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Dr. R Nisha
Assistant Professor (Agricultural Entomology), SRM Institute of Science and Technology, Kattankulathur, Chengalpattu, Tamil Nadu, India

Corresponding Author:
Dr. R Nisha
Assistant Professor (Agricultural Entomology), SRM Institute of Science and Technology, Kattankulathur, Chengalpattu, Tamil Nadu, India

Pesticides on mosquito control *vis-a-vis* health hazards on children's health

Dr. R Nisha

Abstract
Mosquitoes have stood for centuries as one of the most dangerous insects in the world. Although not all mosquitoes indeed cause disease, and not all infections are life-threatening, those that are harmful require serious concern. Many countries face the initial outbreak of mosquito-borne diseases, and before it's too late, it is wise to be precautious and embrace the best mosquito control measures. Pesticides are chemical or biological substances used to kill or repel targeted organisms. All pesticides are poisons. Usage of the pesticides are causing harmful effects on public health and especially children's health is affected much compare to adults. Therefore, implementation of the public health pesticide provisions must include substantial comparative risk-benefit analyses of the significance of mosquito borne disease impacts versus potential human especially children and environmental toxic effects of pesticides used to control public health pests.

Keywords: pesticides, mosquito, health hazards, culicidae, pesticide poisoning, biological control, entomopathogens

1. Introduction
Mosquitoes are medically and veterinary important vectors of the pathogens causing human and animal diseases [1]. Mosquitoes are small, midge-like flies that constitute the family Culicidae. Females of most species are, whose tube-like mouthparts (called a proboscis) pierce the hosts' skin to consume blood. They are generally controlled by conventional insecticides which possess strong secondary effects on the environment. Pesticides are chemical or biological substances used to kill or repel targeted organisms. All pesticides are poisons. Aerosol insecticide sprays, mosquito coils (used outdoors) and insecticide vapour dispensing units (used indoors) can help to clear rooms or areas of mosquitoes or repel mosquitoes from an area. These products should be used in addition to, not in place of, other measures such as appropriate clothing and skin repellents [2]. Pesticides are widely used in mosquito control and there is a need for tools to monitor the toxicity risk of these pesticides to environment and natural predators [3].

2. Mosquito species
Mosquitoes characteristics vary depending on the particular conditions of their habitat of origin. During its life cycle, mosquito goes through four stages, which are egg, larva, pup, and adult, of which the first three stages need stagnant water to develop. Generally, adult mosquitoes are small insects, fragile, with slender bodies, a pair of narrow wings and three pairs of long slender legs. They vary in length from 3.16 to 1.2 inch (5 to 13 mm). They are equipped with an elongated proboscis with mouthparts adapted for piercing skin, which the female uses for snacks and to feed on blood. The following are the common mosquito species [4].

The prevention and control of mosquito-borne diseases globally is conducted through a comprehensive and thorough method of pest management. Where programs are not intended to completely eliminate mosquito populations but rather are aimed to reduce their number and therefore minimize the risk of disease transmission. Methods used to mosquito control include the elimination of breeding sites and the control of mosquito larvae and adults [5].

Table 1: Different mosquito species, their preferred habitat and activity hours

Name	Preferred Habitat	Hours of Activity
Aedes	Temporary floodwater pools, fresh and brackish marshes, containers.	All hours
Anopheles	Fresh- or salt-water marshes, swamps, grassy ditches, the edges of streams and rivers, and small, temporary rain pools.	Dawn, dusk, at night
Culex	Freshwater pools, ditches, ponds, and sewage treatment plants.	Dusk, daytime
Mansonia	Aquatic plants, water lettuce, and cattails.	Sunset
Psorophora	Temporary floodwaters, woodland pools, roadside ditches, and pastures.	Early evening, daytime in shade
Wyeomyia	Bromeliad habitats and pitcher plants.	Daytime

3. Pesticides for mosquito control

Pesticides are chemical or biological substances used to kill or repel targeted organisms. All pesticides are poisons. In many cases they are designed to impact the immune, reproductive, or nervous system of insects. Concerns exist over the safety of present day pesticides. Larvicides, by applying chemical insecticides in the breeding sites, are the best strategy to kill larvae and pupae of mosquitoes in the water. Larvicides are present in several forms ranging from powder, tablets, or liquids and include methoprene, monomolecular surface films, larvicidal oils, chemical insecticides, neurotoxic insecticides, plant-derived products, and larvicidal bacteria (6). Adulticides technique is usually less efficient for mosquito control. However, it is the only way to kill adult mosquitoes and is the last line of defense in reducing mosquito populations. Some of the adult ICIDE used for mosquito control include products derived from microorganisms, plants or minerals, synthetic molecules, organophosphates, some natural pyrethrins, or synthetic pyrethroids [7]. Since its discovery, chemical insecticides have represented the most widely method used to control mosquito-borne vectors.

However, the effects of chemical insecticides on mosquito 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 because it is estimated that about 2.5 million tons of pesticides are used annually, generating worldwide damage amounting to $100 billion annually [8]. Some of the disadvantages that generates when using only chemical products are (a) the selection of new insecticide resistance in pest populations; (b) the resurgence of already treated populations; (c) the generation of waste, risks, and legal complications; (d) the destruction of beneficial species; and (e) the high costs in equipment, labor, and material. In addition, the highly toxic and non-biodegradable properties of insecticides and waste generated in soil, water, food, and crops that affect public health are additional reasons to search new methods to help solve the problems caused by chemical insecticides (8). Consequently, the concept of integrated control arises, a method in which pest and diseases control is performed using chemicals, useful organisms, and cultural practices.

New personal (e.g. clip-on) spatial repellent products containing active ingredients such as metofluthrin are likely to augment the effect of other measures but most have yet to be fully evaluated. Pesticides are used in many products and may affect children's health in a variety of ways. However, there are things parents can do to protect their children from pesticides where they live and play. Pesticide exposure during pregnancy may lead to an increased risk of birth defects, low birth weight, and fetal death. Exposure in childhood has been linked to attention and learning problems, as well as cancer (4). The review is focusing on health effects of pesticides that are currently used for controlling mosquito populations.

3.a. Pesticides commonly used for mosquito control

- Spinosad - Low acute toxicity for humans and pets, and not likely to cause cancer or other long-term harm. Highly toxic to bees. Solution, Powder, Granular, Briquette [9].
- Fipronil - Moderately acutely toxic by ingestion, but not absorbed substantially through the skin. Toxic to the nervous system. Classified as a possible carcinogen by US EPA. In pure form, high acute toxicity to aquatic life and to birds; acute toxicity is less of a concern in dilute products. Pelleted, Powder, Solutions, Granular, Impregnated materials [10].
- Avermectin - High acute toxicity in pure form, but at low concentrations it has low acute toxicity. Toxic to the nervous system and to the developing fetus at very low doses. Not absorbed through the skin to any great extent. Highly toxic to fish and aquatic invertebrates. Ready-to-use solution [9].
- N-Methyl carbamates - Carbaryl Propoxur, High acute toxicity to humans at low concentrations. Toxic to the nervous system, especially for children. Highly toxic to aquatic life. Aerosol, Granular, Solution, Impregnated materials [11].
- Neonicotinoids - Acetamiprid, Dinotefuran, Imidacloprid, Thiamethoxam. Moderate acute toxicity to humans and absorbed through the skin to some extent. Toxic to the nervous system. Imidacloprid has been shown to reduce sperm counts in laboratory animals with long-term exposure. Most are highly toxic to aquatic invertebrates and bees. Acetamiprid has a ranking of hazard tier two, it poses a low acute toxicity risk to humans and is only moderately toxic to bees. Granular, Solution, Aerosol, Impregnated materials [9].
- Pyrethroids - affect the nervous system. Resmethrin have been linked with liver and thyroid problems and they can also interfere with the immune and endocrine systems. It contains the synergist (a chemical that increases the effectiveness of the active ingredient), pipernyl butoxide, which is classified by the EPA as a possible human carcinogen. Sumithrin may affect the central nervous system. It contains 10% pipernyl butoxide. Sumithrin was shown to demonstrate significant estrogenicity. This means it may promote tumor growth in cancers of the reproductive organs including breast cancer and prostate cancer. PERMETHRIN is a synthetic pyrethroid insecticide and neurotoxin. It is more acutely toxic to children than to adults. The US Environmental Protection Agency (EPA) has classified it as a human carcinogen and it has been shown to cause immune system damage as well as birth defects. Pyrethroids are highly toxic to fish, crustaceans, and bees. For that reason, EPA has

established restrictions that prohibit their direct application to open water within 100 feet of lakes, steams, rivers, or bays [9].

- Malathion - is an organophosphate insecticide that can cause acute and long-term neurological health problems. Malathion is being reviewed by the EPA for its potential as a low level carcinogen. It is toxic to fish and highly toxic to aquatic invertebrates and amphibians [12].

4. Health Effects of Pesticides in children

Health effects of pesticides can cause both acute and chronic problems. Acute health effects appear shortly after exposure to these pesticides and can include: skin and eye irritations, headaches, dizziness and nausea, weakness, difficulty breathing, mental confusion and disorientation, seizures, coma, and death. Chronic health effects may not be apparent until months or years after exposure. Such health aliments include nervous, reproductive, and immune system disorders, and cancer [4].

4.a. Children at Higher Risk for Exposure

Children face a higher risk from pesticides because they may be more susceptible than adults or more greatly exposed than adults, because their internal organs are still developing and maturing. Children's behaviour, playing and ignorance of risks, result in greater potential for exposure. Malnutrition and dehydration increase their sensitivity to pesticides. Currently around 200 million children are suffering from malnutrition [13]. They can come into contact with pesticides stored or applied in their homes, yards, child care centers, schools, parks, or on pets. Young children, as parents know, love to put their hands in their mouth. They also crawl and play on floors, grass, or in spaces that might contain pesticides. Because pesticides are still in many places in our environment, a child's amount of exposure can add up quickly [14].

Pesticides are still found in:

- Food
- Insect repellents
- Rodent control products
- Lawn and garden care products
- Pet products

These exposures usually do not lead to instant poisoning symptoms. However, studies suggest that exposure may affect healthy child development.

Pesticides are one of the five worst threats to children's health. The other four are lead, air pollution, environmental tobacco smoke, and drinking-water contamination. Children can be particularly sensitive to exposure to chemicals due to their small body size, immature immune systems and rapid growth cycles. Although everyone is at risk from exposure, the most vulnerable groups are children, pregnant women, the elderly, patients undergoing chemotherapy, and people with compromised immune systems. All pesticides are associated with some risk of harm to human health and the environment. Every pesticide on the market must be registered with the Environmental Protection Agency (EPA). This registration does not guarantee the safety of the product even when used as directed. In fact, the EPA has officially stated that no pesticide can be considered safe and federal law prohibits manufacturers from making claims that EPA registration of their products means they are safe. This paper will familiarize the reader with health effects of pesticides used for mosquito control in New York State. The following section summarizes information about the health and environmental risks that people who are exposed to pesticides face. Specific research reports and studies, as well as selected newspaper articles, support the view that further work is needed to find safe, non-toxic alternative to pesticides [9].

Pesticides have been associated with the development of certain cancers in children, including leukemia, sarcomas, and brain tumors. Many classes of pesticides have been shown to adversely affect the developing nervous system of experimental animals. Parental exposure to pesticides has been linked with birth defects in children [15].

Sources of exposure

- Diet can be a major source of exposure for children. As they grow, children drink more water and eat more food, per body weight, than do adults. Water and food containing pesticide residues may therefore be a source of chronic, low-level or high-level pesticide exposure.
- Growing food on or near contaminated soils, using contaminated water on crops or for washing puts people – and children – at particular risk.
- When a mother to be is exposed to pesticides, the child becomes exposed as well, before birth, while still in the womb. Small children can also come into contact with persistent and bio-accumulative pesticides through breast feeding. Protecting pregnant women and lactating mothers from exposure to toxic contaminants is therefore crucial.
- Pesticides used in the field or in the household are often stored improperly in or around farmers' homes where family members can easily access them. These toxic substances may contaminate food or water and cause air pollution. In some instances, the empty pesticide containers are reused to store water and food.
- Children tend to explore their immediate environment, play close to the ground and put things in their mouths. As a consequence, they may receive significant doses of pesticides from soils, dusts and contaminated objects that can be found in rural areas, homes or gardens.
- Poverty - Poverty can put children in potentially high-risk situations. In poor families, children often help out on family farms where pesticides are used. Pesticide users, including teenagers, may lack access to protective equipment such as gloves and masks, and receive no training. As a result, pesticides are often being used by young workers carelessly, and without protection. In many developing countries, the marketing and advertisement of pesticides is often uncontrolled or illicit. Misbranded or unlabelled formulations, including ready-made solutions in soft drink bottles and other unlabelled liquid containers, are sold at open stands. Low retail prices promote pesticide use but weak legislation and inadequate law enforcement fail to control risks [13].

4.b. Pesticide Poisoning

- It has been reported that an estimated one million to five million cases of pesticide poisonings occur every year, resulting in several thousands of fatalities, including children, and Most of the poisonings take place in rural areas of developing countries, where safeguards typically

are inadequate or lacking altogether. Although developing countries use 25% of the world's production of pesticides, they experience 99% of the deaths due to pesticide poisoning [13].

- Poisons are absorbed through the skin, by the mouth, or by breathing sprays, dusts, or vapors. You or your children can be poisoned if you apply or are present during application of the chemical. Also if you touch contaminated grass, shoes, clothing, lawn furniture, etc., or put contaminated objects (e.g., toys, grass, etc.) or fingers in the mouth [9].

In recent years, products with some highly toxic pesticide ingredients have been removed from store shelves. And while more education on pesticides and better packaging have helped, thousands of cases of pesticide poisonings are still reported to US Poison Control Centers every year [16].

Pesticide poisoning can occur via breathing, drinking or eating, or through the skin or mucous membranes. The symptoms resulting from acute poisoning may range from fatigue, dizziness, nausea and vomiting, to respiratory and neurological effects that may be life-threatening. Chronic, and even low-level exposure to pesticides has been linked to cancer, birth defects, and damage the nervous and the functioning of the endocrine system.

Signs of pesticide poisoning

The signs of pesticide poisoning may look like the flu. If your child shows any of the following signs after coming in contact with a pesticide, call the Poison Control Centers national hotline phone number, 1(800)222-1222, right away.

- Headaches
- Dizziness/Weakness
- Muscle twitching
- Difficulty breathing
- Skin rashes
- Eye burning
- Change in overall level of alertness

4.c. Organophosphates and carbamates

Organophosphates and carbamates are toxic to the nervous system, and some of the pesticides are believed to be toxic to the reproductive system and disruptive to endocrine function. Organophosphate insecticides are phosphoric acid derivatives, having activity against a wide spectrum of invertebrate. It interferes with the action of enzymes called cholinesterases that regulate the neurotransmitter acetylcholine, resulting in first instance to muscle cramps, paralysis, and eventually death (10). Therefore, these insecticides have a toxic action that blocks an enzyme acetylcholinesterase of central and peripheral nervous system of insects, in synaptic junctions. The enzyme rapidly hydrolyzed acetylcholine, resulting in the repolarization of the membrane or the basal plate in neuromuscular connections, preparing for the arrival of a new impulse. By forming strong covalent bonds between insecticide and acetylcholinesterase, the enzyme is inhibited, causing the accumulation of acetylcholine in the synaptic junction and the interruption of normal transmission of nerve impulses [12].

Furthermore, carbamate pesticides, just like organophosphates, act by inhibiting the cholinesterase enzyme. Therefore, the symptoms experienced by insects per carbamate poisoning are similar to those experienced with organophosphates. However, carbamate pesticides block acetylcholinesterase enzyme hydrolyzing acetylcholine in muscle by carbamylation, which is a reversible reaction [9] Therefore, the recovery of carbamate poisoning in humans is faster than with organophosphate intoxication since the acetylcholinesterase enzyme is able to break apart of the carbamate [17].

Two behavioral traits associated with children's exposure to pesticides include their hand-to-mouth behavior, which increases their ingestion of any toxic chemical in dust or soil, and their likelihood of playing close to the ground. Both of these behaviors increases childrens exposure to toxins in dust, soil, and carpets, as well as to toxins that form low-lying layers in the air, such as certain pesticides [18].

4.d. Organochlorines

Organochlorine insecticides are chlorinated hydrocarbons, which are known to be effective to control mosquito populations. Its mode of action is by inhibiting GABA receptor in the nervous system through the interruption of nerve impulses due to the closure of chloride channels [9]. Therefore, when an organochlorine binds to a GABA receptor, the receptor is unable to close GABA chloride channel, which results in stimulation of the nervous system and similar symptoms to poisoning with carbamates or organophosphates [19]. However, with the Stockholm Convention on Persistent Organic Pollutants, which entered into force on May 17, 2004, the use of 12 chemicals including DDT, aldrin, dieldrin, heptachlor, mirex, chlordecone, and chlordane was prohibited because of its long average life and toxicity [12].

4.e. Synthetic Pyrethroids

On the other hand, pyrethroids and pyrethrins used to control mosquitoes break down faster in the sunlight as opposed to chemical or microbial breakdown. However, pyrethroids are considered axonic poisons, composed of more stable substances, or degrade slower in the presence of sunlight than pyrethrins and are generally effective against most of the insect pests of agriculture. Furthermore, pyrethroids can be combined with other active ingredients, such as piperonyl butoxide, to retard its degradation and prevents the insect's system from detoxifying the pyrethroid, making it more effective [9].

Delay that allows the chemical product persists longer in the environment, requiring smaller and less frequent doses to kill pests [20]. This type of insecticidal affects the central and peripheral nervous system of insects and have a rapid knock-down effect, by interfering with the sodium channels of nerve membrane causing the interruption of the transfer of ions and transmission of impulses between nerve cells [21]. Moreover, it stimulates nerve cells to produce repetitive discharges and eventually cause paralysis and death [22]. Furthermore, because pyrethroids act on the nervous system of insects through a different pathway from the organophosphate pesticides, they generally have low toxicity in mammals and birds; however, they are toxic to fish and tadpoles [23].

Two basic poisoning syndromes, Type I and Type II, are seen. Type I pyrethroids produce reflex hyperexcitability and fine tremor. Type II pyrethroids produce salivation, hyperexcitability, choreoathatosis, and seizures. Both produce potent sympathetic system activation. Local effects are also seen: skin contamination producing paresthesia and ingestion

producing gastrointestinal irritation [9].
Adulticiding, or spraying to kill adult mosquitoes, has not yet been proven effective. The Centers for Disease Control and Prevention state that ground and aerial spraying is usually the least effective mosquito control technique. Also included in the report are health effects of pyrethroids such as "asthmatic breathing, sneezing, nasal stuffiness, headache, nausea, incoordination, tremors, convulsions, facial flushing and swelling, and burning and itching sensations. Pyrethroid insecticide poisoning can be of unexpectedly long duration. Pyrethroids can produce reflex hyperexcitability and fine tremor, salivation, choreoathetosis (involuntary movements), and seizure. Several studies indicate that pyrethroids disrupt the endocrine system by mimicking the effects of the hormone estrogen, which can cause breast cancer in women and lowered sperm count in men [23].
The EPA classifies permethrin as a possible human carcinogen on the basis of animal studies in which mice developed tumors at high dose levels. Allergic responses range from mild to severe skin rashes to sneezing and other respiratory problems, such as asthma, sinusitis, and bronchitis [23].

5. Safety approaches to prevent ill effects of pesticides

The control measures outlined below are best used in combination to control mosquito population without much effect on the environment. Removing breeding sites and using window screens can potentially reduce the number of mosquitoes in and around.

5.a. Firstly we can use environmental friendly pesticides as follows, [23].

Microbial agents

Entomopathogenic virus- Among biological agents used for mosquito control can be mentioned derivatives of viruses, bacteria, and fungi. Entomopathogenic virus spreads from one insect generation to the next causing paralysis and eventually death on mosquito larvae being more effective in the first stage of development [24].

Entomopathogenic bateria - *Bacillus thuringiensis-Bacillus thuringiensis Israelensis* (Bti), *Bacillus sphaericus* 2362, Serotype H5a5b

Practically nontoxic to humans, pets, fish and wildlife. Both strains occur naturally in the environment and are highly selective toxins that only target mosquito larvae and that of a few related flies. It's available in the form of granular, Briquette, Solution & Dust formulations. These bacteria, during the sporulation process, produce protein crystals with insecticidal effect and/or some toxins with the same effect [25].
Bacillus initially causes diarrhea and intestinal paralysis in mosquito, giving rise to a decrease of body movements, convulsions, and general paralysis. Internally, within the mosquito stomach, B. thuringiensis releases toxic crystals that paralyze the insect gut stopping peristalsis, causing that the insect stop feeding and die by starvation. Within the gut, bacteria multiply until they break the epithelium and invade the rest of the insect body. However, its use for mosquito control is scarce and presents some drawbacks as its duration in the environment is limited, its dispersion is rather inefficient, and the susceptibility to bacterial infection in the pest population is very heterogeneous. There are very sensitive individuals and other highly resistant.

Entomopathogenic fungus - *Lagenidium, Entomophaga, Neozygites, Entomophtora, Erynia, Aschersonia, Verticillium, Nomuraea, Hirsutella, Metarhizium, Beauveria,* and *Paecilomyces* genera [26].

Fungi are other microorganisms that may be used to control mosquito vectors, of which 400 species are known with insecticide potential. Although, entomopathogenic fungi are not as specific as bacteria or viruses, spores persist and infect insect successive generations, so that when the infection is established, its effects can last several years. Infection occurs by adhesion of the spores on the insect cuticle, where these germinate and penetrate the cuticle leading to insect colonization by mycelium. Cuticle penetration occurs through the use of an enzyme complex that the fungi use to feed. The entomopathogenic fungus most used in controlling mosquito infestations is *Beauveria bassiana*, which produces various active ingredients such as beauvericin [27].

Biocontrol Agents - Predators and parasitoids

The biological control of mosquito larvae with predators and other biological control agents could be a more effective and environmentally friendly strategy, thus avoiding the use of synthetic chemicals and the consequent environmental damage [28]. Among them, some insects and vertebrates such as fish, amphibians, and some mammals have the potential to control mosquito disease–vector populations. Within vertebrates, amphibians, bats, and fish have been used to control populations of mosquito. For example, using larvivorous fish species, control of mosquito larvae in deposits used to store water has been achieved [29]. Moreover, bats are responsible for capturing flying insects such as mosquitoes at night; similarly, toads and frogs consume large numbers of insects, slugs, worms, and other invertebrates [30]. However, the use of frogs and tadpoles for disease vector control is still largely unexplored.

Botanicals- Linalool, Neem oil, Nepeta cataria oil (catnip), Oil of cedar wood, Phenylethyl propionate

When plant and plant derivatives applied correctly, can control insect pests such as mosquito in an efficient manner. Due to their environmental advantages, the use of insecticides of vegetable origin in pest management has been increasing [31] Among plants with potential activity against mosquitoes, Nim or Neem (*Azadirachta indica)* causes stunted growth, loss of appetite, reduction of fertility, molting disorders, morphological defects, and behavioral changes [20]. Moreover, it has been demonstrated that raw or partially purified plant extracts are most effective for mosquito control in place of the purified compounds or extracts [32].
The Tobacco (*Nicotiana tabacum*) is used as insect repellent and nicotine acts on the nervous system of insects through breathing, ingestion, and contact [33]. Other plants from which oils are extracted are garlic (*Ocimum basilicum*) and cinnamon (Cinnamomum osmophloeum), which have been shown to have insecticidal properties against larvae and adults of *A. albopictus, Culex quinquefasciatus, and Armigeres subalbatus*. Several naturally occurring substances are available in products sold for mosquito control, including neem and linalool (from mint and citrus plants). Contamination of surfaces with these common components of foods is not hazardous, but inhalation of the spray can be problematic. It's available in the form of Spray& Solution

formulations.

Biorational insecticides also can be used due to human and environment concern - Insect Growth Regulators-(IGR) Pyriproxyfen, Methoprene, Diflubenzuron

Biorational insecticides are those that have relatively low toxicity to humans and have few environmental effects. Among which, methoprene is an insect growth regulator insecticide with a broad spectrum of action that interferes with the insect life cycle preventing maturity or reproductive stage [34] Meanwhile, the juvenile hormone analogue is a biorational insecticide that causes deformations in larval stage, death in the pupal stage, and sterility effect in adults [35].

Spinosad is another biorational insecticide that comes from *Saccharopolyspora spinosa* neurotoxin, made by a mixture of spinosyns A and D. Spinosad act on the postsynaptic nicotinic acetylcholine receptors and GABA receptors and has proven its usefulness in the dipterans control [36]. Pyriproxyfene is another new-generation insecticide that has been tested in adult and larval mosquitoes causing a reduction in the number of sperm, egg production, blood feeding, and mating activity [37]. Very low acute and longer-term toxicity to humans. High toxicity to aquatic invertebrates. Diflubenzuron affects the hemoglobin of animals in studies. P-chloroaniline (PCA), a metabolite of diflubenzuron, is classified as a probable human carcinogen. Most products with IGRs also contain an insecticide, usually a pyrethroid. It's available in the form of Aerosol, Solution, Powder, Pelleted/tableted & Impregnated materials formulations

Ketones- Dihydro-5-pentyl-2(3H)-furanone

Poses a low acute toxicity risk to humans and pets. Slightly toxic to freshwater invertebrates. It's available in the form of Granular & Solution formulations

Polyalkyloxy Compounds-Butoxy poly propylene glycol (BPG), Poly (oxy-1,2-ethanediyl), alpha-isooctadecyl-omega-hydroxy

Low acute toxicity. BPG is never used as the sole active ingredient in a product, but is often used with pyrethrins, piperonyl butoxide, and pyrethroids. It's available in the form of solution & Spray formulations

5.b. Remove Habitat

The best way to avoid mosquito bites is to locate and remove standing water where mosquitoes can lay eggs. Larvae are usually found on the surface of stagnant water. While it is unlikely that you can eliminate every possible area where water pools, you can minimize popular mosquito habitats.

- Remove any items located outdoors that can collect water, including buckets, old tires, bottles, wheelbarrows, and cans. For inflatable or kiddie pools, change the water frequently, drain or cover when not in use.
- Keep swimming pools circulating and chlorinated at all times.
- Avoid creating small puddles with excessive irrigation. Check to make sure plants have proper drainage and maintain vegetation to reduce the number of places where adult mosquito can take shelter.
- If your home has a septic tank, test it for proper functioning and make sure that no puddles form in the drain field.
- Remove debris from rain gutters regularly and keep street gutters clear to prevent water runoff from pooling. Remember to check items stored outdoors, like plastic tarps, as well as tree stumps for standing water [38].

5.c. Use Natural Enemies

Consider using mosquitofish in areas where standing water cannot be drained in natural pools and ponds. Several species of birds, bats, fish, spiders and predatory insects also eat mosquitoes and will complement other control methods. The mosquito-eating fish, *Gambusia affinis*, is an important control agent for immature mosquitoes. It feeds on the larvae and is most effective in ornamental ponds or other man-made bodies of water that do not connect with natural waterways. Never release mosquitofish into streams, ponds or lakes as they can become invasive [11].

5.d. Seal Them Out

Exclude mosquitoes by keeping doors and windows tightly shut or add screens with insect-proof netting. Keeping fine mesh screens in good repair will maintain an effective barrier. For mosquitoes that do make it inside, try to kill them with an old-fashioned fly swatter.

5.e. Minimize Exposure

- Prevent bites by avoiding the outdoors when mosquito activity is at its greatest, often at dawn, early evening and dusk.
- If staying inside is not an option, wear long sleeves and pants or a hat with netting to minimize exposed skin and avoid areas like swamps, marshes, and slow moving streams where mosquitoes thrive.
- Avoid shady shots and places sheltered from the wind. Biting is less of a problem in sunny, brightly lit areas and a breeze will make it harder for mosquitoes to find you.
- Turn on a fan, moving air will keep mosquitoes and other weak flyers away. This works best in a relatively small area where you can set up a fan or two to create good air flow.
- If there are more mosquitoes in the house than you can kill with a fly swatter, cover beds with netting, especially cribs [39].

5.f. Minimizing the risk of pesticides on children [13]

To reduce pesticide poisoning, FAO, UNEP and WHO urge:

- to reduce and eliminate possible sources of pesticide exposures to children at home and at work;
- to keep pesticides out of children's reach and store them securely in containers that are properly labelled and use child-proof tops;
- to reduce the use of agricultural pesticides through Integrated Pest Management (IPM):
- to train health care providers on the recognition and management of pesticide poisoning;
- to provide training for people on how to use pesticides judiciously and how to prevent exposure;
- to run information and education campaigns via TV and radio programmes;
- to reduce the risks associated with the use of pesticides through a comprehensive life-cycle approach, i.e. addressing all aspects of pesticide management from manufacturing until use or disposal following the FAO International Code of Conduct on the Distribution and Use of Pesticides [40].

6. Precautions to Take When Using Mosquito Control pesticides [11, 40].

- Never spray repellents directly onto your face; apply first onto your hands, then apply the product lightly onto your face and head. Better yet, apply the repellent to a hat and wear the hat.
- Use repellents sparingly; applying heavier doses does not increase protection. Repellents do not kill mosquitoes; they discourage them from attacking treated areas. Effectiveness and duration of repellency vary considerably, with most lasting for four hours or less.
- Apply repellents only to clothing and exposed skin; never use underneath clothing. Do not apply on cuts or irritated skin.
- Never apply oil of lemon eucalyptus on children under three; it has not been tested on children of this age. Do not allow children to handle mosquito-control products.
- Always read and follow the label instructions on the pesticide product. The label is the law.
- Use only US EPA-approved products [20].

7. Tips to Reduce Your Child's Chances of Pesticide Poisoning [13]:

- Reduce exposure to pesticides in foods. Organic produce has been found to have less pesticides and a potentially lower risk of exposure to drug-resistant bacteria. However, the most important thing for children is to eat a wide variety of produce, whether it's conventional or organic. See the AAP clinical report, Organic Foods: Health and Environmental Advantages and Disadvantages, for more information.
- Wash and scrub fruits and veggies under running water. This can help reduce any traces of pesticides that remain on the surface, advises the U.S. Environmental Protection Agency
- Store chemicals safely to reduce the risks for children. Keep these common household pesticides out of children's reach and never put poisonous products in containers that could be mistaken for food or drink:
  - Bath and kitchen disinfectants and sanitizers-including bleach
  - Products used to kill mold or mildew
  - Roach sprays and baits
  - Insect repellents
  - Rat and other rodent poisons
  - Weed killers
  - Flea and tick shampoos, powders and dips for pets
  - Swimming pool chemicals
- Read pesticide labels first. Follow the directions as they are written on the label before using a product. For example, pesticides you use to control fleas and ticks on your pets can be transferred to your children. Protect your pets and children by carefully following the label directions and precautions (website: University of Florida Entomology and Nematology Department).
- Never use bug bombs or broad spraying pesticides. Use chemical-free pest control products or the least toxic method for common household and garden pest problems. When chemicals are necessary, the AAP recommends the use of less-toxic choices, such as boric acid in crevices or bait stations and gels, which minimize exposure to children. Simple actions such as maintaining a clean home, taking out the trash, eliminating household sources of moisture and storing food properly can help the situation. These practices should take place in homes and schools to avoid having to use pesticides.
- Children should not participate in the application of fertilizer. Kids should stay off the lawn after a chemical fertilizer has been applied until it's been exposed to at least a quarter inch of rain or a good watering. Then, wait at least 24 hours before you allow kids to play on the lawn.
- Do not use lindane on children. Talk with your child's pediatrician about head lice control without pesticides.
- If you work with pesticides, be sure you don't "take them home" on your clothes and shoes. Try to change clothes before coming home and remove and store shoes outside.
- Work with schools and government agencies to encourage the use of products with the least-toxic pesticides. Promote community "right-to-know" procedures when pesticide spraying occurs in public areas [21].

8. Conclusion

Pesticides have a role in public health as part of sustainable integrated mosquito management. Other components of such management include surveillance, source reduction or prevention, biological control, repellents, traps, and pesticide-resistance management. We assess the future use of mosquito control pesticides in view of niche markets, incentives for new product development, Environmental Protection Agency registration, the Food Quality Protection Act, and improved pest management strategies for mosquito control [11]. Although the development of new mosquito insecticides, particularly adulticides, is not expected to accelerate in the near future, integrated pest management tools and techniques should improved and also the need to control continued mosquito borne disease outbreaks. Integrated pest management tools have strengths and weaknesses, and continued availability of adulticides is critical. Therefore, implementation of the public health pesticide provisions must include substantial comparative risk-benefit analyses of the significance of mosquito borne disease impacts versus potential human and environmental toxic effects of pesticides used to control public health pests. Public information and legislative campaigns have also become necessary to preserve the availability and use of pesticides for mosquito control.

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