drugs in the facilities during their visits. Over half (54%) of the respondents were satisfied with the service provided at the nearest health facility. In conclusion, malaria knowledge is low among farming community of central Tanzania. Appropriate public health promotion should be designed to show the links of livelihoods and malaria transmission among rural communities.

Keywords: malaria, farming community, knowledge, practice, livelihood, Tanzania

Introduction

Malaria has remained an important public health problem in Africa. It is still a number one killer disease despite several interventions being in place. A recent analysis of health facility data from 2004 to 2011 has shown that the percentage of outpatient with malaria in Tanzania ranged between 16.8% and 37.2% during the past 8 years. During the same period, the percentage of OPD among those aged 5 years and above ranged from 19.3% to 30.5%. The incidence of malaria per 1000 population ranged between 322 (2004) and 243 (2007) indicating only a slight decline from 2009 to 2011 (Mboera et al., 2013). Malaria is still a major public health problem in Tanzania because of a number of reasons related to the socio-economic, environmental and health system factors. In addition, drug and insecticide resistances remain to be among the main reasons for the increased intensity of malaria in Sub-Saharan Africa. Other factors such as climate change, changes in land use and migration of non immune people (Deressa et al., 2005) contribute to occurrence of malaria. It has been documented that malaria costs Africa more than US$12 billion annually, and it might have attributed to slow progress in economic growth in African countries approximately by 1.3% per year (Roll Back Malaria 2003). It has been previously documented that morbidity and mortality resulted to malaria contribute to vicious cycle of ill health and poverty (WHO/UNICEF, 2005).

The success of any malaria control programme depends heavily on community perceptions and practices as regards to malaria transmission, treatment and prevention. Cultural beliefs or inappropriate behaviour and practices can interfere with the effectiveness of control measures. These beliefs and practices often lead to self-care, home remedies and consultation with traditional healers in rural communities (Nyamongo, 2002; Shayo et al., 2003). In such cases, an understanding of the community's knowledge and practices regarding malaria is crucial to the success of specific control measures (Deressa et al., 2005; Mboera et al., 2009). Evidence suggests that malaria treatment and control choices are affected by knowledge of the problem (Nyamongo, 2002; Karanja et al., 2002; Legesse & Deressam 2009). The success in implementing preventive interventions is thus likely to be determined in part by awareness of malaria and the strategies available to prevent it.

Many studies have clearly documented that lack of community awareness on malaria could contribute to the spread of the disease, hinder control strategies and increase risk of exposure to the disease (Collins et al., 1997; Deressa et al., 2005; Legesse & Deressa, 2009). However, it has been shown that household responses to illness are influenced by socio-economic and cultural factors including beliefs about causes and effective cure (Kleinman, 1980; Molyneux et al., 1999; Hetzel et al., 2007) as well as easiness to access health care sources (Kloo et al., 1987; Mburu et al., 1987; Glik et al., 1989).

Access to a primary health care facility is described as a basic social right. It is important to note that improving service provision, strategic policy formation in health care system should be based on information relating to health promoting, seeking and utilization behaviour and

the factors determining such behaviours. Such behaviours occur within some institutional structure such as family, community or the health care services (Kroeger, 1983; Shaikh & Hatcher, 2007).

Most of the communicable diseases, including malaria, are related to socio-economic and behavioural factors. Distribution of these determinants among population influences individual and group differences in health status *(http://www.who.int/social_determinants/en/)*. They include risk factors present in one's living and working conditions, rather than individual factors that influence the risk for a *disease*, or vulnerability to disease. These factors must therefore be established or strengthened, well understood and incorporated into the design and implementation of disease control programmes to improve public health. There are few studies in Tanzania that have documented on the community knowledge and practices on malaria in relation to livelihoods (Mboera et al., 2009). This study therefore was carried out to determine knowledge, practices and social determinants of malaria in relation to livelihoods among rural farming communities of Kilosa District in central Tanzania.

Materials and Methods

Study area

The study was carried out in Kilosa District ($22^0$17'-$32^0$49'E and $9^0$127'-$9^0$3339'N) in central Tanzania, situated at about 300km west of Dar es Salaam. The district has a total surface area of about 14,400 km^2 and a population of 438,175 people (male=218,378; female=219,797) living in 105,635 households with an average household size of 4.2 people. The climate belongs to the tropical savannah of the low latitude environment. The rainfall has a characteristic monomodal pattern; the rains begin in October with a peak in April and continue till May. The mean annual temperature is 25^{o}C (maximum=30^{o}C; minimum= 19^{o}C). Agriculture is the main activity of most people in the district and is characterized by predominance of smallholder and estate farms. The main crops under rain fed agriculture are maize, rice, sorghum, beans, cassava, sweet potatoes, cotton, sunflower, sesame and sisal. Rice is the most important crop grown and marketed food crop under irrigation. Livestock keeping and brick making were also dominant livelihoods in specific parts of the district. Two wards were selected for the study; one with rice farming as the main economic activity and the other ward with pastoralism as the main livelihood activity. Villages were then selected randomly from the two wards which include Mbwade and Twatwatwa (pastoral community), and Malui and Tindiga (rice farming community).

Study design and population

This cross-sectional study was carried out during May 2012 and involved heads of households. The required sample for individuals to be involved in the study was determined using WHO Sample Size Determination in Health Studies (Lwanga & Lemeshow, 1991) assuming 50% anticipated population proportion with malaria knowledge, a 95% confidence interval and a 5% relative precision. To account for drop up within households during the survey, 10% of the calculated sample size was added to get approximately 1,686 individuals to be sampled. With household size of 4.2 that makes on average 402 household to be visited. Taking household refusal rate of 15% total households sample

obtained was 461.

Data collection

The heads of the households were interviewed using a structured questionnaire, alternating between males and females to maintain gender balance. Other information sought includes demographic characteristics, knowledge, and practices on malaria and its preventions. The tool assessed care seeking behaviour on fever cases occurred three months prior the surveys. Knowledge on the linkage between malaria and livelihoods factors was also explored.

Data analysis

Data was analyzed using STATA V11 (Stata Corps). Simple statistics, including percentages and means were calculated. Two-sample test of proportions, Chi-square test and Cuzick's test of trend were used to test association between variables. Using Multiple Corresponding analysis (MCA) and considering criteria set on different knowledge indicators, a variable to define knowledge level with respect to malaria was created with three categories (high, medium and low). Each indicator was given a score of -1, 0 or 1depending on the criteria set. These include participant's knowledge on transmission of malaria, factors that increase mosquito population, strategies (local and national) to reduce mosquito population, potential mosquito breeding sites, malaria signs and symptoms, malaria season, agricultural practice and malaria prevention and control.

Ethical consideration

The study obtained ethical clearance from the Medical Research Coordinating Committee of the National Institute for Medical Research. Permission to conduct the study was sought from regional and district authorities. Oral informed consent was sought from the respondents after the objective of the study had been explained. Privacy and confidentiality was maintained throughout the study. The respondents were assured of their right to withdraw from the discussion at any time they would wish during the interview.

Results

Demographic characteristics

A total of 471 heads of households (38.85% males and 61.15% females) were interviewed. Only 43.3% of the respondents had primary school education (Table 1). Majority of the responded had no formal education (55.84%). The major economic activities of the respondents were crop farming (53.48%) and livestock keeping (35.87%).

Table 1: Socio-demographic characteristics N (%) of respondents at Household Level in Kilosa

Variable		Tindiga	Malui	Mbwade	Twatwatwa	Total
Sex	Female	78 (70.91)	73 (55.73)	60 (66.67)	77 (55)	288 (61.15)
	Male	32 (29.09)	58 (44.27)	30 (33.33)	63 (45)	183 (38.85)
Mean age in years (SD)*	Female	35.2 (14.5)	36.7 (14.1)	37.8 (17.3)	35.8 (15.8)	36.3 (15.3)
	Male	38.6 (16.6)	44.4 (17.6)	46.7 (14.7)	43.1 (15.5)	43.3 (16.4)
Education level	None	64 (58.18)	70 (53.44)	73 (81.11)	56 (40)	263 (55.84)
	Primary	42 (38.18)	58 (44.3)	17 (18.89)	82 (58.56)	199 (43.3)
	Secondary+	4 (3.64)	3 (2.29)	0 (0)	2 (1.43)	9 (1.91)
Main economic activity	Crop cultivation	50 (45.45)	79 (62.2)	27 (30.68)	90 (66.67)	246 (53.48)
	Livestock keeping	47 (42.73)	35 (27.56)	47 (53.41)	36 (26.67)	165 (35.87)
	Mixed farming	6 (5.45)	7 (5.51)	14 (15.91)	3 (2.22)	30 (6.52)
	Others	7 (6.37)	10 (4.73)	2 (0)	11 (4.44)	30 (4.13)
	Total	**110 (23.35)**	**131 (27.81)**	**90 (19.11)**	**140 (29.72)**	**471**

* Mean age and Standard deviation (SD)

Knowledge on malaria

The study observed that a households had an average size of 7 individuals (min = 1, max = 16, SD=3). Mbwade showed higher family size (8 persons) compared to other villages. Mean age of surveyed individuals was 20 years (SD=18) and covered from very young children (<1year) to individuals of about 78 years. The proportion of those with higher knowledge on malaria was low in all four villages (Figure 1). On average, only less than a quarter (23.5%) of the respondents had higher knowledge. About 31% had low knowledge on malaria with 45.6% having medium knowledge respectively (Figure 2). The majority of respondents in Mbwade village (74%) had medium knowledge (Figure 2). However, assessing specific knowledge indicators it was observed that majority (90%) of the respondents knew that malaria was transmitted through a mosquito bite and that fever (70%) was the most common symptom of malaria.

Variation of knowledge was significantly observed between villages within the same farming/ livelihood system. Twatwatwa had the highest level as compared to Mbwade, similarly for Tindiga vs. Malui which is direct related to the prevalence and risk of malaria infection observed in these areas (Chapter 3). Levels of knowledge were significantly associated with education level and presence of health facility (Figure 1).

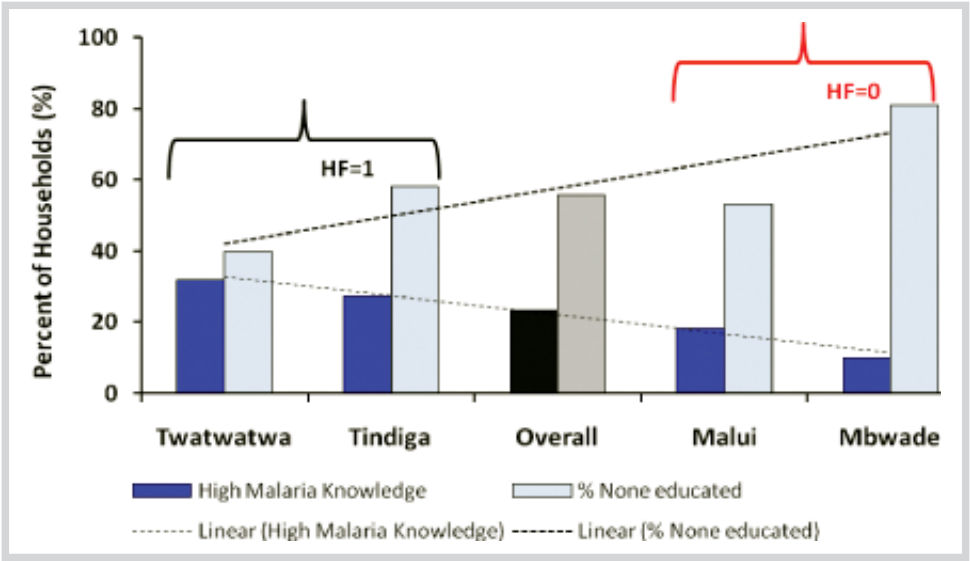

Figure 1: Proportion of households with high knowledge on malaria plotted against those with none educated individual in Kilosa. The presence of health facility and trend lines showing the slope and difference between the two attributes are also indicated.

A larger proportion (56%) of the respondents could not associate any farming practice and mosquito productivity or malaria transmission. However, respondents in Tindiga and Malui associated crop irrigation and mosquito productivity than those in Mbwade and Twatwatwa. Livestock keepers were believed to be attacked/bitten by mosquitoes more (54.2%) than crop farmers (32.4). More than 70% mentioned to stay out between 6 to 10 pm, while only 7.7% were staying out between 10pm to 2am and lastly about 3% stayed out between 2am to 6am. Major sources of health information included health workers (47.2%), community leaders (11%), district or government officials (5.3%) and radio (5.1%). These proportions were very similar for specific education such that malaria. Preferences of how to provide health education to the communities included use of community health workers (19.2%), health workers from HFs (19%), radio (18.4%), public meetings (13.1%) and lastly option was elected/trusted person from the community (9.3%).

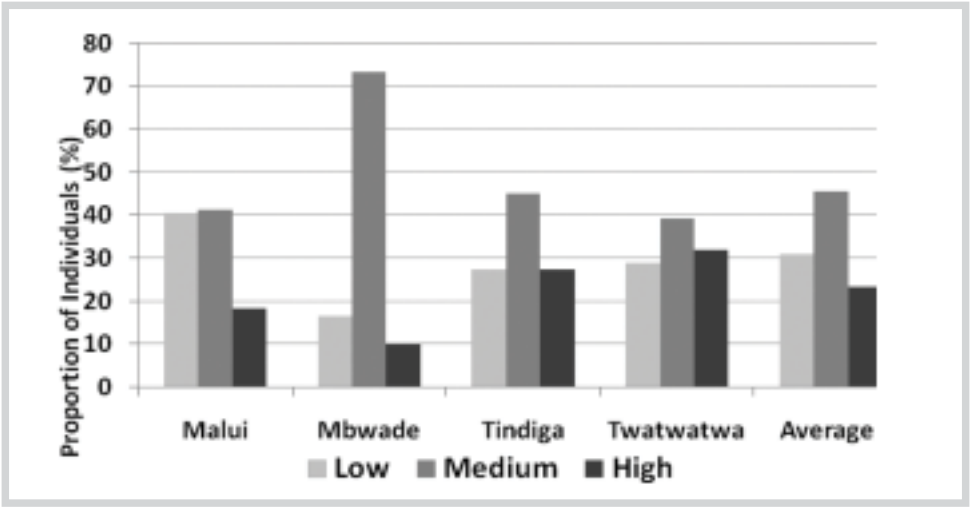

Figure 2: Knowledge of the respondents classified s low, medium and high

History of fever during the previous three months

Of the 2606 individuals recorded in the households, 702 (26.94%) were reported to have had fever in the past three months (Table 2; Figure 2). Among those with fever 56.5% were females. Fever cases were significantly higher in non-educated individuals (31.2%) than in educated ones (21.5%). Women were reported to experience significantly more episodes of fever than men (p-value<0.001). Presence of fever was inversely proportion to increase in age. Young children were reported to have experience frequent cases of fever than their older counterparts. The frequency of fever was reported more among pastoral communities (p <0.01).

Table 2: Number (proportion) of individuals by frequency of fever episodes

No. fever episodes	Malui	Tindiga	Mbwade	Twatwatwa	Overall
Once	106 (71.6)	96 (51.3)	70 (38.5)	92 (55.4)	364 (53.3)
Twice	21 (14.2)	53 (28.3)	39 (21.4)	33 (20.0)	146 (21.4)
Three	9 (6.1)	14 (7.5)	20 (11.0)	8 (4.8)	51 (7.5)
> 3	12 (8.1)	24 (12.8)	53 (29.1)	33 (19.8)	122 (17.9)

About 18.3% of individuals had their fever cases lasted for about three days. However, most (56.4%) cases of fever were reported to last for more than 3 days. Crop farming communities claimed to experience longer periods of fever illness than the pastoral communities (p-value=0.051). It was reported that the duration of illness among women was slightly shorter than among men (p-value=0.04). Duration of fever differed by the frequency of episodes. Those who experienced more episodes had fever lasting for more days than those who reported fewer episodes of fever (Figure 2).

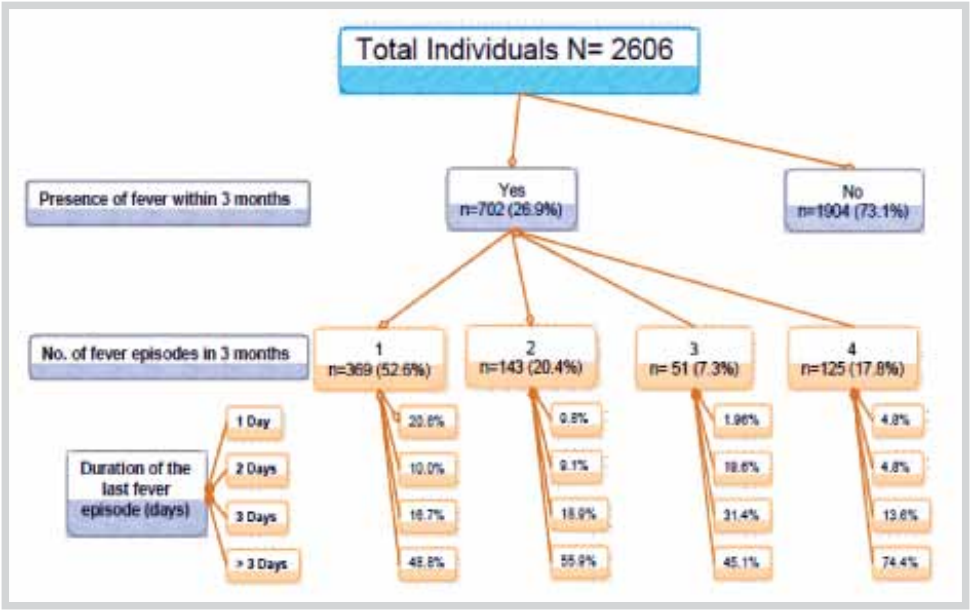

Figure 2: The overall number of fever episodes and duration of illness due to fever

Almost, 79% of the respondents believed that the fever was due to malaria, 12.8% didn't think so while 8.2% were not sure. The proportion of those who mentioned that the fever was due to malaria was significantly higher in the pastoralist community (81.7%) than in the crop farming communities (76.1%) and was statistically different (Two-sample test of proportion: p-value=0.038).

Table 3: Number of individuals with fever, malaria confirmed by either by microscopy or clinically and sought treatment

Village	No. HH visited	No. of individuals	Fever (%)	Confirmed diagnosis	Clinical diagnosis	Seek treatment	Use med
Malui	131	867	193(22.3%)	50 (25.9%)	59 (30.6%)	137(71.0%)	61.7%
Mbwade	90	437	144 (32.9%)	47 (32.6%)	49 (34.0%)	93 (64.6%)	56.9%
Tindiga	110	613	191 (31.2%)	34 (17.8%)	76 (39.8%)	128(67.0%)	52.4%
Twatwatwa	140	689	174 (25.2%)	30 (17.2%)	73 (41.9%)	130 (74.7%)	59.2%
Total	471	2606	702 (26.9%)	161 (22.9%)	257 (36.6%)	488 (69.5%)	404 (57.5)

Key: HH=households

Among those mentioned to have experienced fever, 22.9% received a confirmed malaria diagnosis with most of the diagnoses done at the health facilities (96.2%). About (36.6%)

were diagnosed by a health worker without their blood taken and 16.7% did self diagnosis using signs and symptoms. Only 3.5% were diagnosed by traditional healers and this was significantly higher among crop farmers than pastoralists (p-value <0.001). Non-educated individuals reported to be diagnosed and treated more at health facilities than the educated ones who obtained their treatment mainly from drug stores (Table 4).

Table 4: Number and proportion of individuals with the method used for diagnosis of febrile illness and choice of point of care

Place of Diagnosis	N	Point of Care (%)			
		HF	Drug store	Self medication	TH
HF with confirmatory diagnosis	156	64.82	18.3	15.5	0
HF without laboratory confirmatory	241	65.9	25.7	7.5	0
Traditional Healer	18	66.7	27.8	5.6	0
Friend/Relative	14	46.2	38.5	7.7	0
Self diagnosis	86	11.9	55.2	22.4	7.5
Total		259	130	59	5
Proportion (%)		56.91	28.7	13.02	1.1

Key: HF= health facility; TH= Traditional Healer

Seeking of treatment was significantly different by the size of the household (Figure 3). The larger the size of the household the less frequency of seeking cares for fever/malaria. It also differed between crop farmers and pastoralists (p-value=0.051). Diagnosis through health care providers without blood sample taken was more frequent among individuals from farming communities than pastoralist (p-value=0.029). However, this did not differ by sex or education. Additionally, the study did not observe any evidence to support that higher number of malaria (fever) episodes facilitated early seeking and use of treatment.

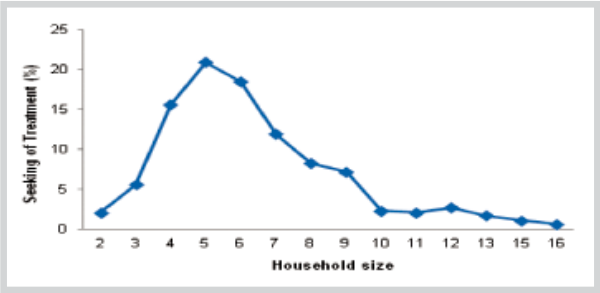

Figure 3: The relationship between size of the household and frequency of seeking treatment for fever

Health seeking behaviour for the individual household members is illustrated in Figure 4 indicating steps taken from recognition of fever, steps taken to confirm whether it was malaria or not and the treatment sought (Figure 4).

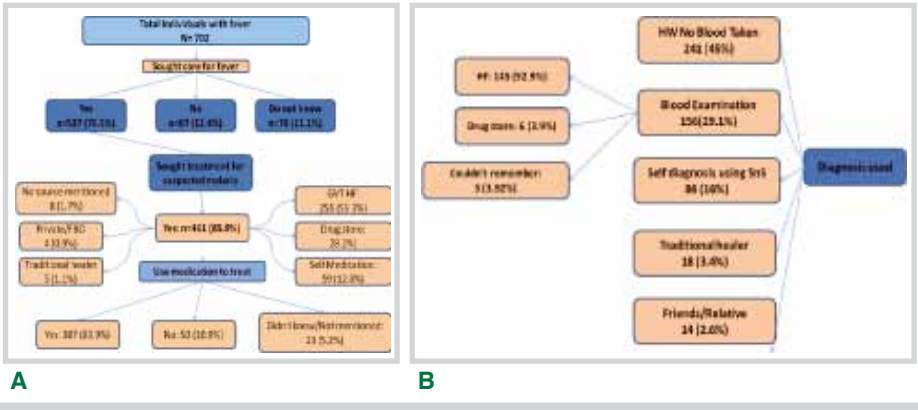

Figure 4: Management of fever among respondents in Kilosa (a) care seeking, source and treatment (b) type and source of diagnosis

Association between symptoms experienced concurrently with fever and suspicion of malaria was also explored. Symptoms that lead to higher suspicion of malaria included a combination of fever + joint pain (93.3%), fever + diarrhoea (91.4%) and fever + headache (90.7%). However, when fever was associated with convulsion or with joint pains+ headache, the suspicion of malaria was 100%. Young children presented mainly nausea, diarrhoea and cough than other groups. Self medication using was common among individuals with headache than those with other symptoms. Blood test for malaria parasite confirmation was frequently done by those with fever + joint pains ($p<0.01$). Individuals with cough mainly were diagnosed by HW without their blood taken while 80% of those with convulsions blood tests were done. All patients found with convulsions and diagnosed clinically by HW on malaria were treated using quinine. Presence of fever + headache seemed to significantly prompt seeking of treatment and use of medicine than other symptom combinations ($p<0.001$). High proportion of sick individuals who sought treatment within 24 hours included those presenting with fever, diarrhoea and nausea, mainly in young children. On contrary, individuals with fever, joint pain and cough were reported to seek medication a week or more after the onset of fever.

Use of medication

More than 82% used medication to treat fever. Main sources of medicines were HFs (47.9%) and drug stores (35.5%). Other sources of care were traditional healers, use of herbs and left over medicine at home. Interestingly, 18 individuals who were diagnosed by traditional healers obtained their medicines from health facility (77.8%) or drug stores (22.2%).

Respondents were asked of the duration before starting medication. Only 37.5% used medication within 24hrs from the onset of fever, while 28.5% within 48hrs and the rest after >48hrs. Main antimalarial drugs used were artemether-lumefantrine (ALu) (61.3%) and Quinine (11.3%). Sulfadoxine-pyrimethamine was mentioned by about 4% of the respondents while about 5.5% used only analgesics (such as aspirin, paracetamol) for the treatment of fever. Some 6.5% (32/488) mentioned to have used combination of antimalarial drugs (ALu and SP), mostly from health facilities (65.6%), drug stores (28.1%) and the rest used leftover drugs in their homes. The frequency of using of SP was significantly higher among educated persons (p=0.02). No difference on timely treatment (within 24hours) by education was observed. However, this differed by sex where women took significantly longer time before starting medication than men (p=0.016). Most individuals who were diagnosed by microscopy were treated using ALu (55.7%) and Quinine (21.4%). On the other hand, 85.5% of those who were clinically diagnosed (without microscopy confirmation) to have malaria by health providers were treated with ALu.

Table 5: Number (%) of respondents with their response on the outcome of malaria treatment using various antimalarial drugs

Response	SP	Chloroquine	Amodiaquine	Quinine	ALu
N	20	3	8	50	294
Fever disappeared	13 (65%)	0 (0%)	6 (75%)	44 (88%)	223 (75.9%)
Other symptoms disappeared	0 (0%)	1 (33.3%)	0 (0%)	2 (4%)	13 (4.4%)
No relief	3 (15%)	1 (33.3%)	0 (0%)	1 (2%)	10 (3.4%)

Key: SP= sulfadoxine-pyrimethamine; ALu= artemether-lumefantrine

Over two thirds (68.2%) of the respondents claimed that the fever disappeared after using the medicine. The majority were those who took ALu (67%) and Quinine (13.2%). However, 33.3%, 15% and 3.4% of those who used Chloroquine, SP and ALu respectively, did not observe any relief after medication (Table 3).

Treatment seeking for the fever perceived to be malaria accounted for the majority of the responses from the respondents. The lowest proportion of respondents (20.7%) sought care when they had diagnosis of perceived malaria done through blood smear examination at health facility (Figure 5).

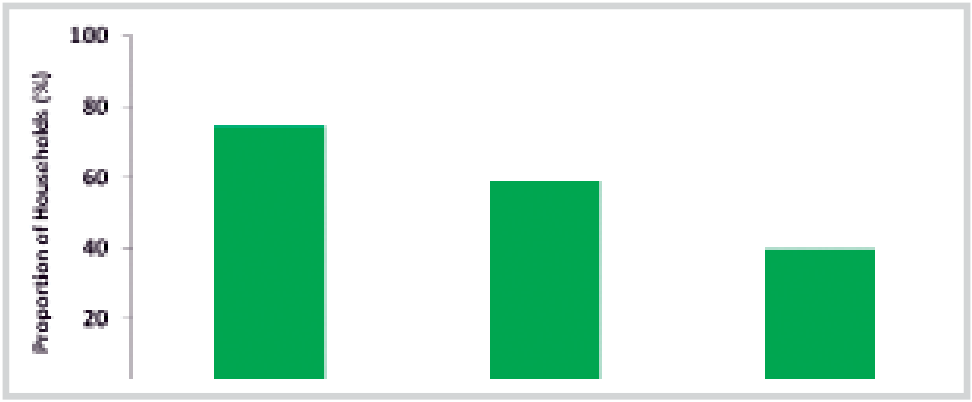

Figure 5: Trend of care seeking for fever cases that were perceived to be malaria

The cost for fever/malaria treatment

The cost for fever medication was on average US$ 2.73 (TShs 4,100). When including other costs (transport charges) the average cost increased to US$ 4 (TShs 6,600; range= TShs 200 to 50,000). However, majority (83.4%) used less than US$ 3.33 (TShs 5,000) and up to 92.4% used less than US$6.67 (TShs 10,000). The cost used by men was slightly higher (US$2.93) than that incurred by female individuals (US$2.53), however it was not statistically different. The cost of treatment was also not significantly different between crop farmers and pastoralists, duration of fever or number of episodes.

Accessibility, waiting time and availability of antimalarial medicines

Facilities that were mentioned to provide health services included Dumila, Kilosa, Kimamba HC, Morogoro Hospital, Msowero, Parakuyo Dispensary, Tindiga and Wami-Dakawa. Some of the respondents (24.5%) were located about 1 km from the nearest health facility while 15% were about 2 km away. About 40% of the respondents lived between 5 and 15kms from the nearest health facility with an average distance mentioned to be about 9kms. Time to reach nearest facility was mentioned to be less than 30mins for about 47% of the respondents. Others mentioned to use between 30mins to 1hour (16.2%), 1-2 hours (18.3%) and more than 2hours (18.3%). Average time was estimated at 95min. More than 56% of the respondents reported availability of antimalarial drugs in the facilities that they were visiting. However, this differed among the facilities (Table 6). Antimalarial drugs were almost always available in hospitals than in other health facilities.

Only 54% were satisfied with the service provided at the nearest health facility. About one quarter (23.3%) of the respondents claimed that the services were not good while the other quarter said the services were very good. Regarding consultation time, majority (83%) of the respondents perceived to have been given enough time to describe their illnesses. However, when assessing the actual time they mentioned, it was found that about 41% were given only 1-5min, up to 75% received 6-10min while the remaining percent were given between 12-30min. Patient waiting time was reported to be less than 30min (52%),

about one hour (23.1%) and more than one hour (24.8%). Waiting time and time provided to a patient to explain his/her problem were highly associated with the level of satisfaction (p-value <0.001). The proportion of those who mentioned that the service was not good was significantly higher among those who spent more than an hour waiting for the services than among those waited for less than 30minutes (Two-sample test of proportion, p<0.001).

Table 6: Availability of antimalarial drugs at health facilities

Type of facility	Name of facility	N0. of respondents	Always available (%)
Hospital	Kilosa	17	82.35
	Morogoro	7	85.71
Health Centre	Kimamba	120	54.17
Dispensary	Dumila	3	100
	Msowero	15	60
	Parakuyo	40	80
	Tindiga	190	47.89
	Wami-Dakawa	8	100

Conventional antimalarial drugs were trusted more (94.8%) than other local treatment, with main drugs mentioned including ALu (76.6%) and Quinine (12.5%). SP was mentioned by 7.7% of the respondents whereas other drugs such as Amodiaquine and Chloroquine were rarely mentioned. About 1.2% of the respondents were of the opinion that analgesics could treat malaria. Some 94% mentioned to comply with ALu treatment regime (taking a full dosage of ALu and adhere to the instructions given). However, only 42.4% mentioned to take their medicine when they move away from home (working in their farms or while animal grazing). The availability of service in remote areas was described by the majority (72.8%) to be very difficult.

Availability and use of mosquito nets

The largest proportion (83.3%) of the respondents had mosquito nets at the time of the survey. About 70% reported to have received a free net from the government. Majority (93%) accepted their nets to be observed and assessed for the quality. Proportions of respondents with high satisfaction on different characteristics of nets were very low (Table 7 and Figure 6)

Table 7: Community satisfaction on the mosquito nets provided by the government in Kilosa (N=320)

Score/Scale	Size	Weave	Shape	Texture	Strength	Durability
Very poor	38.94	26.25	5.96	8.25	11.25	12.85
Not satisfactory	34.27	40.94	17.24	22.54	28.75	26.65
Average	9.35	16.25	21.0	26.98	20.94	25.08
Satisfactory	16.2	15.0	48.59	37.78	32.50	31.35
Very Satisfactory	1.25	1.56	7.21	4.44	6.56	4.08

Combining the scales (Table 7) into three categories which include those who said the quality was (i) not satisfactory (Very poor + Not satisfactory); (ii) average; and (iii) satisfactory (Satisfactory + Very Satisfactory) and assuming a numerical trend between the scales, the proportion of individuals responding to the different categories were plotted against the categories (Figure 6).

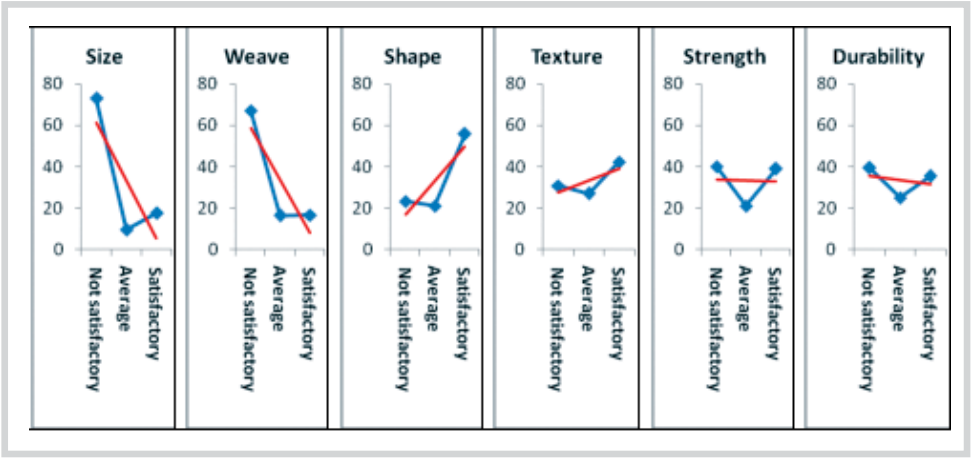

Figure 6: Pattern on scoring quality of nets distributed by the government, Kilosa Tanzania.

It can be observed that major concerns on the quality of mosquito nets were on the size and weave. The shape of the net was the most satisfying factor of the mosquito nets. No patterns could be identified for strength and durability which might indicate poor knowledge on these qualities among most individuals. Distribution of net was found to be fair and satisfactory by only half of the study population (48.1%). However, when asked of the preference of source of nets in future, most (85.7%) preferred mosquito nets from the government and only 14.3% said they would like to buy a mosquito net from a different source. Mosquito nets were mentioned to be used for other things (apart from preventing mosquitoes) such as fishing (23%), garden and plant fencing (36.1%), protect chicks from predators (21.3%) and use as football-goal nets (3.3%).

Discussion

The findings from this study have revealed moderate level of knowledge and practices of the community regarding malaria control in Kilosa district. Proportion of respondents with high knowledge was low when multiple variables were grouped together. However, when each variable was analyzed independently, variation was noted where others were found to have knowledge of more than 80% and others less than 10%. The pastoral communities had more respondents with high and moderate knowledge respectively compared to farming communities. Although farming communities could associate crop irrigation with mosquito productivity, majority could not do so. It is interesting to note that community could associate breeding sites with other livelihood practices. The analysis from study this provide a caution on the danger of relying on single variable in measuring knowledge as it provide false interpretation, and therefore multiple variables should be considered in measuring knowledge. Similar observations have been reported from a neighbouring district of Mvomero (Mboera et al., 2009). When communities have little knowledge, they are likely not to take precaution measures against malaria. In a study in Ethiopia where single variables were used to assess knowledge on malaria indicated that more than three quarters of the respondents were not knowledgeable of the preventive methods against mosquito bites (Legesse & Deressa, 2009). Study in Simanjiro has indicated high level of knowledge regarding the transmission mode but respondents considered the disease difficult to prevent (Malisa & Nduka, 2009). This has implications on the educational campaigns that target on malaria prevention interventions, and behavioural change deems necessary through changing the cultural beliefs. In the same study, very few could associate malaria with stagnant water. However, presence of stagnant water could not directly be linked to breeding sites of malaria vectors, making it more difficult on the educational campaigns. While this study advocate for health education on the linkage between livelihood factors and malaria, other studies indicate education addressing the link between stagnant water, mosquito and malaria (Malisa & Nduka, 2009).

About a half of the respondents claimed to have experience at least an episode of fever during the previous three months. Similar findings have recently been reported elsewhere (Mboera et al., 2009). Farming communities accounted for the largest proportion of individuals who had experienced fever. However, the pastoral communities had more frequent fever episodes than their counterpart. In a previous study in a neighbouring district of Mvomero, individuals with at least primary school education and those in the older age group were more knowledgeable of malaria than their counterparts (Mboera et al., 2009). Although farming communities had fewer episodes than pastoral, their fever lasted longer compared to pastoral communities. It's interesting that pastoral communities could quick link the fever episode with malaria than farming communities. This is directly linked with the level of knowledge as pastoral communities were more knowledgeable than others, attributing to early recognition and early seeking care. Although women had many episodes, they were late in seeking care..

It has been observed that gender and age play a role in making decisions in households in relation to health matters and treatment-seeking (Rahman et al., 2012). In pastoral

communities certain types of health resources fall within the female domain (home-based treatment, caring and supportive roles). However, access to health care is controlled largely by men. Seeking care during illness depends largely on the nature and quality of social support systems available (Glik et al., 1989). Barriers for women to access care result in part from unequal distribution of power and resources within domestic arenas (Chen et al., 1981), often compounded by institutional, cultural and educational barriers to services (Ojanuga & Gilbert 1992). Decision making power structure due to patriarchy system might have attributed to this (Shayo et al., 2013). The male dominance tendency in the ownership of income made even pregnant women who got subsidized nets from the voucher scheme unable to take them as they were necessitated to request money from their husbands (Malisa & Nduka, 2009). This reveals a clear pattern on gender inequalities among the pastoral communities not only in accessing treatment when fall sick but also in accessing malaria prevention interventions.

Regarding the treatment, it was interesting to note that unexpectedly, uneducated individuals consulted health facilities more than educated; that educated individuals were more likely to consult drug stores than others. This implies that more knowledge does not necessarily mean more health facility consultation; as the educated one may perceive to be more knowledgeable on the signs and symptoms, triggering for self medication or consultation of drug stores. Long waiting times at HFs could also be related to such behaviour. These observations have also been reported from a neighbouring rural district of Mvomero (Mboera et al., 2009). Individual perceptions towards the risk of the diseases dictate where to seek care apart from knowledge. Variation was noted regarding the size of the household and care seeking; small family size was mostly likely to seek care when a member falls seek than the large family size. This implies that the household with fewer members might have better health than larger families, therefore advocating for family planning methods with fewer children becomes valid and a choice. However, this observation can be linked with the coverage of insurance package such as Community Health Fund and the limitation of the family members who the fund can cover. In most cases smaller households will have opted to attend health facilities since no cost is involved differently to larger families where out of pocket might be avoided.

Antimalarial drugs used among the respondents in this study were mostly obtained from two sources; health facilities and drug shops. Artemether-lumefantrine (ALu) was a drug of choice by the majority. Sulfadoxine-pyrimethamine was used by small proportions, indicating a continuous use of the previous first line drug. Consultation with drug stores seems to be a trend in Tanzania as it was also found by Mboera et al., (2009). Some studies revealed only 14% of the children received an effective antimalarial in a correct day after the illness onset indicating poor access to prompt and appropriate treatment in rural community of Tanzania (Hetzel et al., 2007).

Costs for malaria treatment were not different between farmers and livestock keepers, indicating the uniformity in the health care system. Disparities however existed between genders; as men would incur more costs than women for the malaria treatment. Costs have

a big influence to seeking care as it has been documented in a number of studies (Mubyazi, 2003; Mboera et al., 2009). Some studies have shown that the higher the socio-economic status particularly with wealth the more likely for the individuals to seek for appropriate treatment and prevention measures (Dickinson et al., 2010). Direct fees have continued to limit access to healthcare and people only have partial information on how the system works, and the opportunities available. The influence of costs in accessing care to the general population has been vividly revealed in one study even by the wealthiest quintile group (Shayo et al., 2013), which might contribute to seeking care from the traditional practitioners or just practice self medication.

Satisfaction with the quality of services provided at the health facility was somehow encouraging as more than 50% were satisfied. Satisfaction was attributed by good provider-clients interaction that they were given enough time to describe the illnesses and waiting time was approximately 30 minutes by 50% of the respondents. However the concept of adequate time was subjective as further analysis revealed 40% to have spent 1-5 minutes. A clear pattern has been seen in this study regarding the satisfaction as those respondents who spent more waiting time were more likely to rate poor quality of care than the counterparts. This trend of satisfaction has also been reported elsewhere in Tanzania (Shayo et al., 2013) though it was more in non public than public health facilities. Inter-personal interactions help sustain system-level trust as trust among clients is induced by satisfaction with service providers (Johns, 1996). It has been shown that perception of interpersonal-based medical service encounters positively influences service quality and patient satisfaction (Chan et al., 2013). Poor staff attitudes towards patients and poor management practices can cause dissatisfaction with services. Corrupt practices in accessing healthcare in Sub-Saharan Africa have been reported in a number of studies (Hunt & Laszlo, 2007; Mæstad & Mwisongo, 2011) leading to low trust and dissatisfaction. Discrimination and lack of respect by health workers towards the poor is also common (Tibandebage & MacKintosh, 2002). Even those who deserve to receive free medical service lose trust in the system as they worry about being ignored by health workers due to their poverty (Chan et al., 2013). Thus, the patient-provider interaction is centripetal to quality healthcare.

A good number of individuals had received free mosquito nets from the government. Despite the fact that the size of the nets was not satisfactory by the majority of the respondents, they were still interested to continue receiving free nets from the government; only 14% would prefer to buy from their pocket. However, possessing a mosquito net does not necessarily reflect the correct usage. In this study, it was observed that some people were misusing mosquito nets for fishing, protecting chicken from predators and fencing of the gardens. This implies that these particular individuals are interested to enhance their livelihood than protecting against malaria. This goes back to the health belief model that people will practice certain behaviour depending on the belief attached to that behaviour (Rosenstock, 1966; Chen et al., 1981Janz & Becker, 1984). As it was revealed in another study that people had little knowledge on the malaria preventive measures, had difficulties to use nets even when distributed freely (Malisa & Nduka, 2009), most likely because they do not understand that they at higher risk of contracting malaria. Lack of knowledge and

negative attitude also seemed to affect mosquito net ownership. Some villagers were less convinced of the effectiveness of insecticide treated mosquito nets in protecting a sleeper from malaria. Already some studies have reported the impact of lack of knowledge as well as negative perception on the uptake of interventions such as mosquito nets (Minja et al., 2001). Generally, health seeking behaviour regarding various illnesses in both treatment and prevention services is influenced by several factors such as household knowledge and attitudes, financial constraints, and the choice of treatment (Rumisha et al., 2003; Shayo et al 2003). With the increased linkages between livelihood and malaria, serious steps should be taken. There is therefore a need for the government to strengthen the education campaign and promotion regarding malaria and the available options for both curative and prevention for the betterment of the future generation.

In conclusion, malaria knowledge is low among farming community of central Tanzania. Appropriate public health promotion should be designed to show the links of livelihoods and malaria transmission among rural communities.

Chapter 7: Malaria, climate change and food security among farming communities in Kilosa District

Abstract: Agriculture, food security, and malaria control are all important issues for health and development in Sub-Saharan Africa. This study was carried out to explore rural community's knowledge, attitudes, perceptions, and practices regarding farming practices, climate change, food security, and malaria. Awareness of the existence of malaria in the sample population was high. The majority (73%) reported that most people get sick from malaria during the rainy season. Half of the respondents felt malaria had decreased in their village during the last 10 years, presumably leaving the other half unimpressed by changes in the malaria burden. Reported mosquito net usage among the farming households was very high (98.9%). Climatic parameters that influence mosquito abundance were rainfall (35.8%), temperature (11.3%) and relative humidity (2.0%). Over one-third of the respondents had outdoor activities starting before 5am in the morning, when the malaria mosquitoes were still biting. Fifty-five percent of the respondents reported that there were times, especially during the harvest season, when they stayed overnight in their farm to reduce travel time and protect crops from grazing domestic/wild animals, birds and insect pests. Most (82%) of the respondents reported to carry with them mosquito nets when spending nights in the farm. Only a quarter of the respondents understood the term climate change. However, there was a general understanding that the rain patterns have changed in the past 10 years and are unpredictable. Some 62% believed that the temperature has increased in the last 10 years. Unpredictable and changing rain patterns are problematic for farmers, because 86% reported they rely on weather patterns to determine planting time for their crops. Only about half the respondents thought the weather forecast provided by the meteorological agency is useful to help determine planting time. Frequent adaptations in farming practices were reported, indicating some resilience to climate change. Three quarters of the respondents reported that they had no sufficient production from their own agricultural farms to guarantee food security in their household for the year. Seventy-three percent reported to having food shortages in their household in the last five years. About half said they regularly experienced food shortage during the rainy season, which is the peak of malaria transmission; this time also intersects with the planting season, when farmers need more energy to put in crop production in order to ensure food security for the next year. In conclusion, farming communities in Kilosa District have little knowledge on climate change and its impact on malaria burden. Food insecurity is common and community-based strategies to mitigate this need to be established.

Keywords: malaria, climate change, food insecurity, knowledge, practice, Tanzania

Introduction

Health depends on a complex web of environmental factors. Public health interventions can have a greater impact on improving overall well being of the communities. This can

be done by recognizing determinants of health and their relationships between them, rather than focusing on solitary issues. This paper suggests that communities affected by malaria also commonly suffer from chronic food insecurity, and that both disorders affect small-scale farmers' livelihoods. Agriculture, food security, and health are interdependent, whereby failure in one sector has negative effects on the others. These interactions operate in a vicious cycle (Figure 1): illness and death, such as that caused by malaria, detract from farm worker productivity, which leads to smaller harvests, thereby resulting in food insecurity, which in turn results in weakened immune systems that are more susceptible to illness (Asenso-Okyere et al., 2011). Further links between agriculture, food security, and malaria show that these issues should be addressed in tandem rather than as stand-alone issues. These in turn affect farmers' livelihoods.

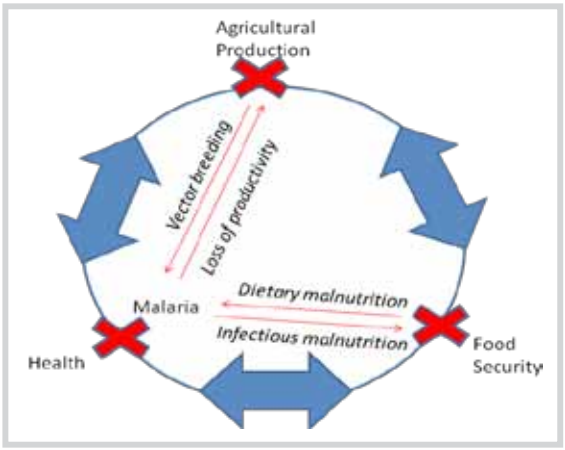

Figure 1: Malaria is perpetuated in the cycle of poor agricultural production, food insecurity, ill health and farmers' livelihoods

Agriculture has an enormous role in public health. Aside from providing food and nourishment for the entire world, agriculture dictates everyday life for the 75% of the world's poor who live in rural areas and subsist on the land (Ravallion et al., 2007). For these households, agricultural production is the main source of labour, food, and income. Many developing countries also rely on agriculture as a significant portion of the national economy, therefore affecting the government's ability to finance public services including healthcare (World Bank, 2008). Looking ahead, agriculture will have an increased role in health as climate change takes a toll on agricultural yields and the individuals and economies that affect farmers' livelihoods. On the other hand, some agricultural practices also pose health hazards, including providing environments for mosquito breeding and thus contributing to malaria (Asenso-Okyere et al., 2009). Agriculture is so tied to health that every campaign against illness and disease should consider the influence of agriculture.

Agricultural development, food security, and malaria reduction are all high on global heath and development agendas. Reducing the incidences of hunger and malaria are each

specific aims of the Millennium Development Goal. Agriculture has recently been heralded as the path to development by the World Bank (World Development Report, 2008). International funding for malaria control rose to a peak of US$2 billion in 2011; while the 2006-2008 world food crisis brought food security to the forefront and has set policymakers to work figuring out how to manage volatile world food prices (World Bank, 2008; WHO, 2011; FAO, 2011).

Despite the attention and funding given to agriculture, food security, and malaria, little research has been done on the links between all three. Research on the relationship between food security, malaria and climate change is almost non-existent (Perez-Escamilla et al., 2009). Links between agriculture and food security are intuitive, yet understanding of this dynamic is still being developed; meanwhile, studies have only recently begun on the interactions between agriculture and malaria (Ijumba, 1997; Asenso-Okyere et al., 2009; Mboera et al., 2007). Though the three areas are considered separate development issues in need of independent intervention strategies, there are reasons to assume that agriculture, food security, and malaria overlap and affect each other. Understanding these links is imperative to health and progress particularly in Africa, where 45 of 53 countries are endemic for malaria and where 90% of global deaths from the disease occur (WHO, 2008). The estimated cost of malaria for African countries is $12 billion and slowing of economic growth by up to 1.3% every year (RBM, 2010).

Tanzania, the largest country in East Africa, is an important place to explore the links between agriculture, food security and malaria. Malaria is considered the top health problem in the nation and the focus of major public health interventions; 95% of the country is malaria endemic (Mboera et al., 2007). Increasing resistance to malaria treatment drugs in Tanzania makes malaria prevention an important strategy (Schönfeld et al., 2007). However, with recent development of marked mosquito resistance against pyrethroid insecticides (Kabula et al., 2013), alternative interventions need to be explored and deployed. Chronic malnourishment and food insecurity is also a problem in Tanzania, made even more serious by escalating food prices around the world (FAO, 2011). Meanwhile, in Tanzania, agriculture accounts for 45% of Gross Domestic Product and employs 75% of the population (Ministry of Agriculture, 2003; Mashindano, 2009). With the majority of agriculture being rain fed, crops are highly vulnerable to climatic changes (Mashindano, 2009). Climate change events including floods throughout the country have already had drastic effects on lives and destroyed crops (FAO, 2011) and have been associated with a number of communicable diseases (Mboera et al., 2011).

Long-term projections estimate significantly declining yields for staple crops including maize, which many people rely on for daily food (Agrawala et al., 2003). Understanding the interactions between agriculture and malaria in Tanzania is of particular significance when considering that they are the major sources of livelihoods and illness. Indeed, a recent evaluation of current malaria control efforts in Tanzania concluded that adoption of an integrated approach is imperative to successfully combating the disease (Mboera at al., 2007; Chapter 9). The following eco-health analysis considers livelihood and environmental

factors involved in malaria transmission by exploring the links between agriculture, food security, and malaria.

This Chapter strives to contribute to knowledge of agriculture as a determinant of health, and to identify links between agricultural development, food security and malaria control. The objective of the study therefore was to determine knowledge, attitudes and practices in a rural maize-farming community in central Tanzania. Specifically, the study aimed to (i) assess the state of malaria, food insecurity, agricultural practices, and adaptations to climate change; and (ii) to identify, areas that offer possible synergies for collaboration between food security and malaria interventions as well as the agricultural sectors.

Materials and Methods

Study Site

The study was carried out in Kimamba Ward in Kilosa District (22017'-32049'E and 90127'-903339'N) in central Tanzania, situated at about 300km west of Dar es Salaam. The climate belongs to the tropical savannah of the low latitude environment. The rainfall has a characteristic monomodal pattern; the rains begin in October with a peak in April and continue till May. The mean annual temperature is 25oC (mean annual maximum=30oC; mean minimum= 19oC). Geomorphologically the district is characterised by mountains, hills, and foot slopes of mountains, undulating plains with broad valley bottoms and alluvial plains comprising the floodplains. In the district seven broad land cover types are recognised which include forest, woodland, bushland, grassland, cultivated land (rainfed and irrigated lands), water bodies and urban land. Natural forests are situated in higher landscapes at the catchments areas which are sources of most of the rivers in the district. In terms of river systems, the district can be divided into the following five areas: (i) Kimamba-Wami system; (ii) Mkondoa-Mkata-Wami system; (iii) Miyombo-Mkata system; (iv) Chali-Great Ruaha system and; (v) Ruhembe-Great Ruaha system. Permanent and seasonal swamps are the other water bodies found in the district and are situated in the Mkata alluvial plain.

Agriculture is the main activity of most people in the district and is characterized by predominance of smallholder and estate farms. The main crops under rainfed agriculture are maize, rice, sorghum, beans, cassava, sweet potatoes, cotton, sunflower, sesame and sisal. These livelihoods are strongly affected by climate, particularly drought that has forced farmers to apply different strategies to cope with it. The district, including Kimamba Ward, experienced severe flooding in 2009/2010, which has been attributed to climate change coupled with environmental degradation (http://www.ifrc.org/docs/appeals/10/MDRTZ0101.pd). Maize farms were particularly affected. For example in 2010, 105 acres of maize farming land in the village of Kimamba A were flooded, covered in sand and mud, and are no longer fit for future farming; 971 acres of maize farmland in the village of Mamoyo were affected by floods, with hopes that the crops can be replanted (Kilosa District Council, 2010). Resultant crop failures due to flooded fields resulted in a loss of income and food insecurity for farming communities. The floods also affected road infrastructures, where 207 km of roads and feeder roads were declared impassable in the district, and electricity faltered due to 100 utility poles being affected. Some families were still displaced and are

living outside the district centre during the study period (April 2011-September 2013).

Study design and sample population

A convenient sample of 399 male and female heads of households over the age of 18 was recruited in Kimamba A and Kimamba B villages. The vast majority of participants were recruited and interviewed in or outside their homes. A community leader was hired to guide and introduce research staff to eligible homes. Each participant obtained verbal and written consent before the interview. Sampled participants were asked to show the next household that qualified for the study. Participants were interviewed in Kiswahili using a semi-structured questionnaire. Of the 399 residents interviewed, the responses of 364 (91.23%) respondents, who were engaged in crop production as their primary occupation were isolated for analysis.

Data collection and analysis

Sub villages involved in the study were Mkwajuni, Sikutali, Sokomsuya, Posta and Uhindini. Household information was collected in six broad categories: (i) Malaria knowledge and perception, which included the cause of malaria, the season people get malaria most, the symptoms and whether has decreased in the study area; (ii) Malaria treatment and prevention, which included the accessibility and use of health care facilities, availability of antimalarial at health facility, various methods used for malaria prevention, mosquito net ownership and usage; (iii) Climate change, which included changes of climatic conditions (rainfall and temperature) for the past 10 years and the impacts to the communities, and changes in farming system and crops as the adaptive capacity; (iv) Food security, which included availability of sufficient food to last before the next harvest season, number of meals per day, types of food available in the household, and the measures taken when experiencing food shortage; (v) Housing characteristics, which included the type of housing material, the number of rooms and people in the house, and presence of open eaves; (vi) Socioeconomic indicators, which include house ownership, economic status and electrification of the home. The socioeconomic status of the household was calculated by creating a weighted score using several assets such as vehicles, land, animals, milling machine, ox-plough, motorcycle, bicycle and radios owned by the household. The score was created by multiplying the reciprocal of the number of households that owned a particular asset by the number of assets owned by a household and summing over all assets.

Results

Socio-demographic characteristics of the respondents

A total of 399 individuals were interviewed. The age of respondents varied between 16 and 98 years with mean of 39.8 (SD=15.5). Of these, females accounted for three quarters of the respondents (Table 1). Most (62.41%) of the respondents had attained primary school education. Majority (91.23%) were involved in farming activities as the main occupation.

Knowledge, Prevalence, Prevention and Treatment of Malaria

Awareness of the existence of malaria in the sample population was high. Majority (97.5%) of the respondents indicated to have heard of malaria. Three quarters (73%) reported that most people get sick from malaria during the rainy season. Nearly all (94.7%) knew that malaria is acquired through a mosquito bite, and virtually all (99.5%) confirmed that mosquitoes were present in their homes and in the surroundings. About 50% of the respondents felt that malaria had decreased in their village in the last 10 years, presumably leaving the other half unimpressed by malaria changes in mosquito abundance.

Table 1: Socio-demographic characteristic of respondents (N=399)

Socio-demographic characteristics		Frequency	Percent (%)
Sex	Male	103	25.81
	Female	296	74.19
Education Level	None	129	32.33
	Primary	249	62.41
	Secondary	21	5.26
Occupation	Farming	364	91.23
	Business	15	3.76
	Employee	5	1.25
	Other	15	3.76

The most commonly known symptom of malaria was fever (66.67%), followed by headache, joint pains, and nausea/vomiting (44.4%, 43.6%, and 40.9% respectively). Lesser known symptoms were diarrhoea, convulsion, and anaemia (18.8%, 2.0%, and 1.5% respectively).

Nearly all (95.49%) respondents mentioned that mosquito nets as the main methods of malaria prevention (Figure 2). Only a small proportion of the respondents mentioned other vector control methods including mosquito coils (4.76%); indoor residual spraying (6.77%); and larviciding (0.75%). Majority (78.7%) of the respondents believed that mosquito nets were the most effective method for preventing malaria. Environmental management of malaria was poorly known by the respondents. For instance, cleaning the environment around the homes was mentioned by 23.31% of the respondents while clearing grass and bushes around home was mentioned by 12.53%. A large proportion (85.21%) of the respondents was of the opinion that reducing the population of mosquitoes would reduce malaria incidents.

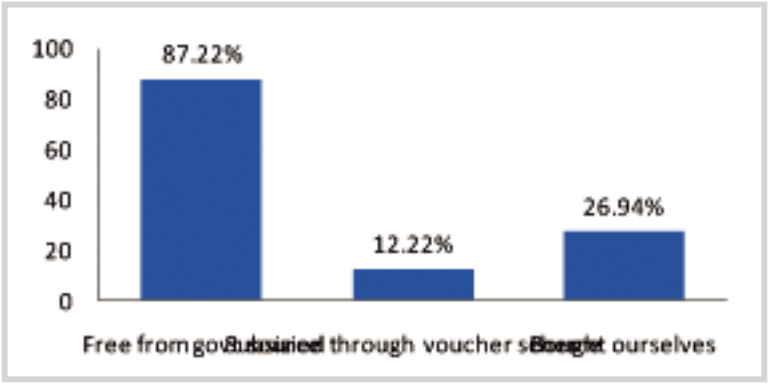

Figure 2: Mosquito net acquisition by respondents in Kimamba, Kilosa District

Reported mosquito net usage among the farming households was very high (98.90%), with an average of at least 2 nets per household. About 87% reported receiving at least one net for free from a government source, and 12 % had received a subsidized net from a voucher scheme (Figure 2). Slightly over a quarter (26.94%) indicated to have bought at least one mosquito net, indicating that nets were a priority for these households. Almost all (96.0%) reported to have slept under a mosquito net the previous night. However, 17.04% of the respondents said there were some nights they did not sleep under a mosquito net.

The majority (98%) of the respondents reported that they sought health care from government health facility when a household member fell sick. However, among them, 12.03% mentioned to seek care from drug stores. A few respondents (18.3%) admitted that sometimes they do not seek treatment from health facilities when someone in the household suffers from malaria. Of these, 4.76% of all respondents reported not seeking treatment from health facilities because of the high cost.

One in three women who had given birth in the last five years (N=183) reported suffering from malaria in their last pregnancy. These women reported attending ante-natal clinic (ANC), during early pregnancy stages. The majority (96.76%) of women had been to ANC two or more times, 49.73% had visited 3 times and 37.16% more than three times. However, 19% reported that they did not receive SP, 55% of them said they had received only one dose of SP.

Knowledge of IPTp among the women was generally low. About one-third of the women do not know the right time for taking SP for IPTp. Only half the women knew that SP at ANC is to prevent malaria. About one third (32.24%) admitted that they did not know why should a woman take SP during SP. When questioned about how to prevent malaria in pregnant women, mosquito nets was the most intervention (87%). The majority (98.91%) said that a health care facility was their first choice of point of care.

Livelihoods and malaria risk

Standing water (57.89%), environmental factors including presence of grasses (42.89%) were the most frequently mentioned factors affecting mosquitoes in and around homes. Climatic factors were not as commonly associated with malaria risk: only 35.84% mentioned amount of rainfall, 11.28% temperature, and 2.01% humidity. Although the respondents apparently knew that the state of the environment around the village contributes to mosquito breeding, but they did not connect that standing water and grass growth are influenced by climatic events. Some 40% of the respondents did not know the linkages between crop farming and malaria prevalence. About 30% believed that rice farming contributed to malaria, and only 11% mentioned maize farming, which is the dominant occupation among the community members.

Over one-third of the respondents had outdoor activities responsibilities starting before 5 am in the morning. Majority of the respondents admitted to wake up early in the morning to travel to their farms, which were distant away. Almost all had to travel 1 to 3 hours from their homes to reach the farms where they worked for the whole day. Over half (55%) of the respondents reported that there are times when they stay overnight in their farms. Over half of these said that the harvesting season was the most common time for spending the night at the farm. Staying overnight in the farms was described as necessary to reduce travel time to and from the farm, protecting crops from grazing animals, protecting crops from wild animals, protecting crops from birds and insect pests. Encouragingly, 82% reported that they brought mosquito nets with them to protect themselves from mosquitoes while sleeping in the farms (Figure 3).

Figure 3: Malaria control measures when sleeping in the farm in Kimamba

Knowledge, Perceptions, Adaptations and Impacts of Climate Change

Only one in four understood the official Kiswahili term for climate change known as Mabadiliko ya Tabia Nchi, which is currently used by the government. There was a general understanding that the rain patterns have changed in the past 10 years (less than 5% said there are no changes). There were a range of descriptions for this change: 35% said the rains begin earlier, while 21% said rains begin late; 22% said that there is more total rain than ever before, but 10% said there is less total rain; 38% described the rains as being more unpredictable (Figure 4 A). There was more agreement on temperature change, with 62% believing that the temperature has increased in the last 10 years (19% said the temperature has not increased, and 18% said there was no change) (Figure 4 B).

Majority (86%) of the respondents reported to rely on weather patterns to determine planting time for their crops. Only about half of the respondents thought that the weather forecast by the Tanzania Meteorological Agency as provided through radio and television is useful in helping them to determine planting time. Three quarters (76%) of the respondents said that land scarcity in the district was a major problem.

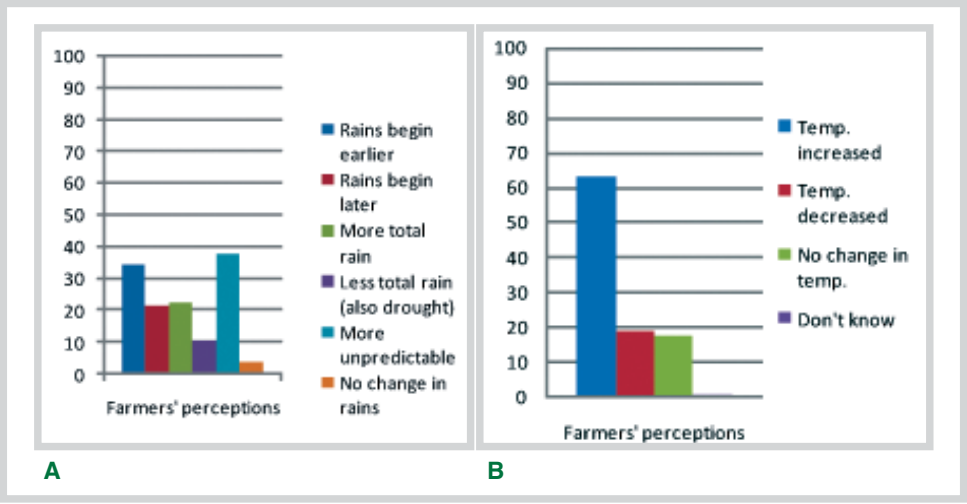

Figure 4: Community perception on changes of rainfall (A) and temperature (B)

Although crop farming was the principal occupation for both women and men, there was a gender disparity in the control of resources. In 59% of households the resources were controlled by the male head of the household, whereas women controlled resources in 20% of the households and the responsibility was shared in only 18% of the households.

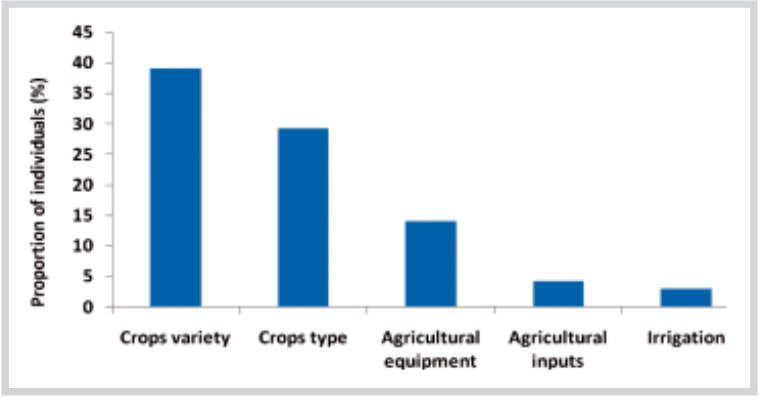

Figure 5: Changes in farming practices in the past 10 years in Kimamba

It was observed that respondents who were relying on rain-fed crop production, employed different strategies to cope with drought. These included switching to more pest-resistant maize varieties, changing cultivars, seeking temporary jobs in urban areas, renting their fields. These were more reported as adaptation farming practices, indicating resilience to climate change. One in three had changed their crop variety in the last 10 years. About 16% had changed crop type and 11% had gained use of equipment (Figure 5). However, inputs and irrigation practices remained mostly unchanged (less than 5% reported the change). When asked about the impact of the 2009/2010 floods in Kilosa, 77% of the respondents reported their households to be affected. Some 30% reported to have been displaced from their homes, with others reporting being still displaced for the past two years. Farmland was heavily affected with 45% of the respondents reporting a permanent loss of part of their land (Figure 6).

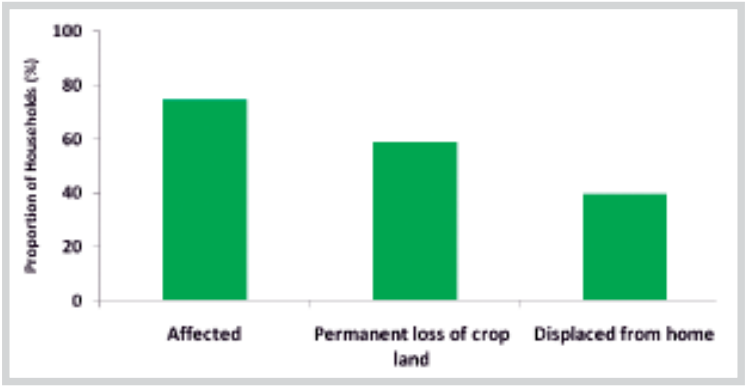

Figure 6: The proportion of respondents who experienced impacts of the 2009/2010 floods

Food security

Food insecurity was described by the majority of respondents to be a common problem across the village. Three quarters of the respondents reported that they had no sufficient production from their own agricultural farms to guarantee food security in their household for the year. Seventy-three percent reported to having food shortages in their household in the last five years. About half said they most often experienced severe food shortage during the rainy season- the season when most households experience several bouts of malaria (Figure 7). This is also the planting season, when farmers need to put much of their energy in farming to ensure high productivity. About a quarter (26%) had less than two meals a day. Maize was as staple food for almost all (98.35%) respondents, meaning their household would be upset by poor maize harvests.

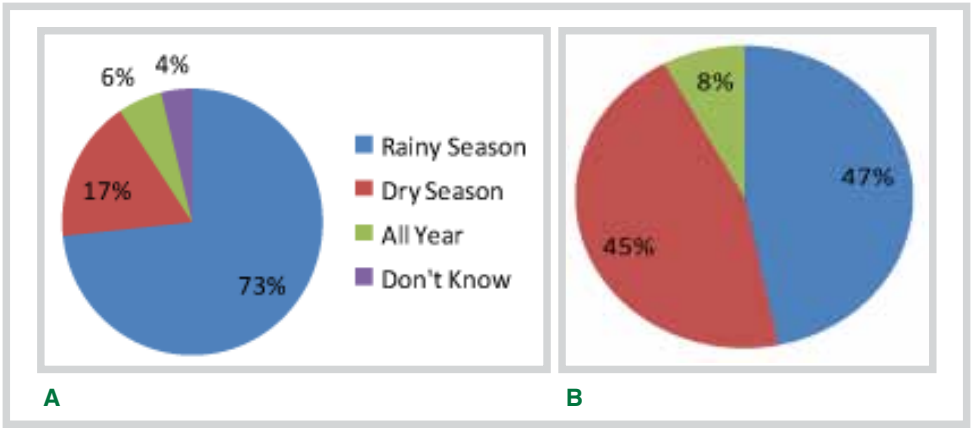

Figure 7: Relationships between incidence of malaria (A) and food shortage (B) experiences

Discussion

The community of Kimamba had at least some basic understanding of malaria, its causes, symptoms and prevention methods. They were apparently employing recommended prevention methods including use of mosquito nets and seeking treatment from health facilities. Despite this knowledge and efforts to scale up malaria interventions, there was no consensus that malaria was declining among the farming communities. Indeed, according to the government health reports, more than 12,000 children under five years old and 15,000 above 5 years attending health facilities in Kilosa were diagnosed with malaria in 2008 (Kilosa District Report, 2008). Nearly 4,000 children under five years old and 5,000 individuals 5 years and above were admitted to hospitals as cases of malaria, resulting in 100 and 91 deaths, respectively. It is clear that the current focused malaria interventions are not addressing the full problem and therefore, a more holistic approach is needed.

This study hypothesized that some malaria interventions, including mosquito nets, may be affected by rural farming lifestyles. One concern with effective mosquito net usage for populations such as Kilosa, where farms are located far from family homes, is resultant time spent out of the home during mosquito biting hours. This may occur when farmers need to leave their home before 5am to reach their field early in the day, or when farmers spend the night in their field to cut down travel time or to protect their crops at harvest time. In these situations, even if households have bed nets in the home they will not be protected at all times. Similar to current study, previously, in a neighbouring district of Mvomero, different farming seasons were associated with increased in number of malaria episodes. However, in Mvomero, rice farming was significantly associated with transmission of malaria than maize farming (Mboera et al., 2010). As to the most preferred source of care for malaria, the conventional healthcare facility has been mentioned in many other studies elsewhere (Rumisha et al., 2003; Mboera et al., 2010).

Indeed, in Kilosa district, the habit of rising before 5am for daily farming activities was

common, which makes mosquito nets ineffective for preventing mosquito bites for some time when mosquitoes are still biting. With such early morning activities, one cannot avoid been bitten by a malaria mosquito. To their credit, the community proved resilient in taking extra measures to use their mosquito nets whenever possible during night farm activities. In fact, spending the night at the field may be a better practice than rising early to go to the farm and being exposed to mosquito bites during commute and when farming. The mosquito net campaigns, which have clearly been successfully adopted in Kilosa as is evident from their widespread use, should take this into consideration and make sure that mosquito nets are being used effectively in make-shift shelters.

Human activity outside the home into late evening and early morning hours is very common in Kilosa district. Outdoor human activities observed in this study have implication in malaria transmission and control. Studies have indicated that An. gambiae complex readily seek hosts in outdoor venues (Reddy et al., 2011). The relevance of outdoor biting behaviour of nocturnal mosquitoes to vector suppression depends greatly on whether outdoor biting coincides with human outdoor activity. Previous studies have reported that host seeking activity of An. gambiae peaks around midnight (Maxwell et al., 1998). Future studies of human behaviour in relation to livelihoods would provide important insights into human activity and other potential risk factors associated with outdoor biting. Although some respondents in this study claimed to bring mosquito nets when carrying out outdoor farm activities, it is obvious that the use of the nets is limited when one has to walk chasing animals grazing in his/her farmstead.

The low awareness of the contribution of farming to malaria is major concern. Without knowing the risks, the community cannot take appropriate measures to reduce unnecessary practices that promote mosquito breeding or minimize exposure to mosquitoes. That agricultural production is not sufficient to provide food for the whole year is another problem with agricultural practices.

The heavy reliance on weather patterns to determine planting time is a growing problem as climate change upsets the anticipated rain cycle. Changing rain patterns devastate crops that were planted based on historic weather forecast because crops planted too early or too late receive little amount of rains. In our study, only about half of the respondents admitted that the weather forecast broadcasted through radio and television was useful. In Central Kenya, the majority of farmers were aware of the presence and importance of weather forecast information in operational decision making processes (IRICP, 2002). In another study in North Carolina, USA, 63% of the farmers were familiar with agricultural weather advisories (Johnson, 1989). In his study, 88% of all growers admitted that the agricultural weather advisory was useful in better management of agricultural operations such as timing of irrigation, scheduling labour for harvest or spraying. The feeling among the farmers that weather forecasts were not useful indicates that weather monitoring and broadcasting could be improved to help farmers determine their planting time. The government plans to provide farmers with information on weather forecast through mobile phones. The new system will benefit more farmers, as it will provide them with relevant and timely agricultural

information from their mobile phones. Although through this system, farmers would get real-time information on weather forecast and agricultural tips, it is important that education on the usefulness of weather forecast to farmers is emphasized to make the plan a reality.

Weather forecast is referred as the prediction of weather in advance. It assumes considerable importance for agricultural activities for the purpose of effective planning of agricultural practices such as sowing of weather-sensitive high efficient irrigation and harvest planning (Singh & Kumar, 2013). Weather plays an important role in agricultural production. It has a profound influence on the growth, development and yields of a crop, incidence of pests and diseases, water needs and fertilizer requirements in terms of differences in nutrient mobilization due to water stresses and timeliness and effectiveness of prophylactic and cultural operations on crops.

Managing seasonal climate risks for food production more effectively is a critical challenge in Sub-Saharan Africa where highly variable rainfed environments and projected long-term increases aridity pose serious risks to agriculture. Seasonal climate forecasts are an important planning tool at the farm level that can lead to better management of seasonal climate risks and instil processes useful to longer-term adaptation. However, in this study, majority of farmers were not aware of the usefulness of weather forecast. It has already been reported that farmer access to existing seasonal forecasts is poor, and the ability of farmers to properly interpret such information to benefit farming operations is inadequate (Johnston, 2011). In a study in India, farmers who received information about the rainfall in advance were observed to save the extra expenditure likely to occur in irrigating their fields. This clearly indicates that farmers using the weather advice from meteorological agency benefited significantly in agricultural productivity (Singh & Kumar, 2013)

The recent catastrophic flooding event in Kilosa made the district an important site for studying the effects of unprecedented flooding, which is expected to increase in Tanzania due to climate change. The high proportion of displaced residents and loss of farmland reported by the respondents pose problems to both malaria control efforts (including mosquito nets hung in the homes) and food security (from subsistence agriculture). Flood preparedness measures should address malaria control and sustainable food security.

The lack of comprehension of climate change shows that the community has not received education on climate change, which could prepare them for possible consequences. There was a general awareness that the temperature was rising and the rains were changing, which may have attributed to some of the change in crop variety reported by the farmers. Such flexibility is important for resilience to climate change.

Similar to our findings in Kilosa District, results from a study in Lushoto in north-eastern Tanzania also have revealed that most farmers were aware of ongoing climate variability. In Lushoto, seasonal drought appeared to have occurred most widely compared to other climate extremes (Mungai, 2013). As regards to coping strategies, studies in Rakai and Hoima in Uganda have reported some innovations for coping with climate related risks. For

instance, farmers in both Rakai and Hoima districts have adapted to climate change by spreading the risk through planting early maturing crops such as beans and sweet potatoes and drought-tolerant crops like cassava mainly for food security concerns (Mungai, 2013).

Food insecurity and malnutrition seriously impedes efforts to control diseases resource poor countries (Semali et al., 2011). In a recent study among HIV infected individuals in Tanzania, more than half of the respondents were food insecure. Low level of food insecurity was associated with having completed primary education and high income. Reporting two or less meals increased the likelihood of food insecurity. In the current study, an important result is the seasonal nature of food insecurity and malaria problems in the district. The greatest time of need is during the rainy season, for both hunger alleviation and malaria prevention. Interventions in these areas must also take into account the changing work habits of the community depending on the crop season. The most key finding is the resilience of the community toward preventing malaria. That the respondents were aware that mosquito nets could prevent malaria and also reported using the nets shows that they are willing to adopt reasonable changes to their lifestyles provided they see the connection to their health. They even made an effort to bring their nets to the fields when their livelihood required them to sleep overnight at their farms. This is evidence that educating Tanzanians about health problems is a key way to alleviate the burden, because knowing the problem allows them to find their own solutions.

It has been described that food insecurity is common in developing countries, especially in Sub-Saharan Africa and Asia. In Sub-Saharan Africa alone, an estimated two billion people experience food insecurity and its consequences like malnutrition and dietary deficiencies (FAO, 2003). A high proportion of households in sub-Saharan Africa are therefore in a constant process to mitigate and cope with hunger or hunger threat in addition to communicable diseases. In Tanzania, it is estimated that 58% of the households are experiencing food insecurity problem (TDHS, 2005) and thus their mitigation and coping strategies are seriously threatened by the high burden of communicable diseases.

In a study in rural Haiti, severe food insecure was a risk factor for perceived clinical malaria (Pérez-Escamilla et al., 2009). Malaria has been described to occur within the context of widespread poverty, poor health, and food insecurity. Kilosa's economy relies on an agrarian sector with very limited access to agricultural inputs (good quality soils, water, fertilizers, pest control, and machinery) and the physical infrastructure (roads, equipment, information technology) needed to market and transport agricultural commodities.

Previous studies have documented an increased risk of malaria associated with micronutrient, including zinc and vitamin A, deficiencies (Caulfield et al., 2004). Given that children living in food insecure households are more likely to consume diets of lower dietary quality and experience micronutrient deficiencies, they may be more likely to have compromised cell-mediated and humoral immune systems, increasing their risk for malaria (Caulfield et al., 2004; Shankar, 2000). It is possible that children living in severely food insecure households are more likely to experience micronutrient deficiencies, resulting in greater impairment in

their malaria-protective immune function (*Caulfield et al., 2004*; *Shankar, 2000)*.

Besides its impact on physical health, household food insecurity and the poverty-related determinants of this condition have been associated with maternal stress and suboptimal psycho-emotional human development in diverse settings (Pérez-Escamilla et al., 2004; Weinreb et al., 2002). Thus, food insecurity may increase the risk of malaria through several stress-related pathways, including adversely affecting children's immune systems, making them more susceptible to malaria

Several limitations of this study restricted its comprehensiveness. Self-reporting could have resulted in recall bias. Convenience sampling may not have accurately represented the entire population, including men who often were not present in the home. There was missing input from farmers who were in the fields during the days surveying occurred. Also, the survey was conducted by a large team, leaving room for inconsistent questioning styles. Finally, the data analysis was limited to descriptive outputs; therefore no bivariate analysis was completed.

This survey revealed information about malaria, food security, and agricultural practices through the eyes of those whom policymakers seek to address. The results show a need for improvement in all three sectors, with some overlapping issues that can be addressed in tandem. Policy implications stemming from this study involve a need for an integrated, cross-sectoral approach among experts in different fields that draws on community participation. A key initiative across all issues is community education. Specifically, women need information about intermittent preventive treatment for malaria, and farmers need to be prepared with news about climate change and possible adaptations in order to ensure food security and economic stability in coming years. There is a need to raise community awareness of links between agriculture and malaria. In conclusion, this study showed that farmers are resilient to challenges to their livelihoods. Given the tools and information about how to prevent malaria and improve their agricultural practices, farmers are willing to make changes to their livelihoods.

Chapter 8: Accessibility, availability and utilisation of malaria interventions among pregnant women in Kilosa District

Abstract: Universal access to and utilization of prevention measures is defined as every person at malaria risk sleeping under a quality insecticide-treated net and every pregnant woman at risk receiving at least two doses of Sulfadoxine-pyrimethamine (SP) for prevention of malaria. The objective of this study was to determine factors affecting accessibility, availability and utilisation of malaria interventions among pregnant women in Kilosa district in Tanzania. Women with children <5 years old or those who had been pregnant during the past 5 years were selected to participate in the study. A structured questionnaire was used to interview women on malaria knowledge and utilization of malaria interventions. Demographic data such as sex, marital status, education, occupation, distance to a health facility and costs related to accessing ante-natal care (ANC) services were collected. Knowledge on the effects of malaria during pregnancy and utilization of intermittent preventive treatment (IPTp) was also assessed. A total of 310 women (mean age=30±9.6 years) were involved. Almost all women (92%) were involved in crop farming as the main source of income. Over 94% of the women had attained primary school education. About a quarter of women had two children of less than 5 years while over 58% had 3 or more children. There was a significant association on the number of under five children and education. Educated women had fewer children than the non-educated ones (P=0.014). One fifth of the women (19.1%) had low level of knowledge while only one tenth had very high knowledge on malaria. Most (71.4%) women had medium general knowledge on malaria. Only 8% of the women had good knowledge on malaria in pregnancy. A significant proportion of women were not aware of the reasons for taking SP during pregnancy (35%), timing for SP (18%), and the effect of malaria on pregnancy (45.8%). Knowledge on malaria in pregnancy had a significant association with levels of education (P=0.024). Almost all women (98%) had a mosquito net. Among those with mosquito nets 87.1% received free from the government. All women attended the ANC during their last pregnancy. However, only 45% attended three times and 41% over 3 times. The coverage of IPT1 was 53.3% and IPTp2 was 41.3%. Higher proportion of women who made three or more visits was among those with only one child. The proportion of making more visits reduced with increasing parity. Timing for first dose of SP for IPTp was 1-3month (28.4%) and 4-6months (36.8%). Over three quarters of women (78.06%) were provided with SP under supervision of the health provider. The knowledge that SP treats malaria was associated to decrease intake of 2 doses of SP during pregnancy. In conclusion, most pregnant women in Kilosa district have low knowledge on malaria in pregnancy and coverage of IPT2 was low.

Keywords: malaria, pregnancy, interventions, mosquito nets, preventive treatment, Tanzania

Introduction

Malaria in pregnancy is one of the major public health problems in endemic areas of sub-Saharan Africa and has important consequences on birth outcomes (De Beaudrap et al., 2013). Malaria infection during pregnancy might results into maternal death, low birth weight, pre-term birth and sometimes early infant death (Teplin et al., 1991; Steketee et al., 1996, 2001; Taylor et al., 2000; Guyatt & Snow, 2001, 2004; Grantham-McGregor et al. 2007). The current the World Health Organization strategies to prevent and reduce malaria transmission and burden in pregnant women include the use of intermittent preventive treatment in pregnancy (IPTp) and insecticide-treated nets (ITNs) (WHO, 2012). Early diagnosis and proper case management compliment the preventive strategies.

The IPTp doses are delivered at health facilities during Antenatal Care (ANC) visits. Up to four doses can be provided, scheduled at each trimester and during delivery. Despite the high proportion of women who attends ANC services during their pregnancy, those who receive IPTp as per guidelines are still very few, in most cases only the first dose is well covered (WHO, 2012).

Tanzania adopted IPTp strategy as a national policy in 2001. According to nation-wide surveys, the proportion of women who received IPTp during ANC visits during their last pregnancy were 31% and 28%, in 2008 and 2010, respectively (TDHS, 2008, 2010). Recent statistics indicate that the coverage of IPTp2 is still low at 31.3% (THMIS, 2013). IPTp2 coverage in Tanzania was among the highest in southern Africa in 2005 but it has dropped to third place after Zambia (63%) and Malawi (54%) in the most recent period (MoHSW/IHI/NIMR/WHO, 2013). The targets for the IPTp indicator in Tanzania were to have coverage of 60% by 2012 and 80% by 2015. On the other hand, dramatic progress has been made in the ownership and use of ITN in Tanzania. During 2008 to 2012 the proportion of pregnant women who slept under an ITN increased from 26% to 76% (TDHS, 2008; THMIS 2007/8; THMIS, 2013). The bulk of the increase occurred in rural mainland where malaria transmission rates are highest. With targets set at 60% by 2010 and 80% by 2015 the trend is promising.

Universal access to and utilization of prevention measures is defined as every person at malaria risk sleeping under a quality ITN and every pregnant woman at risk of malaria receiving at least two doses of SP administered during the second and third trimesters (WHO, 2010). Direct observation of SP by the health worker is highly recommended (White, 2005). However, various factors including socio-economic status, urbanization and performance of health system differentiate the effectiveness of the strategy (Mubyazi et al., 2008).

Kilosa is malaria holoendemic area and studies have shown higher prevalence of low birthweight (17.5%) and stillbirth (4.8%) (Uddenfeldt Wort et al., 2006). This study was carried out to determine factors affecting accessibility, availability and utilisation of malaria interventions among pregnant women in rural community of Kilosa district in Tanzania. Specifically, the study aimed: (i) to determine the coverage of intermittent preventive

treatment for malaria during pregnancy; (ii) to investigate the determinants of utilization of malaria preventive services among women who delivered in the previous five years in the district; (iii) to assess health facility readiness in providing ANC services in relation to malaria in pregnancy; and (iv) to determine insecticide treated mosquito coverage among pregnant women in the district.

Materials Methods

Study area

The study was carried out in Kimamba Ward of Kilosa District (22017'-32049'E and 90127'-903339'N) in central Tanzania. The district has a total surface area of about 14,400 km2 and a population of 489,513 people living in 105,635 households with an average household size of 4.6 people. The climate belongs to the tropical savannah of the low latitude environment. The rainfall has a characteristic monomodal pattern; the rains begin in October with a peak in April and continue till May. The mean annual temperature is 25oC (mean annual maximum=30oC; mean minimum= 19oC).

Study design

This cross sectional quantitative community based survey was carried out during November 2011. The study involved women with children aged less than five years of age. All women with children <5 years of age residing in the selected ward were eligible. Purposive sampling was used to get the sample size of 330, to detect IPT2 coverage of 27% (TDHS, 2010) at a precision of 0.05. The sample size is calculated from the following formula:

$$N = \frac{z2p(1-p)}{d2}$$

Where: N- Total number of subjects required in the sample; Z= a standardized normal; deviate value that correspond to a level of statistical significance equal to 1.96; P= estimate of prevalence of malaria in pregnancy (22%); d= margin of error which correspond to the level of precision of results desired

$$N = (1.96)20.41(1-0.41) = 330$$

Data collection

Women with children underfives or who had been pregnant during the past 5 years (from the day of the survey) were selected to participate in the study. A structured questionnaire was used to interview women on malaria knowledge, availability, accessibility and utilization of malaria preventive measures. Demographic data such sex, marital status, education, occupation, distance to the closest health facility and costs related to accessing ante-natal care (ANC) services were collected. Women' knowledge on the effect of malaria during pregnancy and utilization of SP for IPTp was also assessed. Key questions were: "When should a pregnant woman take the first dose of SP for intermittent preventive treatment of malaria?"; "What are the effects of malaria on the unborn baby?"; "How many times during the last pregnancy did you take SP tablets for IPTp at ANC clinic?" The antenatal cards were reviewed for those who attended ANC clinic to ascertain the information given by the respondents. Card information included gravidity, gestation age at first ANC visit, gestation age at first and second SP doses.

The assessment of the health facility readiness aimed to identify healthcare service factors that influence the IPTp programme implementation including availability of SP and clean, safe drinking water at the ANC; level of staff knowledge and training in IPTp; and supervision and monitoring of IPTp programme. A total of 10 health facilities were selected for this part of the study. A questionnaire was administered to staff of the selected ANCs. In addition, non participatory ANC observations were made using a standardized checklist.

Data management and analysis

Database was prepared using EpiData Version 3.1 software and data were entered using trained clerks. The data cleaning and quality check was done by a statistician by comparing a sample of the questionnaire with the entered data. Data was migrated to STATA (Stata Corps) for further analysis. Cross tabulations were done between selected variables of interest. Various variables of outcome were defined using key questions to assess the knowledge on when SP was supposed to be taken and the rate of SP uptake during pregnancy. The association between different factors and the outcome variables were done using x2-test and proportional tests (where appropriate). The multivariate logistic regression was used to identify effect of predictors adjusting for interactions and confounders. For health care workers, the level of knowledge on IPTp, training on IPTp in the past 12 months, availability of potable and SP at the health facility, directly observed treatment (DOT) practice for SP and monitoring and supervision of IPTp in ANCs were analysed.

Ethical considerations

This study received ethical approval from the Medical Research Coordinating Committee of the National Institute for Medical Research. Permission to conduct the study was sought from the Kilosa District Council, Ward and Village authorities. Meetings were held with Ward Executive Officer and Village Executive Officers where the objective of the study was described to ask for their assistance during the recruitment of the study subjects. Verbal Informed consent was obtained from each respondent before the interview. The consent of each subject was recorded on the survey form.

Results

Demographic characteristics

The survey involved a total of 310 adult women (≥15 years) those who had at least one child. The mean age of the respondents was 30 years (SD=9.6) with age range between 15 and 80 years. Three quarters of the women (74.8%) were married or living with partners. Almost all women (92%) were involved in crop farming as the main source of income. Those who had primary school education (>94%) and secondary were considered educated (Table 1).

Table 1: Distribution of age, education and number of children among pregnant women

Variable	Response	No. (%) with no primary education	No. (%) with at least primary education	Total Number (%)
Age group	15-19	2 (2)	23 (10.95)	25 (8.06)
	20-24	17 (17)	37 (17.62)	54 (17.42)
	25-29	21 (21)	58 (27.62)	79 (25.48)
	30+	60 (60)	92 (43.81)	152 (49.03)
	Total	100 (32.2)	210 (67.7)	310
No. of children (<5 years)	1	8 (8.0)	44 (21.0)	52 (16.8)
	2	25 (25.0)	53 (25.2)	78 (25.2)
	≥3	67 (67.0)	113 (53.8)	180 (58.0)
	Total	100 (32.2)	210 (67.7)	310

Over two thirds (67.7%) of the respondents had at least a primary school education, with those aged 25 years or older accounting for the largest proportion (71.4%) (Table 1). About a quarter of the women had two underfives children at the time of the survey while over 58% had 3 or more children. There was an adolescent fertility of over 8% while about 7% of the women aged >45 years old had an under five child. There was a significant association between the number of underfives and education status. Those with at least a primary school education had a lower proportion of having more than 3 under fives (Two-sample test of proportions, P= 0.014).

Knowledge on malaria in pregnancy

General knowledge of malaria among was assessed based on knowledge on malaria signs and symptoms, transmission, prevention, seasonality and impact of interventions. A knowledge score of 1 was given for each of the indicator questions making a total of 13 points. The score was further grouped into three categories i.e. low knowledge (≤ 5), medium knowledge (>5 to 9) and high knowledge (≥10). One fifth of the women (19.1%) had low level of knowledge while only one tenth had very high knowledge. Most (71.4%) women had medium knowledge on malaria (Figure 2).

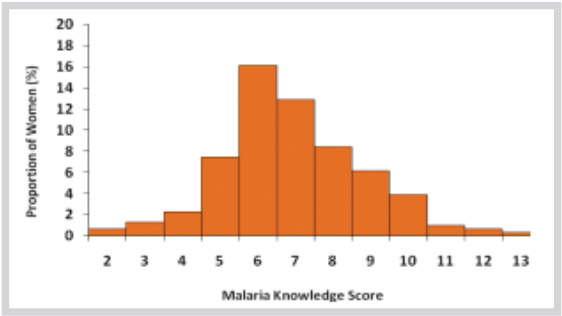

Figure 2: Distribution of women on general malaria knowledge in Kilosa

Knowledge on malaria in pregnancy was assessed based on the response of women on the five key aspects. These were knowledge on timing of first dose of SP (IPT1), reasons for taking SP, effects of malaria on the mother and unborn baby, and other malaria prevention methods (Figure 3).

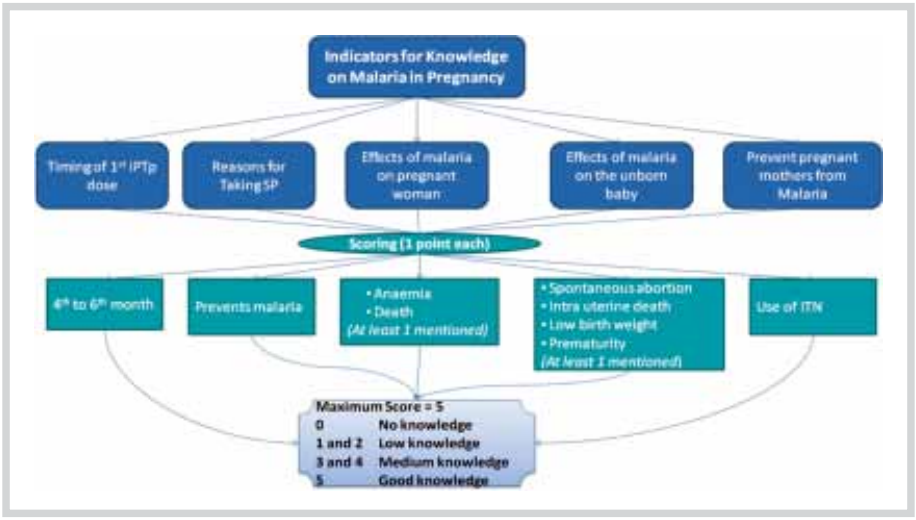

Figure 3: Assessment of women' knowledge on malaria in pregnancy in Kilosa

The assessment indicated that over 8% of the women could not show any indication of having knowledge on malaria in pregnancy (Figure 4) despite the fact that all women mentioned to attend antenatal care services at least once and claimed to receive information on malaria prevention and treatment. Only 8.06% of the women had good knowledge on malaria in pregnancy. The rest of the respondents were classified as medium or low level (Figure 4).

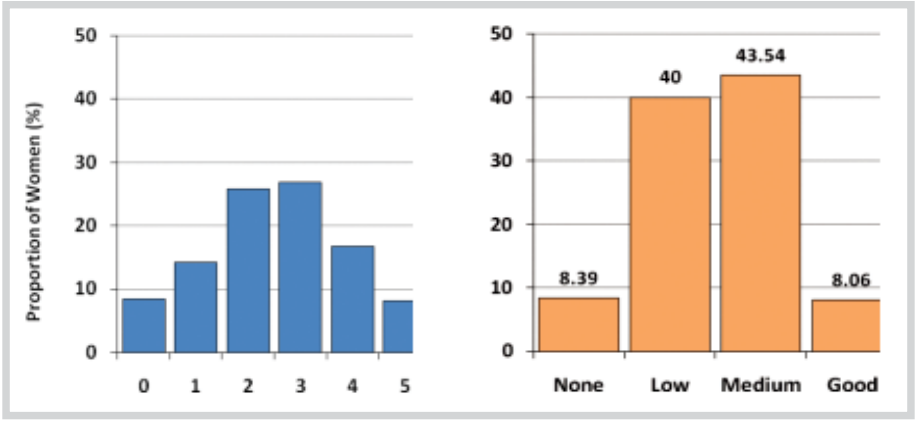

Figure 4: Distribution of women on knowledge of on malaria in pregnancy in Kilosa

Over one third (35%) of the women did not know the reasons for taking of SP while 18% did not know the right time for taking SP for IPT. In addition to that, a large proportion of the respondents were not aware of effect of malaria on pregnant woman (45.8%). Knowledge on the effect of malaria to the unborn baby among mothers in Kilosa was generally poor (Figure 5). The knowledge of malaria in pregnancy had a significant association with level of education (P =0.024).

Figure 5: Knowledge on the effect of malaria to the unborn baby among mothers in Kilosa

Access and utilization of malaria interventions

Over 97% of the women mentioned to have consulted a health facility when suffering from malaria. Health care was mostly sought from the public facilities (98%). Alternative sources of care included traditional healers and self medication mainly obtaining medicines from drug stores or use of leftovers at home. These options were described to be due to cost related to accessing the facilities and low satisfaction with quality of service at health facility.

Almost all (98%) women had at least a mosquito net in their household. The average number of mosquito nets available in the household was 2.6 (SD=1.3). Among those with mosquito nets, 87.1% mentioned to have received free nets from the government net distribution programme. Other sources of nets included through voucher scheme (18%) and self purchase. About 12% of the women had mosquito nets obtained from both free distribution and voucher scheme. The attitude towards effectiveness of mosquito nets in preventing malaria did not differ between those who received free nets and purchased themselves (P >0.05). Most women (96.2%) mentioned to use mosquito nets to prevent themselves from malaria. Cleaning of the environment (21%) and draining of stagnant water (15%) were the other methods of malaria prevention mentioned by the respondents.

All women admitted to attending ante-natal care clinic during their last pregnancy. Proportionally, 45% attended three times and 41% over 3 times. A small proportion (14%) attended two times or less. There was no pattern on attendance with the age of the woman.

The first visit was commonly during the first trimester, mostly during the third month of gestation. However, a significant proportion (35%) of women attended the ANC clinic late during gestation (mostly during second or third trimester) (Figure 6).

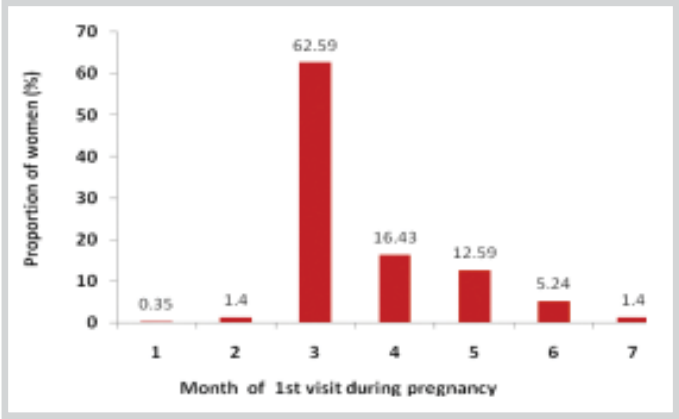

Figure 6: Gestation period during the first ANC visit

The number of children was observed to be related to the number of visits to the ANC services. Higher proportion of women who made three or more ANC visits were those with only one child. The proportion of ANC visits declined with increasing parity (Figure 7). Timing for first dose of SP for IPTp was mentioned to be 1-3 months (28.4%) and 4-6month (36.8%). Over three quarters of women (78.06%) took SP under supervision of a health care provider. Assessing the coverage of IPTp1 and IPTp2 it was observed that, over half (53.3%) claimed to receive SP tablets during ANC visit once during the last pregnancy. Some 41.3% claimed to receive SP dose twice (recommended dose). The responses were confirmed through examination of the ANC cards by the investigators.

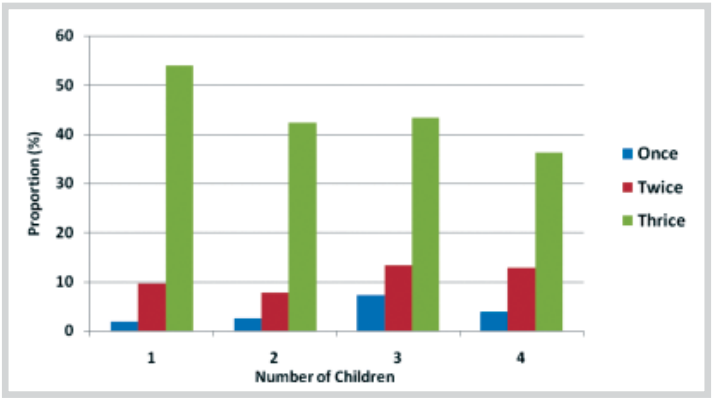

Figure 7: Number of antenatal care clinic visits and parity

Respondents with high knowledge of malaria had more ANC visits than those with low knowledge of malaria in pregnancy (Figure 8).

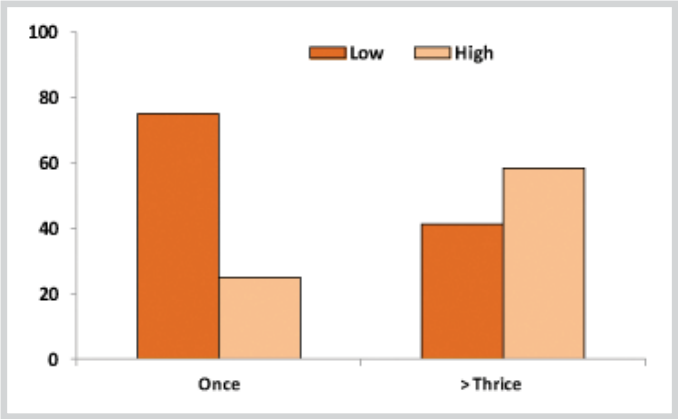

Figure 8: Association between ante-natal care visits and knowledge of malaria in pregnancy

The distance to the nearest health facility for each respondent was assessed. It was observed that facilities that provide ANC were close and accessible by the majority of the respondents. Over half (56.8%, n=176) of the respondent used 15-30 minutes to walk to the health care facility. One quarter used less than 15 minutes and the other used 30+ minutes. On average, 30% of women spent less than 1 hour during their ANC visit (including travel, waiting and service time). Some 34.5% of the respondents claimed to spend between 3-4 hours for travel, waiting and service time for any single ANC visit. Interestingly, younger women reported to spend longer times than the older ones (Figure 9).

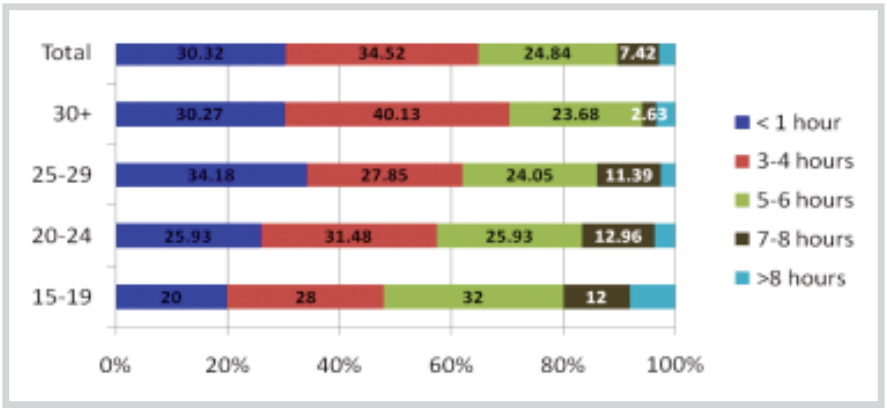

Figure 9: Average time spent for ANC visit including travel, waiting and service time

Over 30% of women claimed to suffer from malaria during their last pregnancy and 95% of them were treated at a health facility. The antimalarial drugs used for treatment were SP (44.4%), Artemether-Lumefantrine (28.70%) and quinine (11.11%). Three quarters (75%) of the women who attended ANC at least once reported having delivered at health facility. Women were satisfied with the quality of ANC service provided at the facilities (Figure 10).

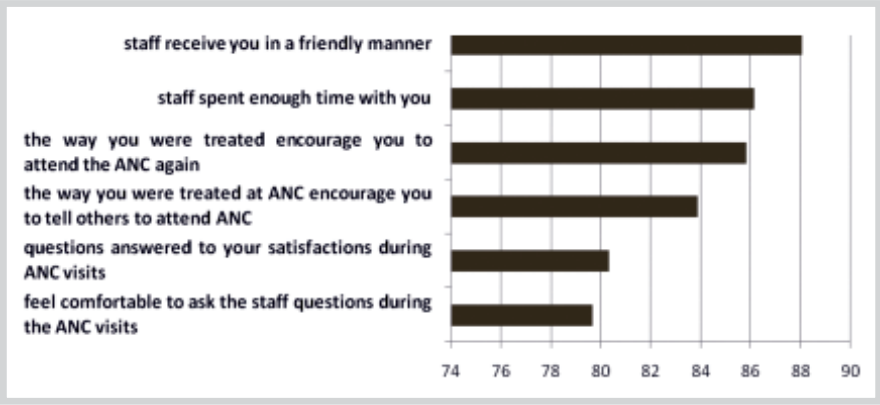

Figure 10: Levels (in %) of the satisfaction of women on the ante-natal care (ANC) service

A simple regression model was fitted to assess the relationship between number of SP dose and other variables described above. However, only knowledge that SP treats malaria was associated with a decrease in the intake of 2 doses of SP during pregnancy. Other variables such as age, number of children (all ages or under 5s), education, distance to health facility, number of ANC visits, knowledge on effect of malaria on pregnancy and usefulness of SP to the mother/unborn child were not statistically significant (P>0.05).

Health facility readiness

Ten facilities were visited and the questionnaires were filled in by 26 health staff. The facilities included three health centres, seven dispensaries and district hospital. Of the total of 26 ANC staff, 6 were nurse-midwives, 4 enrolled nurses, 1 registered nurse, 8 medical attendants, 6 clinical officers and 1 assistant medical officer. Only three health facilities had laboratory facilities. Only the ANC clinic at the district hospital had a capacity to provide blood transfusion services (Table 2). Twenty-five (96%) of the health workers interviewed admitted to experience stock outs of SP for a period from 1-18 months during the 12 month preceding the study. Stock out of SP was reported in 90% of the visited facilities. During the period of stock outs, the ANC staffs were either suspending IPTp service until stocks were replenished or advised their clients o come back on the next visit to receive SP. Otherwise, the health staff would issue prescription for the women to buy SP elsewhere.

Potable water was available at the ANC for taking SP. This was confirmed by the ANC staff who said water was available free of charge. One dispensary and one Health Centre had

no pipe water.

Table 2: Characteristics of health facilities visited in Kilosa district, Nov 2011

Type of HF	Name of Health facility	No. of staff	IPTp-SP outreach services	SP stock out	Laboratory present
Hospital	Kilosa District Hospital	11	No	1 month	Yes
Health Centre	Kimamba	4	No	6 months	Yes
Dispensary	Masange	5	Yes	No	Yes
	Ulaya	11	Yes	8 months	No
	Rudewa	4	Yes	6 months	No
	Kisanga	4	Yes	1 month	No
	Msimba	2	No	12 month	No
	Mvumi	5	Yes	18months	No
	Ilonga	5	Yes	12 months	No
	Chanzuru	3	Yes	6 months	No

*Part of the Kilosa District Hospital

All health workers interviewed had good knowledge on IPTp, although the majority of them did not know the contraindications to SP (Table 3). Of the 26 health workers interviewed only one had formal training on IPTp during the previous 12 months preceding the study. All ANCs had the IPTp national guidelines. Forms for adverse events were not available in all ANCs. Direct observed treatment (DOT) of SP was practiced in all ANCs visited. Surprisingly, none of the health workers admitted to having received a monitoring and supervision visit specific for the IPTp programme during the 12 month period before the study.

Table 3: Knowledge of ANC staff on intermittent preventive treatment in pregnancy (IPTp)

Knowledge components	No. of staff answering correctly	% of staff answering correctly
Definition of IPTp	24	92
Drug of choice for IPTp	25	96
Frequency of SP administration	25	96
Timing of administering SP	17	65
Contraindications to SP	11	42
Benefits of IPTp	18	69

Discussion

The IPTp-SP programme has not successfully being implemented in Kilosa district as the coverage is below the national target of 60% IPT2. SP stock out and lack of qualified health workers was common in all health facilities in the district. Despite high awareness, positive attitudes, and appropriate treatment seeking behaviour among women, completion of the SP regimen was still low with only 41.3% of the women completing two doses of SP. A recent analytical review of the Health Sector Strategic Plan III has indicated that the national coverage of two doses of SP during antenatal visits is still low despite a slightly increase

from 29.6% in 2008 to 31.3% in 2012 (THMIS, 2008, 2013). The poorest wealth quintiles have the lowest IPT2 coverage (25%) while women in the best-off quintile have higher coverage rates but, still below 50%.

Factors such as long waiting and service times at the health facilities for the ANC service are likely to play a role in the observed patterns. Studies elsewhere in Tanzania and sub-Saharan Africa have indicated a combination of lack of awareness, health worker behaviour, stock outs and policy as possible explanations for low recorded coverage of IPTp (Mubyazi et al., 2005; Tarimo, 2007; Ander et al., 2008). In Zambia, where high coverage of IPTp second dose has been achieved and sustained within existing systems, highlights coordinated support to the routine clinic system and training to antenatal care workers as key enabling factors (Steketee et al., 2008). A study in north-east Tanzania reported that health facility workers do aim to stay within the recommendation for IPTp delivery, and reported missed opportunities for protecting pregnant women with two doses (Anders et al., 2008). Tanzania antenatal guidelines differ from the current WHO recommendation which require provision of SP to all pregnant women at their first ANC visit after quickening (WHO, 2007). This is designed to be easily implemented and stays within safety limits of SP in pregnancy; and is not dependent on individual timing preferences for first attendance to antenatal clinic. In a recent meta-analysis, Hill et al. (2013) listed key barriers to the provision of IPTp and ITNs to include unclear policy and guidance on IPTp; general healthcare system issues, such as stock-outs and user fees; health facility issues stemming from poor organisation, leading to poor quality of care; poor healthcare provider performance, including confusion over the timing of each IPTp dose; and women's poor antenatal attendance, affecting IPTp uptake.

In this study, there was no pattern on attendance with the age of the woman. However, the number of parity was observed to be related to the number of ANC visits; with the proportion of ANC visits declining with increasing parity. Moreover, respondents with high knowledge of malaria had more ANC visits than those with low knowledge of malaria in pregnancy. Similar to our findings, a study in southern Tanzania showed age was not associated with second SP dose coverage (Marchant et al., 2008). Marital status, education level and occupation are expected to be predictive of receiving more doses of SP but this was not observed in this study. The free maternal health care policy could have helped overcome these factors as barriers to accessing healthcare through the ANCs. Other studies have also shown that marital status, educational level and household socio-economic status are not associated with a second dose of SP (Mbonye et al., 2006; Marchant et al., 2008). According to Hill et al. (2013) key determinants of IPTp coverage are education, knowledge about malaria/ IPTp, socio-economic status, parity, and number and timing of antenatal clinic visits.

This study showed that approximately two thirds of the respondents attended ANC for the first time when they were in their first trimester and a third of them during their second trimester. In a study in Kenya by van Eijk et al. (2006) about two thirds of women first visited the ANC in the third trimester. The late attendance was associated with perceived lack of quality in the ANC. Despite the early ANC attendance observed in our study, only 41.3% of respondents received two doses of SP – indicating that early attendance does not

contribute to the increase in coverage of the second SP dose. Late first ANC registration has been found to contribute to incomplete IPTp (Ndyomugyenyi & Katamanywa, 2010; van Eijk et al., 2006; Mubyazi et al., 2008).

In this study, readiness of the health facilities to provide the ANC services could be one of the major factors contributing to the poor coverage. Although potable water for DOT was available free of charge in almost all the health facilities the district, SP stock out was common and frequent. Probably higher coverage would have been achieved if SP was available throughout the year. Frequent SP stock out are likely to contribute to low coverage of IPTp in the district. Interruptions in supply of SP to the health facilities have the potential of negatively influencing the IPTp programme (Mubyazi et al., 2008). This potentially undermines the increased ANC attendance by the pregnant women that the free maternal health care policy seeks to achieve if medicines to be given cannot be procured. To ensure DOT is being practiced as recommended in the guidelines for IPTp, availability of SP and potable water as well as commitment of the health workers to observe all pregnant women take SP at ANC is needed.

Compliance to IPTp guidelines, quality and content of the health education given at the ANC depend on the knowledge and training of the ANC staff on IPTp. The findings from this study revealed that although only one health worker had formal training on IPTp in the previous year, the level of knowledge of the staff on malaria in pregnancy was average. Unfortunately, the staffs were not aware of the availability of IPT guidelines in their respective facilities. A study in Kenya has demonstrated an increase in IPTp coverage after health care workers were re-trained on IPTp (Ouma et al., 2007). Formal training and retraining of the health workers is an important factor in improving coverage of malaria and other health interventions. Moreover, regular provision of supportive supervision of the frontline health workers including aspects related to delivery of ANC services has been shown to be strong motivational factors. Usually, each health facility has to have supervision at least once every three months by the members of district Council Health Management Team. However, findings from this study showed this doesn't happen regularly. Similar to our findings, in a study in northern Tanzania, health workers complained that their supervision was not systematic and was not supportive when provided (Manongi et al., 2006). Several studies have shown supportive is essential for quality improvement and job satisfaction (Ahmed et al., 1993; Ben Salem & Beattie, 1996). However, supervisors themselves are often poorly resourced and may not be trained in effective supervision techniques. This is an important area for development in improving the Tanzanian health service.

This study is likely to have faced some limitations. The respondents may not have recollected all that happened during their ANC visits during their last pregnancy leading to recall bias. However, this was minimized by examining ANC records and compared to answers given by the respondents and this was found to be comparable.

In conclusion, this study showed high coverage of insecticide treated nets but low coverage of IPTp among pregnant women in Kilosa district. The knowledge of the pregnant women

on IPTp was average and could have impacted on IPTp coverage. The implementation of simplified IPT guidelines would be critical for reaching the 80% national target for IPTp by 2015. Campaigns that provide educational massages on the risk of malaria during pregnancy and the usefulness of IPTp so as to raise clients' awareness should be emphasised. The government must make sure that SP is available in all facilities at all times. Improving upon the monitoring and supervision of the programme as well as ensuring regular training and re-training of health workers in IPTp will further improve the programme in the district and the country at large.

Chapter 9: Malaria surveillance and use of evidence in planning and decision making in Kilosa District

Abstract: Since 2001, Tanzania has been making concerted efforts to strengthen its Integrated Disease Surveillance and Response system. In this system, malaria is one of the priority diseases that are to be reported monthly. The objectives of this study were to assess malaria information system at facility and district levels to identify key barriers, constraints and priority actions for malaria surveillance strengthening; and (ii) to explore the use of evidence in health planning and decision making at facility and district levels. The study was carried in Kilosa District during October 2012 and involved health facility workers and members of the district health management teams. The existing information system on malaria was evaluated using a structured questionnaire and check list. Data collection also involved direct observations of reporting and processing, assessment of report forms and reports of processed data. A total of 17 health workers (in-charges) from both public and private health facilities were interviewed: two from hospitals, four from health centres and 11 from dispensaries. Of the 17 informants, 15 were familiar with disease surveillance functions. A good number (8/17) received training on disease surveillance during the previous two years (2010-2012). Different means of communications were used for reporting epidemiological information from facility to district level. However, public transport and motorcycles were the major means of reporting to the district level. Most of the health facilities (14/15) faced difficulties in submitting reports due to lack of resources and feedback from the district authority. A good number of health facilities (9/17) reported to perform minimal data analysis. Analysis of malaria was reported in 9/17 facilities, but limited to malaria incidence per age groups. Challenges in data analysis included unavailability of compilation books; lack of computers; poor data storage; incomplete recording; lack of adequate skills for data analysis; and increase in workloads. Data at both facility and district levels were mostly used for quantification and forecasting of drug requirements. In conclusion, malaria information system in Kilosa district is weak and utilization of evidence for planning and decision making is poor. Capacity strengthening on data analysis and utilization should be given a priority at both facility and district levels of the health systems in Tanzania.

Keywords: malaria, surveillance, health management information system, utilisation, Tanzania

Introduction

Disease surveillance is the ongoing systematic collection, analysis, and interpretation of epidemiological dat, closely integrated with the timely dissemination of these data to those responsible for preventing and controlling disease and injury (Thacker & Berkelman 1988). It is a tool to estimate the health status and behavior of the populations served by the

health system. For the same reasons, information on the number and distribution of malaria cases and deaths in space and time is critical for the design and implementation of malaria control programmes, as well as for monitoring and evaluation. It is needed to determine which areas or population groups are most affected by malaria, so that resources can be targeted to the populations most in need (WHO, 2012). Such information is also needed to determine the success of a malaria control programme and to determine whether it is performing as expected.

During the past 10 years, Tanzania has been making concerted efforts to strengthen its infectious disease surveillance through an Integrated Disease Surveillance and Response (IDSR) strategy. Since 1998, several national assessments of the infectious disease surveillance systems have been conducted in the country (Nsubuga et. al., 1998; Franco et al., 2002; Mghamba et al., 2003). Following the 1998 assessment, the Ministry of Health, in consultation with its partners, developed a work plan for integrating and strengthening disease surveillance (February 1999), and identified 13 priority diseases (Franco et al., 2002) to be included in its IDSR strategy. In March 2000, the IDSR Task Force was established; it prepared budgets and approaches to implementing its Action Plan, which was approved in April 1999. In October 2000, the IDSR Task Force had prepared the National Guidelines for Integrated Disease Surveillance and Response as a reference to be used by at facility, district, regional and national levels by district and regional health management teams, national communicable disease programme managers, national epidemiology unit, health management information systems, and medical and nursing tutors in the national training institutions. By 2001 laboratory networking guidelines had been developed, and in 2002, the WHO/AFRO district analysis book was adapted and approved. In January 2002, the Task Force reviewed and approved a preliminary 3-year work plan for strengthening the national IDSR strategy in Tanzania. Since the introduction of IDSR in Tanzania in 2001, only a few studies have been carried out to assess that status and its implementation (Franco et al., 2002; Mboera 2004; Mboera et al., 2004; Eisele et al., 2006; Rumisha et al., 2007)

Delivering public health services requires functional and effective country-level health systems including capable innovative health leadership, qualified healthcare providers, effective human resource systems, reliable data, adequate physical infrastructure, and many other critical inputs (Anyangwe & Mtonga, 2007). Studies have pinpointed weak health systems as critical barriers to improved health across Africa. A weak health system has been described as among the critical factors for underutilisation of the health interventions in developing countries (Anyangwe & Mtonga, 2007). In many cases, the failure to deliver affordable and effective interventions to predictable, preventable and treatable diseases like malaria is a major weakness in the health systems of many developing countries. While health systems in general have received worldwide attention, little has been done to strengthen facility, district and national institutions responsible for stewardship of health systems in Tanzania.

Constant malaria monitoring and surveillance systems have been highlighted as critical for malaria elimination (Barclay et al., 2012). Surveillance systems that can gather, store and

process information, from communities to national levels, in a centralized, widely accessible system will allow tailoring of surveillance and intervention efforts (Barclay et al., 2012). There are indications for malaria elimination in Tanzania (Mboera et al., 2013). To motor the trend of malaria morbidity and mortality an effective, real-time, on-going monitoring systems are important for (i) rapid detection of existing, new or re-introduced infections (Tatem et al., 2009; Lee et al., 2010); (ii) identification of periods of low transmission when the parasite population could be most amenable to elimination (Kamanga et al., 2010; Atkinson et al., 2012; (ii) understanding trends in malaria incidence and prevalence and, (iv) detection of antimalarial drug and insecticide resistance.

To optimize malaria intervention efforts, both practitioners and decision-makers need timely, robust information about epidemiology and distribution of intervention; an ability to access data and to coordinate intervention activities; and, conditions that facilitate data sharing and optimal, group-based decision-making. The objectives of this study were (i) assess malaria surveillance system (as part of the Integrated Disease Surveillance and Response and Health Management Information Systems) at facility and district levels to identify key barriers, constraints, priority actions for surveillance strengthening; and (ii) explore the use of evidence in facility and district health planning of malaria control.

Materials and Methods

This study was carried in Kilosa District in central Tanzania during October 2012. The existing information system on malaria was evaluated using established methods that have been used in Tanzania (Franco et al., 2003; Rumisha et al., 2007. This include description of the system components and levels, evaluation of its main attributes, assessment of its usefulness by the malaria control actions and policy decisions taken as a result of the information provided by it, and description of the resources used to operate the system. Data collection for this evaluation included consultations with key persons involved at district and facility levels, direct observations of reporting and processing, assessment of report forms and reports of processed data, and assessments of the accuracy of diagnosis at health facilities.

Mapping and use of face-to-face in-depth interviews with key informants were carried out to explore the use of evidence in planning at facility and district levels. A structured questionnaire was developed to collect the required information. In terms of data management, the following information was sought: knowledge on disease surveillance; training on disease surveillance, means of communication used to submit epidemiological report; challenges faced and possible solutions to the challenges. The respondents were also asked on whether or not data analysis is been done; when is malaria data analysed, what are the variables of analysis; use of analysed data; factors that facilitate or hinder malaria data analysis and whether or not the district provide feedback of the reports submitted by the facilities. Other important information sought included the use of information for quantification of antimalarial drugs and other supplies.

The following information was also collected using a check list. Availability of registers and forms for IDSR reporting, HMIS Book 2, 5 and 10; completeness in all registers and reporting forms and data storage at the facility. Other information included the availability of the following: (i) Standard case definitions; (ii) Laboratory Diagnosis Register; (iii) National Guidelines for Integrated Disease Surveillance and Response; (iv) National Guidelines for malaria surveillance; (v) Case Management Protocols for malaria at Health Facility; (vi) Guidelines for malaria treatment; (viii) analysed data (graphs, charts, tables); Other malaria registration, reporting forms and guides.

Results

Information on disease surveillance and reporting

A total of 20 health workers from the Council Health Management team (3), hospitals (2), health centres (4) and dispensaries (11) were interviewed (Table 1). Of the 17 informants from the health facilities, 15 were familiar with disease surveillance. A good number (8/17) of health facility workers received training during 2010-2012. Different means were used for reporting by the facilities. Public transport and motorcycle were the major means of reporting (Table 1). Most of the health facilities (14/15) had difficulties in submitting reports due to inadequate funds for photocopying the forms and for paying bus-fare. Most of the health workers were submitting their monthly reports when collecting their monthly salaries. "When there are delays getting my monthly salary, there will be delays in submitting my monthly report. This is because we are using our own money for bus-fare when submitting reports" (In-charge of Dispensary, Ilonga). At hospital and health centre levels, additional barriers in timely submission of reports were mentioned to include shortage of manpower and workload. In addition, some informants complained of the misplacement of their reports at the district office making them to incur additional costs for photocopying and submission of another report. "There is lack of accountability at the district office. Many reports are misplaced and later they ask us to re-submit them. This requires you making photocopies at your own costs" (In-charge of Dispensary, Zombo). Major challenges in submission of reports from facility to the district level included inadequate funds and lack of feedback. Moreover, multiple reports required by vertical programmes add to the staff workload.

Table 1: Means of communication used to submit monthly reports from facility to district level

Type of facility	Name of health facility	Means of communication
Dispensary	Mabwerebwere	Motorcycle
	Kinangali	Public transport
	Chanzuru	Motorcycle
	Ilonga	Public transport
	Tindiga	Public transport; Telephone
	Mvumi	Public transport
	Lumbiji	Motorcycle
	Zombo	Public transport
	Iyogwe	Public transport
	Rudewa	Public transport; Telephone
	Magomeni	Motorcycle
Health Centre	Ulaya	Public transport
	Kimamba	Telephone; email
	Msange	Submit to a nearby (Kisanga) dispensary
	St Joseph Dumila	Public transport
Hospital	Kilosa	On foot- same area*
	Berega	Public transport

*District Hospital and CHMT housed in the same building.

Data management and utilisation

Over half of the health facilities (9/17) reported to perform minimal data analysis. The most common analyses were on the morbidity and mortality by age group and sex. Analysis was also done on immunization coverage and outreach programme. Analysis of the outpatients and inpatient data aimed at determine the main causes of facility attendance and deaths. Most frequently, results were presented in tables. Some informants said that the analysis helps them to monitor progress achieved in some programmes and identify trends incidence disease incidence and deaths. However documentations of the analyzed data were not found in most facilities. Similarly, analysis of malaria was reported in the same 9 facilities. The analysis focused on monthly malaria incidence by age and sex monthly basis as well as on the number of complicated and uncomplicated malaria cases. Factors facilitating data management at facility level included (i) Availability of registers books, tally sheets and reporting forms. All respondents admitted that the fact that it is mandatory to submit weekly and monthly reports to the district office pushed them to do so.

Some challenges in data analysis highlighted during the interviews included unavailability of compilation books and lack of capacity to carry out data analysis. Others included: frequent stock out of tally sheets; lack of computers; poor data storage; poor recording and incomplete recording; and inadequate human resource.

Feedback from higher authorities

Majority of informants affirmed not to have received any feedback regarding the reports they submit to the district authority. However, few were consulted in case there were problems with their reports but no positive feedback was provided "Occasionally, the district might consult you during their supervision visits when some errors are discovered in your report" (In-charge, Berega Hospital). Another respondent from Zombo Dispensary had these to add: "Even when you report a suspected outbreak, the district will respond by asking your send someone to pick up drugs'; no follow-up is been made from the district office. They leave everything to you" Few informants considered the biannual meetings where health personnel from all facilities meet as the only forum where feedback of their performance is provided by the district authority.

Analysed data was used for drug quantification, drug forecasting and planning. Other uses include identifying major causes of morbidity and mortality and distribution of disease in space and time and when data is requested by decision and policy makers.

Information that triggers the ordering of drugs was listed to include: drug stock out, availability of fund, and rate of drug consumption. The majority of the respondents (13/17) reported to carry out drug quantification quarterly. However, drug quantification and procurement by private health facilities were done when needs arise. A number of actions were mentioned to be taken when there was stock-out of medicine in the facilities. These included (i) report to the district authority; advice patients to buy medicine from other sources; buy medicines from nearby pharmacy; use funds from Community Health Fund or Health Insurance to buy medicines; request from MSD through the District Medical Office; prescribe alternative antimalarial drugs; or borrow medicines from a nearby health facility..

Record review and availability of guidelines

The IDSR forms and register books were reviewed to assess their quality. The registers and forms tools were available in most health facilities (Table 2). However the completeness was not assessed by the data collectors in most of the tools. Reports forms that were not available for assessment as many of them were locked by the in-charges who were not around at the time of the interview. Register books were not available in two facilities; in one of the facilities since 2011.

Table 2: The availability and quality of IDSR forms and Register Books in health facilities

Criteria	IDSR Reporting forms	Register Book
Availability of tools	11	16
Completeness in all registers and report forms	3	3
Record keeping		
• Availability	11	16
• Filled and stored properly	11	15
• Accessibility	11	14

District Key informants

The district key informants included the District Focal Person for Malaria and Integrated Management of Childhood Illness, Coordinator for Health Management Information System and Focal Person for Integrated Disease Surveillance and Response Focal person. The three persons could not mention specific date for submission of epidemiological data from health facilities. Challenges in reporting of epidemiological data included: lack of specific budget for reporting, poor communication infrastructure and data management and poor reporting rate by facilities. One of the key informants had these to say: Reports are not received on time because of distance from the facility to district headquarters. We do not have money to pay for transport; and during rainy season, roads are impassable (District IDSR Focal person). Other challenges mentioned included: (i) lack of computer and internet connectivity; (ii) lack of capacity on data analysis; and (iii) too many reporting formats required by various vertical programmes.

At the district level, epidemiological data are compiled both manually and using computers. The IDSR Focal person is responsible for data compilation. Data quality assurance is done by using a Guide provided in the HMIS books. The quality is assessed in terms of completeness and accuracy. The forms are filled monthly. The district Malaria Focal Person is responsible for malaria data analysis. The IDSR Focal person admitted not to have capacity to carry out data analysis; emphasizing that: "I have not received training on data analysis". The HMIS District Coordinator claimed that malaria data are not submitted to him and therefore he is not responsible for malaria data analysis. When asked whether there are guidelines on data analysis; Malaria Focal person and HMIS Coordinator were not aware of the availability of guidelines while the IDSR Focal person admitted that the data analysis is included in the IDSR Guidelines. However, all the respondents said that there were not data interpretation guides.

Both Malaria Focal person and HMIS District Coordinator said that malaria data were used for priority setting, planning and monitoring and evaluation of the control programme. However, when asked how frequently is monitoring and evaluation done, one of the respondents said that it has never been done, while another respondents said to depend on availability of funds. The last M&E was carried out during December 2011/January 2012 and aimed to determine the utilization of insecticide treated mosquito nets. Only the Malaria Focal Person

was aware of the malaria monitoring indicators.

Respondents claimed that feedback from the regional authority was quite rare. Sharing of epidemiological data between sectors was not a practice. When asked of their recommendations to improve data management, the following were suggested: (i) Job aids and guidelines to be made readily available; (ii) there is need to strengthen capacity in data analysis among health workers; (iii) adequate resources (funds) for health management information system to be made available.

Discussion

An analysis of the malaria surveillance systems in Kilosa District revealed the following weaknesses: poor data management; delayed and inefficient reporting; shortage of data collection and processing tools; over-burdened health staff; weak communication systems; weak capacity for facility level decision making; and multiple surveillance systems demanded by different vertical programmes. Like in this study, it has been shown elsewhere in Tanzania that routine recording of patient information into the registers is inconsistent with a number of health workers complaining of lack of tools for recording when attending to patients and other clinical duties (Franco et al., 2002). Many providers complained about the time required to record all the HMIS information properly. Some health care providers have not received training on HMIS or IDSR. Most respondents complained of the burden of compiling and submitting weekly and monthly reports. Similar findings have been reported elsewhere in Tanzania (Franco et al., 2002).

Similar to other studies in Tanzania (Franco et al., 2002; Mghamba et al., 2003) the current findings indicate that some important contextual barriers to an efficient surveillance system include insufficient human and financial resources; limited communications capability from facilities to district level; lack of feedback from the district. In this study, very little or no evidence was found in analysis of epidemiological data at facility and district levels. Some routine analysis of epidemiological data is done, such as identification of top 10 causes of morbidity and mortality. Only a few health workers were carrying out minimal data analyses.

Usually, health activities in the districts and facilities are planned and implemented on the basis of the requirements o f the comprehensive council health plan. To achieve this, baseline health information is required to provide basis for performance improvement. However, this study indicated poor utilisation of routine health information in planning and monitoring of the facility performance. Data analysis and interpretation is an important component of disease surveillance because it transforms the collected raw data into meaningful information, which can be used in making decisions (Mboera et al., 2004).

Due to its importance, data analysis and interpretation need to be done at all levels of the health information system right from the facility to district and national levels. The kind of analysis done at each level varies according to what can be done at that particular level. At whatever level, data are normally analysed by time, place and person. Time analysis enables the comparison of cases reported for the current time (week/month/year) with the

number received in the previous time (week, month or year). This enables the detection of any abrupt or long-term changes in disease occurrence. A study by Mboera et al. (2001) have shown that only few districts of Tanzania were utilizing analysed health information for disease surveillance and planning.

At both district and facility levels, a number of challenges in disease surveillance and health management information systems were identified to include inadequate human resources for health, poor information communication infrastructures including computers and internet; lack of capacity to manage data, lack of adequate budget and different reporting format for different programmes. Similar findings have been reported from various studies elsewhere in Tanzania (Franco et al., 2002; Kajeguka & Mboera, 2003; Mghamba et al., 2003). Inadequate information and communication facilities are common in Tanzania. In recent studies in Tanzania it has been found that the training intensity score, measured as the mean percentage of trainings received by health facilities out of the maximum of 19 topics in the last two years, was 33%. Average guidelines availability was slightly lower (28%) in facilities. Health facilities had the following amenities: 52% of the facilities had a source of electric power; 72% had communication means, mostly mobile phones (65%), and less commonly a land line telephone or shortwave radio; 13% had a functioning computer, and among those only half had internet connectivity (NIMR, 2011).

According to WHO (2012) a malaria surveillance system consists of the tools, procedures, people and structures that generate information on malaria cases and deaths, which can be used for planning, monitoring and evaluating malaria control programmes. An effective malaria surveillance system enables programme managers to: (i) identify the areas or population groups most affected by malaria; (ii) identify trends in cases and deaths that require additional intervention, e.g. epidemics; and (iii) assess the impact of control measures. However, findings from this study, and a further analysis of the disease surveillance systems in Tanzania, has shown that in most districts there is shortage of data processing tools, over-burdened health staff and weak communication systems (Franco et al., Rumisha et al., 2007).

Although, to-date HMIS is available throughout the country and that IDSR has been implemented for over 10 years, health data collection, analysis, reporting and utilisation in disease surveillance is poor. Surveillance information is analyzed by time, place, and person. Knowledgeable technical personnel should review data regularly to ensure their validity and to identify information of use to managers. Simple tables and graphs are most useful for summarizing and presenting data. Timely dissemination of data to those who make policy and implement intervention programs is critical to the usefulness of surveillance data.

Surveillance systems in Tanzania and many other developing countries suffer from a number of common constraints. The system is often impaired by shortages of human, finance and material resources (GAO, 2001). Key positions in health facilities often are filled by people who do not possess the necessary qualifications. Similar to findings in this study, poor

roads and communications make it difficult for health workers to submit to higher authority epidemiological and other health information timely. Multiple surveillance systems are still common in Tanzania and often poorly coordinated. The absence of a clear feedback from the higher authorities discourages lower level officials from putting their efforts in surveillance leading to poor use of surveillance data in evidence-planning and decision making. It is therefore important that the government of Tanzania strengthen the capacity of health facility, district and national levels on all aspects of IDSR and HMIS. As malaria incidence decreases, active case detection using appropriate tests need to be given its due importance to ensure identifying new cases is improved. However, an effective surveillance system requires a level of infrastructure including communication networks absent in many district of Tanzania (NIMR, 2011). In many districts of Tanzania, like elsewhere in Sub-Saharan Africa, there are few landline telephones, computers, internet-accessibility, or roads in good conditions, for the rapid transfer of disease information (Chaminuka et al., 2008; Barrington et al., 2010).

In conclusion, malaria surveillance in Kilosa District is weak. An efficient and effective surveillance system from facility, district to national levels should be able provide valuable insights needed to understand, forecast, and evaluate malaria control programme at all levels. In order to meet malaria elimination objectives, monitoring systems must be able to respond rapidly to the heterogeneity in malaria epidemiology. It is important therefore, efforts been made to strengthen the integrated disease surveillance and response system to able to provide reliable data for monitoring and evaluation of health programmes in Tanzania.

Chapter 10: Key actors and stakeholder engagement in malaria control policy formulation and implementation in Tanzania

Abstract: Malaria is a complex health problem and its control approach needs understanding the socio-economic and environmental factors, and hence the involvement of actors beyond the health sector. The growing recognition by some actors of the relationship between malaria and other sectors such as agriculture, environment, infrastructure, mining and water development, as well as manufacturing firms, suggests the need to explore stakeholders' engagement in addressing this health problem. Although a number of actors are involved in provision of malaria service care, it is important to consider the interactions of all forms of formal and informal linkages and contacts between various agents in the systems of innovation, such as manufacturing firms, research and development institutions, academia, traditional medicine practitioners, hospitals and other external agencies. The main objective of this Chapter was to map and explore key actors and stakeholder engagement in malaria control policy formulation and implementation in Tanzania. This work was done through a desk review of various publications, reports and policy guidelines. The Ministry of Health and Social Welfare and the Prime Minister's Office Regional Administration and Local Government were the key actors in malaria control. Other included Faith-based Organisations and private and non-governmental organizations, health research and academic institutions as well as the mass media and manufacturing firms including pharmaceutical industries and textile mills. Realizing the involvement of various actors in malaria interventions, strengthening formal collaboration and linkages is crucial for a sustainable malaria control approach. Despite the fact that the National Health Policy provides a plan to promote awareness among Government employees and the community at large and that health problems can only be adequately solved through multisectoral cooperation, the linkages between sectors in malaria control is still informal and weak.

Keywords: malaria control, actors, engagement, collaboration, multi-sectoral, Tanzania

Introduction

In Tanzania malaria control is the responsibility of the health sector and is guided by national policies and government reforms. The National Development Vision 2025 and the National Strategy for Development and Poverty Reduction (URT, 2005, 2010) provide the global direction for achievement of the United Nations' Millennium Development Goals (MDGs). The National Health Policy 2007 provides Government's vision on long-term developments in the health sector (MoHSW, 2007). The vision of the Health Policy in Tanzania is to improve the health and well being of all Tanzanians with a focus on those most at risk, and to encourage the health system to be more responsive to the needs of the people. The policy mission is to facilitate the provision of equitable, quality and affordable basic health services, which are gender sensitive and sustainable, delivered for the achievement of

improved health status.

The government strives to reduce the burden of disease and increase life expectancy through the provision of adequate and equitable services. The government aims to ensure the availability of medicines, reagents, medical supplies and infrastructures; and also ensure that the health services are available and accessible to all the people in the country. To complement this, the government continues to strengthen capacity and make available competent and adequate number of human resource for health to manage health services (MoHSW, 2008a). The National Health Policy provides a plan to promote awareness among Government employees and the community at large that health problems can only be adequately solved through multisectoral cooperation.

Tanzania introduced the first National Strategy for Growth and Reduction of Poverty in 2005 (URT, 2005). The aim of this strategy is to increase productivity by encouraging individual and income generation for community development. The recent NSGRP II, 2010/11 - 2014/15 (URT, 2010) build on the achievements of NSGRP I (URT, 2005). The NSGRP II focuses on (i) focused and sharper prioritization of interventions in projects and programmes, in key priority growth and poverty reduction sectors; (ii) strengthening evidence-based planning and resource allocation in the priority interventions; (iii) aligning strategic plans of Ministry Departments and Agencies (MDA) and Local Government Authorities to this strategy; (iv) strengthening government's and national implementation capacity; (v) scaling up the role and participation of the private sector in priority areas of growth and poverty reduction; (vi) improving human resources capacity, in terms of skills, knowledge, and efficient deployment; (vii) fostering changes in mind-set toward hard work, patriotism, and self-reliance; (viii) mainstreaming cross cutting issues in MDAs and LGAs processes; (ix) strengthening the monitoring and reporting systems; and (x) better implementation of core reforms, including further improvement of the public finance management systems (URT, 2010).

Currently, the implementation of the National Health Policy is based on the Health Sector Strategic Plan III (HSSP III) 2009-2015 (MoHSW, 2008a). The objective of HSSP III is to provide health and social welfare services of high quality, effective, accessible and affordable, delivered by a well performing and sustainable national health and welfare system that encourages responsiveness to the needs of the people. The mission is to facilitate the provision of equitable and effective health and social welfare services by formulating policies and guidelines, delivered by an adequate, competent and well motivated human resource to improve the health and well being of the public with emphasis on those most at risk.

The growing recognition by some actors of the relationship between malaria and other sectors suggests the need to explore multi-sectoral opportunities in addressing this health problem. For an appropriate health care delivery system, it is important to consider the interactions of all forms of formal and informal linkages and contacts between various actors in the systems of innovation, such as manufacturing firms, universities, traditional medicine practitioners, hospitals and other agencies. The linkages between the relevant

actors is expected to provide a new approach to problem solving by breaking down traditional boundaries between government ministries, manufacturing firms, civil society, and research institutions to create hybrid solutions that draw on the best each domain has to offer.

The main objective of this Chapter was to explore key actors and stakeholder engagement in national malaria control policy formulation and implementation. Specifically, the study aimed to (i) explore and document malaria control policy development process and to identify stakeholders involved in the process in Tanzania; and (ii) map key actors in malaria control in the country

Materials and Methods

A review was carried out to explore and document malaria control policy development process and to identify stakeholders involved in the process in Tanzania. Literature search included government policy documents, reports and publications. The role and operationalisation of the key actors was documented and analysed to identify multi-sectoral linkages. In collecting the secondary data, the focus was placed towards key actors in health delivery systems in the country using malaria as a tracer disease. A review was also carried out to explore and document malaria control policy development process and to identify stakeholders involved in the process in Tanzania. The review of documents on malaria profile and policy was carried out using current health sector policy framework, specific sector policies and health sector strategic plans. The following government policy documents were available for critical analysis: (i) Malaria Medium Term Strategic Plan, 2008-2013; (ii) Health Sector Strategic Plan III July 2009–June 2015; and (iii) National Malaria Strategic Plan, 2014-2019 preliminary draft.

Results

National policy formulation

The following institutions and organizations were involved in the development of the National Malaria Medium Term Strategic Plan 2007-2013: Muhimbili University of Health and Allied Sciences; Ministry of Health and Social Welfare; Monduli and Hanang District Councils; Arusha Regional Secretariat; and Population Services International. Further analysis indicate that, though the individuals were from six different institutions, all were either medical or health professionals. A number of steering committees have been established to oversee the implementation of the strategic plan. One of the committee, the Malaria Prevention Sub-Committee draws its members from: (i) Health Research Institutions including Tropical Pesticide Research Institute; (ii) Ministry of Agriculture and Food Security; (iii) Prime Minister's Office for Regional Administration and Local Government; (iv) Representatives of Non-governmental organizations; (v) World Health Organization; and (vi) United Nations Children Fund. At least the sub-committee is composed of some members from outside the health sector.

Key actors in malaria control Tanzania

Government Ministries: Currently, the Ministry of Health and Social Welfare and the Prime Minister's Office Regional Administration and Local Government (PMORALG) are jointly responsible for the delivery of public health services. The Ministry of Health and Social Welfare is responsible for policy formulation and the development of guidelines. The PMORALG oversees the operations of the Regional Administration and District Local Governments through the Regional Secretariat and District Council. At the regional level, the Regional Health Management Teams (RHMTs) interpret these policies and supervise their implementation in the districts. The Council Health Management Team (CHMT) is responsible for district council health services including dispensaries, health centres and district hospitals. The District Medical Officer (DMO) heads the CHMT as in charge of all district health services. The CHMT follows guidelines for planning and management of district health issued jointly by MOHSW and PMORALG. The Regional Medical Officer (RMO) heads the regional health management team (RHMT) and reports through the Regional Administrative Secretary (RAS) to the Ministry of Health and Social Welfare on issues related to technical management and to PMORALG on issues related to health administration and management of health services.

Ministry of Health and Social Welfare Agencies: The key actors under this category include Medical Stores Department (MSD) and Tanzania Food and Drug Authority (TFDA). MSD is the sole provider of medicines and medical supplies to the public health care system and to some extent to faith-based organization owned health facilities. The current policy allows for private sector suppliers to cater for private providers. Tanzania has a wide network of drug and supply system run by the MSD. On the other hand, TFDA is responsible for controlling the quality, safety and effectiveness of food, drugs, herbal drugs, cosmetics and medical devices. In Tanzania drugs including herbal drugs and medical devices are evaluated and registered by the TFDA before being approved for distribution and marketing in the country.

Health Research and Academic Institutions: Both public and private health research and academic institutions are among key actors in malaria control programme especially in generating evidence for decision making and policy formulation in Tanzania. The National Institute for Medical Research (NIMR) and Ifakara Health Institute (IHI) are two major health institutions carrying out malaria research in the country. NIMR was established 1979, to regulate, promote and conduct health research in country while IHI Health Research was established 1957 a Field Laboratory of the Swiss Tropical Institute. Apart from NIMR and IHI, malaria researches are also carried out by Muhimbili University of Health and Allied Sciences, Catholic University of Health and Allied Sciences-Bugando, Kilimanjaro Christian Medical University College, Kilimanjaro Clinical Research Institute, African Medical Research Foundation, University of Dar es Salaam and Sokoine University of Agriculture (NIMR, 2013).

Traditional Healers: Tanzania is estimated to have a traditional healer: population ratio of 1:400, thus giving an estimated number of over 80,000 traditional healers with varying specialities. The majority of healers are herbalists using mainly plants and a few animal and mineral products. Traditional healers have been reported to be major partners in the treatment of febrile illness including malaria (Gessler et al., 1995; Makundi et al. 2006;

Mboera et al., 2009a). However, they have been blamed for their perceptions on severe malaria (Makemba et al., 1996; Foster & Vilendrer, 2009). In a study to investigate the involvement of traditional healers in the treatment of degedege (convulsions) in Bagamoyo, Makemba et al. (1996) found that both parents and traditional healers believed that degedege requires traditional treatments. Children that present with severe malaria (with convulsions) are more than often treated by traditional healers (McCombie, 1996, 2002; Warsame et al., 2007).

Manufacturing Firms: Pharmaceutical industries and Textiles have a big role in the health service in Tanzania. Many pharmaceutical substances, such as active pharmaceutical ingredients, are imported from outside the country. There are a number of pharmaceuticals, mostly concentrated in Dar es Salaam. Of all, the Shelys Pharmaceuticals is the largest company in East Africa which started operations in 1988. It manufactures a diverse range of drugs including antimalarials.

Tanzania is in a unique situation in sub-Saharan Africa by having a number of large domestic mosquito net manufacturing firms. These local net manufacturing firms have made substantial progress in expanding the distribution of mosquito nets. The net manufacturing firms in Tanzania include the A to Z Textiles Mills Ltd, Sun Flag Ltd (all in Arusha), and Tanzania Textile Manufacturing Limited (TMTL) in Dar-es-Salaam. A to Z Textile Mills started manufacturing polyester mosquito net fabrics in mid 1970s, which were sold locally. In 1977, the factory started manufacturing mosquito nets on a much larger scale. Currently, the factory is employing over 1500 people with a capacity close to 8 million nets per annum, exporting to over 25 countries in Africa. The A to Z Textile Mill employs a technology from SUMITOMO Japan in the manufacture of Olyset Nets.

With a Cuban assistance, Tanzania is constructing a biolarvicide production plant in Kibaha. The biolarvicide will be used to eliminate mosquito at the larval stage. The construction of the US$23 million is expected to be operation by end of 2013.

Development Partners: The US Centers for Disease Control (CDC) through the President's Malaria Initiative supports malaria control efforts in collaboration with the National Malaria Control Programme as part of the U.S. President's Malaria Initiative (PMI). Since 2005, this effort has improved access to malaria prevention and treatment interventions in Tanzania. Other international actors in malaria control in Tanzania include Malaria No More, Population Services International (PSI), Johns Hopkins University Center for Communication Programs, Tanzania Red Cross, United Against Malaria, MEDA and World Vision.

Mass media and musicians in malaria control in Tanzania

In 2010 Tanzania introduced an anti malaria campaign including Malaria Haikubaliki - which involves several partners of the society including entertainment, business, sport and religious organizations in malaria control across the country. In support of this landmark effort, President Jakaya Kikwete, lead the "Malaria Haikubaliki: Tushirikiane Kuitokomeza" (Malaria is unacceptable: Working together, we can eliminate malaria) awareness campaign.

In spearheading the campaign, the Ministry of Health and Social Welfare joined hands with prominent Tanzanian musicians, international partners, senior government officials and the business sector to stage the Zinduka ("Wake Up!") concert. A number of television and radio stations throughout the country broadcasted the event with a call-to-action for all Tanzanians for the malaria fight. The objective of the effort was to increase practices to prevent malaria such as consistently sleeping under an insecticide treated mosquito net, detecting and treating malaria early; and compliance to intermittent treatment among pregnant women. The national campaign is anchored at the community and household level by community mobilization activities implemented by Population Service International and Johns Hopkins University.

During the same period of time, Tanzania Red Cross conducted "Hang Up" and "Keep-Up" campaigns across the country. Faith-based Organizations including Christian Social Services Commission and the National Muslim Council joined the Malaria Haikubaliki campaign to engage faith leaders and their congregations in the effort to combat malaria nationwide. To date, the Malaria Haikubaliki awareness campaign is led by the Tanzanian government under the Ministry of Health and Social Welfare.

Since 2009, musicians from both within and outside Tanzania have been involved in the malaria control campaign. For instance, to commemorate second World Malaria Day on 25th April 2009, the occasion that was officiated by Hon. Mizengo Kayanza Pinda, the Prime Minister of the United Republic of Tanzania, the activity was graced by the participation of the famous Musician Yvonne Chaka Chaka, who is also the African Ambassador for Malaria and a local famous Tanzania musician, Judith Wambura. During the launch of the Zinduka ("Wake up") campaign, 18 musicians were invited to stage a concert to promote the initiative.

Public-private partnership in malaria control

A number of private institutions are playing a great role in malaria control in Tanzania. The National Insecticide Treated Nets (NATNETS) was formed in July 2002 as a steering committee to implement the scaling up of ITN strategies through the promotion of ITN use by making nets available, accessible and acceptable. This body is made up of Tanzanian Government Departments, Non-governmental organizations and development partners. The main aim of NATNETS programme has been to scale up the use of ITNs in the country and is made up of four components: (i) The Tanzania National Voucher Scheme (TNVS) supported by the Global Fund to fight AIDS, Tuberculosis and Malaria was launched in October 2004. Its objective was to enable groups most at risk from malaria (pregnant women and infants) to have access to ITN at a subsidised cost; (ii) The Strategic Social Marketing for Expanding the Commercial Market of ITNs in Tanzania (SMARTNET) project was implemented by Population Service International and supported by development partners. The project aims at changing behaviour through mass promotion campaigns and supporting rapid development of a commercial distribution system for ITNs and insecticide re-treatment kits. (iii) An ITN Cell was created within the National Malaria Control Programme of the Ministry of Health in May 2003 to become the executive body coordinating and

supporting the ITN process and for establishing and managing the TNVS.

There are numerous large-scale private sector companies with large workforce that have a strong incentive to prevent malaria as it reduces worker productivity. As the company workers and labourers interact with surrounding communities it is also essential for companies to address malaria transmission in those areas. Such companies include Geita BioReC Tanzania Limited in Meatu District (Imbahale & Mukabana, 2013) and Mtibwa Sugar Company in Mvomero District (Mboera et al. 2007A). Realising this, a private sector platform called the 'Malaria Safe Programme' has been created to develop joint approaches. The programme is based on four pillars: education, protection, visibility and advocacy. Main interventions include protecting employees against malaria and educating them about prevention; by distributing ITNs to employees and their families and encouraging regular net use; and promoting malaria test and treatment according to guidelines. Telecommunications companies such as Zantel have joined the programme recently.

Recently, Geita Gold Mines, Geita District Council, Plan International and Research Triangle Institute of the United States formed a public-private partnership to target malaria in Geita. The objective is to develop and implement a sustainable and integrated malaria control programme that is efficient and cost effective. The project was formerly initiated in 2008 focusing on indoor residual spraying and distribution of insecticide treated mosquito nets (http://www.dailynews.co.tz/index.php/).

The emphasis to involve private sectors in disease control is a recent initiative. This emphasis followed realization by the international community recognized that, in tackling the health problems of low income countries there is a need for better coordination of the traditional public and private sector roles in order to harness the synergistic combination of the strengths, resources and expertise of the different sectors (Buse & Waxaman, 2001; Widdus, 2001). Consequently in recent years there has been an increase in the number of partnerships in health both at the global and national levels. The involvement of private sector in malaria control in Tanzania has been described in detail by Njau et al. (2009). During the past 10 years, The Tanzania NGO Alliance Against Malaria (TaNAAM) has spearheaded malaria control activities in Tanzania. TaNAAM and two of its' partners – AFRICARE and Plan Tanzania have been receiving financial support from Global Fund for AIDS, Tuberculosis and Malaria and played a great role in developing a country-wide advocacy and behavioural change and communication strategy towards the change of malaria treatment policy in Tanzania (Njau et al., 2009).

Political will and multi-sectoral malaria control approach

The Tanzanian Government has shown great political will to combat malaria through its participation in the African Leaders Malaria Alliance (ALMA) and other forums. The Alliance intends to provide a forum for high level, collective advocacy to ensure: efficient procurement, distribution, and utilization of malaria control interventions; the sharing of most effective malaria control practices; and ensuring that malaria remains high on the global policy agenda. His Excellency, Jakaya Mrisho Kikwete, the President of the United

Republic of Tanzania was the first head of ALMA.

To improve malaria control in the country, the next National Malaria Strategic Plan, 2014-2020 (which is still under development) intends to engage politicians, policy and decision-makers in political debate. The programme intends to develop a comprehensive package of advocacy tools and interventions aimed to those in power to increase the focus and budgetary allocation for malaria control. Target groups include Members of Parliament and ministers and senior managers of relevant ministries including the Health, Finance, Industries, Agriculture, Education and Regional Administration and Local Government (MoHSW, 2013).

Discussion

Although a number of actors are involved in provision of health care, the linkages are strong between institutions within health sector and between the health sector and the private sector. This review indicate a major disconnect between sectoral ministries. Except for the Regional Administration and Local government, no clear and strong linkages between the health sector and other sectoral ministries were identified. In both National Malaria Strategic Plans of 2007-2013 and 2014-2020, there was no involvement of experts from other sectoral ministries. The lack of other sectors involvement devoid of the plan an inter-sectoral approach of addressing a complex health problem that cuts across ecosystems, livelihoods and health systems. Bringing health initiatives to scale often requires massive collaboration within government as well as coordinated efforts among government, international agencies, manufacturing firms, business, civil societies, non-governmental organizations, and communities. In Tanzania such systems are exceedingly fragile, with the infrastructure for collaboration and coordination often weak. However, in this review, it was realised that a number of actors are involved in malaria control from different angles though all of them had health as one of their mandate. It was interesting to note how mass media organizations were involved in the malaria control campaigns.

Like in the current strategic plan, in the proposed National Malaria Strategic Plan 2014-2020, the Ministry of Health and Social Welfare through the National Malaria Control Programme envisage to establishing a Malaria Steering Committee to be responsible for strategic decisions in respect of malaria control (MoHSW, 2013). The composition of the National Malaria Steering Committee will include senior representatives from Ministries responsible for Finance and Local Governments, Development Partner Group, Tanzania National Coordinating Mechanism Secretariat, World Bank, World Health Organisation, and the Zanzibar Malaria Control Programme. In addition, a Malaria Vector Control Sub-Committee to include among others, a representative from research institutions, Tropical Pesticide Research Institute, National Environmental Management Council, Division of Environment of the Vice President Office and the Ministry of Agriculture will be addressed. Such institutional linkage is expected to stimulate system changes by enabling cross-sectoral health leadership team to develop and implement innovative malaria control and prevention programmes. This is a commendable move, though it has limited the number of sectors to be involved in the future of malaria control in Tanzania. The linkages between

the relevant sectors will provide a new approach to problem solving by breaking down traditional boundaries between sectoral ministries to create hybrid solutions that draw on the best each domain has to offer.

Chapter 11: Inter-sectoral approach in malaria control in Tanzania: policy and decision makers' perspectives

Abstract: Malaria is a complex health problem that cuts across a number of sectors. Establishing inter-sectoral linkages is important to facilitate joint efforts to address the problem at the national, district and community levels. The objective of this study was to explore stakeholders' opinions as regards to different sectoral activities that contribute to malaria transmission and control and the likelihood that in future, an intersectoral approach in malaria control in Tanzania will be adopted. This study involved Kilosa District Council officials and Government Ministries and other national level stakeholders from all key sectors. Data were collected through participatory meetings organized at district and national levels. The sectors involved were health, agriculture, environment, livestock, fisheries, education, works, irrigation, water resources, land development, forestry, and community development. At the district level, using a systematic sampling method, participants were divided into three groups: Production Sector, Construction Sector and Social and Education Sector. Participants were given three key questions to discuss and deliberate on: (i) sectoral activities are likely to impact malaria? (ii) inter-sectoral approach used to control malaria in the district; and (iii) the efforts, challenges and opportunities for intersectoral collaborations in malarial control?. At the district level, the sectoral activities identified to contribute to malaria transmission were: irrigation, burning of forests; fishing activities, nomadic life style, water storage, road and house construction, brick making, poor drainage systems, and farming systems. The district representatives admitted that to some extent intersectoral collaboration exist though not specifically for malaria control. Lack of budget was the reason for a weak intersectoral collaboration. The district representatives agreed that malaria is contributed to a greater extent by human activities that cut across all sectors. At national level, 26 senior officials from Production (agriculture, fisheries, livestock, mining, and industries); Economic (works/construction, transport, and energy); Social (education, health, water, social welfare); and Cross-cutting sectors (environment, employment, finance, private sector) participated through a self-administered questionnaire and discussions. Over two thirds agreed that malaria was an indirect agenda in their organization activities. Sectoral activities that contribute to malaria transmission were identified to include road/house construction activities, agriculture (including urban agriculture), irrigation, mining (including quarry), water supplies, poor disposal of waste (including pit latrines), poor maintenance of roads and fish farming. About half of the respondents admitted that their sectors have some contributions to make in malaria and other disease control in Tanzania. These included multi-sectoral research, improved management of irrigation water, control of zoonotic diseases, control of HIV/AIDS, environmental management and local funding for malaria interventions. Lack of strong inter-sectoral approaches in human disease control programmes was attributed to lack of flexibility in sectoral plans and selfishness among policy makers to share resources. About half of the respondents were of the opinions that

an inter-sectoral approach would improve malaria control in Tanzania. They all agreed that to improve malaria control in future, an inter-sectoral approach needs to developed and implemented.

Keywords: malaria, human activities, livelihood, inter-sectoral, participatory, community, Tanzania

Introduction

In recent years, there have been increased efforts to combat malaria in Tanzania through the use of insecticide treated mosquito nets, indoor residual spraying, early diagnosis and prompt treatment. However, the disease has remained the leading public health problem in the country (MoHSW/IHI/NIMR/WHO, 2013). Malaria is responsible for more than one-third of deaths among <5 years and one-fifth of deaths among pregnant women. Malaria has remained number one public health problem because of various reasons including weak health systems, limited national budgets and poor governance. Others include antimalarial drug and insecticide resistance, environmental changes that favour vector population increase and demographic factors such as land use change patterns, climate change, and significant human migration.

Malaria is a social, behavioural as well as a medical problem. It is apparent that socio-economic factors influence people's decisions regarding where they live and where they will locate their dwellings; such decisions in turn affect exposure to malaria. The economic benefit derived from locating homes near swamps that are known to be malarious, for example, may outweigh the perceived loss from contracting malaria (http://www.aaas.org/international/africa/malaria91/rec4.html). In a study in Burkina Faso, malaria risk was found to be significantly higher among children who lived in households with lower economic or education levels, near the hydrographical network, in sparsely or irregularly built areas (Baragatti et al., 2009).

It has already been recognised that socio-economic and environmental factors affect health, exposure to illness, risk for illness-producing behaviours, and the household response to the respective health problem. Malaria tends to become increasingly geographically and demographically focused in population groups that share social, occupational, behavioural and geographical characteristics (Cotter et al., 2013). Some livelihood activities, such as rice farming, expose people to malaria than others. Exposure to malaria risk because of livelihood practices. Some occupational and behavioural factors that require people to stay outside the home put these groups in contact with malaria mosquitoes (Himeidan & Kweka, 2012; Thomas et al., 2012; Burki, 2013). It has been shown that exposure to malaria risk because of working practices, such as working through the night, is higher for a low-status occupational category (Worrall et al., 2002). Malaria is, therefore, a complex health problem related to socio-economic and environmental factors that cut across a number of sectors.

The fact that there are linkages between environment, livelihoods and malaria poses an opportunity for the various sectors to work together to help solve each other's problems.

However, in Tanzania, getting different sectors to work together has never been practical. Usually, government ministries, departments and agencies are organized strictly along sectoral lines. Instead of collaborating, they most often find themselves competing over resources (Mboera et al., 2007a). Establishing inter- and multi-sectoral linkages is important to facilitate joint efforts to address the problem at the national, district and community levels. The objective of this study was to explore stakeholders' opinions as regards to different sectoral activities that contribute to malaria transmission and control and the likelihood that cross-sectoral approach in malaria control will be adopted in future. This study explored and addressed the gaps in understanding of the roles of different sector in malaria transmission and control, challenges and opportunities for future collaboration in malaria control in Tanzania.

Materials and Methods

Data collection

This study was carried out in two stages. At first, district officials in Kilosa District were involved. At a later stage, national stakeholders involving senior officials from Ministries, Research Institutions, Non-governmental organization were invited to participate, either through email communication or in a workshop.

Data were collected through participatory workshops organized at district and national levels. The district level workshop was held on October 8, 2012 at Kilosa Clinical Officers' Training Centre. The workshop was attended by representatives of the District departments responsible for health, agriculture, environment, livestock, fisheries, education, works, irrigation, water, land development, forestry, and community development. The workshop was facilitated by researchers from the National Institute for Medical Research and Sokoine University of Agriculture.

District involvement: During the workshop, the participants were requested to fill a self- administered questionnaire to get their views on opportunities and challenges of intersectoral approach in malaria control in the district. Thereafter, using systematic sampling method, participants were divided into three groups: (i) Production Sector group- composed of participants from Agriculture, Livestock, Forestry, Irrigation, and Fisheries; (ii) Construction Sector - with participants from departments of Works, Land Development and Water Development; and (ii) Social Sector - composed of participants from Education and Community Development departments. Participants from health sector were allocated in all the three groups. Participants were given 30 minutes to discuss based on the following key questions: (i) What sectoral activities are likely to impact health paying specific attention to malaria in Kilosa District?; (ii) Are there inter-sectoral collaborations in control malaria in the district?; and (iii) What are the efforts, challenges and opportunities for intersectoral collaborations in malaria control in the district?. A plenary session was convened after the group discussions.

National Stakeholders: On 17th July 2013, the project held a national consultative experts' workshop with 26 senior officials from various ministries. Later, the staffs' opinions were elicited using a four-page open-ended questionnaire. The questionnaire sought information on the contribution of each sector in the transmission and control of malaria and possible future inter-sectoral approaches in malaria control in Tanzania. Other questions were on the probable reasons for lack of intersectoral approached in the current human disease control programmes and whether establishing intersectoral strategies would improve malaria control in Tanzania.

Results

District officials

Malaria burden in Kilosa District

A total of 14 informants from different sectors were interviewed. All informants regardless

of their sectors considered malaria as an important public health problem. One of the informants confirmed by saying *"most of the reported cases at health facilities are due to malaria and the disease ranks number one among the top ten" (*Informant, health sector). Malaria was described to have an impact in the development due to reduction in manpower and resources spent in taking care of the patients.

A wide range of factors contributing to the malaria burden in Kilosa were mentioned (Table 1). There were a number of misconceptions about mosquito nets, some relating them with politics. "Politics contribute to malaria. For example there is a perception that the mass distribution of mosquito nets was a business issue between the government and donors as a result people ignore their proper usage ending up using them for keeping chickens" (Informant, Department of Environment). Factors contributing to malaria burden in Kilosa district as identified by the participants included the: (i) Presence of large water bodies such as swamps, ponds, irrigation schemes; (ii) Poor community knowledge about malaria control and its control; (iii) Location of houses; (iv) Delay in seeking care among the communities; (v) Poverty; (vi) Poor use of mosquito nets and misuse of nets for fishing and gardening; (vi) Night activities; (vii) Poor agricultural practices; (viii) Poor environmental sanitation; (ix) Climate changes; (x) Drug resistance; (xi) Politics; (xii) Culture; (xiii) poor health services (due to poor case management, unavailability of antimalarial drugs; and inadequate skilled human resource.

To substantiate some of the reasons, one Key Informant had these to say: "Kilosa is surrounded by many permanent water bodies including rivers and swamps which are good habitats for mosquito breeding." Another informant from the Department of Forest added "With the currently observed climate changes, there will be an increase in mosquito density and hence malaria transmission". Yet, another informant added: "I think the community knowledge on the association between mosquitoes and malaria and how to prevent it is poor. For example there are some people who even fear using the mosquito nets" (Informant, Department of Water)

Table 1: Sectoral involvement in malaria control in Kilosa District

Production Sectors (Agriculture, Livestock, Fisheries, Forest)	Social Services Sector (Health, Education, Community Development)	Construction Sectors (Works, Land, Water)
-During the inception of the IPMA Project -Awareness creation especially on the use of mosquito nets -Controlling of borrow-pits used for taking gravel for road works -Health education -Supervise all environmental sanitation issues in the district	-Malaria diagnosis -Health education -Collecting, compiling and reporting malaria data -Community sensitization on malaria interventions, especially in scaling up of mosquito nets -Advocacy to politicians and Council Management Team	-Training to irrigation and water users on waterborne diseases including malaria -Attending meetings like IMPA and the district malaria team that was recently formed -Community health education especially on the proper use of nets-not for fishing and environmental sanitation

Stakeholders' involvement in malaria control: In addition, to the department of health, the majority of respondents mentioned a wide range of stakeholders including other departments, faith-based organizations, non-governmental organizations, politicians, community leaders and community members as key stakeholders in malaria control. Some went further to say that malaria control is the responsibility of everybody, both men and women. Specifically, the following comments were made: "Everybody in the district should take responsibilities to control malaria through environmental cleanliness and use of mosquito nets" (Informant, Department of Fisheries). "Stakeholders include health and other departments; this means, the Kilosa District Council and the community are key stakeholders in malaria control" (Informant, Department of Water). Out of 14 informants, 13 admitted to have being involved in malaria control activities as outlined in Table 1.

Sectoral activities which are likely to contribute to malaria transmission

According to the informants, major sectoral activities that contribute to malaria transmission include land use and management, agricultural practices and production systems (including animal husbandry, irrigation agriculture, urban farming), economic development projects (water dams for irrigation and hydroelectricity), construction works (roads, houses), water management and poor environmental management. Others included night activities such as farming, travelling, pastoralism and fishing.

From discussions, members of Group 1 agreed that that irrigation schemes, burning and clearing of forestry tend to increase mosquito productivity through creation of open spaces and providing water bodies that are likely to support mosquito breeding. In addition, participants described that irrigation activities, uncontrolled clearing of forest for farming and charcoal production, uncontrolled animal grazing and nomadic lifestyle, are some of

activities that in one way or another contribute to increase in breeding sites of mosquitoes and malaria transmission. Fishing activities also play part in malaria transmission since most fishing activities are done at night and fishermen put clothes that do not cover all parts of the body, and hence expose themselves to mosquito bites.

Members of Group 2 listed a number of sectoral activities that have impact on malaria transmission. They included use of temporary water tank storage during construction, brick making, poorly planned water drainage systems and poorly designed shallow wells. The group added storm water channels constructed alongside roads that are left unattended, blocked by dirty and lead to stagnant water. Such water bodies provide suitable mosquito breeding sites. Borrow pits that left behind by quarry activities and brick making, discarded containers, were also described as potential mosquito breeding sites. Poor town planning (with no drainage systems), allocation of plots close to swampy areas which are likely to provide mosquito breeding sites were also cited. Other activities that create mosquito breeding sites include leaking water pipes, poorly constructed water aprons, and unprotected traditional wells.

On the other hand, Group 3 identified brick making, crop irrigation, road construction and urban agriculture as development activated contribute to malaria transmission in the district.

Intersectoral collaboration at district level

Of the 14 informants 12 indicated to collaborate with other departments in implementing sectoral functions. According to these findings, health sector was mentioned to have jointly worked with other departments such as planning, water, irrigation, education, culture and community development in executing its functions. "In advocacy and sensitization on malaria control we do collaborate with other sectors such as water, culture, community development and education" (Informant, Department of Health). On the other hand, the Department of Community development was described as a cross-cutting sector and it has been involved in all developmental issues including public health education in malaria control. In general, it was pointed out that there as strong collaboration between the Departments of Water, Community Development and Health than between other sectors in the district.

Nine of the 14 district informants described some kind of inter-sectoral activities that have been carried out in the district, most of them related to environmental management. There were also some collaborative activities between departments of livestock and health in implementing a one health approach in zoonotic disease control. Departments of Irrigation and health have worked together in the design of irrigation schemes to avoid creating conditions for water-borne diseases. Department of Environment has collaborated with Health on environmental sanitation activities. The department of water had collaborated with almost all other departments in infrastructural development projects. One key informant had these to say: "It depends on the type of activities. For example in protecting water sources we do collaborate with department of natural resource" (Informant, Department of Water). An informant from the department of Forestry said to have collaborated with departments

responsible for land, community development and environment through a project called Participatory Forest Management.

Intersectoral activities that exist in the district

Different views were discussed on the efforts that are in place, challenges and opportunities to ensure intersectoral collaboration. Fishing and community development sectors have been working together in initiating developmental projects. Health and Livestock department have worked together in rabies campaigns sensitising community on the need to vaccinate dogs and cats against rabies. Health and works departments have collaborated during road construction and house constructions. Health and fisheries sectors have collaborated in educating community on illegal fishing using poisonous chemicals. Fisheries, forestry and environment departments have collaborated in protection of water sources. Fisheries and agricultural sectors have worked together towards the improvement in agricultural irrigation schemes. Land Development and Works departments have collaborated in land surveying, designing, supervision of infrastructure and construction. Community Development department have worked with several other sectors in providing community education during campaigns such as malaria control and child immunization. The department has facilitated the formation of malaria education clubs in primary schools.

Other collaborative efforts in the district included an inter-sectoral Participatory Forest Management Programme that oversees forest management. The district has established routine meetings between head of departments where cross-cutting issues are discussed and decisions made. Lack of adequate funds, irresponsibility, lack of commitment, poor infrastructure and topography, and lack of skilled staff were identified as some of the challenges during group discussions. It was described that most often it was difficult to harmonize resources for cross-cutting activated due to conflict of interest. Most sectors are under-funded and do not have budget item for inter-sectoral activities. To improve inter-sectoral collaboration, participants were of the opinion that the district needs to have a specific budget item for inter-sectoral activities and the government should formulate a policy that directs district on inter-sectoral collaboration.

Challenges and opportunities for inter-sectoral collaboration at district level

As regards to the major challenges to establish inter-sectoral malaria control approach in the district, majority (12/14) of the respondents mentioned the following: (i) availability of funds for implementation of inter-sectoral activities; (ii) inadequate human resources with capacity in ecohealth approaches; (ii) perception that malaria control as the responsibility of health sector alone; and (iv) lack of a district framework on inter-sectoral collaboration. One informant had these to say: “It impossible to have intersectoral collaboration due to poor communication between departments and lack of funds. Usually, each sector would wish to fulfil its own goals” (Informant, Department of Fisheries). To improve inter-departmental collaboration, some participants suggested introducing quarterly meetings at the district level to review departmental activities to identify those that could be implemented in an inter-sectoral approach. From group discussion, all the three groups admitted that intersectoral collaboration does exist in the district, though does not specifically target malaria control.

All informants commended the efforts done by the project to advocate for establishing inter-sectoral collaboration initiatives in malaria control. They had the following reasons to support the initiative: (i) Malaria cuts across a number of sectors and with the current environmental changes there is likelihood of malaria burden to increase; (ii) Inter-sectoral collaboration will help different sectors to be involved in joint planning and budgeting for malaria control; (iii) It will facilitate sectors to share and learn from each other and contribute to malaria control efficiently; and (iv) It will facilitate easy implementation of the other inter-sectoral activities. One had these to say: "Since malaria is associated with by human activities, by engaging different sectors it will be easier to reach many people through different activities" (Informant, Department of Health).

District proposal on intersectoral strategies for malaria control

Specific multisectoral strategies were proposed to respond to gaps identified in the research findings and issues raised from the group discussion:

Management of water reservoirs: It was proposed to use of biological larvicides in irrigation or water development schemes. Fish farming to be introduced in water reservoirs to control mosquito larval populations. It was recommended that wells should be covered and protected. Professional advice should be followed when installing water pump to avoid leakages and allow proper drainage of the spilled water.

House construction and brick making: House construction: Strategies to reduce exposure risk for mosquito bite including creating community awareness on the need installing mosquito proof screens in their houses should be initiated and strengthened. It was proposed that proper town planning be effected to encourage drainage systems. Land and town planners should make sure that construction of houses is done away from potential mosquito breeding sites. There should be an involvement of several key sectors including works, land, health and other sectors in town planning. Areas for bricks production should be allocated away from human settlement. A by–law should be enacted to control brick making industry. Tax may be imposed to brick makers to facilitate the management of brick making industry. Collaboration among land officers, trade officers, lawyers, health officers, environmental officers and village leaders should be strengthened. Awareness should be raised among local community members of the risks versus benefits of brick making close to human settlements.

Night livelihood and social activities: Night socio-economic activities such as crop protection, fishing and social gatherings were some of the major risks activities in acquiring malaria) identified through the discussion. It was proposed that community education should be emphasized to create awareness on malaria prevention and control techniques. Farmers should be sensitized on use of mosquito nets, mosquito repellents and long-sleeved clothes during nigh crop protection activities. During fishing activities, awareness among fisherman should be raised to ensure use of appropriate mosquito protective measures. Community needs to be educated that night socio-economic such as crop protection, fishing and social gathering are the major risks activities to acquiring malaria.

Establish a Coordination Unit and Specific fund for inter-sectoral activities. It was highly recommended that the government should set aside specific budget item for inter-sectoral activities. The fund should be controlled by the District Executive Director. It was recommended to establish a steering committee for intersectoral collaboration in malaria control. To start with, it was agreed to use the multi-sectoral District Malaria Advocacy Team to form an interim "District Malaria Inter-sectoral Steering Committee".

National level

The participants were drawn from four main sectors, namely: Production sector (agriculture, fisheries, livestock, mining, and industries); Economic sector (works/construction, transport, and energy); Social sector (education, health, water, social welfare); and Cross-cutting sector (environment, employment, finance, private sector). Some of these participants came from the Prime Ministers' Office, Municipalities of Kinondoni and Ilala in Dar es Salaam region, the National Environmental Management Council, Private institutions, world Health Organization, Research and Academic Institutions (Table 2). The workshop was attended by a total of 36 participants; of these 18 were provided with and filled self-administered questionnaires. In addition, a number of questionnaires were sent to other senior officials by email and eight of them responded. In total, 26 questionnaires were received back.

Table 2: Number of participants and their respective sectors and ministry/institutions

Sector	Number of participants	Ministry/Institution
Production	4	Agriculture, Food Security and Cooperative
		Livestock and Fisheries Development
		Mining (Energy and Minerals)
		Industries (Trade and Industries)
Economic	6	Works
		Transport
		Energy (Energy and Minerals)
Social	8	Education and Vocational Training
		Health (Health and Social Welfare)
		Water
		Social Welfare (Health and Social Welfare)
		Communication, Science and Technology
		Community Development, Gender and Children
Cross cutting	8	Environment (Vice President's Office)
		Labour (Labour and Employment)
		Finance
		Planning Commission
Others	10	Muvek Development Solutions
		National Institute for Medical Research
		Sokoine University of Agriculture
		Muhimbili University of Health and Allied Sciences
		World Health Organization

Malaria as an agenda in sectoral plans

Of the 26 respondents, over two thirds agreed that malaria was an indirect agenda in their organization activities. For example, participant agreed that malaria was an important agenda and commented as: “Application of insecticide for the control of malaria whether through residual house spray or larviciding may affect the ecosystem if the insecticides are not carefully selected and applied in an environmentally manner” (Participant, National Environmental Management Commission). Another participant from the cross-cutting sector noted that: “Mitigation measures for communicable diseases including malaria is our concern in all development projects we implement. Management plans for health impacts are required in every environmental impact assessment reports”. Another participant added: “In the mining sector malaria is an agenda. We ask companies to fill borrow pits due to quarry activities because we know they are likely to be good breeding sites of malaria causing mosquitoes” (Participants, Ministry of Energy and Minerals). In addition, one participant had these to say: “Public health pesticides that are used inside houses are registered with the Tropical Pesticide Research Institute under the Ministry of Agriculture and Food Security. We understand, some of the pesticides used for malaria vector control have impacts on agricultural sector and the vice versa. We need to collaborate to avoid mis-use and development of insecticide resistance”

Sectoral activities that contribute to malaria transmission

Analysis of the questionnaire revealed that of the 26 respondents, about half of them mentioned that some of their sectoral activities contribute to malaria transmission. These included construction, agriculture, irrigation and mining activities. One participant had these to add: “Construction of irrigation channels, disposal of empty pesticide containers and farming practices, all contribute to mosquito productivity and malaria transmission” Another one from the social sector added: “Water dams constructed in different parts of the country by my ministry somehow contribute to malaria transmission”. A participant from the economic sector said: “The poorly designed drainage structures, borrow pits, and pot holes are good mosquito breeding sites”. Finally, another participant from the cross-cutting sector had these to say: “There is haphazard disposal of water containers that contribute to breeding of malaria mosquitoes”

Sectoral involvement in malaria control and other health programmes

Of the 26 questionnaire respondents, less than half mentioned that their organizations had been involved in malaria control activities in Tanzania, including policy formulation, training, advocacy and implementation of control measures. Participants from different sectors admitted to be informally involved in advocacy and awareness campaigns on malaria control, cleaning up of surroundings and areas that indirectly contribute to mosquito breeding grounds. Some respondents added that their organization have contributed resources including funds to malaria control campaigns. Specifically, one participant from the economic sector said that: "In collaboration with telecommunication companies, we have participated in malaria prevention advocacy and awareness campaigns through donation of mobile phone sets". "My ministry is responsible for approving budgets for health and other sectors including the control of malaria programmes. My ministry has participated in the negotiations and signing of grants for malaria control with development partners" Still another participant from the cross-cutting sector has these to comment: "My institution was involved in the preparation of guidelines for indoor residual spraying in Tanzania".

Of the 26 national respondents, about half mentioned that they envisaged that there were some contributions that their organizations/sectors could make in malaria control or any other disease control in Tanzania. The contributions included participation in research, management water resources, control of zoonotic diseases, mitigation of HIV/AIDS, Community awareness about malaria control, policy formulation on malaria control, and environmental management. Generally, participants envisaged their involvement in research and development has contributed substantially in improving socio-economic status of Tanzanian population. One participant from the economic sector commented that: "We have a leading role in the campaigns aimed at controlling malaria in Tanzania. The city and town authorities are instructed to ensure that all standing water on streets is drained that dirty is removed from the drainages to allow water to flow smoothly all the time".

Political will towards inter-sectoral collaboration

Of the 26 respondents, about two-thirds of them mentioned that there were initiatives in their Ministries and organizations that indicate there is political will and high level of commitment towards inter-sectoral collaboration. Almost all respondents referred to Tanzania Commission for AIDS (TACAIDS) as the best approach in multi-sectoral initiative in disease control. "Almost at all level, there is a high support of HIV/AIDS control with the coordination of TACAIDS" (Informant, Social Sector). Another respondent from the production sector made similar comments as: "Yes, HIV/AIDS is one of problem that is being addressed in an inter-sectoral manner. All issues around this disease have been integrated in various organizations and sectors" This sentiment was echoed by another participant from the cross-cutting sector who said: "The campaign against HIV/AIDS has been exceptional treated. If all diseases control initiatives could utilise a receive similar strategy, then disease control programme would be successful"

Challenges to intersectoral approaches in malaria control

Of the 26 respondents, about half gave their opinions about the probable reasons for the lack of inter-sectoral approaches in disease control programmes in Tanzania. The main included the rigidity of the Ministry of Health and Social Welfare to invite other sectors, the arrogance of medical personnel, and lack of a national coordinating body. Others included the selfishness among policy makers to share resources. Respondents described that there are several organizational issues posing challenges to collaborative actions including the sectoral differences in mandates, disciplines and management cultures.

One respondent from the social sector mentioned as: "There is no intervention package for malaria that address inter-sectoral collaboration. There is lack of important agenda" Still, another respondent from the production sector said: "The mindset! Traditionally, researchers have been working in 'silos'. There are no efforts to involve different stakeholders including the private sector in conceiving research ideas and even in involving them in implementing malaria control interventions" A respondent from the economic sector commented as: "There is lack of inter-sectoral forums to discuss malaria control programmes. Also, there is absence of policies for controlling malaria in different government organizations and sectors". "There is lack of priority setting, awareness and inadequate budget allocation for disease control including malaria in sectors other than Health" (Respondent from Cross-cutting sector).

Opportunity for future intersectoral collaboration in malaria control

Of the 26 respondents, about half gave their opinions whether establishing inter-sectoral collaborations between different sectors would improve disease (including malaria) control in Tanzania. Half of the respondents were of the opinion that inter-sectoral policy on malaria control and joint activities between sectors are likely to minimize malaria burden. However, it was urged that sectors should avail resources for joint malaria control activities. For example, one participant from the economic sector said: "Each sector mobilise resources to address issues that contribute to malaria transmission and control that are within its sectoral mandates". "If every sector in the country embarks on controlling malaria there would be greater impact on the reduction of morbidity and mortality due to malaria and this would reduce the burden that is shouldered by the Ministry of Health" A respondent from Social Sector commented. "There should be harmonization of multi-sectoral policies putting emphasis on malaria control as one sector cannot do it alone" A respondent from Cross-cutting Sector added. "Inter-sectoral collaborations would allow the sharing of information that is necessary for planning and policy making and hence enhance better utilization of limited resources" A respondent from Production Sector concluded.

Thirteen of the 26 respondents agreed that there are opportunities for intersectoral collaboration in malaria and other disease control in Tanzania. The opportunities included the willingness of sectors to collaborate and political will. One participant from the cross-cutting sector alluded to this as: "Yes, opportunities are there and we need to exploit them to support the current national malaria control initiative. As it is for the HIV/AIDS campaign, malaria control should be among the top agenda in all sectoral activities in this country. For

example, the country has now embarked on Kilimo Kwanza seriously, and large irrigation projects are going to be implemented in various parts of the country. This is the right time for the government to bring in other sectors including Health, Environment, Education, and Community Development to make sure water-borne diseases are not going to problems associated with agricultural development programmes. To enhance intersectoral collaboration, a respondent from the Social Sector had this to suggest: "We need seminars on inter-sectoral collaboration to strengthen our capacity in addressing cross-cutting issues, including malaria control" A participant from the economic sector commented as:"However, inter-sectoral collaboration requires specific budget allocation. There is potential for inter-sectoral collaboration in malaria control as various sectors are engaged in activities which in one way or another contribute to the burden of the disease. What is needed is to identify who should take a leading role in this new approach"

How to improve intersectoral collaboration in malaria control

Of the 26 respondents, about half gave their opinions on areas that should be done to improve inter-sectoral collaboration in malaria and other disease control measures. The aspects mentioned include awareness raising, provision of human and financial resources, advocacy, empowerment, allocating enough budgets, sharing of expertise, formulation and coordination of policies and guidelines and advocacy for political support. One respondent had this to say: "At community level, we need to raise community awareness on livelihood activities that contribute to malaria transmission and the community should play a role in the malaria control programme. One of the respondents suggested that: "At community level, make malaria control should be a permanent agenda in village meetings. Further suggestions include that "At district level, the council should develop guidelines that details each sector's role in the inter-sectoral approach for malaria and other disease control measures. Similarly, at the national level there be a policy document that details each sector's role in the inter-sectoral approach for malaria control measures". It was proposed that at the district level, District Executive Director should organize meetings with all departments and set strategies for undertaking collaborative activities on different aspects including control malaria. Moreover, the government was advised to commission a consultancy to explore and advice on how inter-sectoral collaboration for the control of malaria could be implemented. It was also proposed that research institutions should carry out studies and analysis to map key livelihoods and ecological determinants for malaria in Tanzania identifying common issues of interests of different sectors to be able to identify the contribution of each sector in malaria control.

Discussion

In this study, several sectoral activities were identified to contribute to malaria transmission. These included agricultural practices and production systems, infrastructural development programmes, demographic changes including population movements as a result of livelihoods activities. Such sectoral activities and development projects have the capacity to influence the transmission and control of malaria. This study has provided a rare opportunity to identify sectoral activities and livelihoods practices that contribute to malaria and in developing strategies to improve livelihoods practices and malaria control.

In many parts of Africa, water resource development projects such as multi-purpose reservoirs and irrigation schemes have been shown in many cases to increase the incidence of vector-borne disease especially malaria (see Mboera et al., 2007a). In addition, the resources of development sectors other than health must be tapped and coordinated to bring to bear the broadest approach and resource base for tackling malaria control. It is therefore clear that that if not anticipated and corrected for in the initial plan, most sectoral activities and development projects will result in an increase in malaria transmission.

Malaria control programme in Tanzania is implemented vertically from the Ministry of Health and Social Welfare through the National Malaria Control Programme and the district councils with little involvement of the targeted community and sectors other than health. Usually, the involvement of sectors other than Health is limited in regards to their inputs in the implementation of the proposed interventions. It needs to be noted that the involvement of various sectors in malaria control programme is crucial because a number of sectors other than health contribute to creation of mosquito breeding sites or expose individuals to mosquito bites, and hence increase malaria transmission. Like in the current study, it has already been shown that in order to help communities develop appropriate malaria control interventions, the involvement of various sectors including health, agriculture, community development and natural resources is important (Mlozi et al., 2006; Mboera et al., 2007a). These sectors are expected to contribute their knowledge and experience to improving local skills and abilities so that the malaria control programme can make appropriate decisions and take the actions that are effective and relevant to the local context.

Humankind's long history with malaria has provided ample opportunity for the trial and failure of many approaches. It is now increasingly recognized that a much broader, coordinated approach, range of skills, and resource base are required to tackle the malaria problem in Africa. An ecohealth approach has been shown to be more robust in malaria control than the traditional medical approach (Okelo et al., 2012). This is because, in addition to epidemiologists and parasitologists, entomologists are necessary to study the occurrence and habits of the vectors; sociologists and anthropologists are needed to ascertain the local beliefs and practices regarding the perceived cause of malaria, and local methods of prevention and treatment; community development specialists must provide the link to working effectively with communities to conduct assessments and to plan appropriate programmes that respond to the problems and priorities identified by the communities. Environmental health engineers have to make sure that mosquito breeding sites are minimised in all construction projects. Moreover, because of fact that various sectoral activities contribute to malaria transmission, and because of the complexity and scope of malaria interventions, operational, and human problem in Sub-Sahara Africa, specialists need to be drawn from a variety of relevant disciplines to work together in a trans-disciplinary manner. Within such scenario, there is need to establish planning for malaria control in development efforts falling outside of the health sector. Malaria associated with development efforts can be contained by ensuring that prevention and control measures are built into project planning and implementation requirements.

To enhance malaria prevention and control, the cross-sectoral integration of ministries involved in specific development efforts must be established or strengthened. Certainly, the health sector must play a leading role in planning, implementing, and monitoring development efforts that may have an adverse impact on malaria. The health sector should therefore take the initiative in developing national and district plans and to coordinate anti-malaria activities, effectively involving other relevant sectors, non-governmental organization, civil societies, schools, and communities. Such health sector-coordinated groups would be responsible for increasing awareness of malaria as a problem among sectors other than health.

Departments of education, agriculture, water resources, works, community development and land development, for example, should all consider malaria as being directly relevant to their respective missions, encouraging cross-sectoral cooperation at the national, district, and community levels. For instance, fostering collaboration between a village health worker and an agricultural extension worker for community outreach, education, and training programmes, and for regulation of insecticide use is crucial at the community level as evidenced in this study. Already, in Sudan, the Health Education and Community Participation Unit utilizes extension officers who promote health education messages by linking up with farmers (http://www.aaas/international/Africa/malaria91/rec1.html). Strengthening community-level collaboration in the maintenance of local water resources and small irrigation projects is crucial to avoid creating mosquito breeding sites. In addition, cross-sectoral collaboration is likely to be important in promoting research on community structures and behaviours to facilitate development of appropriate education messages and control strategies; and supporting cooperation among development workers from health and other sectors to convey malaria and development-related messages to the community, emphasizing the relationship between development and health.

In recent years, One Health approach that anchor on collaborative efforts of multiple disciplines, has been described as pivotal in attaining optimal health for humans, animals, plants and the environment (One Health Initiative, 2011). The lack of sustainable institutionalisation of inter-sectoral partnership may be attributed to a number of factors such as attitude of the human and animal health experts, unavailability of adequate resources, lack of clarity of mandates and lack of institutional framework (Kayunze et al., 2013). A study in Egypt as shown that even staff in the same sector such as the human health or the animal health sector but with different training specialisations may have different attitudes towards collaboration among themselves (Mazet et al., 2009; El Sayed & Sleem, 2011). Like in our current study, in a study in Tanzania by Kayunze et al. (2013), two thirds of the respondents indicated that inter-sectoral collaboration in reference to management of risks attributable to zoonoses was inadequate; and that more than three-quarters of the respondents were ready to support the adoption of one health approaches.

In this study, an ecohealth approach based on three methodological pillars namely trans-disciplinarity, participatory and gender equity was used (Charron, 2012) to explore the possibility for an intersectoral approach in malaria control at both district and national levels.

Trans-disciplinarity requires full participation of each of various groups and validates their complete inclusion. Through the participatory approach used in this study, the stakeholders promptly identified the range of potential challenges and opportunities through exploring the inter linkages between different sectoral activities and malaria transmission in Tanzania. A similar approach has been described in a previous study in Mvomero District (Mlozi et al., 2006; Mboera et al., 2007a).

As observed in this study, financial resource is among the major limiting factors in strengthening inter-sectoral collaboration at the district and national levels in Tanzania. Inter-sectoral cooperation requires financial support as well as evaluation to determine how they can best be strengthened. It is also clear that to be sustainable and effective, inter-sectoral programmes must have their own funding and clear authority. For instance, in Ethiopia, a diverse group of specialists, including members of the Ministries of Health and Community Development and the National Institute of Medical Research, organized themselves to apply a cross-sectoral approach to controlling malaria and other tropical diseases. Of particular concern to the Ethiopian group have been changing concentrations of human habitation because of both planned and unplanned migration and settlement (USAID/AB, 1991). In Kenya, the District Development Committees (DDCs) are responsible for intersectoral environmental planning and implementation of district-level water projects. In addition, they have supervisory roles in the development of national-level projects, within the involved districts. The DDCs, through their recently established District Water Boards, also supervise and advise the community-level projects (http:.//www.aaas/international/Africa/malaria91/rec1.html).

The need for collaboration arises from the diverse nature of the malaria problem. Malaria problem has multiple determinants, affects many people and sectors, and requires action by different sectors. Many sectoral activities contribute to mosquito productivities and transmission and it is important for all sectors to collaborate to try and influence the likely success of malaria control initiatives that are undertaken at community, district and national, levels.

Lack of skills on inter-sectoral collaboration at the district and national levels was identified as one the major challenges. It is important that district and national malaria programme managers be trained cross-sectorally – for example to have knowledge on agriculture, water, environment and economics so as to prepare them for inter-sectoral collaboration. Training should expose students to other perspectives, encourage exploratory ideas and provide experience working in an inter-sectoral team in order to prepare students for cross-cutting work. In Tanzania during the 1950s-1960s, malaria assistants, malariologists, entomologists, and engineers were trained to work on the malaria control programme. However, these personnel have not been trained in large enough numbers to deal effectively with the growing problem. For instance, currently the national malaria control programme has only a few environmental health officers, vector control officers and engineers. Capacity strengthening in these areas is crucial to implement malaria control strategies holistically.

In conclusion, current strategies for malaria control in Tanzania need to be sustainably maintained. However, without considering the impact of development activities including livelihoods, they are unlikely to be result into sustained control of malaria. The interventions must address issues of livelihoods and ecosystems in an inter-disciplinary and inter-sectoral approach. Unless other key stakeholders see the benefits of malaria control, even the best-designed prevention strategies are unlikely to be effective. It is recommended that all development projects take into account the potential for an adverse impact on malaria and other health problems. Project plans must thus include provisions for reducing the potential for transmission. Development of such plans and mechanisms for monitoring impact can best be achieved by inter-sectoral teams. Controlling malaria associated with these development efforts would be strengthened by changing the requirements for project planning and implementation to mandate that these experts should operate as a team throughout the project life to monitor project impact, recommend revisions to the project as required, and evaluate actual compliance with and effectiveness of revised malaria control efforts.

Intersectoral cooperation needs to be encouraged at all levels including the community level. Coordination with the national or district government that take consideration the participation of all key sectors is necessary in order to obtain the support critical to the success of malaria control programme. The community particularly has a contribution to make in the management or proper use of amenities for housing, water supply, and sanitation. Further, sustained good management by the community requires some commitment on its part and comes when members are involved in decision making and implementation in the provision of the desired facilities. The future malaria control strategy should be broad based, and inter-sectoral in its planning and operation. Intersectoral cooperation needs to be encouraged at all levels.

Chapter 12: Participatory knowledge translation in malaria, ecosystems and livelihoods in Tanzania

Abstract: Health research in Sub-Saharan Africa has not been very effective in terms of knowledge translation to the end-users as researchers' main ultimate objective has been in publishing papers in peer review journals most of which are out of reach of the general population. This makes research evidence remain as one of the least utilised resources in the continent. Knowledge translation is an interactive process of knowledge exchange between health researchers and knowledge end-users. The objective of this Chapter is to describe the activities that were carried out by the project to share research findings through various forums at community, district, regional and national and international levels. At the district level, the concept, objectives and activities of the research project were shared with various stakeholders through an inception workshop. Throughout the implementation of the project, research findings were shared through feedback meetings, workshops and scientific conferences. At community, district, regional and national levels, an eco-health approach was used to bring together key stakeholders in malaria, ecosystems, livelihoods and health systems, to share the research findings and identify gaps and recommend solutions. The participatory approach in knowledge translation provided a unique opportunity for researchers to provide answers and solutions to some of the gaps identified. Participation of community, district, regional and national stakeholders provided unique perspectives on knowledge translation process and outputs. It has identified limitations to the common interpretations of knowledge translation principles and highlighted the characteristics of collaborative research initiatives that are of greatest importance to community partners. The involvement of district and regional key departments provided an opportunity for planning malaria control strategies for Kilosa district. At all levels, the interaction between the knowledge user and the researcher resulted in mutual learning and the process was described to be beneficial to both.

Keywords: research, knowledge translation, community, decision, policy makers, Tanzania

Introduction

Knowledge translation (KT) is an interactive process of knowledge exchange between health researchers and knowledge users (Kothari & Armstrong, 2011). According to Canadian Institutes of Health Services Research (CIHSR, 2004) KT is defined as the synthesis, exchange, and application of knowledge by relevant stakeholders to accelerate the benefits of global and local innovation in strengthening health systems and improving people's health. Knowledge translation is defined as the use of knowledge in practice and decision making by the public, patients, health care professionals, managers, and policy makers (Straus et al., 2011). Failures to use research evidence to inform decision making are apparent barriers across all key decision making groups.

Review of the evidence base for the science and practice of knowledge translation has

identified several gaps including the need to develop valid strategies for assessing the determinants of knowledge use and for evaluating sustainability of knowledge translation interventions (Straus et al., 2011). To date, various knowledge translations have been described to include research utilisation, knowledge to action, translational medicine and implementation science. Conventionally, the components of knowledge translation include knowledge synthesis, dissemination, knowledge exchange, and ethically sound knowledge application. In the Knowledge to Action framework proposed by Graham et al., sustained knowledge use is one of the main components of effective KT (Graham et al., 2006).

Knowledge synthesis involves the contextualization and integration of research findings of individual research studies within the larger body of knowledge on the topic. It also involves synthesis to determine what is known in a given area or field and what the knowledge gaps are. On the other hand, dissemination involves identifying the appropriate audience for the research findings, and tailoring the message and medium to the audience. Knowledge exchange refers to the interaction between the knowledge user and the researcher resulting in mutual learning; it encompasses the concept of collaborative or participatory, action oriented research where researchers and knowledge users work together as partners to conduct research to solve knowledge users' problems. Ethically, sound knowledge application is the iterative process by which knowledge is actually considered, put into practice or used to improve health and the health systems. It is emphasised that knowledge translation activities must be consistent with ethical principles and norms of a given community. Knowledge translation is therefore, about making users aware of knowledge and facilitating their use of it to improve their health and health care systems.

Communicating research findings is aimed at promoting the concept of research as continuous process, from problem identification to application of results, involving a broad range of stakeholders; and sensitising researchers to the need to communicate with various stakeholders at all stages of the process, and to explore strategies and mechanisms for doing so. Like elsewhere in the world, most of the health research findings in Tanzania find their way into peer review journals; which are not accessible by the majority of the local communities and or policy makers. In Tanzania, the use of participatory knowledge translation in health research introduced by National Institute for Medical Research in 2007 has been a tool to provide a crucial forum for sharing research findings with the community, decision and policy makers (Mboera et al., 2007b).

The establishment of a knowledge translation institutional mechanism is envisaged to ensure that the evidence be accessible, timely, credible, trusted, relevant to the local context, and packaged in a user-friendly format. The mechanism has been used to provide for and build capacity for more effective linkages between researchers and policymakers. Appropriate utilisation of findings of research will lead to more accurate preventive action against diseases. Already, the use of KT has provided a framework where problems and solutions were shared discussed and agreed upon (Mlozi et al., 2006; Mboera et al., 2007). It has been shown that research will have a greater likelihood of being used in decision making if all the stakeholders are identified and encouraged to take ownership in defining

health problems and seeking solutions (Mboera et al., 2005; Okello-Onen et al., 2012).

This Chapter describes the knowledge translation process that was used to bring together researchers and knowledge users to share findings of a study on malaria and livelihoods in a rural district of Tanzania. Knowledge users in our context include researchers, policy-and decision-makers from the community to the national levels.

Knowledge translation for community members

Meetings were held to share the research findings with the community from 9th-12th October 2012. The meetings involved a total of 44 community leaders from five villages of Tindiga, Malui, Mbwade, Twatwatwa and Kimamba. They were composed of Ward Executive Officers, Village Executive Officers, Village Chairpersons, representative of the Village Health Committees, community development officers, health officers and agricultural extension officers. One meeting was conducted in each village with participants ranging from 8-11 people. Facilitation was provided by the researchers and the District Malaria Focal person. The objective of the meetings was to share findings from the studies carried out in the five study villages of Kilosa District. The meetings also aimed at getting community's views on the findings presented, factors contributing to malaria burden in their respective communities and actions to be taken to improve the situation.

The findings were grouped into three categories: malaria burden, malaria vectors and transmission levels and community knowledge and practices as regards to malaria. The research findings were shared in Kiswahili through oral and poster presentations. The lead presenters were alternating from one village to another but opportunities were available for clarification by other investigators during the presentations. This was followed by an interactive discussion, moderated by the respective facilitators. The District Malaria Focal Person provided clarifications on issues that were directly under the District Council's mandate. Documentation of the discussions and issues raised was made by one of the researchers.

Community leaders in all the villages were impressed and thanked the researchers for sharing the research findings with them. They, however, complained that many studies were carried out in their villages but researchers do not provide feedback to the community. Investigators were requested to remind other scientists on the importance of providing feedback of their respective research findings to the community. Community leaders promised to utilize the research findings in their plans and in developing strategies to address the identified gaps. They said that having the poster with findings will facilitate discussions in different meetings involving leaders and community at large. "Next time we have our Ward Development Committee meeting we will go through the findings and share with our community members. I do hope that the same will be done by the in-charge of our dispensary to educate those attending health care facility" (Community leader, Tindiga).

The pastoral community members were surprised by the high level of anaemia among their children. "Statistics on anaemia in your study have shocked us. What causes children

to have such high level of anaemia? What is the source? This information will help us to develop strategies to reduce the problem" (Community leader, Twatwatwa). It was made clear that children suffer more from a number of infectious diseases that cause anaemia. In addition, malnutrition was also mentioned to cause anaemia. When worms were mentioned as one of the causes of anaemia participants wanted to know further about worms? "The expert has told us that worms contribute greatly to anaemia but did not mention why children have worms. What causes worms? What type of food stuff contributes to that in children?" (Community Leader, Twatwatwa). Clarifications were provided to the questions raised by the community leaders (Table 1).

Table 1: Issues raised during community knowledge translation meeting

Village	Issue	Response
Tindiga	What is a malaria parasite? Can a person with malaria symptoms recover without treatment with medicines?	Malaria parasites are the germs that cause malaria. A person with malaria may recover spontaneously because his immunity can protect him.
	During mosquito sampling, why were the selected houses included those with poor construction?	It is true that houses used for mosquito sampling were selected based on location and construction. Traditional houses have wide eaves that allow easy entry of mosquitoes. These were the houses preferred for mosquito trapping.
	In wards of our hospital there are large numbers of mosquitoes. Why?	Mosquitoes may enter any building as long as there are openings.
	Are there plans to have Malaria Rapid Diagnostic Tests (MRDT) available in all health facilities?	MRDTs have been distributed in all facilities and staffs have been trained on how to use them.
	What should be done to increase crop productivity using irrigation agriculture while minimizing mosquito productivity?	1. There is need for joint inter-sectoral planning 2. Use of rice variety that need less water 3. Application of intermittent irrigation
	Request was made to have the posters to be distributed to all schools, dispensaries and village offices	1. Posters were provided to all schools, government offices and health facilities in the study villages 2. More posters will be printed and provided to the respective sites as requested

Village	Issue	Response
Malui	What are factors associated with high incidences of malaria?	Poor environmental management Poor house construction Poor irrigation practices Poor implementation of mosquito control programmes
Twatwatwa	Why is prevalence of anaemia among children the highest in Twatwatwa?	1. Malnutrition 2. Parasitic infections including malaria, intestinal worms, etc.
	What caused our children have worms?	Poor hygiene and sanitation Prevention can be implemented through improved hygiene and sanitation -including cleanliness, hand washing, washing of fruits, wearing of shoes.
	At what level of pregnancy should a woman start to attend clinics?	Soon when the woman discover to be pregnant.
	In recent year, the drug to treat malaria was changed from SP to ALu. However, there are people who say that ALu is ineffective. Is this true?	ALu is safe and effective
	Schistosomiasis is very common in our village. We would like to request for research on Schistosomiasis	Possibilities to carry out research on Schistosomiasis will be explored

Village	Issue	Response
Kimamba	Cost and lack of drugs contribute to the delay in seeking of care from health facility	Community is urged to seek appropriate care from health facility – drug availability will be improved
	Women get more fever cases but delay in seeking care. What should we do?	All women are urged to seek care promptly and to adhere to the recommended malaria prevention methods
	Lack of appropriate outdoor interventions when spending nights in the farm contribute to more malaria	Repellents may be used when outdoors People to be advised to put on long-sleeves clothing at night People should avoid unnecessary outdoor activities at night
	Brick making is a source of income but contribute to malaria mosquito productivity. What shall we do?	Brick making should be done in specified areas away from human habitation – efforts should be made not to allow standing water in the pits – pits to be filled when not in use
	Several times patients are told by health workers that they have typhoid fever. We request research to be done on this area	Possibilities will be explored to carry out such studies. However, it is important to have confirmatory laboratory diagnoses for each ailment
Mbwade	What are the causes of anaemia?	Infectious diseases, Worm infestation and malnutrition
	There is frequent stock-out of drugs in our health facility. Any explanation?	District will be urged to make drugs readily available at health facility
	Why is SP given to pregnant women? At what interval should it be administered?	SP is important to prevent mother and foetus from getting malaria. Two doses of SP are recommended from the second trimester
	Why some SP brands from Tanzania have many side effects compared with those from Kenya	The composition of SP from all companies needs to be the same. Report any drug adverse reaction to the nearest health facility
	From your study, why only a few pregnant women received SP as recommended?	This is likely to be due to poor compliance and poor attendance to antenatal care clinics. Moreover, few women had good knowledge on the effect of malaria in pregnancy

Conflicting information from health officers and agricultural officers was mentioned by a number of participants. For instance, an Agricultural Extension Officer in Tindiga had this to say "We are always advising farmers to use irrigation agriculture to increase crop productivity. What can we do such that the same farmer can increase productivity at the same time maintain good health?" Malui participants were surprised by the findings of this study and had the feelings that the existing policy contradicts each other; "While in agriculture we are encouraged to use rice bunds to retain water and increase rice production, the health officers tell us that the same bunds increase mosquito productivity- putting us at risk of malaria. What should we do then?" (Community Leader, Malui). It was clarified that the bunds may be used as long as the areas are kept wet but not flooded continuously. Several examples were provided where improved rice cultivation reduced malaria such as in Lower Moshi and Ndungu Rice Irrigation Schemes in Kilimanjaro Region and Mkindo in the neighbouring district of Mvomero.

Although the findings showed that Kimamba had fewer mosquitoes, participants complained that malaria incidence was high. They said that in the past, there was a mosquito larvae extermination programme, which is not currently been done. Kimamba leaders complained of the poorly constructed water pump aprons that contribute to creation of mosquito breeding sites.

The main complaint from Mbwade participants was stock-out drugs at their health facilities "…Just imagine a person pays TShs 1,500 for the patient card, consultation fee and then later she/he is told that there are no medicines..." (Community leader Mbwade). Participants requested that the government should direct health facility staff that in case of drug stock-out they should not charge the patients. They also requested the cost of medical care to be split into several items such as consultation fee, laboratory fee and drug costs instead of lumping them together. The meeting agreed that this concern will be forwarded to the higher authority.

In responding to the issued raised by the community, the research and district team emphasized the following: "The study findings have revealed that malaria is contributed to a greater extent by human socio-economic activities so it is the responsibilities of the community to change the situation…The community should not wait for the government to come and help". The research team advocated community leaders to take actions whenever possible using the findings presented to prepare their own plans. The team took the opportunity to provide explanation of the currently rolling out of the use of malaria rapid diagnostic test (MRDT) in all health facilities. The initiative is expected to reduce the problem of unnecessary prescription of antimalarial drugs. That means, ALu will only be prescribed to patients confirmed to be positive of malaria infection. Community leaders were requested to sensitize their respective communities to consult health facilities whenever they fall sick, and for mothers to go to the clinic whenever they detect they are pregnant.

Following the dissemination of the results to community, the research team visit a month later, witnessed village leaders to be using the findings to sensitive heads of household

to send their children to receive anthelmintics during the National Schistosomiasis and Intestinal Worms control campaigns.

Knowledge translation for decision makers at district level

A knowledge translation workshop was held on October 8, 2012 at Kilosa Clinical Officers' Training Centre in Kilosa. The workshop was attended by representatives of the District departments responsible for health, agriculture, environment, livestock, fisheries, education, works, irrigation, water, land development, forestry, and community development. The workshop was facilitated by researchers from the National Institute for Medical Research and Sokoine University of Agriculture.

The workshop objective was to share research findings with key district stakeholders and identify strategic inter-sectoral interventions. During the district workshop, the researchers presented findings of their study on "Malaria and Livelihoods in Kilosa District," while the District Medical Officer made a presentation on "Malaria Situation in Kilosa District". From the presentations, it was realised that malaria prevalence and transmission in Kilosa district is low. However, there are variations between villages, livelihoods and ecosystems. Anaemia among schoolchildren was high, especially so among children in the pastoral communities. Knowledge on malaria transmission and prevention was high as well as the mosquito net coverage was high. Community had poor knowledge on the linkages between livelihoods practices and malaria transmission. Brick making was described to contribute highly in mosquito productivity in Kimamba. Anopheles gambiae was the main malaria vector mosquito.

All workshop participants regardless of their sectors admitted that malaria is an important public health problem. A reason given was the fact that malaria morbidity and mortality rates are high especially for under-fives and pregnant women. One of the participants had these to say "Most of the reported cases at both inpatients and outpatients are due to malaria and the disease ranks number one among the top ten" (Department of Health). Malaria was said to have an impact in the development due to reduction in manpower; time lost in taking care of the patients or waiting for recovery could be spent in the production activities.

A wide range of factors contributing to the malaria burden in Kilosa were identified. "Politics contribute to malaria. For example, there is a perception that the mass distribution of mosquito nets was a business venture between the government and donors. As a result some people mis-use the mosquito nets: using them for protecting chickens from vultures" (Department of Environment). Factors contributing to malaria burden in Kilosa district as identified by the participants included: (i) Presence of large water bodies such as swamps, ponds and irrigation schemes; (ii) Poor community knowledge on malaria and its prevention; (ii) Living around swampy areas; (iii) Delay in seeking care among the communities; (iv) Poverty; (v) Poor use and mis-use of mosquito nets; (vi) Culture and night social activities; (vii) Mis-diagnosis by health providers; (viii) Poor agricultural practices; (ix) Poor environmental sanitation; (x) Climate changes; (xi) Drug resistance; (xii) Unavailability of antimalarial drugs; (xiii) inadequate skilled human resource for health; and (xiii) poor

governance.

To substantiate some of the reasons, one participant had these to say: “Kilosa is surrounded by many permanent rivers and swamps which are good habitats for mosquito breeding.” Another participant from the Department of Forest added that with the currently observed climate changes, there will be an increase in mosquito density and hence malaria transmission. In addition, another participant added: “I think the knowledge on the causes for malaria and how to prevent it hasn’t spread much in the villages. For example, there are some people who even fear using the mosquito nets” (Informant, Department of Water).

As regards to malaria control key actors in the district, majority mentioned a wide range of stakeholders including all departments in the district, faith-based organizations, non-governmental organizations, politicians, community leaders and community members themselves. “Everybody in the district has the responsibilities to control malaria through environmental cleanliness and use of mosquito nets.” (Informant, Fisheries). “Stakeholders include health and other departments of the Kilosa District Council and the community at large as they suffer from malaria mostly” (Informant, Department of Water).

Knowledge translation for policy makers and national level stakeholders

An invitation was extended to all government Ministries, a selected number of research institutions and non-governmental organizations. The objective of the workshop was to share findings of research findings on malaria, ecosystems and livelihood carried out in Kilosa District. The workshop was held on Wednesday 17th July 2013 at the National Institute for Medical Research in Dar es Salaam. Workshop participants were senior officials from the Ministry of Works, Ministry of Health and Social Welfare, Ministry of Industries and Trade, Ministry of Agriculture, Food Security and Cooperative, Ministry of Water, Ministry of Labour and Employment, Ministry of Energy and Minerals, Ministry of Transport, Ministry of Communication, Science and Technology, Ministry of Community Development, Gender and Children, Ministry of Finance, and Ministry of Livestock and Fisheries Development. Other participants were from the Planning Commission, National Environment Management Commission, World Health Organization, Ilala and Kinondoni Municipal Councils, National Institute for Medical Research, Muvek Development Solutions, Sokoine University of Agriculture and Muhimbili University of Health and Allied Sciences. A total of 36 participants attended the workshop. The findings of the research project were presented under the following topics:

1) Overview of the Project
2) Malaria prevalence in relation to livelihoods
3) Malaria mosquito productivity and transmission indices
4) Knowledge and practices about malaria in relation to livelihoods
5) Malaria, climate change and food security among farming communities
6) Factors influencing the uptake of malaria preventive services among pregnant women
7) Inter-sectoral collaboration in malaria control in Tanzania

The presentations were followed up with questions and answers session. One participant had a question on the mosquito net use in relation to malaria prevalence in the two study villages. The participant wondered on how possible that mosquito net use in Kimamba was higher than in the other study villages yet malaria prevalence was similar to that observed in Twatwatwa, the village which had lower net use coverage. Also the participant asked on the relationship between accessibility of the health care services malaria prevalence. Another participant wanted to know on the high risk of malaria among the pastoralists when it is believed that keeping animals near to human settlements do divert mosquito from biting humans. Other participants suggested that since malaria burden has declined in recent year, then the Ministry of Health and Social Welfare should divert its resources to other health problems. Responding to the questions, the National Malaria Control Programme representative said "Malaria is still a challenge in our society, and the society is still at risk of malaria infection due to weak disease surveillance system and other reasons. We need to sustain the gains and this requires more resources before we eradicate the disease".
Following a presentation on malaria mosquito productivity and transmission, participants also asked by the prospects of Tanzania using DDT in malaria control and its impacts on human life. Some participants were in favour of DDT based on experience from other Sub-Saharan Africa countries. The most dominating issue that was discussed in the plenary session was the need of involving ministries other than health in malaria control in the future.

Knowledge translation and planning workshop for Regional and District stakeholders

This workshop held in Morogoro in September 25, 2013, brought together 42 participants from the Morogoro Regional Secretariat, Kilosa District Council, Mass Media, Tropical Pesticides Research Institute, Catholic University of Health and Allied Sciences, National Institute for Medical Research and Sokoine University of Agriculture (Table 1).

Table 1: List of participants and their institutions

Group of Institution	Specific Institution/Department	No. of participants
Mass media	Independent Television	2
	Clouds TV	1
	Channel Ten (Africa Media)	2
	SUA Television	2
Research Institutions	National Institute for Medical Research	8
	Tropical Pesticide Research Institute	1
Universities	Sokoine University of Agriculture	3
	Catholic University of Health and Allied Sciences	1
Regional Secretariat	Regional Commissioner	4
	Medical Office	2
	Agriculture and Food Security	1
	Water	1
	Livestock Development	1
	Natural Resources	1

	Community Development	1
	Works	1
Kilosa District Council	Community Development	1
	Agriculture, Irrigation, Cooperative	1
	Fisheries	1
	Education	1
	Works	1
	Livestock Development	1
	Health	2
	Planning	1
	District Executive Director	1

The workshop was officially opened by Morogoro Regional Commissioner, Mr. Joel Bendera. The objectives of the workshop were: (i) to share the research findings of the project titled "Integrated Research Partnership for Malaria Control through an Ecohealth Approach in Africa (IPMA) carried out in Kilosa District; (ii) to develop plan for implementation of the findings. The following presentations were made:

1. Malaria prevalence and transmission intensity in relation to livelihoods in Kilosa District
2. Community knowledge, attitudes and practices on malaria
3. Utilization of malaria interventions among pregnant women
4. Intersectoral collaboration in malaria control

During the discussion, a number of questions and issue were raised:

1) Whether or not the low malaria prevalence among pastoral community was attributed to the fact that mosquito were biting cattle rather than humans
2) Memory recall was likely to affect the response on whether or not someone in the household had fever during the past three months
3) The knowledge of fever among communities should also consider the education status of the head of the household in addition to livelihoods and ecosystems factors
4) Education should be given a priority in malaria control, and this should go together with implementation of
5) The findings of this study should be shared with all other sectors so as they realised their activities have contribution to malaria transmission and control
6) Fumigation of public vehicles should be introduced to minimize the transfer of mosquitoes from one area to another.
7) Intermittent irrigation should be encouraged among rice farmers to minimize mosquito productivity.
8) The issue of stock out of antimalarial and other drugs should be addressed holistically to make sure drugs are available in all facilities throughout the year.

After the presentations, the participants were divided into three groups and each group was given a specific assignment, in relation to the following areas:

1) Malaria and Livelihoods

2) Malaria and ecosystem
3) Malaria and Health system.

Each group was given 60 minutes to discuss the major findings and suggest recommendations to improve malaria in Kilosa District.

Table 2: Major findings and recommendations on malaria and livelihoods

Livelihoods	Findings	Recommendations
Crop farming	• Water management • Traditional flooding of rice fields leads to all year round breeding of mosquitoes and malaria transmission	• Encourage rice farmers to opt for dry resistant varieties • Introduce intermittent irrigation • Introduce Azolla plant that minimize mosquito productivity
Livestock production	Pastoralism Pastoral community are in constant movements They live in poor housing structures High prevalence of anaemia and food insecurity	Sensitize community on proper house construction – with mosquito screens Improve social services and encourage settlement of pastoral communities.
All	Cultural issues and practices Residents dress scantily when carrying out farming activities Night social activities Temporary shifting to farms expose farmers to mosquito bites	Carry out community sensitization on behavioral change and health education Community sensitization on proper dressing, especially at night

Table 3: Major findings and recommendations on malaria and ecosystems

Ecosystem	Findings	Recommendations
Rice farming	Malaria prevalence relatively higher Rice irrigation agro-ecosystem support high mosquito productivity	Encourage rice farming using intermittent irrigation

Dry savannah	Anaemia prevalence relatively higher Brick making creates mosquito breeding sites Most mosquito breeding sites are manmade (abandoned water vessels, etc.)	Address diet improvement and education on the importance of nutrition to human health through collaboration between health and nutrition experts Community to be encouraged to fill pits and borrows left after brick making Community to be educated on proper disposal of unused containers

Table 4: Major findings and recommendations on malaria and health systems

Health systems	Findings	Recommendations
Governance	Livelihood and ecosystem not addressed strongly in National Health Policy and National Malaria Control Strategic Plan; Although, the Health Policies described the need for intersectoral collaboration, its implementation is still weak	Issues related to livelihoods and ecosystem should adequately address in all health sector plans and strategies. Intersectoral approach to malaria and other disease control programmes should be introduced and implemented. Intersectoral collaborations should be coordinated by the Prime Minister's Office
Resources Human resource Finance Infrastructure	Human resource for health is inadequate and inequitably distributed Some health staff capacity is limited Inadequate budget Lack of information technology facilities (computers, internet, telecommunication, etc.)	Government should recruit adequate human resource for health There should be friendly working environment and incentives for staffs working in remote areas On job training programmes should be strengthened More funds allocation to the health sector Each sector has to allocate funds for intersectoral collaboration

Health Information Management System	A minimal data analysis is done at facility and district level Data rarely used for planning Information Technology facilities not available	Capacity of the District and facility staff should be strengthened through training and provision of ICT equipment
Health service delivery	There is no specific organized outdoor malaria interventions IPTp coverage very low Stock out of medicines	Research should address the need for outdoor malaria interventions Research on IPT to establish the reasons for low coverage should be encouraged More health education to pregnant women should be provided Procurement procedures for drugs should be reviewed to address shortage of medicines

Health promotion messages using wall calendars

A wall calendar was developed, printed and distributed to all wards and village government offices, primary and secondary schools and health facilities in the study sites. Some wall calendars were also provided to the Kilosa District Council departments. The wall calendar had five pages and each page displayed photographs of activities related to malaria, ecosystems and livelihoods in Kilosa District. The title of the calendar was "Malaria and Livelihoods in Kilosa District, Tanzania" which appeared on all five pages. Each page provided some health promotion messages as regards to malaria prevention in Kiswahili language (Figure 1-5).

On the cover page the health promotions message reads: Malaria kills: prevent children and pregnant women from malaria.

MALARIA NA SHUGHULI ZA KIUCHUMI WILAYANI KILOSA, TANZANIA
(Integrated Research Partnership for Malaria Control through an Ecohealth Approach in East Africa)

Malaria inaua: Wakinge watoto na wajazito dhidi ya malaria

Figure 1: Cover page of the wall calendar

The calendar page for January, February and March 2013 carried the following health promotion messages:

1. Livelihoods activities contribute to malaria transmission
2. Make sure brick making pits are filled so as not to allow standing water for long periods of time
3. Make sure the area around water taps does not allow standing water

- Hakikisha mashimo yanayochimbwa udongo wa kutengenezea matofali hayaruhusu maji kutuama kwa muda mrefu
- Hakikisha maeneo yenye bomba za maji hayaruhusu maji kutuama Shughuli za kiuchumi huchangia janga la malaria

JANUARI 2013						
J3	J4	J5	AL	IJ	J1	J2
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

FEBRUARI 2013						
J3	J4	J5	AL	IJ	J1	J2
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			

MACHI 2013						
J3	J4	J5	AL	IJ	J1	J2
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Figure 2: Calendar page for January, February and March 2013

Page 3 of the calendar covered the months of April, May and June. The health promotion messages on this page were:

1. Every member of the community should make sure that mosquito nets are used appropriately for prevention against mosquito bites and malaria.
2. Crop and livestock farmers should carry with them insecticide treated mosquito nets when shifting to their farms.
3. Community involvement in malaria control is crucial for sustainable interventions.

1. Kila mwanajamii ahakikishe matumizi sahihi ya vyandarua vilivyosindikwa viuatilifu
2. Wakulima na Wafugaji wahakikishe wanajikinga dhidi ya malaria wanapohamia maeneo mengine

Ushirikishwaji wa Jamii ni muhimu ili kuboresha mbinu za kilimo na afya za wananchi

APRILI 2013						
J3	J4	J5	AL	IJ	J1	J2
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	11	18	19	20	21
22	23	24	25	26	27	28
29	30					

MEI 2013						
J3	J4	J5	AL	IJ	J1	J2
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

JUNI 2013						
J3	J4	J5	AL	IJ	J1	J2
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21		23
24	25	26	27	28		30

Figure 3: Calendar page for April, May and June 2013

1. Jamii ihakikishe upatikanaji wa chakula cha kutosha kila wakati.
2. Jamii izingatie usafi wa mazingira hususan matumizi ya vyoo na maji safi.
3. Jamii ihimize akina mama wajawazito kuhudhuria kliniki kwa wakati na kutumia dozi kamili ya SP.

Malaria, minyoo na ukosefu wa lishe bora huchangia kwa kiwango kikubwa upungufu wa damu kwa watoto na mama wajawazito

JULAI 2013						
J3	J4	J5	AL	IJ	J1	J2
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	11	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

AGOSTI 2013						
J3	J4	J5	AL	IJ	J1	J2
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

SEPTEMBA 2013						
J3	J4	J5	AL	IJ	J1	J2
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

Page 3 of the calendar covered the months of July, August and September 2013. The health promotion messages on this page were:

1. Malaria, worms and malnutrition contribute highly to high prevalence of anaemia among children and pregnant women.
2. Every household should ensure availability of adequate food for members of the family throughout the year.
3. It is the responsibility of the community to ensure clean environment, proper hygiene and sanitation, including proper use of latrines.
4. Pregnant women are to timely seek antenatal care for intermittent preventive treatment of malaria.

International Scientific Conferences

Findings of this study were presented at various forums including international scientific conferences:

1. 26th Annual Joint Scientific Conference, Arusha International Conference Centre, Arusha, Tanzania, April 16-19, 2012
2. 27th Annual Joint Scientific Conference and 2nd One Health Conference, Snow Crest Hotel, Arusha, Tanzania, April 16-19, 2013
3. Integrated Research Partnerships for Malaria Control in Africa: Results Sharing and Consolidated Workshop, Nairobi, July 22-24, 2013
4. Soils, Land-use and Health Conference, Lushoto, Tanzania, August 27-29, 2013

Titles of presentations made

1. Pastoralism and malaria burden in Sub-Saharan Africa
2. Malaria prevalence and transmission in relation to livelihoods in Kilosa District, Central Tanzania
3. Malaria and livelihoods: knowledge and practices in Kilosa District in Central Tanzania
4. Malaria, farming practices, climate change and food security in Kilosa District, central Tanzania
5. Enhancing cross-sectoral approach in setting malaria interventions strategies at district and community levels in a rural district of central Tanzania
6. Knowledge, attitudes, and practices on malaria prevention among pregnant women in Kilosa, Tanzania
7. Uptake of intermittent preventive treatment during pregnancy in Kilosa District, Tanzania
8. Malaria burden in relation to ecosystems and livelihoods in Kilosa District, Central Tanzania

Discussion

All health care systems are faced with the challenges of improving quality of care and reducing the risk of various communicable and non-communicable diseases. Globally, health systems fail to use evidence optimally, because of poor research communication capability of researchers and demands from end-users including decision and policy makers (Mboera et al., 2009). The result is inefficiency and a reduction in both quantity and quality of life. Health research in Sub-Saharan Africa has not been very effective as researchers main ultimate objective is in publishing papers in peer review journals. This makes research knowledge remaining as one of the least utilised resources in the continent. Providing evidence from health research (e.g., through publication in journals) is necessary but not enough for the provision of optimal care. Research can only contribute to the progress of humanity once it is effectively communicated to policymakers so that it can influence decisions and actions (von Grebmer, 2008). Recognition of this issue has created interest in knowledge translation.

In this study, through knowledge translation process at community and district levels, the investigators were able to communicate health research findings to their research

communities, at the point of evidence generation. It has already been reported that a major challenge in achieving health development in any given developing country is addressing the dichotomy between research findings and decision-and- policy making (Mboera et al., 2009). The work that researchers conduct often does not reach decision and policymakers because of inadequate and inappropriate communication. There is a tremendous need for research findings to guide planning, programme development and policy formulation for better health care delivery. It was interesting to observe that in some villages, the research findings provided were used by local government leaders to sensitive the communities to participate in the national deworming campaigns. In fact, this indicates that the knowledge translation process provided useful information that was made available at the right time to those who needed to make decisions.

As in this study, research findings will have a greater likelihood of being used in decision making if all the stakeholders are identified and encouraged to take ownership in defining health problems and seeking solutions. A similar scenario has been described in a neighbouring district of Mvomero by Mlozi et al. (2006). In general, the needs of policymakers are simple: they want the right information, in the right form, at the right time. But what sounds like a truism is difficult and sometimes cumbersome to put into practice. Consumers of research results are not alike; their communication needs can differ tremendously. The right form in which to convey information depends on a policy maker's background, perspective, and political context. But policymakers do have a common preference. They are more likely to read research results and policy implications that are timely and clearly and succinctly presented. It is important therefore, that researchers must develop some skills in communication and advocacy for specific target groups. They must understand how resource allocation decisions are made and how policy is developed, implemented, and monitored.

Evidence-informed health promotion and public health is an emerging and ever-changing theme in research and practice (Armstrong et al., 2006). The research communication in this project involved all key sectors, beyond health. Within and beyond the health sector, evidence-informed health promotion and public health is often seen as "health sector business". However, promoting and sustaining engagement between sectors is a core priority for improved population outcomes. The need for this engagement is prompted by the recognition that the evidence required to design, implement and evaluate public health interventions such as those of malaria is held sometimes by other sectors including agricultures, environment, fisheries and works. A knowledge translation workshop described in this study is unique and most probably the first one that has brought to one forum almost all sectors in the country. It has been suggested by Srinivasan et al. (2003) that policy makers, governments, researchers, health specialists and communities should work in partnership to create healthy environments. Success in health promotion and public health interventions that require multi-sectoral cooperation depends on a collaborative approach to gathering and applying evidence. The complexity of decision making in health promotion and public health makes the use of development of evidence contentious and challenging (Armstrong et al., 2006).

At community, district and national levels, the need for intersectoral collaboration in tackling malaria problems was echoed. However, it was realised that to bring several together sectors to address a common public problem is a nightmare (Chapter 9). One promising way to strengthen capacity for evidence-informed public health decision making may be to develop partnerships between health sector practitioners and academics in other sectors and disciplines, such as agriculture, community development, environment, education, construction (Armstrong et al., 2006), etc. as indicated in this study. The methods employed in this study of gathering information across sectors to identify public health priority issues is underused in many circumstances.

The use of Healthy Message Calendar is in uncommon in Tanzania. To our knowledge this is the first time wall calendars have been used to communicate research findings and healthy messages in Tanzania. In New Zealand, a health promotion intervention using the 'Healthy Messages Calendar' has been used among community groups (Robertsone & Neville, 2008). In an evaluation exercise six month later, it was learnt from village leaders that the wall calendar was a valuable health promotion tool that provided appropriate health information to the people of Kilosa. Discussion with village leaders indicates that the community were very enthusiastic going through the calendar especially when considering that the photographs were taken from among themselves and from their own areas.

This project has shown exemplary example on various methods and forums that can be used to communicate research findings effectively. There are strong economic, moral and political reasons for making better use of research evidence. Economically, researchers need to ensure that public investment in research is wisely spent by maximizing the use made of the findings and helping to identify cost effective policy decisions based on sound evidence. Morally, researchers have a responsibility to intervene in people's lives through health and other social care services, based on the best possible evidence of positive outcomes to maximise benefit and limit harm. Politically, public expectations, especially, in health interventions, are that policies will reflect evidence, making it important for politicians to at least appear to use research.

In conclusion, the involvement of community, district and regional managers, decision and policy makers provided an opportunity for sharing research findings at the right time and place and enhanced planning malaria control strategies for Kilosa district. At all levels, the interaction between the knowledge user and the researcher resulted in mutual learning and the process was described to be beneficial to both.

Chapter 13: General Discussion

The work described in this report is part of the Integrated Research Partnerships for Malaria Control in Africa (IPMA) initiative. The initiative was launched by Canada's International Development Research Centre (IDRC) Ecosystems and Human Health (Ecohealth) and Governance, Equity and Health (GEH) programmes (www.idrc.ca). The aim was to foster partnerships for integrated research across malaria-endemic regions of Sub-Saharan Africa: that is partnerships that create synergies among environmental, health systems, and community-based approaches to malaria control. The IPMA initiative serves to promote systems thinking emphasizing collaboration, multi-stakeholder engagement, sensitivity to equity, and sustainability. This Chapter provides a synthesis of the preceding chapters on malaria, ecosystems and livelihoods.

In Sub-Saharan Africa, the tropical climate and land use changes either through environmental management, modification and manipulation, have either a positive or negative effect on mosquito reproduction and survival (Birley & Lock, 1998). Human activities associated with settlement, livelihoods, or other environmental development activities such as road construction and water development schemes may result in the creation of favourable mosquito breeding sites (Kitron & Spielman, 1989). These infrastructural and agricultural developments, coupled with human population growth, more often have resulted in increases of mosquito vector and malaria transmission.

In Africa, traditionally, malaria has been viewed as a disease of the rural areas and associated with farming communities. In recent years, agricultural development has taken off in Africa, and modernization of agricultural production systems including irrigation has caused a shift in malaria transmission in many areas. In addition, deforestation either for expansion of agriculture or logging and timber industry, is another dramatic land use change that leads to a reduction of forest canopy and an increased exposure to sunlight, which substantially affect the survivorship and development of time of larval and adult mosquitoes (Afrane et al., 2007; Yasuoka & Levins, 2007; Imbahale, 2009).

The results of this study are categorized into three major themes: (i) Malaria and Livelihoods; (ii) Malaria and the Ecosystems; and (iii) Malaria and the Health Systems. The themes have been broken into subthemes and the recommendations are proposed accordingly. Broadly, the main livelihoods of the people in Tanzania are driven by water availability and resource management availability (crop farming, livestock farming and mixed livelihoods). Socio-economic and cultural factors and practices also play important roles in malaria transmission, acquisition and control.

It was found that rice agro-ecosystem was characterized by higher mosquito abundance and higher malaria prevalence. Dry savannah inhabited by pastoral communities was characterized by moderate malaria transmission, food insecurity and high burden of anaemia among children. On the other hand, mixed livelihoods were characterized by low

malaria prevalence but high levels of anthropogenic activities that create potential mosquito breeding sites. In terms of the health system, the findings indicate that there frequent shortage of antimalarial drugs, lack of diagnostic services; poor malaria case management and low coverage of IPTp2 were common. There is inadequate and inequitably distributed professional health workforce. Knowledge on disease surveillance among district and facility level workers is poor. Reporting of epidemiological data from lower to higher levels is poor, incomplete and not timely. Only a minimal data analysis is done at facility and district levels and data are rarely used for planning and decision making.

Socio-economic factors and practices were identified to play important role in malaria transmission, acquisition and control. The studies identified the following practices to promote increased mosquito biting among the communities: (i) Night outdoor community activities, including temporal shifting to farm, which expose farmers to mosquito bites; and (ii) Poor housing structures among crop and pastoral communities, which allow easy entry of malaria mosquitoes. On the other hand, the health system was observed to strive to deliver malaria disease management and preventive care through the widespread use artemisinin combination therapy, intermittent preventive treatment in pregnancy and insecticide treated mosquito nets as the main interventions. However, the health system was found to be considerably handicapped in a number of ways making it difficult to achieve the set targets. There were no specific organized outdoor malaria interventions targeting crop farmers and pastoralists to complement indoor malaria strategies.

To address malaria, livelihoods, ecosystems and health systems, an integrated malaria vector control (IVM) is required. IVM is defined as a rational decision-making process for the optimal use of resources for vector control and includes five key elements: evidence-based decision-making; integrated approaches; collaboration within the health sector and with other sectors; advocacy, social mobilization, and legislation; and capacity-building (Beier et al., 2008). Despite the fact that in 2004, the WHO adopted IVM globally for the control of all vector-borne diseases and the fact that IVM is described in the current National Malaria Control Strategy (2008-2013) very little evidence is available to indicate that the IVM strategy has been holistically implemented in Tanzania. The scaling-up with insecticide-treated nets (ITN) and indoor residual spraying (IRS) coverage has remained the mainstay of malaria control in the country. The findings of this study indicate clearly that further strengthening of vector control components through IVM is relevant.

It is important that malaria control programme realises that ITNs and IRS that act against the adult mosquitoes indoors are not the only effective tools. Efforts should equally be addressed to promote the use of physical barriers such as house screens, habitat management to reduce mosquito breeding site, larviciding, and other interventions (MacCormack, 1984; Kirby et al., 2009; Fillinger et al., 2009).

In conclusion, the studies described in this report, have clearly shown that water and land resource management are important drivers of rural community livelihood systems. It is therefore critical to strengthen community capacity in water and land resource management

strategies to prevent negative impact on health and ecosystem. Appropriate environmental management to minimize and eliminate potential mosquito breeding sites should be implemented. It is important that malaria control strategies include water-management-based interventions and improved livelihoods.

Ensuring sustainable and effective malaria control requires rethinking of how we manage mosquito populations. Malaria being a problem that cuts across different sectors – an intersectoral malaria approach is envisaged to be the best way forward. This recommendation is based on the fact that inter-sectoral approach provides complementarity and capitalizes on the potential synergies to accelerate both malaria control and improve livelihoods in a healthy ecosystem. To implement inter-sectoral approach in malaria control in Tanzania, it is important that each sector should reviews its ways of operations, practices and procedures to identify those that are potentially contributing to mosquito productivity, malaria transmission, or insecticide resistance. Similarly, each sector should review its potential and role in addressing determinants of malaria of which concerted efforts by multiple sectors are required.

Acknowledgements

We would like to acknowledge the excellent technical and field assistance of Dionis Rwegoshora, Grades Stanley, Godlisten Materu, Eric Mgina, Nuru Akida, Anna Makanta, Joseph Kombe, Deogratus Massawe and Esther Kimambo. The authors wish to thank the local Ward and Village Government Leaders of Kimamba for their acceptance to sample mosquitoes in their farms and around home premises.

We are grateful to Doroth Wei, Carrie Fahey, Phillip Paul and Mary Zinga who for their enthusiasm and interest in participating in this study. The four had opportunities to carry out their University research studies within the project.

Special thanks to Mr. Kesheni Senkoro and his Data Management Unit team for data entry, cleaning and initial analysis. We are grateful to the entire study subjects, the Ward, village leaders, heads of household and mothers of Kilosa for their enthusiasm and cooperation during the interviews.

Thanks Dr. John Bosco Lindi (District Medical Officer), Dr. Wilbert Chuwa (District Hospital incharge), Ms. Ms. Rosemary Nguruwe (District Malaria Focal Person) and District Reproductive and Child Health Coordinator and staff of the Kilosa District Hospital and health centers and dispensaries for their extended cooperation during data collection. We are grateful to the all officials from the Government Ministries, Morogoro Regional Secretariat and Kilosa District Council for their inputs and participation in the knowledge translation workshops inter-sectoral malaria discussions.

The National Institute for Medical Research, Sokoine University of Agriculture and Kilosa District Council are thanked for their logistics and administrative support. This study received financial assistance from International Development Research Centre of Canada through the Integrated Research Partnership in Malaria Control through an Ecohealth Approach in Africa Project.

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