



REVIEW ON INSECTICIDE-TREATED BED-NETS FOR MALARIA MOSQUITO CONTROL

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Abstract

Mosquito control through Insecticide treated bed nets (ITNs) lead to significant malaria control. Pyrethroid insecticide used for treating bed net that helps to control malaria mosquitoes. Mosquitoes show very sensitive to ITNs due to use of insecticide. ITNs act as both repellent and destroyer of mosquito resulting in a great number of mosquitoes affected by it. When many people protected under ITNs, at that time the survival rate of mosquito reduced due to using of ITNs. ITNs have no adverse effect on human health as well as environment except insect. They also provide more protection for communities, especially children and pregnant women. The charge for retreating bed nets as well as funding of ITNs from different organization show greater efficiency resulting in the highest cost effective approach to progress. However, ITNs are the most effective, ecofriendly as well as a cost efficacious method for mosquito malaria control. The amount anti-malaria anti body levels of children could be reduced due to long time user of ITNs. The effectiveness of ITNs relies on different factors such as season, amount of mosquitoes, mosquito's irritation, climate as well as types of bed nets.

Introduction

Mosquito belongs to Culicidae family, which is a small group of insects like flies. About 3,500 mosquito species are identified all over the world. They act as a vector that carry and transmit different infectious pathogens resulting in various diseases. They are responsible for causing viral diseases like dengue fever, parasitic diseases like malaria and bacterial diseases like tularemia (Muslu, 2011). Female mosquitoes of the *Anopheles* to lay viable eggs resulting from blood meals. Several species of mosquitoes sucking blood from the human body e.g. *Anopheles*

gambiae sensu (Ngonghala et al. 2016). Mosquitoes collect blood meals from human with *plasmodium* parasites.

The most dangerous life threatening and mosquito born disease is malaria, which markedly affecting the moderate poor regions of the world. The main severe disease of the large tropical area is malaria. The symptoms of malaria were first reported from china in 2700BCE. Malaria usually caused by mosquitoes, which are mainly Anopheles family belongs to different plasmodium species. Recently, malaria caused due to the pathogen of five plasmodium parasites. Among these, parasites, *Plasmodium falciparum* is the most severe, dangerous pathogen for causing remarkable symptoms and greatest mortality and morbidity. About 3 billion people in 100 countries whose are suffering malaria, annually (WHO, Geneva, 2015). Most of the children deaths are found in southern Saharan Africa which is caused mainly *Plasmodium falciparum*. In addition, the highest malaria frequency was found in the Solomon Islands and Vanuatu which situated in the Asia region. It was observed that the yearly prevalence rate of 130.9 per 1,000 people as well as 24.3 per 1000 residents in the Solomon Islands and Vanuatu respectively in 2006 (Drame et al. 2010). Particularly low income countries, malaria is a major problem for causing health hazard. There are different types of methods available for controlling mosquitoes that are responsible for causing malaria, such as biological, chemical and mechanical methods.

Among these methods, chemical method is more effective due to its suitability and stability. These chemical methods consist of insecticide treated bed net, long-lasting insecticidal nets (LLINs), impregnated insecticide as well as indoor residual spraying more effective. In this scientific essay it is looking for the effectiveness of insecticides treated bed nets for controlling mosquito considering different aspects of ITNs drawbacks as well as fruitfulness.

History of ITNs use for mosquito control

The net of mosquito has a lengthy history. The term came from the India journal in the mid-18th century. It was used by the ritual Hindu worship. The mosquito nets are being used from the historical period against irritating insects. The armies of US, German as well as Russian used insecticide treated bed nets during the Second World War for saving their soldiers, particularly from malaria. The pyrethroids insecticides are used since the late 1970, for their great insecticidal motion and little mammalian poisonousness. When the net preserved with insecticides is called insecticide treated bed nets (ITNs) which were established in the 1980s for

control of malaria (Murray, 1978). Recently, the World Health Organization (WHO) allotted new worldwide direction for the use of mosquito nets that are dried with insecticide to guard persons from malaria. The Health ministry in Kenya, established the novel general approach to prevent of malaria through increasing the practice of insecticide treated bed nets among the people in 2001. According to Government of Kenya, about tenfold of children was sleeping below the ITNs from 2004 to 2006. As a result, around 44% children were protected than the children whose are not under ITNs. The international research team along with the malaria Control Division of Kenya have been observing the reporting as well as effect of this discovery. Firstly, WHO supported the all community members for using ITNs. Afterwards, President Mwari kibaki hurled a strength, about US\$17 million contribution was supported by the Global Fund to prevent Malaria, AIDS and Tuberculosis in 2006. These contributions were assigned for buying 3.4 million ITNs that distributed among the children of 45 districts out of 70 through two operations. Consequently, around 38 countries of African Continent achieved ITNs freely as well as rest of the countries have devices to retail ITNs at funds charges. As a result, the use ITNs is increasing day by day due to getting free supply as well as subsidy.

Pyrethroids treated bed nets

Only pyrethroid insecticides are permitted for use in ITNs. Pyrethroids are insecticides chemically alike to pyrethrins initiate in usual pyrethrum removed from the *chrysanthemum* flowers, recognized for centuries for their insecticidal potential. At present pyrethroids are the most effective chemical that are used for controlling mosquitoes, *Aedes* female especially during increases. They are particularly used for reducing of mature mosquitoes due to their comparative protection for human. Pyrethroids are being used as for treating bednets in the form of lambda-cyhalothrin, cyfluthrin, alpha-cypermethrin, etofenprox, deltamethrin as well as bifenthrin (Baldacchino *et al.*, 2015). Besides, they retain high insecticidal effectiveness at small quantities as well as their rapid reduced residual effects. The security as well as the effectiveness of pyrethroids for various submissions in vector control, as well as decontamination of aircrafts evaluated by the World Health Organization (WHO).

Present situation of acceptability of ITNs for mosquito control

In last ten years, the acceptance of ITNs has increased to people around tenfold across the malaria affected areas in the world (WHO, 2014). This also helps remarkable reduction of mortality from malaria. The villagers about 95% of Nicaragua, Ecuador, Peru as well as Ecuador

received ITNs. Moreover, the percentage of people saved by ITNs enlarged from 2% to 33% in 2000 and 2012 respectively. The international subsidy also increased from not more than \$100 million to \$1.76 billion in 2000 and 2010 respectively. It also noted that the using of ITNs has significantly increased from about 6% to 68%. One experiment was conducted to determine the users of ITNs during pregnancy. At the first time of pregnancy, 359 women (72%) among 500 women taken ITNs who are living in Jinja, Uganda (Sangaré et al. 2012). In households, the use of ITNs increased from 1% to 60% over the last decade, conducted by some sub-Saharan African countries with the help of international donors. ITNs are more effective and usually more used in sub-Saharan Africa. The spreading of malaria differs across the country and it is not unlikely that the level of transmission affects the ITNs. The number of ITNs that having household reflects the effectiveness of ITNs as well as cluster-randomized controlled trials (RTCs) were examined and in urban area the usefulness of ITNs is not clearly characterized. The average users of ITNs each household was lower in urban areas in comparison to rural areas as well as each household has minimum one ITNs. It also reported the amount of household including all members who slept under ITNs was lower in urban areas in comparison to rural areas. The children who are living in rural areas using more ITNs and knew that malaria could be protected by using ITNs.

Mechanism of ITNs for mosquito control

Human could be protected by providing mosquito nets that perform as a physical barrier. Various types of artificial insecticides such as permethrin and deltamethrin are usually used for treating nets in order to destroy kill mosquitoes and prevent mosquito bites. Thus, people get protection against malaria through applying these nets. They possess excito-repellent attributes that act as chemical barrier beside physical. They help to decrease vector control of human as well as rising the defensive effectiveness of the mosquito nets. For getting maximum efficacy, each six months insecticide should be applied for re-soaking of ITNs. If nets are washed frequently in that case nets should be re-impregnated every 6 to 12 months. In that case, the nets are dipped with water, which containing insecticide and then nets are kept in a shady place for drying. Therefore, ITNs play an important role in killing mosquitoes than other nets. These nets not only kill the mosquitoes, but also decreasing the amount of mosquitoes that remain in the house. In addition, they also responsible for reducing the life cycle of mosquitoes. The number of mosquitoes and the rate of sporozoite could be reduced by using ITNs. It was reported that decreased of

mosquitoes bite from 74.5%-76.6% as well as malaria frequency reduced 32.1% in order to using of ITNs. Usually, ITNs help to reduce malaria vectors when come into contact with it. Besides, it also supports to guard those people who are not slept under ITNs. As a result, all children as well as an adult can get reasonable communal-wide benefits. Thus, the spread of malaria decreased by using ITNs through vector control. According to research settings, 50%, defensive effectiveness of ITNs remarkably have been increased than untreated nets. Moreover, the efficacy of the ITNs depends on effective insecticide. Mosquito nets mainly made of nylon. Moreover, it consists of polypropylene, cotton, polyester as well as polyethylene. The size of the nets varies 1.2 mm to 0.6mm. Among these materials, polyethylene is the best due to its longevity as well as hardness.

The insecticides that are used for treating bednets help to repel mosquitoes resulting in people are protected by the net. Besides, if a mosquitoes not attacked by the chemical, after human biting the mosquito takes rest on the bed net and they killed by adjacent insecticide. ITNs offer combine individual protection through prohibiting mosquitoes biting, thereby decreasing spreading of mosquitoes. Moreover, in case of community protection reduced the longevity of mosquitoes resulting in outbreak of sporozoites which stages are responsible for causing malaria (Birget, 2015). Thus one person using these net for own protection while another person would be less effective using by them. ITNs efficacy also influenced mosquito breeding through improving management of environment. Another experiment reported that ITNs have the ability to altering the behaviour of host feeding in mosquitoes. After treating the vector with ITNs, vector stayed more anthropophilic. It also reported that the behaviour of anophelines also changed due to introduction of ITNs that directed toward earlier biting or outdoor. ITNs are recently used for decreasing population, feeding frequency and mosquitoes alive rate. The use of ITNs in wide scale could be possible to protect the members who are remained in that area without a bed net.

ITNs benefits and effects on human health

The insecticides which usually used for treating beds are less toxic to human and other living organisms except insects. They are responsible for killing of insects, particularly at less doses. The nets acts as protector between the vector of mosquitoes as well as human. Besides this, they also supply individual wide space protection. The cost of investment is low in comparison to other methods. Besides, per unit investment of ITNs saved more life. Around 370,000 child

deaths could be saved from malaria, if every child treated with ITNs in sub-Saharan Africa who's aged under five years. ITNs are the major control programs of malaria and the amount of households in sub-Saharan Africa that used net, children die due to malaria increased from 3% to 53% in 2000 to 2012 respectively (Lim et al. 2011). According to Steinhardt (2016) described that clinical malaria decreased due to regularly spreading of ITNs widely. The experiment was conducted by (Drame, 2010) through using marker of immunological on the basis of *Anopheles salivaria* that respond to antibody to human. The levels of immunoglobulin G (IgG) to *An. gambiae* was markedly connected with the inflation of *An. Gambiae* exposure and infection of malaria. The results indicated that the dispersion of malaria decreased due to induction of ITNs, despite the present of *plasmodium falciparum* was very low. Also reported malaria that leads to hospitalization reduced 30% in case of perfect household whereas environmental factors such as removing of larval sites could decrease the possibility for malaria hospitalization not more than 20%. Every year around 800,000 deaths occurred globally due to malaria. The most of the mortality observed in sub-Saharan Africa particularly in adolescent children. It was observed that the rate of mortality the children under of an age of five 20 percent in endemic areas. Widely spreading of ITNs has been changed from reporting of cluster-randomized controlled trials (RCTs) indicated that using of net showed that in case of child mortality the reduction of pooled relative parasite prevalence was 18% and 13% respectively (Eisele et al. 2010). Insecticides treated bednets are most important inexpensive and conventional method for decreasing mortality that occurred by mosquito. It was reported from Gambian that 1-4 years old children showed 37 % mortality due to malaria in the primary health care center villages than non-primary health care centre. The experiment that was conducted on the efficacy of insecticide treated nets for decreasing child mortality in 17 sub-Saharan African countries. The results showed significant reduction of malaria transmission due to using of insecticide treated bed nets resulting in less number of child mortality occurred. Concluding to a Cochrane review, ITN reduced child mortality by 18% in sub-Saharan Africa (Killeen et al. 2007). Decreasing mortality would have possible by applying it in the high malaria transmission area. However, estimating that 5.5 children saved per 1000 due to using of ITNs per year. ITNs decrease malaria clinical incidence that occurred by *plasmodium falciparum* as well as *Plasmodium vivax* contaminations by an average 50%. It also helps in decreasing the incidence great volume parasitaemia. ITNs help to decrease mortality considerably in low transmission area than high transmission area. For

instance, one survey that was conducted in Gambia concluded that the children under an age of 1 to 59 months could be decreased mortality about 42% due to applying of ITNs. One experiment that was conducted in Kassena-Nankana district of Ghana indicated that decrease of 17% children mortality under an age of six months to four years due to applied of permethrin impregnated bednets (Binka et al. 1998). In addition, highest mortality rate was observed in two years old children and was higher in damp season (July – December).

The impact of ITNs on malaria morbidity

ITNs play an important role in decreasing morbidity of malaria, especially low as well as high range area. The number of morbidity was decreased due to using ITNs in urban and rural areas 66% and 47%, respectively. The morbidity of malaria greatly influenced by ITNs. For example, it was found that the reduction of parasitaemia remarkable 53% and 31% of medium and high transmission areas, respectively due to using of ITNs and IRS combinedly. Considerable malaria morbidity was observed in intermediate as well as high transmission areas. For instance, it was reported that severe illness could be prohibited from using ITNs as well as both of patients and healthcare workers showed high cost. A review was conducted on ITNs assessments which consisted of 22 studies from South America, Asia as well as Africa. From the result, it could be concluded that ITNs decrease childhood morbidity as well as ITNs may be applied all malaria regions (Lengeler, 2004). The results showed that ITNs increase the amount of hemoglobin level in children of Africa by 1.7% crammed cell size. ITNs also influence the public health. They have also effect on children's growth, even the effects are very moderate. Municipal involvement experiments report that ITNs are only responsible for reducing of morbidity not contamination of malaria intermediate and low transmission areas. Malaria morbidity steadily decreases in Africa by the utilization of ITNs, but in Asia, their aides have been less reliable. The efficacy of ITNs in decreasing morbidity of malaria relies on some factors such as the equal of malaria endemicity, people immunity, the performance, the weather, the taking as well as procedure of the ITN by the people. The effectiveness of ITNs for reducing morbidity also depends the vectors of Anopheline biting performance. Therefore, the effectiveness as well as the acceptability of ITNs depend on malaria morbidity.

Effectiveness of ITNs on mosquito malaria control

The effectiveness of bed net depends on four features: 1. Seasonality (most of the people about 90% used beds rainy season period, half the people about 52% used whole the year), 2. Less

amount of mosquitoes (when mosquitoes are few most of the people do not take protection against mosquito trouble, so the utilization of bed nets are less), 3. Mosquito irritation (the defendants of about 59% suggested that bed nets are used for this reason against mosquito) and 4. Climate (more than half about 68% of the people do not use bed nets when the weather is hot) (Lim et al. 2011). Besides, the effectiveness of ITNs depends on the quantity and kind of insecticide. For instance, pyrethroid is the most effective insecticides than others insecticides. ITNs not only covered the protected area, but also it protected the unprotected area. It was observed from the trials of western Kenya, Tanzania as well As central China that ITNs would be more effective for decreasing the density of vector population when the large area of the community is attained. When ITNs are used in a house, the mosquitoes are not remained up to 300m in that house. Another experiment reported that 18 fold malaria reduction occurred due to treated nets with insecticides. In that case, mosquitoes die due to their incomplete blood feeding. After once, feeding mosquitoes survive until the time of lay eggs before taking another feeding. The results of the experiment revealed that the efficacy of ITNs was about 50-60% in controlling malaria disease. One study in eastern Myanmar showed that the effectiveness of ITNs for controlling malaria both in urban and rural areas was found. For instance, the children under an age of five years old slept under effective ITNs was 32.5% and 67.5% Urban and rural areas, respectively. It also reported that less than one and one from Urban and rural household respectively, taking ITNs that was very low to fulfill the 100% coverage in 2015. Moreover, the majority of people in the family who were sleeping under ITNs was 6.9% and 15.3% in Urban and rural areas respectively. The effectiveness of ITNs also depends on the reliable use and proper hanging position of the nets. It was observed that the malaria infection of children reduced due to proper use of ITNs. The children who took ITNs consistently in suitable position of hanging net permanently and hung it every night found that they were affected less by malaria infection than others.

The effectiveness of ITNs as well as the density of mosquito influenced by utilization of pesticide and native agriculture. The density of mosquito also affected by various types of crops that are grown near to the home. As a result human are affected by the malaria infection. On the other hand, different types of pesticide such as pyrethroid insecticide are used for decreasing malaria infection of people. Thus, the effectiveness of ITNs could be reduced indoor biting or outdoor biting malaria vector. The infection of malaria vector also depends on the position of

people from the ITNs. The higher transmission of malaria was found in Africa and majority of malaria vectors were observed at early morning as well as late night. Therefore, the efficacy of ITNs would be effective in this area. As *Anopheles annularis* bit whole night as well as bit both outdoor and indoor equally, it could be controlled by using ITNs easily (Fornadel et al. 2010). On the other hand, the efficacy of ITNs for controlling vector diminished in East Asia despite a mosquito bit both early in the morning or evening and outdoors. However, the effectiveness of ITNs plays a vital role for controlling mosquito malaria control.

Discussion

Insecticide treated bed nets (ITNs) are one of the most significant approach for malaria mosquito control. Nowadays, ITNs are very much used by the people. It has a great contribution for saving cost as well as durability. It has no adverse effects on human health and the environment. In spite of having some disadvantages, the method is more acceptable to the people due to its effectiveness. The acceptability of ITNs is growing day by day for its useful effects. ITNs act both as a repellent or killer of mosquito. Therefore, it is cost effective and ecofriendly. The mechanism of ITNs for mosquito control is very simple and effective. Recently, people are more interested in using of ITNs for its effectiveness and stability. The use of ITNs is only found in Africa continent such as Ghana, Gambia and Sub-Saharan Africa. The utilization of ITNs is very less of the other continent especially America continent. Considering this, their spreading is very necessary for malaria mosquito control. The application method of ITNs is very easy, quick and less time consuming because requires less time for drying. The amount of insecticide requires a very small amount particularly for dense fabrics resulting in quickly work and cost-effective. They could be applied in particular areas where mosquitoes attack. Large amount of nets could be treated with insecticide at the same time resulting in save money and time, especially in village.

Many experiments have been conducted on communities which cover large number of bed nets around 70% (Hawley, 2003). They also reported that 30-40% suffering reduction in case of bednet users, which are less than in nonusers (Atieli et al. 2011). However, it was observed that constant use of ITNs, the amount of larval site presence and different types of crops were significantly associated with malaria, the children who are under ITNs. Impregnate ITNs affects the mosquitoes of Anopheline in different ways. Vector population and survival of vectors could

be reduced by applying of ITNs. Besides, this nets could be used for alter foraging behaviour. ITNs also change the outdoor biting of Anopheline in the early evening or changing host. When the mosquitoes are sited on the bednets, the midgut cells of mosquitoes are affected due to insecticide. Tremors are created in mosquitoes body, mosquito become inactive and eventually die (WHO, 2008).

ITNs are effective for higher frequency of malaria areas. The economic analysis indicated that, despite the uncertainty and variability in their protective efficacy in the different study sites, ITNs could still be cost-effective, but not if they displaced funding for early diagnosis and effective treatment which is substantially more cost-effective. According to economic analysis, it was apparent that the uses of ITNs are economical in the various learning aspects. It also observed in their early analysis stage that using of ITNs also cost effective. ITNs are being more used for decreasing malaria mortality and morbidity, especially in Africa constantly, but their profits have been not more in Asia. All pesticides are toxic by nature and present risks of adverse effects. The high protective efficacy of ITNs was observed in the areas of higher incidence of malaria. Insecticide-treated bed nets (ITN) reduce malaria morbidity and mortality in Africa, but their benefits have been less consistent in Asia.

The demerits of ITNs are instruments should be needed for spraying. Besides, skilled persons need for spraying at the proper dosage. A considerable amount of insecticide may be banished to the environment. The people of the villages do not accept of bed nets due to unsuitable as well as air does not pass through the bednets during summer season. They also not perfect in the period of cold with sleeping near a fire. They prevent night time works as well as movement due to fear of adverse effect of chemical. People have misconception about ITNs due to lack of knowledge. Moreover, sleeping pattern as well as a domestic space should be restructured due to use ITNs. In addition, the extra cost of insecticide as well as lack of knowledge about its importance, it is less acceptable to the people. Repeat treatment of bednets is a main obstacle to spread of ITNs all over the world. Despite of its demerits, insecticide treated bed nets should be implemented in a large scale for controlling of malaria strategies.

Conclusion

Insecticide treated bed nets are the most popular, less time consuming, more effective, ecofriendly as well as cost effective method to control malaria mosquito. It is holding a good position to reduce childhood mortality by reducing the spread of malaria. Besides, considering

environmental issue ITNs being holding an acceptable position to the health as well as environmental conscious people throughout the world. It will be better to survey on region or country specific for giving more conspicuous and acceptable comment on ITNs effectiveness.

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