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Review Article

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Mosquito control: A review

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ABSTRACT

Mosquitoes are small insect which comprises the family culicidae. They are World wide except for Antartica and polar or subpolar regions of the World. Mosquitoes are vectors of many diseases such as malaria, yellow fever, West Nile Virus, dengue fever, filariasis, and some arboviruses. They are regarded as the most deadliest animal family ever known in the World. Filling, leveling and drainage of breeding sites are measures intended to reduce the population of mosquitoes. Provision of window screens, insecticides and insecticide treated nets are some effective control methods of mosquito. Application of natural enemies, genetically modified method and sterile insect release technique are other measures for the successful elimination of the vector. At least many literatures discussed the control of mosquito vectors. However, this report is to review the importance of mosquitoes, its methods of control and challenges encountered during its control.

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1. BACKGROUND

Mosquito control activities like other vector control have historically represented a major component of malaria and other disease control programmes [1]. These activities involve measures designed to eliminate or reduce the mosquito population through cultural, biological, chemical and genetical control [2]. However, there is no single control measure which is exclusively adopted for mosquito control but rather multidisciplinary approaches are best suited for better results. The multidisciplinary approach is through the combined efforts of the entomologist, Agricultural biologist, parasitologist, veterinarian, medical/health workers and those alike to bring all their experiences and skill through the use of integrated control method [3]. Despite these combined efforts to control mosquitoes, the problem continues to persist especially in the tropics. This is particularly as a result of insceticide resistance, environmental conditions, socio-cultural values, political and economic problems. Mosquitoes transmit various organisms viz; nematodes (filarial worms), protozoa (plasmodia) and viruses which causes disease in man and other animals [4]. It is against this back ground that this review is aimed at highlighting the control of mosquitoes due to its economic importance. In providing information concerning the subject matter, the following set aims and objectives are to be reviewed: (a) To review the importance of mosquito; (b) To review various ways by which mosquito is controlled; (c) To review the challenges of mosquito control.

2. MOSQUITO BIOLOGY

Mosquito are two-winged fly grouped in the phylum arthropoda, Class-Insecta, Order-Diptera, Sub-order-Nematocera, Family-culcidae. They are found in the tropics, temperate zones as well as in the artic circles. They are divided into three subfamilies. The culicinae; this is made up of three tribes, anophelines, culcines and mergharines. The chaoborinae and Dixinae both of which are of no medical importance [2]. The tribe of anophelini consists of three genera but only the genus anopheles is of medical importance, while the tribe culicinae consist of twenty five genera, only three of which are of major medical importance. These are Aedes, Culex and mansonia [5]. The major genera of medical importance can be distinguished based on the following features listed on the Table 1 below.

Table 1. Distinguishing features of mosquitoes of medical importance.

Form	Anopheles	Culex	Aedes	Mansonia
Egg	Boat shaped laid singly with floats	Cylindrical or concave shaped eggs laid in batches.	Cylindrical or concave shaped, eggs laid in raft or singly.	Eggs laid in rafts.
Larvae	Palmate hairs present on dorsal surface of abdomen, no siphon tube surface feeders.	Palmate hairs absent on surface abdomen, siphon tube well developed for bottom feeders.	Palmate hairs absent on surface abdomen, have dorsal breathing tube surface feeders.	Bottom feeders.
Pupa	Breathing tube short and broad anteriorly.	Breathing tube long and rectangular in shape.	-	-
Adult	Body colour yellow/orange have colour patches on scales. Nocturnal in habits. A pair of thick clubbed palp is present. Abdomen rest directed away from resting surface. Antennae pilose in male and plumose in female.	Body colour brownish, no patches on scales, nocturnal in habits. A pair of selender palp but not clubbed. Abdomen rest almost parallel with resting surface. Atinnae pilose in male and plumose in female.	Body colour black, no patches, diurnal in habits. Rest with abdomen pointing towards resting surface. Antinnae pilose in male plumose in females.	Large mosquitoes legs markings conspicuous wings covered with triangular broad scales of mixed colours usually white and brown.

Source [5]

2.1 Mosquito Breeding Habitats

The breeding places of mosquitoes include practically any kind of water except the open sea [6]. According to WHO [7] the following factors are incriminated in the breeding mosquitoes.

2.1.1 Salt Marshes

These serve as breeding areas for several species of mosquitoes, primarily *Aedes sollicitans*, *Aedes cantator* and *Aedes taeniorhychus*. Areas such as depressions and neglected ditches can breed millions of mosquitoes. Adult females deposit their eggs on the marsh surface where the eggs must dry 24 hours. When the monthly high tides flood the marsh the egg laiden depressions is fill with water and the larvae hatch and develop rapidly. The adult mosquitoes emerge within one or two weeks following the moontides.

2.1.2 Temporary wood and pools

Shallow temporary pools are common in wood land areas during the spring and wet summers. A variety of mosquitoes usually breed in such areas, some of the commonest are, *Aedes canandensis*, *Aedes excrucians* and *Aedes vexans*. These mosquitoes lay their eggs along the edges of the pool and rely on rain water or melting snow to hatch the larvae.

2.1.3 Road side ditches

These are suitable habitats for many species of *Culex* mosquitoes. The larvae of *Culex pipiens* and *Culex restuants* survived in waters with high organic content. Culex mosquitoes lay their eggs directly on the surface of water for extended period of time breed large numbers of mosquitoes.

2.1.4 Fresh water ponds

The larvae of Anopheles are found primarily in small ponds clogged with vegetated growth breed huge numbers of these mosquitoes because fish and other aquatic predators cannot easily find and feed on them.

2.1.5 Artificial containers

Tires, tin cans, bottles, buckets, tanks and flooded basements provide an excellent predator's free mosquito breeding habitats. Mosquito that prefer natural habitat such as tree holes have adapted to using these man made nurseries. In such instance, abundance of litter and other debris allow proliferation of millions of mosquitoes during a season. *Aedes albopictus* notorious for transmitting several diseases is one of such species that have capitalized on breeding in tires and other artificial containers.

2.1.6 Tree holes

Natural containers such as pitcher plants serve as a good source for breeding moquitoes. *Aedes tiseriatus* known to transmit several disease agents prefer tree holes and can be very common mosquitoes in wooded areas. Frequent rainfalls mantains standing water in these areas and breed mosquitoes throughout an entire summer.

2.1.7 Fresh water marshes

Mosquitoes breeds very prolific in cattail marshes as well as areas with other emergent water vegetation. The larvae attach themselves to the stems and roots of the vegetation to obtain oxygen. They do not swim in water to feed and breath. Because of this adaptation, the lavae are not exposed to the predators.

2.1.8 Hardwood and coniferous fresh water swamps

These swamps breed variety of mosquitos' specie. They are primarily breeding habitat for the mosquito *Culiseta melanura*, the enzootic vector of Eastern Equine Encephalitis (EEE) virus. The larva lives deep within the recesses of the root cavities of the large trees.

2.1.9 Running water

Streams with running water produce few mosquitoes. Mosquitoes need still water to lay their eggs. However, anopheles and culex mosquitoes are sometimes found in isolated pockets of water away from the main flow of the stream.

3. IMPORTANCE OF MOSQUITO

3.1 Disease transmission

Among all the existing insect pests' mosquitoes are the most important vector of diseases transmitted to man and other warm blooded animals [3]. Anopheles mosquitoes are responsible for the transmission of plasmodium which causes malaria fever in man. The infective form called sporozoite is introduced into man by the female anopheles mosquito. They are inoculated into the blood in the sub-cutaneous tissue, when the mosquito feeds on man [5]. The sporozoites penetrate a parenchyma cell and grow within it to form schizont. The schizont divides and form mirozoites which finally ruptures and liberate into the blood circulation. The cycle involve the production of haematin pigments which sensitizes the host and produces in him, clinical manifestation of malaria fever such as head ache, muscular aches, anorexia, nausea, vomiting and diarrhoea. Complications may also occur due to malaria infection such as cerebral, algid malaria, hypoglycaemia and black water [8].

The filarial worms are transmitted by several species of mosquitoes, especially species of Anopheles, Culex and Aedes. When an infective mosquito feeds on man, the microfilariae escape on to the skin. They penetrate the skin usually through the bite of the mosquito. They pass through the peripheral lymphatic where they migrate and grow. Finally they settle down in lymph nodes and become matured [5]. The adult worm causes blockages of the lymph gland resulting in elephantiasis. The circulating larvae produce metabolites which induce some allergic manifestation shown as urticaria or fugitive swelling with oedema [9]. Sasa [10] reported that infection with *Wuchereria bancrofti*, *Brugia malayi* and *Brugia timori* are the most common cause of severed filariasis. Periodic *W. bancrofti* is transmitted by *Culex*, *Anopheles* and *Aedes* mosquitoes. Sub-periodic *W. bancrofti* is transmitted by *Aedes* mosquitoes. Nocturnal periodic *B. malayi* is transmitted mainly by mosquitoes belonging to the genera anopheles and mansonia. Sub-periodic *B. malayi* is transmitted by mansonia.

Yellow fever is a viral infection transmitted by species of Aedes. The infection is transmitted by forest dwelling species e.g. *Aedes simpsoni*. These mosquitoes do not feed on man and thus not responsible for transmitting the infection to man. However, infected monkeys often leave the forest for the plantation to feed on banana and other crops. They are then exposed to biting species of Aedes, which therefore become infected. Man becomes infected when he visits the plantation and is bitten by infected *A. simpsoni* [11,12].

Mosquitoes also transmit a disease causing organsim such as encephalitis. While human malaria does not occur in some developed countries, an outbreak of encephalitis is constantly reported in such areas. In 2002, a type of encephalitis caused by the ''West Nile Virus'' was found in washington state. The viral disease is transmitted by various species of mosquitoes belonging not only to genus Aedes but also Culex and others. West Nile Virus is primarily a virus of birds and transmitted from infected birds to other birds by mosquitoes. Other animals and people are incidental hosts and obtain the virus from infected mosquitoes [13].

Oyerinde [5], reported that several species of Aedes are known to be capable of transmitting ''dengue'' a viral disease. The important specie in Nigeria is Aedes aegypti. The disease is transmitted to man by inoculation when mosquito is obtaining a blood meal. No animal reservoir has been reported but monkeys may serve as reservoir host.

3.2 Economic importance of mosquito

Among the disease transmitted to humans by mosquito is malaria. It remains the most important of the tropical disease as a major cause of morbidity and mortality and accounts for over one million deaths a year in Africa alone. Nearly 90% of the 200 million estimated malaria infected people in the World are in Africa. About 300-500 million acute attack per year it is estimated occurs worldwide with about 80% of the cases (including deaths) occurred in tropical Africa. Most of these victims are pregnant women, infants and young children [14]. Molta [15], reported that at least 50% Nigerians suffer from one form of episode of malaria or the other making the most significant health problems in Nigeria. Malaria contributes to the slow economic growth in Africa by about 1.3% yearly and has lowered down the African GDP level by about 32%. Malaria causes man-hour loss, absenteesm from school/work and causes reduced productivity, income lost, low birth weight, anaemia, still birth and death [16].

Sasa [10] reported that infection with lymphatic filarial worm affect an estimated 200 million persons and put more than a billion people at risk of infection. In may 1997, the World Health Assembly passed a resolution calling for global elimination of lymphatic filariasis as a Public Health Problem. The human suffering that results from lymphatic filariasis can scarely be imagined. An estimated 14 million persons suffer from lymphoedema or elephentiasis of the leg and as many as 25 million men have urogenital disease caused by lymphatic filariasis. The obviuos effects of these conditions on physical mobility and capacity to work have led the World Health Organization to rank lymphatic filariasis as the second leading cause of long term disability in the world [17]. Perhaps even more important, however the devastating is, but often hidden psychological and social effects of disfigurement, uncontrolled odour, sexaul, disability and painful acute bacterial infection are caused by filarial worm, Gerusa *et al* [18]. The economic impact of repeated episodes of illness and long term disability is a major cause of under-development in many countries today [17]. Lymphatic filariasis has steadily increased poverty especially in Africa, and that there is tremendous handicap in adults and children.

Other disease of economic importance transmitted by mosquito especially of the *Aedes species* may include; yellow fever, encephalitis and dengue fever. In 1793, a yellow fever outbreak occurred in Philadelphia killing about 10% of the city's residents and sickened another 20%. Encephalitis another flavivirus has had epidemic out breaks in the central United States. The virus is a potential for la crosse encephalitis (LAC), a bunyavirus, which is usually associated with the mid-west. Dengue fever is a mosquito borne problem throughout the Caribbean and Mexico. The disease is haemorrhagic in form and fatal [3].

3.3 Mosquito Nuisance

In addition to those indirect effects of mosquitoes on health, they also affect human health directly by their presence which may be a cause of annoyance often leading to loss of sleep and consequently result in nervous breakdown in some people. The mosquito bite is often associated with pruritus especially in sensitised persons. This provokes scratching and may lead to secondary bacterial infection [5]. Rozenda, *et al* [19], reported that where nets are commonly used, people perceive mosquitoes to be a great nuisance and thus perceive the nets to be of high benefits. Nebe *et al* [20], reported that nearly about 94% of women in coastal area of Lagos use mosquito nets because of nuisance effects of mosquitoes.

4. MOSQUITO CONTROL

4.1 Cultural Method in Mosquito Control

According to Nebe *et al* [20], protection agaist vectors such as mosquitoes involve the application of aromatic herbs, smoking and swatting of rooms with leaves of plants such as *Azadirachta indica* is popularly used in parts of Western Nigeria. Gunnar [21], reported that ointment made with eucalyptus or neem pounded and mixed with grounghnut oil is used in parts of northern Nigeria to repel mosquitoes at night. Some plants are generally mosquito repellants. *Citronellal* and *geraniol* deter mosquitoes to come close when crushed in hands. Lemon balm (*Melissa officinalis*), which is easy to grow from seed, contains the repellents *citronellal*, *geraniol* and *geranial.* The essential oil in catnip (*Nepeta cataria*), nepetalactone, was found to be about 10 times more effective at repelling mosquitoes than DEET. Crushing hands with lemon thyme (*Thymus x citriodorus*) and lemongrass (*Cymbopogon citratus*) repel mosquitoes for some time [22]. F.M.O.H [1] reported that replacement of humans settlements away from vector breeding habitats have drastically reduced mosquito bite in some areas. It is usually seen in rural areas that walls of mud huts are white washed to avoid attracting mosquitoes [23].

4.2 The use of insecticides

Arrese [23] reported that successful environmental hygiene programmes have been conducted in Nigeria by massive spraying of insecticides such as Diochlor-diphenyl-trichloethane (DDT), benzene hexachloride, dieldrin, and the organ phosphorus compound as diazion, fenthion (Baytex), malathin and dichlorvos (DV) to kill mosquitoes and larvae. A trusted method is by spraying the breeding sites with the insceticides. Studies have reported that the use of DDT is still one of the most effective and economical forms of insceticides in the control of mosquitoes. The use of DDT was partly responsible for the reduction of mosquitoes in areas where it is now mainly eradicated. There has been report on the use of larvacides in Nigeria which involves the application of petroleum products on surface of stagnant water which blocks the spiracular opening of the larvae which become asphyxiated. Application of poisonous substance like paris green which when ingested by feed larvae result to the death of the larvae. Dieldrin and aldrin also have larvicidal properties. They are mixed with sand and cement and thrown into shallow ditches of water where insecticides are released.

4.3 Insecticide-treated bed nets (ITNs)

Insecticide-treated nets (ITNS) have been shown to be effective and cost-effective means for the control of mosquito bites especially among children less than five years [24]. The Abuja Declaration on Roll Back Malaria by African Heads of States in April, 2001 committed National Governments and their development partners to the goal of increasing coverage with ITNS to 60% of target group WHO [25]. There continues to be debate about the specific mechanisms through which the target for increasing coverage set in Abuja [3]. The debate is echoed about appropriate means of delivering this key public health tool. The Nigerian National malaria control strategy emphasizes sales of ITNS on the user free basis [1]. This is why the Federal Government announced free distribution of ITNS to pregnant women and children. Sexton *et al* [26], reported that apart from controlling mosquito bite, nets offered protection from cold weather and kept the bed clean. Bradley *et al* [27], also reported that nets offer privacy and often implying a role in beautifying the home. For many years scientist have known that bed nets would be more effective in mosquito control measures, if insecticide were applied to them, mosquito are naturally attracted to the humans sleeping inside the nets and alight on the net, the insecticide kills them [28].

This form of personal protection has been shown to reduce severe diseases due to malaria in endemic regions. Untreated bed nets form a protective barrier around persons using them. However, mosquitoes can feed on people through nets with even small holes without any protection [29,30,31]. The application of pyrethroid a residual insecticide enhances the protective efficacy of bed nets. It kills mosquitoes and other insects. It has a repellent property that reduces the number of mosquitoes entering houses to feed on blood and also reduces the longevity of mosquitoes [32,33]. Pyrethroid insecticides have very low mammalian toxicity, but they are highly toxic to insects and have rapid knockdown effect, even at very low doses [34, 35]. The pyrethroid insecticide has a high residual effect which does not rapidly breakdown unless washed or exposed to sunlight [36]. The nets are treated at intervals of 6-12 months, and more frequently if the nets were washed. It is treated by simply dipping them in a mixture of water and insecticide and drying them in a shady place [37].

The frequent re-treatment is a major barrier to full implementation of ITNs in malaria endemic areas. A long lasting insecticide treated nets that retain lethal concentrations of insecticides for at least 3 years have been developed for an effective malaria control strategy [38].

4.4 Indoor residual spraying

Most malaria vectors are endophilic; resting inside houses after taking a blood meal. These vectors are susceptible to indoor residual spraying (IRS) [29]. Indoor residual spraying involves coating the walls and other surfaces of a house with a residual insecticide [39, 40]. Indoor residual spray does not directly prevent people from being bitten by mosquitoes; rather, it usually kills mosquitoes after feeding, when they come in contact with the residual sprayed surfaces [41, 31, 42]. Indoor residual spray prevents transmission of infection to other persons, and for it to be effective it has to be applied in a high proportion of household area. Dieldrin and dichlorodiphenltrichloroethane (DDT) are the primary residual spray used for malaria control during the global malaria education campaign because of their cheapness and durability. The campaign did not achieve its stated objectives but it eliminates malaria from several areas and reduces the burden of the disease in other areas [29, 43]. The resistance of mosquitoes to DDT and dieldren and their impact on environment, led to the ban of the use of DDT and dieldren in malaria control programmes. Dichlorodiphenltrichloroethane applied in houses was found to be accumulating in food chain, making it inappropriate for spray in houses [44]. Residues of DDT were also found in breast milk due to intake of contaminated food. The DDT was in turn replaced with organophosphate or carbamate such as malathion and bendiocarb. However, DDT has been re-introduced for malaria control in some parts of Africa with some success; and it has reignited debate over whether or not DDT should have a place in malaria control [29,45].

4.5 Environmental control

Developing countries, especially Africa, are involved in many developmental projects; such as; water schemes, construction of dams and bridges, oil drilling, mining activities, urban planning development, logging activities, building of airports, road and railway construction [46]. These projects have been responsible for the increase in mosquito breeding sites, thereby increasing human mosquito contact and transmission [47]. Other environmental changes that can generate larval breeding sites include deforestation, agriculture and irrigation [48]. Some rivers in the dry season have sandy bed, and as the dry season continues the river bed reduces, leaving small spots of water which are perfect breeding sites for mosquito larva [49]. It will be good to reduce the bed of the river such that there are no longer spots of breeding sites during the dry season [50]. Developmental project that affect the environment should include health personnel for proper evaluation of the health risks associated with the project [41]. Good drainage systems will reduce mosquito breeding sites and improve sanitary conditions [47]. According to Oyerinde [5], F.M.O.H. [16], the control of mosquitoes through environmental manipulations and modifications include activities such as irrigation system, filling drainages, clearing, disrupting the life cycles of mosquitoes periodically by denying them their food plants, burying all receptacles and other measures that tend to reduce mosquito breeding. Others include altering water levels, changing water salinity, clearing vegetation and aforestation/deforestation.

4.6 Larval control

Larval control can mainly be attained through environmental management, chemical and biological control [50]. The larval habitats may be destroyed by filling depressions that collect water by draining swamps or by ditching marshy areas to remove standing water. Containers breeding mosquitoes are to be removed or standing water in cans, cups and rain barriers around houses are to be covered [51]. Mosquito species with difficult habitat elimination are to be targeted with chemical insecticides in the habitats. Biodegraded oils are to be applied to the water surfaces; thus, suffocating the larvae and pupae. Toxins from bacterium *Bacillus thurigiensis var israelensis* are specific to mosquitoes, midges and black flies, and these are to be applied as chemical insecticides [52]. Methoprene is specific to mosquitoes and it is applied in the same way as chemical insecticides. Mosquito fish (*Gambusia affinis*) are effective in controlling mosquitoes in larger water bodies. Other potential biological control agents such as fungi (*Laegenidium giganteum*) or mermithid nematodes (*Romanomermis culicivorax*) are widely used for mosquito control [41, 53]. Some fungi species such as *Cephalosporium*, *Penicillium rubrum* and *Phialoplura redicicola* when innoculated into infected areas regulates the growth and survival of mosquito larvae by providing unfavourable conditions for its growth. Protozoa species such as *Nosema algera* and *Vavraia cuticis* reduce the population of mosquito larvae by affecting the larvae or by forming bacilliform spores which infect the eggs of insect vectors. The application of nuclear polhedrosis viruses and iridoviruses attack the mid gut epithelial tissues of mosquito larvae which results in their deaths [2,54].

4.7 Genetically modified (GM) mosquitoes

Mosquito-transfer method in the transmission of malaria is an effective mode in the spread of the disease [55]. Female Anopheles mosquito laying eggs require extra protein which she gets by sucking blood from vertebrate animals. When the animal she feeds on is carrying malaria parasite the mosquito picks it up. The next time she feeds on the animal, she transfers the parasite to the animal blood stream [56, 57, 58].

The genetically modified (GM) mosquitoes can help in wiping out the malaria carrying mosquitoes [59]. Better, stronger mosquitoes that are unable to spread malaria can be created and released into the wild [60]. The created mosquitoes will eventually win the survival game and replaced the mosquitoes that are able to spread malaria [61]. A gene is activated to make the mosquitoes immune to any particular parasite and lose the ability to pass it on. In this case a gene that controls the SM1 peptide in the mosquito's gut is turned on. The protein, SM1 peptide stops the development of malaria parasite while living in the mosquito. These allow the genetically modified mosquito to live longer than the wild mosquito [62]. The engineered mosquitoes are safely introduced into the population and out-compete the wild mosquitoes [63]. The released strains have to mate with the target population in order to drive the transgenes into the resultant population [64]. Before the release of the mosquitoes, an international agreement has to be reached, the genetics of the target population has to be characterized and compared to the released strains [65]. In this technique, a resistant strain may be developed and the transgenes can make the mosquitoes a viable carrier for other diseases. An increase in the genetic variability of the transgenic mosquito will help to minimize and completely eliminate the risk involved [66].

4.8 Sterile Insect Technique (SIT)

This is a method in which millions of sterile mosquitoes are released into the wild [67, 65]. The released mosquitoes are males as it is the females that usually cause damages to humans through the taking of blood meal [68]. The sterile males compete with the wild males for female mosquito [69, 70]. If a female mosquito mates with the sterile male, then, it will have no offspring, thus, reducing the population for the next generation [71, 72]. Repeated releases of the sterile male mosquitoes will eventually wipeout the population.

The application of the sterile insect technique (SIT), entails the mass production, sterilization and release of sterile male insects into a target population in a wide area, usually integrated as a pest management strategy [73].The sterile insect technique has proven to be safe, effective and environmentally friendly to suppress, eliminate or contain particular insect pest population [74]. The insects to be released into the wild are irradiated with cobalt-60 Gamma-cell (Noridon 220) [71]. A dosimetry system is used to verify the dose received by the mosquitoes [75]. Before irradiation, the mosquitoes are sexed manually by looking at the terminals under a stereoscope [76]. The mosquitoes are irradiated either in the pupal or adult stage [73].

4.9 Use of other preventive measures

William *et al* [39], reported that the widely used preventive measures against mosquitoes include, killing mosquitoes with broom, fan, or hand, using a mosquito coil, covering the body with thick cloth while sleeping or wearing long clothes, closing doors and windows before dark and using insecticide sprays. Other personal protection measures against vectors of malaria may include the use of window screens, wearing of light-coloured clothes and long pants [50].

5. Challenges in mosquito control

5.1 Cost of control

Vyas *et al* [77], reported that about 10-12% of household own at least one untreated net and neglible number of treated net in Nigeria. The explanation for the low coverage is due to affordability problems as household economic status has been related to net ownership [78, 79]. There have been other inconsistencies in ITN policy in Nigeria for example; custom duty on imported nets was reduced from 40% to 5% in 2002. Later that year, it was raised again to 70%, it was reduced once more in may, 2003, Onwujekwe *et al* [24]. Sponsler [80], reported that there is a low coverage in the use of insecticides to control mosquitoes in developing countries due to high cost of the insecticides. In Nigeria mosquito control programme have been deteriorated or been abandoned because of cost and lack of commitment [16].

5.2 Resistance to insecticides

Mosquitoes are developing resistance to the major classes of insecticides which have been used to control the vector. Portions of the effect to eradicate mosquitoes during the 1950s and 1960s were scientifically naive and politicaly uncommitted. Funding for vector control was cut prematurely leading to resurgence of insecticide resistant vector population [3]. Arrese [23] reported that DDT, the most effective and economical form of insecticide is becoming resistant to mosquitoes. WHO [3] reported that the over use of any insecticide products lead to the appearance of insecticide resistance. Insecticide resistance can arise through overly-aggressively targeting certain species or life stages with a single product, such that the small percentage of any species or life stages of any species population might be naturally resistant to whatever insecticide used. As such for avoidance of resistance problems alone, it is important to rotate a variety of insecticides in the control of vectors.

5.3 Effects of mosquito control on health

The performance of mosquito control, present challenges like its effects on health. Alonso *et.al* [81], reported that some villagers mostly complained of the smell of the insecticides on treated bednets, and the fear that the chemical might be harmful to their health. Sexton *et al* [26] reported that people complained that sleeping under nets makes them feel hot during hot season. Sponsler [80], also reported some people are allergic to insecticide repellents and coils due to the smoke that this devices emit. Studies have shown that environmental laws are leading towards the total ban of the use of DDT. This is due to its persistence in the environment and effects on the ecosystem, it is regarded as a persistent organic pollutant.

5.4 Recommendations

(i) Public enlightment campaign. This should involve a sustained public health education on vector and strategies to control them.
(ii) Human environmental changes such as road building, mining, deforestation, logging and new agricultural and irrigation projects have created new breeding sites for mosquitoes. Government should therefore endeavour to bring out a rolling plan that will take care of such project during the cause of executing them to avoid mosquito breeding.
(iii) Proper funding should be allocated to the health sector for research and vector control.
(iv) Government should take look at their various edits with the aim of stipulating appropriate penalties for violation of environmental laws.
(v) Government should set up their campaigns and public awareness on environmental sanitation.
(vi) Customs duty on imported products for mosquito control should be reduced by the government.

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