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Review Article

An overview of insecticide usage and resistance of insect vector to insecticide: An implication to public health

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ABSTRACT: Insecticides are highly effective when optimally implemented and crop damage from insect pest infestations and diseases transmitted by insect vectors often result in serious consequences, warranting the need to use insecticides. The main strategy for the elimination of insect vectors is the use of chemical insecticides. Since its discovery, chemical insecticides have represented the most widely method used to control insect vectors and insect pests. The use of insecticides has helped to reduce insect-borne diseases. However, despite their benefits, insecticides pose potential danger to public health when inappropriately handled. Almost all public health insecticide classes and nearly 90% of all insecticides worldwide are used for agricultural purposes. The insecticide resistance development in disease vectors are as a result of selection pressure due to agrochemicals and this occur in places where pesticides are more frequently applied, indiscriminately used and misused. Despite increasing concern about overuse and misuse of insecticides in developing countries, insecticide is still intensively used and the massive use of these chemicals have caused detrimental effects on the agroecosystem, such as the acquisition of resistance, pest resurgence/replacement, and environmental pollution. Insecticide resistance may increase insect's vectorial capacity, which may lead to a dramatic increase in the transmission of the disease and even to a higher prevalence than in the absence of insecticides. Disease control failure, however follow from vector control failure. Increase in diseases transmission, mortality, injury to the crop and potential losses in crop production, disruption of biological control programmes and increase in management costs for additional chemical controls to prevent further injury are the consequences of insect resurgence, replacement and or resistance.

Keywords: Usage, insecticides, pests, vectors.

INTRODUCTION

Insecticide-based vector control intervention serve as the mainstay to minimize the vector-borne disease burden throughout the world (Karunamoorthi and Sabesan, 2012). Though effort has been made to introduce environmental, biological, and immunological methods of control, chemical insecticides remain essential to most of the vector-borne disease control programs, especially where no alternative means of preventing transmission of the disease are available (Gratz and Jany, 1994).

An insecticide is any toxic substance that is used to kill or control insects pest that infest cultivated plants or to eliminate disease-carrying insect vectors in specific areas (Melissa, 2019). It is also defined as any substance or a mixture of substances intended to prevent, destroy, repel, or mitigate insects (Manyilizu, 2019; Ramesh, 2016). Agriculture and horticulture, together with vector control programmes account for the greatest use of insecticides. Insecticides are classified on the basis of their chemical compound, mode action or penetration (Ramesh, 2016). Based on their chemical properties, chemical insecticide are classified into four groups; organophosphates, carbamates, organochlorines, and pyrethroids which are widely used for agricultural pest control and various vector control programmes (Ramesh, 2016; Hassan et al., 2018). The synthetic contact insecticides are the primary agents of insect control. In general, they penetrate insects readily and are toxic to a wide range of species (Ramesh, 2016). Because of worldwide use, these chemicals pose health risks to non-target species, including people, domestic and companion animals, wildlife, and aquatic species (Ramesh, 2016). Most synthetic insecticides are contact poisons which are often sprayed or dusted directly onto plants and other surfaces fed upon by insects (Melissa, 2019). Insecticides are highly effective when optimally implemented (Lengeler, 2004*;* Mabaso et al., 2004), nevertheless the compounding factors such as inadequate resources and operational ability, insecticide resistance, and the use of adulterated or poor-quality insecticides (Karunamoorthi et al., 2010), all combine to reduce their efficiency. Crop damage from insect pest infestations and diseases transmitted by insect vectors often result in serious consequences, warranting the need to use insecticides (Oluwole and Cheke, 2009). However, despite their benefits, insecticides pose potential hazards to human health and the environment when inappropriately handled (Kishi, 2005). Despite increasing concern about overuse and misuse of insecticides in developing countries (Tijani, 2006a), where over 3 million people have suffered severe acute insecticide poisonings (Larsen, 2003), insecticide is still intensively used.

The main strategy for the elimination of insect vectors is the use of chemical insecticides (Cuervo-Parra et al., 2016). Since its discovery, chemical insecticides have represented the most widely method used to control insect vectors especially mosquito. However, the effects of chemical insecticides on vector populations are usually transitory because vectors can rapidly develop resistance against them. On the other hand, the environmental problems caused by the excessive use of chemical insecticides are a matter of current concern (Cuervo-Parra et al., 2016). The use of insecticides has helped to reduce insect-borne diseases. However, the massive use of pesticides has caused detrimental effects on the agroecosystem, such as the acquisition of resistance, pest resurgence, and environmental pollution. Insecticide residues accumulated in plants often end up in water bodies where some vector larvae feeding on such plant debris or grow in water bodies enriched with plant compounds and interactions between these xenobiotics generate tolerance to insecticides or promote detoxification pathways of these insecticides against insects like mosquitoes (David et al., 2006).

NEED FOR INSECT CONTROL

In Africa, rapid population growth, food insecurity, weak control systems, and poverty have accelerated the use and misuse of insecticides (Manyilizu, 2019). Human also continues to face endemic transmission and the re-emergence of vector-borne diseases, principally malaria, dengue fever and dengue hemorrhagic fever (DF/DHF), lymphatic filariasis, Japanese encephalitis, Chikungunya virus, Human African trypanosomiasis, *Leshmaniasis onchocercaisis* and recently zika virus infection. All these parasites and viruses are transmitted to humans by suitable insect vector species, some of which are capable of transmitting more than one disease pathogen (Manguin et al., 2010). In order for humans to sustain life and productivity, food security, and safety for survival and growth, control and manipulation of obstacles or challenges by humans are unavoidable (Manyilizu, 2019). Insecticide are important for economic development, food security (enough food, to avoid hunger), food production (able to conduct agricultural activities for food availability without pest disturbance), food safety (preventing biological harm to consumers), food quality (appearance and texture), vectors of diseases control, improving human and animal health, decreasing morbidities and mortalities and insect nuisance control (Manyilizu, 2019). Insect vectors spp transmit pathogens to humans resulting in significant morbidity and mortality as well as placing a profound burden on human productivity and development (Chareonviriyaphap et al., 2013). Despite decades of organized vector control efforts, malaria, dengue, lymphatic filariasis and Japanese encephalitis, remain real threats in some part of the world (Chareonviriyaphap et al., 2013). One of the most effective means of prevention of these diseases involves vector control to reduce the risk of transmission. In some instances, this requires the use of various chemical compounds as insecticide (larvicides applied to aquatic habitats and adulticides to non-aquatic habitat) applications through indoor residual sprays (IRS) and the use of insecticide-treated bed nets in order to reduce vector survival and density and thus human-vector contact (Chareonviriyaphap et al., 2013).

INSECT VECTORS OF DISEASES AND INSECT PESTS OF CROPS

The high population densities associated with environmental modifications have created conditions that favours the proliferation of certain arthropod vectors and pests (Service, 1991). Vector-borne diseases are responsible for 17% of the global burden of parasitic and infectious diseases. Vector-borne diseases pose significant unrestricted health problem globally (Chala and Hamde, 2021). Insect vectors and insect pests include female *Anopheles* mosquito that transmits *Plasmodium* spp causing malaria (Manyilizu, 2019). *Culex* and other mosquito species transmit *Wuchereria bancrofti* causing elephantiasis in Sub-Sahara Africa leading to permanent disability. Fleas harbored by rats transmit *Yersinia pestis* causing plague and tsetse flies transmit *Trypanosoma brucei rhodesiense* and *Trypanosoma brucei gambiense* causing sleeping sickness (Asmare et al., 2017). Locust, grasshopper, weevil and larvae of some lepidoptera are capable of destroying both field and stored agricultural crops. Dengue and Chikungunya viruses transmitted to humans by two main mosquito vectors *A. aegypti* and *A. albopictus*. Mosquitoes of the genus *Aedes, Mansonia* and *Culex* are important vector in the transmission of the yellow fever disease, West Nile and zika virus (Cuervo-Parra et al., 2016).

INSECTICIDE USAGE AND ITS IMPLICATION

For long, chemical insecticide have been used for increasing agricultural productivity and safeguarding the public health. Chemical control of insect vectors and crop pests is a dominant strategy that is commonly applied to control insect pests of crops and insect vectors of diseases in sub-Saharan African countries where there is intense agricultural production, and farming represents the primary source of food and/or income (NEPAD, 2013). The serious use of pesticides in agriculture started in the nineteenth century and expanded in the twentieth century (Jarman and Ballschmiter, 2012). Generally, the intensive use of pesticides is triggered by occurrence of serious crop pests, including insects (Manyilizu, 2019), farmers desire to increase crop yields and the readily availability of agrochemicals (Philbert et al., 2019). Insecticides are often considered a quick, easy, and inexpensive solution for controlling insect pests and insect vector in agriculture, public health and other areas (Karunamoorthi and Sabesan, 2012). Farmers and agricultural operation owners determine insecticide type, quantity and the frequency of application depending on costs, government and industry recommendations, producer instructions, community precedents, and personal experience (Ngowi et al., 2007). Farmers switch pesticide class if inefficacy is perceived, and are less likely to properly dispose of unused or expired pesticides (Reid and McKenzie, 2016). Chemical insecticides such as larvicides, lethal ovitraps and repellents are commonly applied against immature stages and adult insects through indoor residual sprays, fumigants, space sprays and treated bed nets (Manyilizu, 2019). The use of pesticides/insecticides for vector control is promoted by the World Health Organization (WHO) and has proven to be highly effective (WHO, 2006). Today, almost all public health insecticide classes and nearly 90% of all insecticides worldwide are used for agricultural purposes (Ranson al., 2002). The insecticide resistance development in disease vectors are as a result of selection pressure due to agrochemicals (Diabate et al., 2002). Insecticide resistance occur in places where pesticides are more frequently applied (Reid and McKenzie, 2016), indiscriminately used and misused *(*Karunamoorthi and Sabesan, 2012*).* Insecticide wastes and remains are often directly discharged into aquatic habitats which end up forming breeding habitats of some insect vectors and insect pests (Philbert et al., 2019). Surprisingly, insect pest and insect vectors including mosquitoes and other aquatic invertebrates survived such mixtures of insecticide exposures in farms and water bodies in their immature stages (Philbert et al., 2019). This high tolerance of these arthropods larvae to a mixture of insecticides is of public health concern, as it is capable of increasing selective pressure of insect vectors against the relevant insecticides (Oluwole and Cheke, 2009).

Another problem with misuse and abuse of insecticides is the ability of some target insect populations to develop resistance and the resistant strains of the insects multiply and eventually form a majority of the population. And insect spp that is formerly susceptible in an insect population to an insecticide but no longer controlled by the same insecticide is referred to as resistance spp (Melissa, 2019). Hundreds of species of insect vectors and insect pests have acquired resistance to different synthetic organic insecticides, and strains that become resistant to one insecticide may also be resistant to another that has a similar mode of action to the first. Once resistance has developed, it tends to persist in the absence of the insecticides for varying amounts of time, depending on the type of resistance and the species of insects involved (Melissa, 2019). Insecticides may also encourage the growth of harmful insect populations by eliminating the natural enemies that previously held them in check. The nonspecific nature of broad-spectrum chemicals makes them more likely to have such unintended effects on the abundance of both harmful and beneficial insects (Melissa, 2019).

IMPLICATION OF VECTOR RESISTANCE AND REPLACEMENT/RESURGENCE TO PUBLIC HEALTH

Insect vectors transmit many of the most dangerous human diseases and insecticides remain one of the most important element of vector control programmes. After decades of repeated use of insecticides, most of these vector species have demonstrated the capacity to evolve resistance to the chemicals. Insecticide resistance is generally considered to undermine control of vector-transmitted diseases because it increases the number of vectors that survive the insecticide treatment and may lead to cross or multiple resistance among different classes of insecticides which could substantially impair the usage of existing insecticides. Multiple resistances are mainly due to the wide-spread and sequential application of different classes of insecticides to control several species of insect vectors and insect pests (Diabate et al., 2002). Insecticide resistance may increase the insect's vectorial capacity, which may lead to a dramatic increase in the transmission of the disease and even to a higher prevalence than in the absence of insecticides (Ana et al., 2010). Disease control failure, however follow from vector control failure (Rivero et al., 2010).

Insect vector and pest resurgence can also occur when an insecticide treatment destroys the pest or vector population and kills, repels, irritates or otherwise deters the natural enemies or when an insecticide treatment controls the primary insect vector or pest. After the expiration of the residual activity of the insecticide, the insect vector or pest population is able to increase more rapidly and to a higher abundance when natural enemies are absent or in low abundance. Replacement of a primary insect vector or pest occurs elevating the secondary insect vector or pest to primary status. Disruption of natural controls is not always the cause of resurgence or replacement events. A dose-response phenomenon called hormesis can occur in insect vector or pest populations exposed to sublethal doses of insecticides. This often leads to an increase in fecundity (physiological hormoligosis) or oviposition behaviour (behavioural hormoligosis) of the insect vector or pest leading to a significant increase in its abundance.

Primary insect vector or pest resurgence and its replacement by a secondary one are important problems of use of synthetic organic insecticides in health and agricultural system which have persisted up to the present day (Pedigo and Rice, 2006). The consequences of insect resurgence or replacement are an increase in diseases transmission, increase in mortality, increase in injury to the crop and potential losses in crop production, disruption of biological control programmes and increase in management costs for additional chemical controls to prevent further injury (Horton et al., 2005).

CONCLUSION

Arthropod/insect-borne diseases remain a major public health issue and insecticides are often considered a quick, easy, and inexpensive solution for controlling insect pests and insect vector in agriculture, public health and other areas. Safeguarding the public health and increase in agricultural productivity make use of widespread of same insecticides. The use of insecticides has helped to reduce insect-borne diseases. However, despite their benefits, insecticides pose potential danger to public health when inappropriately handled. Injudicious and indiscriminate use of these chemicals and the presence of their residues in soil, air as well as in surface and ground water are of grave-concerns. Contamination by chemical insecticides/pesticides pose significant risks to human health as well as environment and non-target organisms. Intensive and massive indiscriminate use of these chemicals have led to acquisition of resistance, pest resurgence/replacement, and environmental pollution. Insecticide resistance may result to increase in insect's vectoral capacity, which may lead to increase in transmission of diseases concern and even to a higher prevalence than in the absence of insecticides. Increase in diseases transmission and mortality due to vector control failure, injury to the crop and potential losses in crop production, are consequences of insect resurgence, replacement and or resistance due to inappropriate chemical application.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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