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Updates on Mosquito Control Methods

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Abstract

Control of mosquito involves the use of all appropriate technological and management techniques that brings about an effective degree of mosquito prevention and suppression in a safe, cost effective, and environmentally sound manner with inter-sectoral participation. Approaches to mosquito management can be direct or indirect. Direct interventions include the removal of breeding habitat, use of biological controls or the application of pesticides. Indirect approaches reduce human-mosquito conflict, for example utilizing planning mechanisms and educating the public to avoid mosquitoes. Another important indirect approach is for mosquito managers are actively link and collaborate with other departments/authorities to minimize the potential for mosquito breeding. Integrating malaria prevention activities with other health programming, pioneering village-based health care delivery systems that share resources, personnel, health education, and treatment to address several diseases at once.

Keywords: *mosquito, control, integrated vector management*

Updates on Mosquito Control Methods

Current Mosquito control methods

In the past year different control methods are applied to control malaria throughout the world. However, evolution of resistance to cheap and easily available drugs and insecticides, changes in environmental condition and population movement makes malaria control difficult especially in developing country. Even though different methods of malaria control have been implemented in the past, however currently the very best control method of malaria is still towards the vector, Anopheles mosquitoes. Now-a-days different mosquito control methods are applied throughout the world, which are classified in to five main categories: chemical control, environmental management, biological control, Genetic control and personal protection methods (Kathleen, 2002)

Chemical Control

A chemical is toxic substances (insecticide) that are used to kill the adult or the larval stage of mosquitoes (Grieco et al., 2007). Chemical control of mosquitoes has been the most widely successful vector control method since the 1940s, after the discovery of DDT. Perhaps before 1940s petroleum oils and Paris green chemical larvicides has been used to control malaria (Rozendaal, 1997). However, the first chemical that has been widely demonstrated as a valuable tool for the prevention of malaria transmission was DDT (Pant, 1988). During the WHO-sponsored malaria eradication program of the 1950s and 1960s, global DDT use was high, but it has declined significantly over the past 30 years, this is because of the development of DDT resistance by the vector species and its undesirable effect on non-targate organisms and the environment. Due to these problems, ranges of chemicals have been employed in place of DDT as malaria vector adulticides or larvicides. Early replacements have included organophosphates (malathion, temephos, pirimiphos-methyl, and fenitrothion) and carbamates (bendiocarb, carbosulfan, and propoxur). More recently, light-stable pyrethroids—including permethrin, deltamethrin, cypermethrin, cyfluthrin, and lambda-cyhalothrin—and the pyrethroid mimic etofenprox have also been used (Chavasse & Yap, 1997; White, 1999). These chemicals can be applied as residual house spraying (IRS), larviciding space spraying and insecticide-treated nets . The advantages of chemical methods are; malaria management can be organized quickly, are effective, and can produce results at relatively low cost if used efficiently. They have also a special role in control programs for mosquito-borne diseases, particularly at the early stages of intervention to allow other control measures to develop and play effective roles in an integrated strategy. Although, it have this advantages but prolonged chemicals use have resulted in the development of resistance, change in biting habits of vectors, undesirable effects on non-target organisms and fostered concerns on environmental and human health (Dalvie et al., 2004; Das et al., 2007; Grieco et al., 2007). Thus, investigators continued their research to develop appropriate chemical insecticide. An appropriate insecticide should be highly toxic to the insect, safe for humans and no target organisms, persistent on the wall or ceiling surface, acceptable to the inhabitants of the house, easy to apply, and fairly inexpensive (Rozendaal, 1997).

Environmental Management

The concept of modifying vector habitat to discourage larval development or human vector contact is generally referred to as environmental management (EM) (WHO, 1980). Environmental management is typically applied to reduce the burden of mosquito-borne diseases over the long term. These interventions focus on avoiding creation of vector breeding areas, changing natural habitats, or improving human habitation to reduce the abundance of a target vector while creating minimal adverse environmental and social impacts. Examples of environmental management include marsh alteration, filling, grading, drainage, vegetation plantings and house screening. Different researchers show how environmental management was used for the control of malaria mosquito (Kathleen, 2002). At two industrial sites in India, integrated bioenvironmental malaria control projects included small-scale filling of construction borrow sites, unused ditches, and low-lying areas with fly ash (Dua et al., 1991; Dua et al., 1997). In both areas, incidence of malaria declined significantly, although the impact of any one of the many control techniques would be difficult to assess. In another study, intermittent irrigation involves the periodic draining of the fields timed to occur at a frequency that prevents the mosquito larvae from completing their development cycle. This method has proven successful in rice-growing regions in India, China, and other parts of Asia (Lacey & Lacey, 1990). Changes in placement and structure of human habitations as well as changes in behavior may reduce human-vector contact (Rozendaal, 1997; Ault, 1994; WHO, 1982). There was also a study that show Zooprophylaxis can also be used as EM technique, which is animals are used to divert mosquitoes by placing cattle sheds between houses and mosquito breeding sites (Schultz, 1989). In conclusion, this method of malaria vector control is effective, however, its application is difficult compared to the other malaria vector control methods.

Biological Control

Biological methods consist of the utilization of natural enemies of targeted mosquitoes and of biological toxins of plants and bacteria to achieve effective vector management. They are typically most feasible with easily identifiable breeding places, mainly for larval stage (Kathleen, 2002). At present, the principal biological control agents that have been successfully employed against Anopheles are predators, particularly fish, and the bacterial pathogens Bacillus thuringiensis israelensis (Bti) and Bacillus sphaericus (Bs) that attack the larval stages of the mosquito (Das & Amalraj, 1997). Other organisms showing promise include a number of fungal pathogens, the nematode Romanomermis culcivorax, and the aquatic plant Azolla (Lacey & Lacey, 1990). The advantages of biological control agents in comparison with chemical controls can include their effectiveness at relatively low doses, safety to humans and non target wildlife, low cost of production in some cases, and the lower risk of resistance development (Yap, 1985).However, biological control agents against malaria vectors can be more difficult to use than chemicals. Agents that effectively suppress larval populations under laboratory conditions often fail under less favorable field conditions. Furthermore, biological control agents tend to be more specific in terms of which mosquitoes they can control and which habitats they will work in (Das & Amalraj 1997).

Genetic Control

The successful application of recombinant DNA technology to problems in medicine and agriculture, and the promise of even greater successes in the near future, have invited reconsideration of genetic manipulation of vector populations as a control strategy for malaria and other vector-borne diseases. This method involves the effort to reduce or eliminate the population malaria vectors by the introduction of sterility factors, usually by release of sterilized males or females. However, currently this genetic-control strategies are based not on elimination or reduction of the vector population, but on modification of the capacity of the natural vector to support parasite development. Several small genetic control projects targeting Anopheles mosquitoes, with most effort now focused on the major African malaria vector A. gambiae, have been carried out, yet none with any particular success even though many ground work has been done. Therefore, clearly an enormous amount of work remains to be done before a transgenic, mosquito-based genetic control strategy can be implemented. Furthermore, it is unlikely that reduction or elimination of a mosquito population by classical genetic control schemes would be economically feasible for most malaria-affected country (Collins and Paskewitz, 1995; Tabachnick, 2003).

Personal protection methods

The deterioration of IRS programmes in some countries led to the resurgence of malaria and the abandonment of the global campaign for eradication. Eventually, this failure spurred renewed interest in personal protection measures for reduction of malaria transmission. Personal protection measures are based mostly on insecticide-treated nets and repellants. Insecticide-treated clothes are also part of personal protection methods though it is not widely used (WHO, 2006)

Insecticide treated nets (ITNs)

An insecticide-treated net is a mosquito net that repels, disables and/or kills mosquitoes coming into contact with insecticide on the netting material. There are two categories of ITNs: conventionally treated nets and long-lasting insecticidal nets. A conventionally treated net is a mosquito net that has been treated by dipping in a WHO-recommended insecticide. To ensure its continued insecticidal effect, the net should be re-treated after three washes, or at least once a year. A long-lasting insecticidal net is a factory-treated mosquito net made with netting material that has insecticide incorporated within or bound around the fibres, usually using permethrin. The net must retain its effective biological activity without re-treatment for at least 20 WHO standard washes under laboratory conditions and three years of recommended use under field conditions (WHO, 2006; WHO, 2007). ITNs have widely been tested by different researchers in the control of malaria and have shown a great potential in reducing both morbidity and mortality due to malaria. On the basis of five community-randomized trials, when full coverage is achieved, ITNs reduce all-cause child mortality by an average 18% (range 14–29%) in sub-Saharan Africa. The general implication of this is that 5.5 lives could be saved per year for every 1000 children under 5 years of age protected. It was also concluded that ITNs reduce clinical episodes of malaria caused by Plasmodium falciparum and P. vivax infections by 50% on average (range 39–62%), as well as reducing the prevalence of high-density parasitaemia. Furthermore, ITNs have been proved to be effective against a range of other vectors involved in the transmission of diseases such as leishmaniasis, Japanese encephalitis, lymphatic filariasis, and Chagas disease. They also provide protection against nuisance mosquitoes and kill head lice and bedbugs, which contributes greatly to the acceptance and use of ITNs by the population. Unfortunately, the application is difficult and many people do not own nets due to many reasons. Many studies have shown the various factors that deter use of ITNs. Cost has been implicated as one of the major reasons for non-ownership of nets. Beside this there are still operational problems slowing down the scaling up of Insecticides Treated bed nets (ITN) usage. Which includes, seasonal variation of ITN use in the community, equity and access constraints, low rates of net retreatment with insecticides, early bits in the evening before bedtime, insecticide resistance and sleeping outside the house, which makes it rather difficult to use bed nets despite the fact that it puts the victims at high risk of mosquito bites. Another factor affecting use of nets is often people who are unfamiliar with ITNs, or who are not in the habit of using them need to be convinced of their usefulness, which is difficult for most developing country. These problems associated with use of ITNs limit their use especially in poor communities and other underprivileged communities like refugees. This points out to the need to utilize less expensive alternatives and more appropriate malaria control methods in such communities (Kimani et al., 2006; WHO, 2007; Animut et al., 2008; Kweka et al., 2008; Kitchen et al., 2009).

Repellants

An insect repellent is a substance applied to skin, clothing, or other surfaces, which discourages insects from landing or climbing on that surface. The use of repellents in protecting people against vector-borne diseases is predicated on the assertion that reducing human/vector contact will reduce the incidence of disease. These repellants have the following advantages; they are available in various forms (cream, lotion, soap, jelly) and modes of application, easy to apply and prevent human-mosquito contact by acting as an irritant to the mosquitoes. However, they have a certain disadvantage like; evaporate quickly and so are short lived (few hours), requiring regular applications, do not knock down or kill mosquitoes, overall cost may be high and effectiveness to control malaria is limited, has to be used in addition to other measures. Having said this about the advantage and the disadvantage, repellants are classified in to two: synthetic repellants and plant-based repellants based on their method of productions (MOH, 2002; Okumu et al., 2009).

Synthetic repellants

Synthetic repellents are derived from chemical compounds, which are tending to be more effective than plant-based repellents. Different researchers were made different study on different synthetic repellants to evaluate their efficacy of repelling mosquitos. During World War II, field tests were conducted in Papua New Guinea, which investigated the response of An. farauti and culicine mosquitoes to ethyl hexanediol, dimethyl phthalate and diethyl phthalate. Dimethyl phthalate was found to be superior, providing 40-60 min of protection, whereas ethylhexanediol and diethyl phthalate provided 20-40 min of protection. (Frances et al., 1999). These tests were conducted before the development and release of DEET, N, N-diethyl-3-methyl-benzamide (N, N-dimethyl-m-toluamide), and this chemical is now the active ingredient in most commercially available repellent formulations. In 1987, Charlwood and Dagaro tested the effect of a repellent containing 20

Plant based fumigants

Among poorer populations that cannot afford shop-bought personal protection methods, plant-based fumigants are extensively used, and less commonly, plants are hung around the home or rubbed onto the skin. A study from rural Guatemala found that >90% of households interviewed burned waste plant materials such as coconut husks to drive away mosquitoes Kein et al., 1995). In Mexico this is 69% (Rodriguez et al., 2003). In the Western Pacific, in Papua New Guinea, wood is burned in the early evening by up to 90% of the population and was shown to repel 66-84% of the vector Anopheles karwari as well as nuisance culicines (Vernede et al., 1994) In the Solomon Islands, 52% of people use fire to drive away mosquitoes (Dulhunty et al., 2000). In Sri Lanka, 69% of families burned neem kernels and leaves (Azadirachta indica) to repel mosquitoes, along with mosquito coils (54%), despite almost all houses being regularly sprayed with residual insecticide (Konradsen et al., 1997). In Bolivia a plant known as Attalea is burning on charcoal, they found 35% and 51% protection against An. darlingi and Mansonia spp respectively. Another test is done on Mentha arvensis essential oil by using kerosene lamps, and they reduced biting by 41% inside traditional homes against Mansonia spp., although they were ineffective outdoors against An. darlingi (Moore et al., 2007). In Africa, the use of traditional fumigants is widespread. Thirteen percent of rural Zimbabweans using plants and 15% using coils. Thirty-nine percent of Malawians burn wood, dung or leaves. Up to 100% of Kenyans burned plants to repel mosquitoes (Seyoum et al., 2002b) and in Guinea Bissau 55% of people burned plants or hung them in the home to repel mosquitoes (Palsson and Jaenson, 1999). In Tanzania, in the experimental hut at field conditions, deterrence induced by burning of Ocimum and other plants ranged from 73.1.0% to 81.9% for An. arabiensis and 56.5% to 67.8% for Cx. Quinquefaciatus (Kweka et al., 2008). Furthermore, a study conducted in traditional houses of western Kenya showed a repellency of 48.71% by C. citriodora and 44.54% by O. kilirnandscharicum and O. suave during application of plant material by thermal expulsion against Anopheles gambiae s.l. the main vectors of malaria in Africa. They also showed a residual effect against An. garnbiae s.l. with 36-44% repellency. Additionally, this study showed the intact potted plants of O. americanum and L. carnara repelled An. gambiae s.1. by 37.91% and 27.22% respectively and thermal expulsion of leaves and seeds of O. kilimandscharicum repelled An. Funestus (Seyoum et al., 2003). In another study potted plants of Ocimum americanum, Lantana camara, and Lippia uckambensis repelled at an average of 39.7%, 32.4% and 33.3% of Anopheles gambiae s.s., respectively. The combination of O. americanum with either L. camara or L. uckambensis repelled 31.6% and 45.2% of the mosquitoes, respectively. This study is the first to show that live intact plants can reduce domestic exposure to malaria vector mosquitoes (Seyoum et al., 2002a).

In Ethiopia, similar studies were done to evaluate the impact of traditional application methods natural fumigants. A study conducted by Dugassa et al. (2009), the result showed that on direct burning of the plants, 65-73% repellence efficacy against An. arabiensis were found, least E. camaldulensis and highest O. basilicum. By the same method of application, from 66% up to nearly 73% repellency efficacy was fond against An. Pharoensis, however, C. citriodora gave the highest repellency while E. camaldulensis the least. On thermal expulsion, C. citriodora exhibited the highest repellency (71.9-78.6%) while E. camaldulensis showed (72.2-72.9%) repellency against An. Arabiensis and An. Pharoensis respectively. In this study all the tested plants gave significant protection (>65%) against the house-entry and biting of two important malaria vectors in Ethiopia (Anopheles arabiensis and An. Pharoensis). In another study made in laboratory conditions by direct burning on traditional charcoal stoves, revealed that the roots of S. macroserene (Wogert in local native language, Amharic) have potent repellent efficiency (93.61%). The leaves of Echinops spp. (Kebercho in local native language, Amharic), O. integrifolia (Tinjut in local native language, Amharic) and O. europaea (Woira in local native language, Amharic) were shown a repellency efficacy of 92.47%, 90.10% and 79.78% respectively. This study identifies that these four Ethiopian traditional indigenous insect/mosquito repellent plant materials are very effective against Anopheles arabiensis (Karunamoorthi et al., 2008).

Therefore, different investigators have done many researches on different plants to evaluate their efficacy of repelling mosquitoes. Though, these researchers show that the repellant efficacy of this plants both in laboratory and field conditions but none of them show the effect of single application of plants in field conditions. Therefore, the focus of this study is to fill this gap, which means to evaluate the repellence efficacy of traditional fumigation of some selected plants: *Corymbia citriodora, Ocimum suave*, Ocimum *basillicum*, *Eucalyptus camaldulensis*, and *Eucalyptus globules via* a single application under figures.

Conflict Of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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