VECTOR CONTROL GUIDELINES FOR MALARIA ELIMINATION IN ZANZIBAR

Zanzibar Malaria Elimination Programme

MINISTRY OF HEALTH
ZANZIBAR

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FOREWORD

Current data show that, malaria prevalence in Zanzibar is less than 1 percent since. This is a result of concerted efforts to fight malaria and reduce prevalence from around 40 % before 2007. These tremendous achievements have been largely due to intensive implementation of effective combined interventions including LLINs, IRS, ACTs, which were stepped up beginning 2007 and were supported by strong surveillance systems of the different interventions. To-date, Zanzibar is globally classified among countries with very low transmission settings that are eligible for malaria elimination.

As Zanzibar moves towards elimination, it is imperative to have malaria vector control guidelines to govern the implementation of malaria vector control activities in order to coordinate the implementation, monitor and evaluate applied interventions.

These guidelines for malaria vector control in Zanzibar aim to establish a set of technical and operational framework for Zanzibar Malaria Elimination Programme, communities, and all stakeholders involved in malaria vector control activities on the Islands.

The Ministry of Health is committed to strengthen integrated vector control activities and ensure proper implementation of the vector control programme in line with the targeted goal of malaria elimination.

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Finally, we sincerely thank Dr. Alhaji Abdullah S. A., Manager, ZAMEP, for his support and encouragement in initiating the development of the guidelines.

ACRONYMNS AND ABBREVIATIONS

ANC	Antenatal Care
CBO	Community-Based Organization
CDS	Continuous Distribution System
CHSZ	College of Health Sciences, Zanzibar
DDT	Dichloro-Diphenyl-Tetrachloro-ethane
DHMT	District Health Management Team
EIR	Entomological Inoculation Rate
EPI	Expanded Programme on Immunization
GDP	Gross Domestic Product
GF	Global Fund
HBI	Human Blood Index
IEC	Information Education and Communication
IRS	Indoor-Residual Spraying
ITM	Insecticide-Treated Material
ITN	Insecticide-Treated Net
IVC	Integrated Vector Control
IVM	Integrated Vector Management
LLIN	Long Lasting Insecticidal Net
LSM	Larval Source Management
M&E	Monitoring and Evaluation
MBR	Man-Biting Rate
MoH	Ministry of Health
NGO	Non-Governmental Organization
OPD	Out-Patient Department
PMI	President’s Malaria Initiative
PPE	Personal Protection Equipment
RBM	Roll Back Malaria
RTI	Research Triangle Institute, International
SBCC	Social Behaviour Change and communication

ULV	Ultra-Low Volume
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization
WHOPES	World Health Organization Pesticides Evaluation Scheme
WODFA	Women Development for All
ZHMT	Zonal Health Management Team
ZMCP	Zanzibar Malaria Control Programme
ZAMEP	Zanzibar Malaria elimination Programme
ZEMA	Zanzibar Environmental Management Authority

EXECUTIVE SUMMARY

Malaria in Zanzibar has been significantly reduced in the past 10 years from prevalence of approximately 40 % (prior to introduction of combined interventions) to less than 1 % and to-date and is no longer considered to be a major public health problem.

The predominant malaria parasite species is *Plasmodium falciparum* accounting for (68.29%) with other species such as *P. malariae* (15.45%) and mixed infections of *P. falciparum* and *P. malariae* (11.38%) playing a less significant role.

Anopheles arabiensis (89.2%) is the predominant malaria vector in followed by *An. merus* (9.8%) and *An. rivolurum* (0.1%), whereas *An. gambiae s.s* has not been detected in recent times. These achievements have been the result of combined interventions particularly, vector control and malaria case management. The two interventions have been implemented in parallel with advocacy (Social Behaviour Change and Communication (SBCC)/Information Education and Communication (IEC)), malaria surveillance (Epidemiological and Entomological), management and coordination as well as operational research. Despite the fact that so much has been achieved to-date, there are some challenges that, if not addressed properly and timely, could compromise these results. Recent data from entomological surveillance indicate that there has been an increase in *Anopheles* vector density biting outdoors, thus posing a risk of outdoor residual malaria transmission. Other challenges include insecticide resistance, human migrations, reintroduction of mosquitoes and malaria parasites from other countries where malaria is endemic.

In order to safeguard and sustain gains that have been achieved so far, and which are in line with initiatives of the Government to make Zanzibar malaria free by 2025 and to join other countries declared by WHO to have achieved malaria elimination status, it is important to consolidate intervention measures in keeping with the overall goal of malaria elimination from Zanzibar. As such, it has become necessary to develop Malaria Vector Control Guidelines to provide a framework under which decision makers, implementers and other stakeholders in malaria control activities could act in order to reach the ultimate goal of a malaria-free Zanzibar. These Guidelines are also in line with the Zanzibar Malaria Control Strategic Plan (2013/14 – 2017/18) is specifically linked to malaria control activities and is in line with implementation of the National Health Policy (2011).

The objective of the guidelines is to provide a set of technical and operational framework to policy makers including ZAMEP, development and implementing partners for planning, implementing,

monitoring and evaluation of malaria vector control activities in line with the malaria elimination from Zanzibar.

At this stage where Zanzibar is contemplating malaria elimination, choice of the most appropriate method or combination of measures for malaria vector control is very important and is dependent on knowledge of the local vector species, their bionomics, ecology, response to interventions and efficacy of control measures in place and their cost effectiveness. During this phase, core strategies will be IRS and the use LLINs whilst complementary methods will focus on larval source management (LSM), biological control, cultural practices, and these will be implemented in parallel with advocacy (Social Behaviour Change and Communication (SBCC)/Information Education and Communication (IEC)) in support of malaria surveillance (Epidemiological and Entomological), management and coordination as well as operational research.

The WHO recommends use of LLINs by young children and pregnant women because both are considered to be high risk groups. However, within the Zanzibar context, and in keeping with the intended ultimate goal of malaria elimination, the entire population is considered to be at risk and therefore, they are eligible for protection by LLINs.

Indoor-residual spraying will be applied with the expected result that, it will reduce vector density, but more importantly, the average survival of the female population of malaria vectors. These two parameters together with Human Blood Index (HBI) and biting habit (frequency of biting) have significant impact on vectorial capacity of the vector population. Indoor-residual spraying will be performed under two situations, namely, active foci, where there is on-going malaria transmission and targeted areas with annual malaria incidence of >1 case/1000 population.

The use of complementary methods, which include, mosquito proofing of houses, use of repellents and other household insecticides will be encouraged at all community levels.

The LSM will be done in active malaria foci with potential but clearly defined mosquito breeding sites. Mapping of mosquito breeding sites is a pre-requisite for larval source management. Biological agents and IGR will be among the larvicides of choice using community based approach. Training of community on sketch mapping and principles of application of larvicides to mosquito breeding sites is essential for larval source management.

Some human activities may be responsible for development of mosquito breeding sites and therefore, necessary provisions of the Public and Environmental Health Act (2012) and its associated Regulations (2012) together with those of the Environmental Management Act (2015) will be applied in order to ensure that implementation of any project has minimal or no negative environmental impacts that may compromise what has been achieved so far in line with the malaria elimination initiatives.

ZAMEP will collaborate with marine ports and airport authorities to develop regulations for space spraying in marine vessels and aircrafts that are bound for Zanzibar before departing from their last destinations where malaria is endemic.

The use of biological control in Zanzibar is not yet documented and research results are needed to reveal its measurable impact on vectors or malaria transmission.

The potential integration of the different vector control methods and how they can be applied to different developmental stages of the *Anophelines* mosquito lifecycle will be borne in mind when implementing malaria vector control during the malaria elimination phase.

Like other countries, in Zanzibar, insecticides are used in various activities in various sectors, particularly agriculture, horticulture, animal husbandry, poultry and public health. These insecticides are available in different formulations such as wettable powder, capsulated suspension, emulsion concentrate, granules, dunks, pellets and aerosols. This situation is likely to exert selection pressure directly or indirectly on malaria vectors and induce or encourage development of insecticide resistance in malaria vectors. As such, it is of paramount importance to monitor insecticide resistance, especially during this phase where malaria elimination is envisaged.

The monitoring and evaluation (M&E) of malaria vector control interventions necessitates collection of a wide variety of data and reliance on certain indicators in order to measure successes and setbacks. Various coverage and impact indicators have been designed to provide ZAMEP with sufficient data for decision-making on choice of interventions, operational effectiveness and efficiency for their desired impacts. Similarly, ZAMEP needs to make timely operational decisions in line with activities planned for implementation. Also, district teams need to be able to process field data sets as quickly as they become available so that corrective measures can be applied timely operationally in poorly performing areas.

Another important area that will be emphasized during this phase is operational research. It is hoped that, operational research will provide useful information that will help policy makers at the Ministry level as well as ZAMEP to make informed decisions and that are commensurate with initiatives aimed at eliminating malaria from Zanzibar.

1. INTRODUCTION

Malaria in Zanzibar has been significantly reduced in the past 10 years from prevalence of approximately 40 % (prior to introduction of combined interventions) to less than 1 % and to-date and is no longer considered to be a major public health problem (DHS Report, 2015/16). By 2016, malaria incidence among the population in Unguja and Pemba was estimated at 3.3/1000 and 0.2/1000, respectively (ZAMEP Annual Report, 2015/16). Between 2015 and 2016, of the 182,907 people screened, 0.84% were positive. The predominant malaria parasite species is *Plasmodium falciparum* accounting for (68.29%) with other species such as *P. malariae* (15.45%) and mixed infections of *P. falciparum* and *P. malariae* (11.38%) playing a less significant role.
Anopheles arabiensis (89.2%) is the predominant malaria vector in followed by *An. meru*s (9.8%) and *An. rivolurum* (0.1%), whereas *An. gambiae s.s* has not been detected in recent times (ZAMEP, 2016). These achievements have been the result of combined interventions particularly, vector control and malaria case management. The two interventions have been implemented in parallel with advocacy (Social Behaviour Change and Communication (SBCC)/Information Education and Communication (IEC)), malaria surveillance (Epidemiological and Entomological), management and coordination as well as operational research.

Despite the fact that so much has been achieved to-date, there are some challenges that, if not addressed properly and timely, could compromise these results. For example, recent data from entomological surveillance indicate that there has been an increase in *Anopheles* vector density biting outdoors, thus posing a risk of outdoor residual malaria transmission. This outdoor-biting behaviour has an implication on the current malaria vector control interventions (IRS and LLINs) as well as the overall status of malaria transmission in Zanzibar. Therefore, there is need for Zanzibar to devise plans for implementing complementary interventions targeting the outdoor-biting and resting mosquitoes. Other challenges include insecticide resistance, human migrations, reintroduction of mosquitoes and malaria parasites from other countries where malaria is endemic. In order to safeguard and sustain gains that have been achieved so far, and which are in line with initiatives of the Government to make Zanzibar malaria free by 2025 and to join other countries declared by WHO to have achieved malaria elimination status, it is important to consolidate intervention measures in keeping with the overall goal of malaria elimination from Zanzibar.

In spite of the prevailing situation, whereby so much has been achieved with regard to malaria control in Zanzibar and the associated challenges pointed out above, there are no written guidelines to provide a framework under which decision makers, implementers and other stakeholders in malaria control activities could act in order to reach the ultimate goal of a malaria-free Zanzibar. Therefore, these guidelines are intended to provide a framework for malaria vector control activities, criteria, tools, together with associated monitoring and evaluation and operational research that are pertinent and conducive for malaria elimination in Zanzibar.

1.1. Purpose of the Guidelines

The National Health Policy (2011), is based on premises that strive to maintain a healthy population of the people of Zanzibar. This is an important realization because a healthy population is a basis for socio-economic development. From 2006, the Government of Zanzibar in its efforts to implement the National Health Policy (2011) and with help from partners has been undertaking IRS and distributing LLINs in Pemba and Unguja. Of particular importance is the Zanzibar Malaria Control Strategic Plan (2013/14 – 2017/18), which is specifically linked to malaria control activities and is in line with implementation of the National Health Policy (2011).

In a span of ten years (2005 -2015), Zanzibar has undergone tremendous transformation in terms of reduction of malaria burden (ZAMEP Annual Report, 2015/16). In order to sustain this achievement, it has become necessary to develop guidelines, which are commensurate with the *status quo* and to consolidate gains and progress towards malaria elimination. The guidelines are intended for decision makers, planners, technical staff and partners, to provide them with relevant information and references on existing global strategies and interventions that would be necessary for adoption in order to contribute significantly towards malaria elimination from Zanzibar.

1.2. Objective

The objective of the guidelines is to provide a set of technical and operational framework to policy makers including ZAMEP, development and implementing partners for planning, implementing, monitoring and evaluation of malaria vector control activities in line with the malaria elimination from Zanzibar.

2. CURRENT MALARIA VECTOR CONTROL OPTIONS

The Choice of the most appropriate method or combination of measures for malaria vector control depends on knowledge of the local vector species, their bionomics, ecology, response to interventions and efficacy of control measures in place and their cost effectiveness.

Components of integrated vector management (IVM) include; indoor-residual spraying (IRS), insecticide-treated nets (ITNs) – particularly long-lasting insecticidal nets (LLINs), environmental modification, environmental manipulation, larval source management (LSM), biological control, use of repellents, zooprophylaxis and house screening.

Vector control interventions to be applied during the malaria elimination phase in Zanzibar will be categorized as follows;

Core vector control methods – long lasting insecticidal nets (LLINs) and indoor-residual spraying (IRS).

Complementary vector control methods – larval source management (LSM), biological control, cultural practices, and these will be implemented in parallel with advocacy (Social Behaviour Change and Communication (SBCC)/Information Education and Communication (IEC)) in support of malaria surveillance (Epidemiological and Entomological), management and coordination as well as operational research.

The above methods of choice are in line with Section 94(1) of the Public and Environmental Health Act (2012), which provides for application of these measures in order to control disease vectors in Zanzibar. Specific details pertaining to malaria elimination are provided for under different sections of the draft Malaria Elimination Regulations associated with the Public and Environmental Health Act (2012).

Although it is not the subject of these guidelines, it is worth mentioning here that, the intended vector control interventions will be implemented hand in hand with case detection and management in the human population.

2.1. Core vector control methods

2.1.1. Long-lasting Insecticidal nets (LLINs)

Conventional nets provide a physical barrier against mosquito bites, whilst LLINs augment the physical barrier by adding the chemical component, which acts by repelling and killing adult mosquitoes, thus reducing their average survival rate and hence preventing disease transmission as well as biting nuisance. Research on pyrethroid-treated nets has revealed that, LLINs are very effective in preventing morbidity and mortality associated with malaria, particularly in children under five years of age and pregnant women.

Long-lasting insecticidal nets provide protection at both individual and household levels, and when coverage is higher (≥ 80 %) within the community, the mass effect confers protection to almost all community members and longevity of local malaria vectors is reduced to such an extent that, they are unable to transmit malaria. Long-lasting insecticidal nets are recommended for use in a variety of epidemiological settings, from low, seasonal transmission to intense, perennial transmission. The WHO recommends use of LLINs by young children and pregnant women because both are considered to be high risk groups. However, within the Zanzibar context, and in keeping with the intended ultimate goal of malaria elimination, the entire population is considered to be at risk and therefore, they are eligible for protection by LLINs.

2.1.1.1. Strategies of LLINs Distribution in Zanzibar

Previously, mass distribution of LLINs in Zanzibar was conducted once every three years whereby community members were issued with nets at the ratio of 1 net to 1.8 people, as recommended by the World Health Organization (WHO, 2011). The ZAMEP will continue to distribute LLINs free of charge through routine outlets to improve coverage. However, mass distribution of LLNs will be considered when net ownership within the community falls below 40%.

2.1.1.2. LLINs Delivery channels

i. Health facilities (Continuous Distribution System): - beneficiaries are; pregnant women and under-fives during ANC and EPI visits. The distribution of LLINs through health facilities to certain beneficiary groups has been shown to increase clinic attendance for ANC and immunization services.

ii. Community level (Shehia): - beneficiaries are all community members eligible to receive the LLINs.

2.1.1.3. Social mobilization

Distribution of LLINs will run concurrently with provision of information, education and communication to raise awareness and sensitization.

Key messages will include:

- Why use LLINs,
- Where and how to access LLINs,
- Importance of using LLINs versus conventional nets,
- How malaria is transmitted,
- Proper maintenance of LLINs
- Regular use of LLINs
- Safety of LLINs to the users

2.1.1.4. Monitoring durability of LLINs

Monitoring of durability of LLINs will be done at regular intervals following distribution to assess the life span of nets with regard to fabric integrity and bio-efficacy against malaria vectors. The relevant protocol will be adopted during such monitoring surveys.

2.1.1.5. Regular supervision and monitoring of LLINs

All LLIN distribution channels will be visited routinely to assess the distribution efficiency, storage and proper record keeping.

2.1.1.6. Mass distribution of LLINs

Mass distribution of LLINs will be carried out whenever general coverage of nets is assessed and found to be below 40%. The following activities will be conducted to ensure efficient distribution mechanism:

a. Registration of households

b. Net quantification
c. Community mobilization
d. Training of distributors
e. Actual distribution
f. Monitoring and evaluation (M&E)

2.1.1.7. LLINs brands

Only LLINs that have been recommended by WHO and approved by mandated local authority for use in Zanzibar will be distributed to community members. Vendors and the general public will be discouraged from selling and purchasing untreated nets, respectively. Additional measures could be taken by ZAMEP by invoking Section 32(2) of the draft Regulations of the Public and Environmental Health Act (2012) to restrict importation and use of unauthorized public health insecticides or products that could compromise initiatives to eliminate malaria from Zanzibar., Hence enforced, this clause could be used to ban importation of regular nets that do not conform to ITNs or LLINs.

2.1.1.8. Disposal of old and torn LLINs

Disposal of old and torn LLINs remains a major challenge in malaria elimination programme in Zanzibar and many other countries with similar settings. However, the Ministry of Health in collaboration with Zanzibar Environmental Management Authority (ZEMA) and partners and in consultation with WHO, will have to work out the best, environmentally safe and sustainable ways of disposing of torn, dilapidated and obsolete LLINs.

The National Environmental Policy (2013) is implemented through enactment of the Environmental Management Act (2015), which with its associated EIA Regulations (2002) requires EIA as a prerequisite prior to implementation any project in Zanzibar. All proposed malaria control interventions involving the use of insecticides or insecticidal products should undergo EIA conducted in keeping with Section 2.8 (Hazardous substances) of the Environmental Policy (2013) because it recognizes the need for extra care to protect limited water resources, biodiversity and the whole environment in general. Additionally, it should be explicitly stated how liquid, gas and solid waste products will be disposed of.

2.1.2. Indoor-residual spraying

Indoor-residual spraying refers to the application of an insecticide formulation with residual activity on all stable surfaces inside human habitations. The actual surfaces to be sprayed should include all potential resting places for local *Anopheles* vectors of malaria. The expected result of indoor-residual spraying is to reduce vector density, but more importantly, the average survival of the female population of malaria vectors. These two parameters together with Human Blood Index (HBI) and biting habit (frequency of biting) have significant impact on vectorial capacity of the vector population.

2.1.3. Choice of Insecticide for IRS in Zanzibar

Zanzibar will consider the following factors when selecting the insecticides of choice for IRS.

Efficacy: For IRS to be effective, malaria vectors must be susceptible to the insecticide of choice.

Residual efficacy (persistence of chemical on a given surface): Toxicity of the insecticide to mosquitoes should remain high for at least 4 months or over a sufficiently long period to cover the malaria transmission season in order to reduce the need for multiple applications, which implicitly translate into operational cost.

Insecticide formulation: The insecticide of choice and its formulation must be one that remains stable on a treated surface, meaning, it is not easily absorbed, adsorbed by the surface to which it has been applied. It should be stable enough not decompose as a result of exposure to sunshine as well and should be one that provides sufficient lethal dose to malaria vector mosquitoes resting on the sprayed surfaces (WHO, 2002).

Other factors to be considered include operational costs and safety.

The list of insecticides for IRS that are currently recommended by the WHO and approved by mandated local authority is presented in Appendix I.

2.1.4. Selecting areas for IRS application

To-date Zanzibar is globally classified to be in a very low transmission setting < 100 cases/1000 population per year.

Indoor-residual spraying will be performed under two situations as follows:

- Active foci, where there is on-going malaria transmission and

- targeted areas with annual malaria incidence of >1 case/1000 population

2.1.5. IRS operational plan

Environmental Impact Assessment (EIA) is a pre-requisite for IRS to ensure the safety of the environment and other organism. Prior to undertaking IRS, EIA will be conducted in accordance with the requirements of the Environmental Management Act (2015) and its associated Regulations of 2002 as well as taking into consideration those of development partners. Training, monitoring and field supervision will be a package to maximize the quality and effectiveness of the operation. Assessment of the IRS quality will be done immediately after spraying followed by insecticide decay rate using relevant protocols.

In order to perform systematic spraying that is effective and based on better coverage, geographical reconnaissance will be undertaken in the targeted areas and active foci to make available the following information that usually helps in developing the IRS operational plan. These are:

- Map of the area with its boundaries
- Important ecological features, such as potential breeding sites
- Distances and accessibility of the area
- Total number of structures to be sprayed
- Average size (surface area) of structures to be sprayed
- Total surface area of structures to be sprayed
- Amount of insecticide to be used
- Types of structures
- Total population to be protected

NOTE: For more information on IRS operations refer to WHO (2000; 2015), USAID/PMI Manual (2016).

2.1.6. Disposal of IRS chemical waste

All IRS liquid wastes will be disposed of in specially designed soak-away pits that have been constructed at all operational sites in Zanzibar whilst solid waste including sachet, cartons, gloves, scarfs, masks, torn overall (PPEs), will be incinerated in special designated incinerators. In case containers used to package the insecticides are made of material that can be recycled, a special permit will be sought from ZEMA in order to recycle them by producing environmentally safe products such as conduit pipes for conveying waste water. This is possible when containers are made of plastic materials. Other solid wastes including spray pumps and its components and bottles of insecticides will recycled as per ZEMA guidelines.

3.1.3. Complementary methods

3.1.3.1. Personal protection methods for vector control

These methods include, mosquito proofing of houses, use of repellents and other household insecticides. Mosquito proofing of dwellings involves covering of doors, windows and eaves with screens and repairing of cracks and crevices in walls. This is a very effective method for those who live in modern houses; however, many rural communities live in poorly constructed houses, which would be difficult to make them mosquito proof. This is further complicated by climatic factors such as high temperatures and relative humidity, which make it less conducive for mosquito proofing because it may interfere with overall ventilation. In Zanzibar, this method will be encouraged at community level.

Repellents may be applied to clothing or skin depending on their safety attributes. Others include insect electrocutors, aerosol sprays, mosquito coils, vapourizers and fumigants as recommended by the WHO and approved by relevant local mandated authorities.

3.1.4. Larval source management

Larval Source Management (LSM) is a part of integrated malaria vector management aimed at reducing vector population density. This is a complementary intervention to LLINs and indoor-residual spraying. The LSM will be done in active malaria foci with potential but clearly defined mosquito breeding sites. Mapping of mosquito breeding sites is a pre-requisite for larval source management. Biological agents and IGR will be among the larvicides of choice using community based approach. Training of community on sketch mapping and principles of application of larvicides to mosquito breeding sites is essential for larval source management. Data collection and monitoring tools will be deployed to evaluate the performance and effectiveness of larviciding activities. Larvicides recommended by the WHO and approved by mandated local authority for application in Zanzibar are listed in Annex II.

3.1.5. Environmental modification

Habitat modification is a permanent alteration of the environment, defined as ‘a form of environmental management consisting of any physical transformation that is permanent and may apply to land, water and vegetation. It is aimed at preventing, eliminating or reducing the habitats of vectors without causing unduly adverse effects on the quality of the human environment’ (WHO, 1982).

Some human activities may be responsible for development of mosquito breeding sites and therefore, necessary provisions of the Public and Environmental Health Act (2012) and its associated Regulations (2012) together with those of the Environmental Management Act (2015) will be applied in order to ensure that implementation of any project has minimal or no negative environmental impacts that may compromise what has been achieved so far in line with the malaria elimination initiatives.

2.1.7. Environmental manipulation

Habitat manipulation is a form of environmental management aimed at producing temporary conditions that are unfavourable for the breeding of malaria vectors. Unlike habitat modification, habitat manipulation may have to be repeated to remain efficacious, and is normally directed at one particular vector species: controlling water levels, including intermittent irrigation (although in some cases this may result in small pools that are very conducive to mosquito proliferation), stream flushing, shading, clearing of aquatic vegetation, straightening and steepening of shorelines, changes of water salinity and water pollution are some of the environmental manipulation measures (WHO, 1982).

Efforts to address temporary changes that discourage mosquito breeding and resting such as earth filling, draining of temporary water bodies around home yards will be encouraged at community level.

2.1.8. Space spraying

Ultra-low volume (ULV) aerosol generators produce very smallest droplets and allow for an excellent distribution in space. Sometimes, space spraying either indoors (fumigation) or outdoors requires special equipment such as thermal, cold or electric foggers. They are very useful in times of epidemic situations or when vector density reaches unprecedented levels to such an extent that disease outbreak may pose potential threat. For large scale space spraying in epidemic control, vehicle-mounted aerosol generators are used (WHO, 2003; WHO, 2006). Space spraying is an effective method for drastic reduction of adult vectors with no residual effect.

With regard to malaria elimination agenda, ZAMEP will collaborate with marine ports and airport authorities to develop regulations for space spraying in marine vessels and aircrafts that are bound for Zanzibar before departing from their last destinations where malaria is endemic. Insecticides and aerosol formulations recommended by the WHO and approved by mandated local authority for application in Zanzibar are listed in Appendix III.

2.1.9. Biological control

Biological control of mosquitoes involves introducing into the environment their natural enemies, such as parasites, disease organisms and predatory organisms. They may include insects, viruses, bacteria, protozoa, fungi, plants, nematodes and fish. The effective use of these agents requires a good understanding of the biology, ecology and behaviour of the vector to be controlled as well as that of the vector and of local environmental conditions. Such methods may be most effective when used in combination with others, such as environmental manipulation or the application of larvicides that do not harm the biological control agents. Several organisms have proved effective against mosquito larvae. Biological control manual will be consulted during implementation (Bosch, 1976; WHO, 2003).

The use of biological control in Zanzibar is not yet documented and research results are needed to reveal its measurable impact on vectors or malaria transmission.

2.1.10. Expanded polystyrene beads

For a long period of time, floating layers of expanded polystyrene beads have been used to prevent mosquito breeding in confined sites such as cess pits and water tanks. They are usually used to control nuisance biting mosquitoes such as *Culex quinquefasciatus,* which breed in wet pit latrines. This is a very important complementary strategy, which can be used together with other measures in integrated malaria vector control programmes in order to produce an appreciable impact on mosquito biting density. This is because community members can seldom differentiate between *Anopheles* and *Culex* species i.e. as long as they are bitten by mosquitoes, it may be construed to imply that malaria control measures are ineffective. However, often times, it may be difficult to convince some partners to support such complementary intervention measures (despite the fact that this may have bearing on IRS results with regard to community appreciation of reduction in mosquito biting nuisance, as for most of them, all mosquitoes are equally bad). In Zanzibar and in most other places, this method has a limited role in malaria vector control however it is an idea that can be advocated to communities using pit latrines in so far as there is a mechanism in place to avail them expanded polystyrene beads. Previous successful experience in Zanzibar includes the control of *Cx. quinquefasciatus* in Makunduchi, Zanzibar that reduced biting density of this species by 99 % (Maxwell *et al*., 1999; Curtis *et al*., 2002).

The potential integration of the different vector control methods and how they can be applied to different developmental stages of the *Anopheline* mosquito lifecycle is summarised and presented in Figure1.

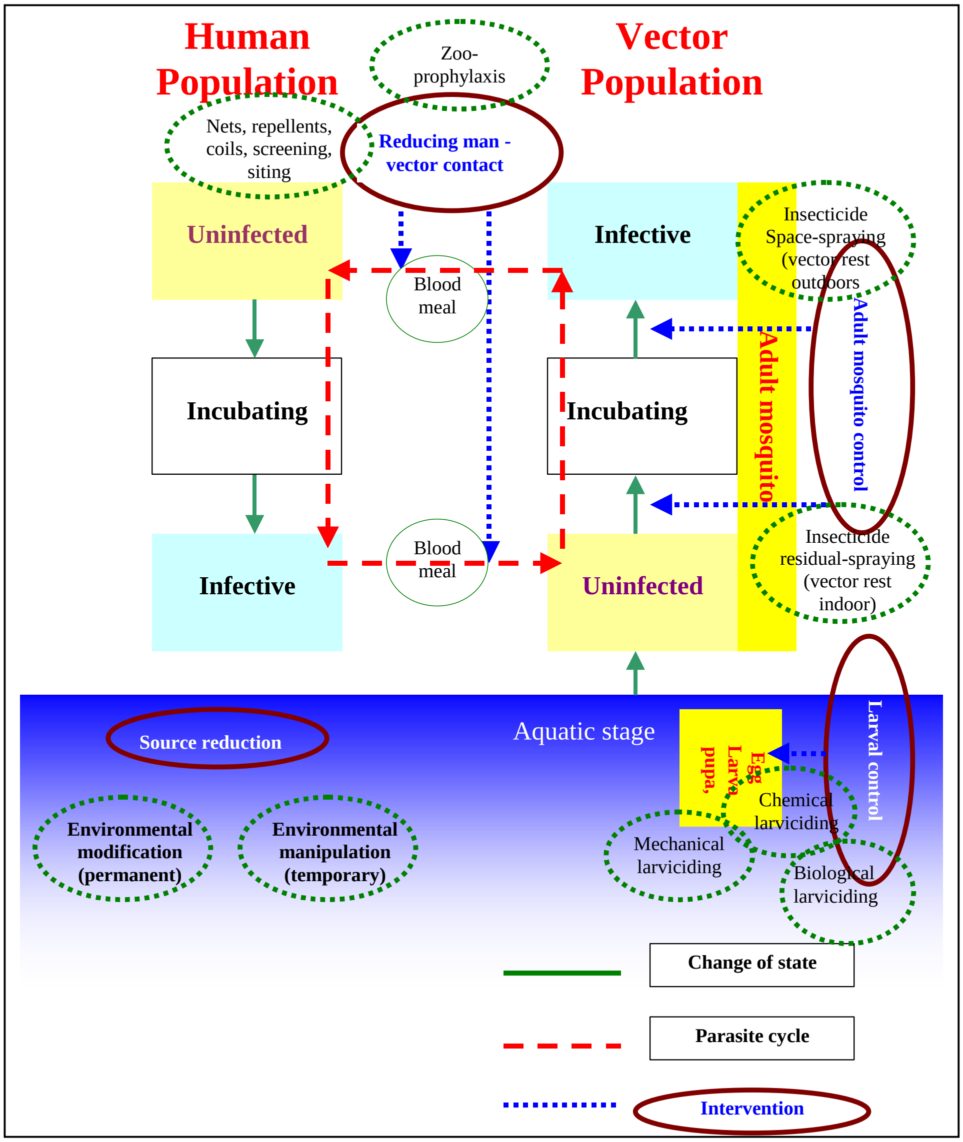

Figure 1. Specific control measures and where they could be used in the lifecycle of *Anopheline* malaria vectors.

3. MONITORING OF INSECTICIDE RESISTANCE

Like other countries, in Zanzibar, insecticides are used in various activities in various sectors, particularly agriculture, horticulture, animal husbandry, poultry and public health. These insecticides are available in different formulations such as wettable powder, capsulated suspension, emulsion concentrate, granules, dunks, pellets and aerosols. This situation is likely to exert selection pressure directly or indirectly on malaria vectors and induce or encourage development of insecticide resistance in malaria vectors. As such, it is of paramount importance to monitor insecticide resistance, especially during this phase where malaria elimination is envisaged. Monitoring results should be used to guide evidence-based decisions related to appropriate mitigation as described in the Insecticide Resistance Monitoring and Management Plan, (MoHZ, 2016).

3.1. Insecticide resistance indicators

- Insecticide susceptibility status,
- mechanism of mechanisms
- Resistance intensity assays
- Quality assurance after IRS (Bioassay)

3.2. Entomological indicators

The monitoring and evaluation (M&E) of malaria vector control interventions necessitates collection of a wide variety of data and reliance on certain indicators in order to measure successes and setbacks. Various coverage and impact indicators have been designed to provide ZAMEP with sufficient data for decision-making on choice of interventions, operational effectiveness and efficiency for their desired impacts. Similarly, ZAMEP needs to make timely operational decisions in line with activities planned for implementation. Also, district teams need to be able to process field data sets as quickly as they become available so that corrective measures can be applied timely operationally in poorly performing areas. Sampling for malaria vectors must be done at frequent intervals through (i) routine or trend observations, (ii) spot checks, and (iii) focal investigations.

The following indicators should be used for monitoring and evaluating insecticide resistance:-

3.2.1. Entomological indicators

- Presence, abundance and proportion of mosquitoes of a given species infected with sporozoites
- Age or parity of the vector
- Feeding behaviour of the vector:
    - Exophily
    - Endophily
    - Exophagy
    - Endophagy
    - Host is preference through Human-blood index (HBI)

Collection of above data will be used to provide information on the following entomological indicators:

- the human-biting rate of the vector
- resting behaviour
- biting density
- average longevity of the population of vectors
- Sporozoite rates
- proportion of blood-meals taken on people (human-blood index)
- entomological inoculation rate
- vectorial capacity
- Distribution of malaria vectors (mapping)

4. OPERATIONAL RESEARCH

Zanzibar will have to invest in operational research, which provide useful information that will help policy makers at the Ministry level as well as ZAMEP to make informed decisions and that are commensurate with initiatives aimed at eliminating malaria from Zanzibar.

4.1. Operational Research areas

- **Innovative approaches to address potential changes in vector behaviours.**

  Currently ZAMEP is using IRS and LLINs as the principal methods applied for malaria vector control targeting mainly indoor resting indoor biting mosquitoes, therefore innovative methods will address both behavior (indoor/outdoor), so far it is not clear as to which factor is contributing significantly to the change in mosquito behavior (species or insecticides).

- **Susceptibility studies for insecticides**

  The use of LLINs, IRS, acaricides and possibly agricultural insecticides increase selection pressure on malaria vectors. Therefore, the need for insecticide resistance monitoring is very critical for the program to determine susceptibility, intensity and mechanism of resistance so that elimination efforts may not be compromised.

- **Quality assurance for IRS followed by assays on insecticide decay rate**

  This is be done immediately after IRS spraying to assess quality of spraying and operators' performance whereas insecticide decay rate assesses the decline of residual efficacy on sprayed surfaces and is important for estimating intervals between IRS cycles.

- **Durability study for LLINs**

  This will be performed after Mass LLINs distribution to determine the life span of LLINs with regards to physical integrity and bio-efficacy against malaria vectors.

- **Feasibility study for malaria vectors using biological control**

  Biological control has never been implemented or documented in Zanzibar. However, in collaboration with other partners, feasibility studies to assess the potential for using larvivorous fish, nematodes or other natural enemies as supplementary method for malaria vector control will be done in order to enhance elimination efforts.

- **Surveillance of malaria vectors in response to climate change**

  Recently study reports revealed that, rising temperatures as a result of climate change is responsible for accelerates breeding of malaria vectors. In Zanzibar, the last two decades have been associated with climatic changes, which resulted in flooding of many areas, thus increasing potential breeding sites and consequent proliferation of large numbers of mosquitoes. Extended drought and unpredictable weather fluctuations might influence vectors to change breeding behavior. Therefore, there is a need to conduct research on the impact of climatic changes in connection with malaria elimination strategies.

- **Feasibility of using smart phones and satellites in vector mapping and reporting**

  The potential for using smart phones and satellites in malaria vector mapping and reporting will be investigated to enhance better outcomes towards malaria elimination in Zanzibar.

- **Malaria vector bionomics and dynamics of Species**

  Entomological surveillance will continue at both routine sites and active foci to assess the potential malaria transmission parameters and risk including species composition, entomological inoculation rate, feeding and resting behaviuor. This is crucial as IRS/LLINs is applied and in one way or another may influence phenotypic as well as genotypic behaviour of malaria vectors.

- **Studies on Knowledge Attitude and Practice**

  These will be done as community surveys at certain interval to collect information on LLINs knowledge on malaria transmission, personal protective measures including LLINs with regards to ownership, misconception and use.

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APPENDIX I

Insecticides recommended by WHOPES and approved and registered for IRS in Zanzibar

Insecticide compounds and formulations	Class	Dosage (g/m^2)	Mode of action	Duration of effective actions (months)
Bendiocarp, WP	C	0.1-0.4	Contact and airborne	2-6
Propoxur WP	C	1-2	Contact and airborne	3-6
DDT WP*	OC	1-2	Contact and airborne	3- 6
Fenithrothion WP*	OP	2	Contact and airborne	2-6
Malathion WP	OP	2	Contact and airborne	2-3
Pirimiphos-Methly WP & EC	OP	1-2	Contact and airborne	2-3
Alpha-cypermethrin WP & SC*	P	0.02 – 0.03	Contact and airborne	4-6
Bifenthrin WP	P	0.025 – 0.05	Contact and airborne	3-6
Cyfluthrin WP	P	0.01-0.025	Contact and airborne	2-3
Deltamethrin WP*	P	0.01-0.025	Contact and airborne	2-3
Etofenprox WP	P	0.1-0.3	Contact and airborne	3-6

Insecticide compounds and formulations	Class	Dosage (g/m^2)	Mode of action	Duration of effective actions (months)
Lamda-cyhalothrin WP*	P	0.02-0.03	Contact and airborne	3-6
Lamda-cyhalothrin SC*	P	0.025-0.03	Contact – slow release formulation	9-12

Source of data: (WHOPES report 2002)

***Insecticides currently registered for use in Tanzania.**

A current list of registered insecticides in Tanzania is available at the TPRI website (www.kilimo.go.tz/tpri.htm/)

EC = Emulsifiable concentrate; WP = Wettable powder; SC = Suspension concentrate; OC = organochlorine; OP = Organophosphate; C = carbamate; P = Pyrethroids.

APPENDIX II

Larvicidal products, that could be potentially used for larval control

Larval control	**Formulation**	**Dosage of active ingredient**
Organophosphates		
Temephos	EC, GR	56-112 g/ha
Fenthion	EC	22-112 g/ha
Primiphose-methly	EC	50-500 g/ha
Chlorpyriphos	EC	11-25 g/ha
Microbial insecticides (Biocides)		
Bti (*Bacillus thuringiensis)*		
B. sphaericus	Slow-release	(b)
	Slow-release	(b)
Insect Growth Regulators (IGRs)		
Diflubenzuron	GR	25 – 100 g/ha
Methoprene	EC	20 – 40 g/ha
Pyriproxyfen	GR	5 – 10 g/ha

Source of data (WHOPES, 2002):

EC = Emulsifiable concentrate; GR = Granule; (b) = Dosage depends on formulation

APPENDIX III

The following insecticides are recommended by WHOPES and approved locally for aerosol or space sprayings*

Compounds	**Dosage of active ingredients (g/ha)**
Organophosphates	
Fenitrothion	25 - 300
Malathion	112 – 600
Pirimiphos-methly	250
Pyrethroids	
Cyfluthrin	1 – 6
Deltamethrin	0.5 – 1.0
Lambda-cyhalothrin	0.5 – 1.0
Pemethrin	5 – 10
Resmethrin	2 – 4

*A current list of registered insecticides in Tanzania is available at the TPRI website (www.kilimo.go.tz/tpri.htm/)