Malaria interventions and control programmes in Sub-Saharan Africa: A narrative review

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Abstract: Malaria transmission and prevalence involves a triangular web of interactions between man, vector, and the environment. Any meaningful effort in malaria control, elimination and or eradication should target weakening and or breaking the forces of interactions within the triangle. In sub-Saharan Africa, effective malaria control programme is encumbered by myriad of challenges. The unabated burden of malaria could be ascribed to efficient malaria vectors with strong niche for ecological expression that maintain high levels of transmission at all seasons. Parasite genotypic heterogeneity, multiple expressions of traits of adaptations to parasitism and unpredictable behavioural changes are the smart ways the infectious agent thrives, persists and expresses ecological niche with scaring symmetry. Environmental factors and climatic changes, population movement, deteriorated socioeconomic situation, lack of access to effective and timely antimalarial treatment, use of sub-standard and or fake anti-malarial drugs, self medication and non-compliance to drug dosage are the galvanizing factors to poor intervention outcomes. Above all, for ages, in most settings and communities, there is lack of knowledge regarding the causative agent of malaria. Diversionary factors

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PUBLIC INTEREST STATEMENT
The outlook for malaria elimination in sub-Saharan Africa is deciphered. At the moment, no one can say authentically when it will be possible to eliminate malaria in sub-Saharan Africa. Year in year out, the narratives for reporting morbidity and mortality of malaria in sub-Saharan Africa remains almost the same: Every second, an African child dies of malaria! Pregnant women and children are at risk of malaria! Malaria is a disease of public health concern! These are the unending narratives from time immemorial.

While it is a common knowledge that malaria is one disease that we all know the causative agent, the breeding place, the biting mode and transmission, yet it is difficult to contend the disease. It is on this basis that our team made a thorough review by gleaning through literatures on various malaria elimination efforts in sub-Saharan Africa, made recommendations and suggestions that will help policy and consolidate gains and change the recurrent narrative.
and misconceptions such as eating too much palm oil, standing in the sun, drinking too much of alcohol, jinxing and witchcraft attacks are brands of porous perceptions on causes and risk factors of malaria. And if a thousand and one sophisticated strategies are put in place to eliminate malaria in sub-Saharan Africa where indigenous and factorial perceptions with rhetorical contrast of ideas hold sway, then, a predictable defeated performance is the expected result. For the sustenance of the gains already recorded in the fight against malaria in sub-Saharan Africa, the role of the community as a strong partnership for change cannot be underestimated.

Subjects: Biology; Entomology; Epidemiology; Medicine

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1. Introduction
Malaria remains a leading cause of death in the sub-Saharan Africa despite efforts to control it at vectorial and parasitic levels (World Health Organization [WHO], 2016). The problems have been attributed to insecticide and drug resistance genes in the vector and in the parasite, which have proved very difficult to tackle over the years. Unabated virulence of the Plasmodium strains have been a major problem coupled with host poor immune response to infection. Children below the age of 5 and pregnant women suffer the greatest burden of the disease. It remains a public health problem and a major cause of morbidity and mortality with an estimated 216 million clinical cases in year 2016 with 90% of cases in African region (World Health Organization [WHO], 2017).

Epidemiologically, the reported numbers of malaria cases and deaths are used as core indicators for tracking and monitoring the progress of malaria control programmes (World Health Organization [WHO], 2014). The main sources of information on these indicators are the disease surveillance systems operated by ministries of health of various countries in sub-Saharan Africa (WHO, 2014). However, in such countries, the factorial analysis of malariometric report may be influenced by a number of factors: First, hospitals and clinics are not under compulsion to report malaria cases and often no sanctions or punishments are meted on defaulters hence report submission is mostly a matter of lip-service. Secondly, routine reporting systems often do not include patients attending private clinics or treated at home, so disease trends in health facilities may not reflect trends in the entire community. Thirdly, not all malaria cases reported are confirmed by microscopy or RDT and so, some of the cases reported as malaria may be other febrile illnesses (WHO, 2014). Above all, incidences and deaths from malaria that takes place in hard-to-reach communities are usually not reported (WHO, 2017).

Measures for effective malaria control and intervention programs have been recommended (Tanner et al., 2015). However, these measures have been poorly implemented in affected areas. This makes malaria a ubiquitous killer in sub-Saharan Africa where reason runs parallel with aberrant ideology aside from the lack of political will tackle the diseases (Chuma et al., 2010). This review paper focuses on the various intervention strategies in malaria control and elimination with associated limiting factors and recurrent decimal.

2. Intervention through health facilities case management of malaria (HFCMm)
Case management refers to effective treatment of malaria within 24 h of the onset of symptoms (World Health Organization [WHO], 2010). Health facility case management of malaria remains a vital component of malaria control strategies with emphasis on early diagnosis and prompt treatment with effective anti-malarial medicines based on WHO guidelines (WHO, 2010). Also, WHO 3Ts Campaign acronym: Test, Treat and Track to explore intentions and purposes have been
beautifully coined as a corner stone for apt understanding among health workers to treat only confirmed malaria cases by microscopy and rapid diagnostic test (RDT), rather than to give presumptive treatment by conjecture (WHO, 2010, Ruizendaal et al., 2014).

In most, if not all countries in sub-Saharan Africa, ACTs are the recommended regimen for treatments of malaria and RDTs kits are recommended for use most especially at the grass-root level as a new malaria treatment policy. Some of such combinations include artemether plus lumefantrine, artesunate plus amodiaquine, artesunate plus mefloquine, and artesunate plus sulfadoxine-pyrimethamine. Also, treatment regimen varies with malaria presentations (uncomplicated or severe malaria) in countries and regions based on the level of resistance of a partner drug in combination (WHO, 2010). In severely ill patients, antimalarial treatment with supportive nursing care, usually on hospital admission, is vital to recovery. Monitoring and treatment of hypoglycaemia, administration of essential antipyretics, blood transfusion in severe anemic patients, administration of appropriate drugs to arrest convulsion and fits are essential components in hospital-based interventions (WHO, 2010, Joseph et al., 2013).

However, one of the factors that limit the effectiveness of HFCMm is the accuracy of malaria diagnosis by microscopy. It has been a challenge in most health facilities in sub-Saharan Africa and elsewhere due to poor competence of microscopists and inability to report on malaria species (Olukosi et al., 2015). Previous reviews on the subject in Peru, Thailand, Kenya, Cambodia and Indonesia, have shown high level of discrepancies (diagnostic disagreement) among microscopists in time past (O’Meara et al., 2006, 2005). Such diagnostic disagreements were seen in microscopists giving out discordant views on two separate slides prepared from the same patient of the same blood sample and two or three separate microcopist estimating different malaria parasite density (MPD) when viewing the same slides.

Moreover, advances in malaria diagnosis by microscopy has shifted away from the semi quantitative “plus” reporting system to a more quantitative form of actual counting of the parasite (O’Meara et al., 2005). Before now (and though it is still in use), malaria microscopy results were expressed as scores of parasite density based on visual observation to highlight if the parasite seen are scanty (+): 1–10parasites/100hpf; moderate (++):11–100 parasites/100hpf or high (+++): 1–10 parasites/hpf and >10 parasites/hpf (++++) in very heavy infections. However, modifications in quantifying malaria parasite density involves the actual counting of the parasites together with the patient’s white blood cells (WBC) within the same fields, and then multiplying the ratio by the measured or estimated density of WBCs in the patient’s blood (O’Meara et al., 2006). Till date, this technique is still new and a mirage in some health facilities in sub-Saharan Africa and most diagnosis of malaria is done by conjecture by ill-trained laboratory personnel.

Also, in sub-Saharan Africa, overlapping symptoms of fever in malaria akin to other parasitic, viral and bacterial infections is common and only a proper malaria diagnosis could draw a line of distinction between them, thus creating an end point in good clinical laboratory practice and rational therapeutic care. Poor prognosis and or diagnosis by conjecture and default could hinder effective malaria control and over diagnosis may lead to wrong perception of the true efficacy of anti-malarial medicines when they appear to “Cure” self-limiting febrile conditions mistaken for malaria (Agomo et al., 2006). This could be a road map to future drug resistance.

Above all, one of the limiting factors of HFCMm is inability to make financial deposits to hospital cashier in the face of malaria exigency (Chuma et al., 2010; Hetzel et al., 2008). There is no health insurance coverage for majority of those residing in rural communities where the deadly scourge of malaria is high. And as would be expected, lack of money to pay at the hospital before the sick is attended to serves as a discouragement to seek medical intervention in the first instance. And since nature abhors a vacuum, the sick with malaria exigency runs to the mosque, the church and the voodoo priest for prayers, treatment and interventions (O’Neill et al., 2015). Over the years, this
has been a recurrent decimal in HFCMm in sub-Saharan Africa-delayed decision to seek medical intervention due to lack of money to pay at the health facility.

3. Intervention through community case management of malaria (CCMm)

Most children who die of malaria do so due to delays in seeking treatment (Getahun et al., 2010). WHO has proposed community case management of malaria especially in communities where medical facilities are inaccessible (World Health Organization, 2005). CCMm, formerly known as home-based management of malaria, is a strategy recommended by the World Health Organization, which aims at reducing the malaria burden by improving early access to malaria-directed healthcare (Ruizendaal et al., 2014).

CCMm, therefore, aims at ensuring prompt access to efficacious anti-malarial drugs through community-based trained volunteers. It requires that effective and appropriate treatment with first-line ACTs, as well as guidance on referral criteria are provided at the community level through trained community-based providers, such as community health extension workers (CHEWs), coordinators and private vendors (WHO, 2010).

Previous reviews on CHEWs role in CCMm shows that malaria treatment were done presumptively, but recent WHO modified guideline for CCMm, CHEWs are now expected to treat only malaria patients with confirmed diagnosis, usually with the use of RDTs (Ruizendaal et al., 2014). Numerous studies to evaluate CCMm project shows that success has been recorded in most cases, with potentials for greater success if community sensitization and education is done routinely (Ajayi et al., 2008). There is no gainsaying that in Africa, the majority of children with fever are treated at home, so reaching the home and community more effectively with anti-malarial treatment is likely to have an impact on malaria control. Increasing the availability and improving the use of effective anti-malarials for the treatment of suspected malaria at home have the potential to reduce the time between onset of symptoms and delivery of treatment, and could result in a reduction in malaria morbidity and mortality (WHO, 2010). However, WHO’s CCMm treatment with confirmed cases only have not been fully evaluated and failures or success of the program is yet to be brought to fore. This information is most needed as a critical component of malaria eradication and control program especially at the local level where the chunk of malaria illness and deaths occurs, undocumented. Also, CCMm requires that health community workers and or coordinators move freely in the community to assist in treatment or get to the house where the sick lie to treat suspected cases of malaria. Sadly, distance, awareness, trust and availability of CHEWs are the factors to poor implementation (Hetzel et al., 2008).

4. Intervention through the use of traditional herbal medicines (THM)

Traditional medicines have been used to treat malaria for the thousands of years and are the sources of the two main groups (artemisinin and quinine derivatives) of modern anti-malarial drugs (Willcox & Bodeker, 2004). In sub-Saharan Africa, various species of herbs are used as THM in the treatment of malaria (Odugbemi & Akinsulire, 2007). The part used could be the roots, bark, leaves or whole plants, some of which are Azadirachta indica (Neem tree), Cymbopogon giganteus (Lemon grass) and a host of others. The Research Initiative on Traditional Antimalarial Methods (RITAM) was founded in 1999 with the aim of furthering research on traditional medicines for malaria. The initiative now has in excess of 200 members from over 30 countries. It has conducted systematic literature reviews and prepared guidelines aiming to standardize and improve the quality of ethno-botanical, pharmacological, and clinical studies on herbal anti-malarial and on plant-based methods of insect repellence and vector control (Bodeker & Willcox, 2000).

Traditionally, anti-malarial herbal medicines are usually boiled with water, palm wine, water from fermented corn and pounding using local mortar with a solvent of choice added to make effusion, concoction and decoctions of extract. However, studies provided limited information on the methods used to prepare the remedies, making it difficult to replicate them. In some cases, this is deliberate: to protect intellectual property rights (Willcox, 1999). In most cases, bark chips,
roots and leaves or in combination of medicinal trees are added to local gin (alcohol) or water and kept for some days for the extraction of active ingredients. Usually, such herbs are not washed and fungal powders that carry potent mycotoxins can be seen on then. Others that cannot be seen such as spores of Clostridium and Bacillus species are not ruled out. And without measurement, toxicity test on organs, efficacies testing/microbial safety etc., such concoctions are consumed in a bid to cure malaria. But sad enough, in some cases, toxicity and death arising from plant toxins, local gin and microbial poisons can mistakenly be taken as the worsening state of the diseases. In most cases, talismans, charms and amulets are tied to a baby’s neck, wrist and hand angle to prevent convulsion, fevers and recovery from malaria. Over the years, this has been the recurrent decimal as regards self-seeking malaria intervention in sub-Saharan Africa especially among the poorest of the poor where ignorance and poverty holds sway and determines the way of life.

5. Intervention through vaccines
As our understanding of the underlying causes of malaria grows, it may be possible to develop therapies that target malaria and prevent infection (Miller et al., 2013). One of such therapies is the use of vaccines, which have witnessed numerous field trials over the years. Experimental model vaccines, such as attenuated live parasites and transmission-blocking antigens, induce immune responses superior to naturally acquired immunity (Matuschewski & Mueller, 2007). Current vaccine trial and research is directed at three developmental stages of the parasite: the sporozoites, the merozoite and the gametocytes (Strickland, 1999). RTS, S vaccine, a circumsporozoite vaccine, given with an adjuvant system (AS01 or AS02) has consistently shown protection against Plasmodium falciparum malaria in children and infants in phase two trials conducted in seven African countries. However, as at year 2015, only 26–50% success story were recorded (RTS, 2015).

   Over the years, high-level, sustained, protective immunity through immunization by the bites of irradiated mosquitoes carrying Plasmodium falciparum (PF) sporozoites (SPZ), and whole blood stage parasites can be gleaned from literatures, in human and animal model (Seder et al., 2013). For the latter, this technique has been advanced beyond administration to mosquitoes by manufacture of aseptic, radiation attenuated, metabolically active, purified, cryo-preserved PFSPZ for an injectable vaccine that met regulatory standards (Luke & Hoffman, 2003).

   One of the most promising vaccines, SPf66, the first sub-unit vaccine, which comprised short peptides two major GPI-anchored proteins: MSP1 and CSP together with some unclassified peptide fragments, failed to offer the much needed protection in clinical trial conducted in South America and in The Gambia (Richards & Beeson, 2009; Strickland, 1999). Since then, several other vaccines have been tested but with dismal outcomes. Organizations such as African Malaria Network Trust (AMANET), The Bill & Melinda Gates Foundation (BMGF) (direct funding), Wellcome Trust, UK and a host of others are notable names in support of malaria vaccine projects across the globe. However, at the moment, sub-Saharan Africa is yet to witness a malaria vaccine that completely protects against the scourge of malaria and current vaccine strategies have only resulted in dismal performance in terms of efficacy.

6. Intervention through biological and vector control
Some observers and analyst have viewed that the best approached to malaria control and elimination is the application of integrated vector management (IVM) strategy either at the larval or adult stages of the vector (4). In sub-Saharan Africa, two methods stands out in this strategy: uses of long lasting Insecticidal nets (LLIN) and indoor residual spraying (IRS). Larval control is seen as a secondary control measure when rated with LLIN and IRS (Maheu-Giroux & Castro, 2013). Principal Lavicidal control agents are the larvivorous fishes, and the bacterial pathogens (Bacillus thuringiensis israelensis and Bacillus sphaericus) (Das & Amalraj, 1977; Kathleen, 2002). Other organisms showing promise include a number of fungal pathogens and some local plant (Adeboyo et al., 2014). However, the use of larval source management has not been given a place in contemporary malaria control programs in sub-Saharan Africa (Maheu-Giroux &
Castro, 2013) and presently, this can best be seen as an academic exercise. In most setting, pilot larviciding have been carried out with challenges such as lack of define policy, strategic framework and plan of action (National malaria strategic plan, 2014–2020).

The effectiveness of implementing malaria vector control strategies in the context of the various eco-epidemiological types has been challenging (World Health Organization, 2006). From the pictorial topography of the ecosystems that ranges from the desert, savannah, forest, wetland, coastal areas, plains and valleys (World Health Organization, 2006) where the vector breeds unabated, malaria control from a vectoral-aquatic angle looks like a very tall dream. Also, various agricultural development projects such as irrigation, poor water channelization and ubiquitous open well/water reservoirs in most communities, flood and poor housing types especially among the poorest of the poor are the galvanizing factors that provide vectorial breeding sites with ease. Despite these challenges, key vectoral control program such as IRS and LLIN recommended by WHO has been used in most settings and communities with some degree of success (Ediau et al., 2013; World Health Organization, 2006). However, knowledge about IRS is inadequate and negative perceptions about its use are prominent especially among the rural and less educated individuals (Ediau et al., 2013).

Vector control remains the most generally effective measure to prevent malaria transmission and is therefore one of the four basic technical elements of the global malaria control strategy (GMCS) (World Health Organization, 2006). Basic requirements that guarantee vectoral control includes; human shelters that have walls to be sprayed, access to the interior of all houses, and a relatively stable human population without a high frequency of replastering of sprayable surfaces (World Health Organization, 2006). But, sadly, in most parts of Sub-Saharan Africa, culture, tradition and religion debars access to human shelter. In most houses in northern parts of Nigeria and other places, inscriptions on door post such as “ba shiga” meaning “visitors are not allowed” is boldly written. In such scenario, malaria control officers are not excluded. Conditions such as these are counter-productive in malaria eradication effort aside from exophilic vectors, pyrethroid and DDT resistance, which has now been established in Anopheles gambiae (Badolo et al., 2012).

7. Intervention through community engagement
Early diagnosis, prompt and effective case management are important components and thrust of any malaria elimination strategy (Tynan et al., 2013). Gaining a detailed knowledge of community perceptions of malarial symptomatology and treatment-seeking behaviours is essential in guiding effective community participation for malaria control and elimination (Tynan et al., 2013). Gleanings from literatures shows that local perception measured through knowledge, attitude and practice (KAP) surveys conducted in many countries and settings showed that communities linked malaria causalities to various agents and actions such as mosquito bites, sitting in the sun, eating unripe fruits, drinking dirty water or house flies, and severe malaria with convulsions relate to witch crafts and evil spirits (Ruizendaal, Dierickx, Grietens, Schollig, Pagnoni, Mens et al., 2014). Such perception is a factor in decision to seek appropriate treatment among those who get it right (Ruizendaal et al., 2014), but could ultimately result in death due to malaria among those who get it wrong.

For effective strengthening and maximal benefits from methods currently in use aimed at malaria elimination, adequate synergy between service delivery and the community is the answer. It has been suggested that in designing policies for malaria control, local contexts, perceptions and cultural dynamics should be considered for sub-optimal community acceptance (Das et al., 2013). For example, in providing bed nets, the sociocultural perceptions and behavioural patterns of colours, form, mesh and texture of the bed net materials by the community should be taken into consideration (Das et al., 2013). In most settings in sub-Saharan Africa, the same material used for bed nets is the same used as inside linings of coffins. Bet-net distribution without first addressing the phobia of coffin and what should be done is a failure from the start. In northern parts of Nigeria, oral polio vaccines were rejected by caregivers because of poor polio risk perception and religious beliefs. Communication strategies were used to increase the awareness of polio
as a health threat and communities were educated about the benefits and safety of the vaccine through highly influential leaders such as The Sultan, Emirs, politicians and the Alfas before it was accepted by the people (Gidado et al., 2014).

In communities where nomads, pastoralist, migrant farmers, fishermen and others reside, distributing the same bed net types used by persons with stable homes is a defeated idea from the start. Also, in communities where trade-medical practitioners and faith healers abound, training and engaging them in malaria symptom detection, treatment using ACTs and referrals to the right place when danger signs are detected can be most beneficial especially in hard-to-reach communities.

Paradoxically, sitting in posh offices in state capitals to design malaria eradication project without community engagement platform will result in a dismal result. We should be reminded that the success of any public health interventions anchors on the availability of effective interventions, its accessibility to the people in need, and effective utilization by the communities at risk (Ruizendaal et al., 2014). This will certainly require community mobilization, participation and empowerment for the interventions to be sustainable, equitable, accessible and beneficial to communities in need (Ruizendaal et al., 2014).

In malaria control method that requires environmental management in rural setting, the role of community as a key player cannot be quantified. Stagnant water as the main source of breeding sites for mosquito larva are common scene in communities and most times, resident creates them to solve their domestic water needs, not knowing the demerits of their action. In such setting, methods and education for behavioural change has been suggested to curtail it (Keiser et al., 2005).

Also, every malaria control armamentarium and diagnostic devices such as RDTs meant to tackle malaria are designed for the community and educating them on acceptability and usage will be beneficial to all. Conversely, distributing such as a gift will be counterproductive in malaria elimination program.

Over the years, lack of a well planned and coordinated synergy between the health care providers and the beneficiary (The community) could be regarded as the main reason why efforts in malaria eradication and elimination in sub-Saharan Africa has not been very successful.

8. Intervention through environmental management (EM)
Environmental management for vector control, according to the WHO (World Health Organization (WHO), 2014), is defined as “The planning, organization, 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 minimising vector propagation and reducing man-vector-pathogen contact”. The concept for specific technique in EM could be seen from three main thematic. These are: Environmental modification, Environmental manipulation and Modification of human habitation and behaviours (Castro et al., 2009; Keiser et al., 2005).

EM is not a replacement of other interventions, but one of several optional components that will make up an integrated vector management (IVM) approach in a vector control programme (Castro et al., 2009). It is a fulcrum in which other factors and armamentariums reside to effectively bring a long lasting result in malaria elimination. This involves a physical change (often permanent and long term) to potential mosquito breeding areas designed to prevent, eliminate, or reduce vector habitat (Kathleen, 2002). From vectoral ecotypes to variation in environmental seasons, EM if well implemented can break the forces of interaction within the three components of malaria transmission: man, vector and the environment. Paradoxically, in sub-Saharan Africa, human activities that negatively modify environment includes: lack of proper town planning and coordination, dumping of refuse in drainage resulting in blockage, presence of artificial pond and stagnant water at construction site with no legislation to contain such, ubiquitous presence of open cans and motor tyres, lack of proper water
channelization and sometimes blocking drainages to build houses. In the light of these challenges, a strong synergy between the health care strategist/planners and the community in combating the negative usage of environment is the only way out of the quagmire. If things continue the way they are, then, the concept for malaria elimination in sub-Saharan Africa will continue to meander at the ground level with a dismal result.

9. Recommendations and suggestions
The conceptualization and implementation of malaria control programmes in sub-Saharan Africa must take into consideration the understanding of local malaria situation. Malaria control officers must be trained to have full knowledge in epidemiology, seasonal weather variability and effect on mosquito breeding sites, malaria Genomics, Immunology, Vaccinology, Bioinformatics and a host of other inter-related science. There should be follow up training and encouragement of trainees and experts to remain in Africa to further circulate knowledge and strengthen skill in teaching and research.

Also, having a multi-sectorial partnership with developed countries in the fight against malaria for scientific, financial and technical support cannot be underrated. In addition, conducting periodic campaign to include politicians, opinion leaders, private sector, youths and civil societies will greatly help as well. Such commitment will galvanize and birth a strong movement that will raise a collective voice and momentum in malaria eradication and elimination in sub-Saharan Africa.

At the institutional level, there are reputable research institutes in almost all the countries in sub-Saharan Africa that engage in malaria research. It could be well said that having extramural partnership within Africa and the global community for focused research goals will be of help in exchange of knowledge and ideas. The present day morbidity and mortality due to malaria is unacceptable and scientists in sub-Saharan Africa should be worried about it. Prioritizing our program and policies should be our goal for effective service delivery.

10. Conclusion
Malaria transmission and prevalence involve a triangular web of interactions between man, vector and the environment. Any meaningful effort in malaria control, elimination and/or eradication program should target the forces of interactions within the triangle. For the sustenance of gains already recorded in the fight against malaria in sub-Saharan Africa, the role of the community as a strong partnership for change cannot be over-emphasized. This will strengthen the current intervention strategies in malaria control and elimination while eliminating the recurrent decimal in achievements and result. The best time to do it is now.

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