Ministry of Health
National Malaria Control Centre

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Insecticide Guidelines for IRS

Indoor Residual Spraying

02

Ministry of Health
National Malaria Control Centre

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1.0 Introduction

Vector control is an important part of the current global strategy for controlling major vector-borne diseases, and chemical control the most important element in an integrated approach to vector control. In order to facilitate the safe and judicious use of insecticides in vector control programmes, there is need to develop an insecticide management system based on regular monitoring and reporting of insecticides used in the different disease control programmes.

Insecticides have been the cornerstone of vector-borne disease control for the past fifty years. The first global campaign to combat malaria was the World Health Organization's (WHO) Malaria Eradication Programme which ran from 1956 to 1967 and depended greatly on Indoor Residual Spraying (IRS). Today, IRS continues. Four different classes of chemical insecticides—organochlorines, organophosphates, carbamates and pyrethroids—are in use and play a significant role in public health through vector control programmes. In recent years, the use of pyrethroid insecticides has increased, whereas the use of organochlorines and some of the more toxic organophosphate compounds has decreased.

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Generally, all insecticides are poisons and can be harmful if improperly used. Users should

be fully aware of the hazards they pose. They can enter the body by three different routes: the skin (dermal absorption), the mouth (ingestion), and the lungs (inhalation). Poisoning may occur while preparing, spraying, storing, or transporting insecticides. Taking special safety precautions and using common sense minimizes the risk of poisoning that insecticides not only pose to users, but to other people, non-target organisms, and the environment (including drinking water, food, and soil).

Precaution must be central to a proper insecticide management and monitoring system. People who work with insecticides should receive quality training in procedures for handling insecticides safely.

These guidelines contain fundamental information and instructions for health workers and partners who control malaria through IRS in Zambia. It is hoped that their adherence to these guidelines will facilitate the judicious use of insecticides in malaria control and reduce disease burden in Zambia.

2.0 Definitions

2.1 Insecticide

An insecticide is a toxic chemical that is used to kill insects, but can also injure and even kill people, animals, and plants if improperly used. Properly used, lethal doses of insecticide can be given to insects without doing collateral harm.

2.2 Formulation

Insecticides are seldom used at full strength but, rather, formulated with other substances. Thus, an insecticide as it appears on the market is composed not only of a toxic part (either called the toxicant or the active ingredient), but of a toxic part and one or more non-toxic parts (often referred to as inert materials). The typical ingredients of a formulation include an active ingredient, solvents, carriers, surface active agents, and special additives. The inert materials may serve to dissolve the active ingredient, act as carriers, disperse the active ingredient, improve effectiveness, reduce toxicity, or break the active ingredient down into smaller parts, making the resulting formulation diluted, extended, and easier to apply. Formulation has great influence on the effectiveness of an insecticide.

2.3 Active Ingredient

The active ingredient is the toxic or poisonous part of the insecticide. It is the most important part of a formulation as it determines the other ingredients. Relevant properties of active ingredients include its melting or boiling point, water solubility, and stability.

2.4 Toxicity

Toxicity measures the degree to which a substance may cause harm to human, animal, or insect. It is usually expressed in terms of Lethal Dosage (LD). To compare the toxicity of various insecticides, the value of Lethal Dose 50 (LD50—see below) is used. Acute oral and acute dermal toxicity is measured by observing test animals' responses to single doses of toxin. Toxin doses are measured in milligrams of active ingredient per kilogram weight of test animal (e.g. rat, rabbit). A milligram is one millionth of a kilogram so these units are called parts-per-million (PPM).

2.5 LD50

LD50 refers to the dose, measured in PPM, of a chemical that kills 50% of a population of test animals. Insecticides

are divided into various hazard classes according to their LD50 values. The toxicity of an insecticide is determined by the concentration of its active ingredient and its formulation. For any insecticide, a granule formulation is safer to use than a spray, and a coarse spray is safer to use than an aerosol.

The most highly toxic chemicals are applied as granules since fine powders are too easily inhaled.

"LD50 refers to the dose, measured in PPM, of a chemical that kills 50% of a population of test animals"

A chemical's LD50 value is not absolute: it varies between different species of animals and even different individuals within a single species of animal. Each species, and each individual (to a lesser extent), reacts differently to different chemicals. This often causes toxicity to be misinterpreted but also allows for species targeting. Toxicity also varies depending on the route of absorption into the body. An LD50 value of a chemical may vary depending on whether it enters the body through the mouth (ingestion), the skin (dermal absorption), or the lungs (inhalation).

2.6 Modes of Action

Insecticides generally kill insects by interfering with their normal life processes. Different insecticides have different modes of action in killing insects. For example, some insecticides kill insects on contact by interfering with their nervous systems. Insecticides that kill on contact are called knockdown insecticides, while others, which kill in time, are called systemic insecticides.

3.0 Insecticide Formulations

As mentioned above, insecticides are rarely used in their pure form (i.e. solely active ingredient). Usually a pure active ingredient is mixed with different inert ingredients to create a formulation that makes it easier to apply the active ingredients. Insecticide formulation can greatly affect the effectiveness of attempts at disease control.

Common formulations come as dusts, wettable granules, wettable powders, emulsifiable concentrates, suspensions, solutions, and capsule suspensions. Dusts are used dry. In general, the smaller the size of the particles of an insecticide, the less toxic it is.

Wettable powders have the appearance of dusts but are meant to be diluted or suspended in water and used as sprays.

To make an insecticide dust (e.g. DDT) act as a wettable powder, a dispersing and wetting agent is added. Wettable powders are more concentrated than dusts and are composed of up to 75% active ingredient. Further details on each type follow:

3.1 Wettable Powders (WP) and Water-Dispensable Powders (WDP)

Powders consist of active ingredients, wetting agents and inert carriers. They tend to be odourless and easily absorbed by porous materials. Special care must be taken while working with them because they are easily inhaled.

3.2 Wettable Granules (WG)

Granules are like wettable powders but less hazardous: they are courser and therefore do not become airborne and inhaled easily.

3.3 Emulsifiable Concentrates (EC)

Emulsifiable concentrates consist of an active ingredient, a solvent, and an emulsifier. The formulation is economical as it may be shipped in high concentrations and diluted later with water. However, they tend to stain sprayed surfaces.

3.4 Capsulated Suspensions

Capsulated suspensions consist of either wettable powder and water or suspension concentrate and water held in a capsule. Since their ingredients take longer to settle, they are easier to keep suspended in water than wettable powders.

3.5 Solutions

Solutions are made up of an active ingredient and a solvent. They are ready-to-use formulations.

4.0 Insecticide Packaging and Labelling

Insecticides should be packaged and labelled according to WHO specifications. Packaging them in water-soluble sachets ensures that the insecticides can be added easily and directly into water-filled spray pumps thereby reducing the hazard associated with handling and mixing them in separate containers.

Labels should be in the English (Zambia's official language) and indicate the following:

(a) Date of manufacture
(b) Date of expiry
(c) Trade or brand name
(d) Generic name
(e) Contents
(f) Ingredients
(g) Net volume or weight
(h) Registration or licence number
(i) Type of formulation
(j) Name and address of manufacturer, distributor, and/or formulator

It should also provide directions for use, safety instructions, warnings (symbolic or textual), and measures to take in case of accident (e.g. ingestion, contamination). It also provides physicians with instructions on which antidote to use in case of poisoning.

5.0 Insecticide Types and their Characteristics

Currently, there are two major classes of insecticides used in Zambia: organochlorines and pyrethroids. Of the organochlorines, only DDT is used. Of the pyrethroids, alphacypermethrine, lambdacyhalothrin, and deltamethrin are used. They are detailed below:

5.1 Organochlorines

5.1.1 DDT

DDT is a white, crystalline, tasteless, almost odourless, solid substance. It does not occur naturally in the environment and is a man-made synthetic.

Thus, the presence of DDT in the environment is generally a result of human dispersal of DDT residuals through land, water, and air.

DDT is insoluble in water, but very soluble in ethyl ether, acetone, benzene, and other organic solvents. It is stable

in strong acids and can withstand acid permanganate oxidation.

It is considered to be a relatively safe insecticide to use in public health vector control activities.

5.2 Pyrethroids

Pyrethroids are a group of synthetic insecticides that are similar to a natural pesticide called pyrethrum, which comes from chrysanthemum flowers. Pyrethroids are widely used to control Malaria vectors.

5.2.1 Alphacypermethrine

Alphacypermethrine is a synthetic pyrethroid insecticide developed specifically for the control of major vectors harmful to public health. It is a broad-spectrum, high performance product that acts through contact or ingestion and provides extended control at exceptionally low dose rates. It is of low mammalian toxicity, and, when used in accordance with directions on its labels, is safe for humans and domestic animals. Alphacypermethrine is available in a variety of formulations and concentrations.

5.2.2 Lambdacyhalothrin

Lambdacyhalothrin is a synthetic pyrethroid discovered the early 1980s as an insecticide for agricultural and public health applications. The compound is made up of two isomeric forms (known as enantiomers) which are present in equal proportions.

It is a broad-spectrum insecticide effective at low rates of application against major insect pests in a wide range of crops. It also has the ability to prevent a build up of insect populations and acts both by direct contact with insects and ingestion.

5.2.3 Deltamethrin

Deltamethrin is one of the most popular and widely used insecticides in the world. It is a broad-spectrum insecticide with uses ranging from agriculture to home pest control. While mammalian exposure to deltamethrin is classified as safe, it is highly toxic to aquatic life, particularly fish, and therefore must be used with extreme caution around water.

6.0 Insecticide Selection

Safety, residual effect (persistence on applied surfaces), ease of handling, cost, and community acceptance all must be considered when selecting a particular formulation.

The vector, environment (including housing), surfaces, and other factors may influence the outcome of IRS.

Therefore, they also must be considered carefully when selecting a suitable insecticide. Specifically, consideration must be given to the following:

(a) Behaviours and ecology of target vectors
(b) Cost
(c) Residual effect
(d) Safety
(e) Biological effectiveness of the insecticide against the target vectors
(f) Susceptibility of the local vector species
(g) Resistance of target vectors to insecticides (not considering this can make vector control difficult

and expensive)

(h) Impact of insecticides on the environment (including non-target organisms, e.g. fish, birds, people)

(i) Registration status of insecticides by relevant regulatory authorities such as the Environmental Council of Zambia (ECZ)

(j) Transportation requirements from point of manufacture to point of use

(k) Availability of application equipment

(l) Close collaboration with suppliers or manufacturers in choosing insecticides most suitable to targeted locales

(m) Type of wall surfaces in targeted locales

(n) Disposal

7.0 Safety in Handling Insecticides

Following guidelines to ensure the safety of the environment and workers, insecticides must be carefully and correctly applied only on target surfaces.

Before any IRS campaign, it is necessary to set up a system for monitoring and evaluating that collects knowledge that can either justify the campaign's continuation or cessation. Relevant information, such as the application experiences of spray operators and the performance of equipment and protective clothing, should be recorded.

Also, the spray operators should know that they need to observe all instructions, restrictions, and precautions on insecticide labels. This requires them to read the instructions carefully.

All insecticides must be stored in a lockable room in their original containers with their labels intact. They should be kept away from food, feed, and clothing, and out of reach of animals, children, and unauthorized people. Experience in dealing with insecticides is useful to ensure safety; services of experienced persons should be engaged as often as possible.

All insecticides must be applied correctly on targeted surfaces to avoid contamination of non-target surfaces. Insecticides should also be applied at correct dosages to avoid excessive residue build-up and injury to non-target plants, animals, and people.

When handling insecticides, the following precautions should be taken:

(a) All Personal Protective Equipment (PPE) should be worn

(b) Before any insecticide is used, its label should be checked for precautions that must be taken

(c) Eating, drinking, and smoking are prohibited

7.1 Storage

It is important that insecticides are correctly stored to maintain their quality. The following should be especially considered in the storage of insecticides:

(a) The store should be lockable, sufficiently far from people's homes, and not susceptible to floods and fires
(b) Unauthorised personnel should not have access to the store
(c) Warning signs should be placed at each entrance of the store
(d) Insecticides should be stored in their original containers with labels intact
(e) Food should neither be stored nor eaten in the store
(f) The store should be kept dry
(g) Insecticides should be stored away from fires and direct sunlight
(h) Insecticide containers should be stacked well to prevent breaks and spills
(i) A bin card for stored insecticides must be available in the store

7.2 Waste Management

Insecticide management should take into account, among other things, empty packaging material, spills, leftover insecticide from the field, expired insecticide, contaminated material, waste from washing, and dead insects . Wasteful disposal can be avoided by accurately estimating amounts needed for field operations. Some aspects of waste management depend on location:

7.2.1 The Field

All empty insecticide containers and left over insecticide should be returned to

the supervisor for safe keeping prior to disposal. Biodegradable waste should be buried but non-biodegradable waste, e.g. DDT waste, should be collected for disposal later.

7.2.2 District Store

The insecticide packaging materials and leftover insecticide should be handed over to the store manager for safe keeping. As above, biodegradable waste should be buried but non-biodegradable waste, e.g. DDT waste, should be collected for disposal later.

7.2.3 Central Level

The principle supplier, in liaison with the National Malaria Control Centre (NMCC), should arrange to reclaim all stored insecticide waste and dispose of it. Foreign suppliers should also liaise with the ECZ to reclaim waste across country boundaries.

The NMCC will, from time to time, review the guidelines and facilitate preparation and implementation of insecticide waste management.

7.3 Regulation of Insecticide Use

Insecticide transportation, storage, disposal, and use are regulated by the Environmental Protection and Pollution Act (EPPA) of 1990 (refer to Guidelines for Sound Management of Indoor Residual Spraying Insecticides).

Vendors conducting door-to-door spraying of housing should be regulated to ensure quality, standardized, and safe spraying services. Insecticide should be handled and used by professionally qualified personnel.

Zambia is currently permitted to use DDT for malaria vector control. The permission is granted provided that Zambian authorities ensure that DDT is used solely for malaria control and in accordance with all the regulations and requirements of the Stockholm and Basel conventions and the WHO. The use of DDT for any other purpose, including agriculture, is strictly banned in Zambia. Locally, DDT use is regulated by the ECZ and the NMCC.

7.4 Procurement

Procurement of insecticides will be centrally done on behalf of implementing districts (refer to the General Guidelines for Indoor Residual Spraying). Others who wish to procure DDT for vector control will do so only with permission from the MOH and ECZ.

7.5 Safety Precautions and First Aid Procedures

The following precautions and procedures should be followed to ensure maximum safety and minimum harm:

(a) If insecticide accidentally comes in contact with skin or clothing, remove the clothing and wash the skin with plenty of water
(b) Keep extra sets of PPE
(c) Maintain effective communication with supervisors (with mobile phones, etc.)
(d) If insecticide is accidentally inhaled, immediately get to a location where there is fresh air
(e) If insecticide is accidentally ingested, rinse the mouth with plenty of water and see a healthcare provider at once (do not induce vomiting unless specifically instructed to do so on the insecticide label)
(f) When consulting a healthcare

provider in case of accident, take the insecticide label

(g) Ensure familiarity with first aid procedures on insecticide labels

"When consulting a healthcare provider in case of accident, take the insecticide label"

7.6 Symptoms of Poisoning

In order to protect one another, workers must know the signs and symptoms of insecticide poisoning. If someone has been poisoned, co-workers should get victim medical help immediately. They should not leave them alone. When taking them to a healthcare provider, they should take with them the insecticide label or, if necessary, the entire insecticide container. If they take the entire container, they should not carry it in the passenger space of the vehicle. Symptoms for different insecticides are detailed below:

7.6.1 Chlorinated Hydrocarbons (e.g. DDT, Chlordane, Lindane)

Not many chlorinated hydrocarbons have poisoned insecticide users. Early indications of poisoning include headache, nausea, vomiting, general discomfort, and dizziness. The victim may also be unusually excited or irritable. With severe poisoning, convulsions occur with or without earlier symptoms. Coma may follow the convulsions (refer to hospital).

7.6.2 Synthetic Pyrethroids (e.g. Deltamethrin, Icon)

Toxicity to warm-blooded animals is generally low, but pyrethrins, the active ingredient in pyrethroids, may elicit inhalant allergic responses: stuffy or runny nose, scratchy throat, asthma and, rarely, anaphylactic shock in extremely sensitive persons. Symptoms can be managed with antihistamines for less severe reactions and adrenalin or hydrocortisone for severe asthma or anaphylaxis.

7.6.3 Organophosphates (e.g. Parathion, Malathion)

Symptoms almost always begin within 12 hours after exposure. They usually occur in approximately the order in which they are listed below:

(a) Mild poisoning causes fatigue, headache, dizziness, blurred or dark vision, excess sweat and saliva, nausea and vomiting, stomach cramps and diarrhoea

(b) Moderate poisoning causes difficulty in walking, weakness, chest discomfort, muscle twitches, pinpoint pupils, and increased severity of earlier symptoms

(c) Severe poisoning causes unconsciousness, severely pinpointed pupils, muscle twitches, secretions from mouth and nose, breathing difficulty, and death if not treated

7.6.4 Carbamates (e.g. Propoxur)

Carbamates cause about the same symptoms as organophosphates, but a physician can treat the poisoning more easily.

8.0 Community Perception of Insecticides

The following are common causes of community perceptions, misconceptions,

and actions that can negatively affect the efficacy of malaria vector control programmes in Zambia:

(a) Lack of adequate information about mosquito behaviour can skew community perception on the effectiveness of insecticides
(b) Community opposition to insecticide based control can be due to a lack of insecticidal effect on non-target insects and pests
(c) Certain social customs, like regular re-plastering and painting of housing, could render sprayed surfaces ineffective
(d) Expectation of immediate mosquito death may influence community acceptance
(e) Communities may expect to both smell insecticide and see dead insects as evidence of working insecticide for long periods of time
(f) Lacking information about why different insecticides are used for different types of housing, communities may believe that some insecticides are simply more effective and, therefore, reserved for people of higher social economic classes
(g) Communities may expect to see neither mosquitoes nor cockroaches in their houses after spraying
(h) Communities may believe that insecticides are over-diluted and stolen. Whether this theft is real or perceived, an explanation of how insecticides are diluted can assuage suspicions
(i) There may be either real or perceived insecticide resistance
(j) Lobbying by environmental groups against certain insecticides (e.g. DDT) may influence community acceptance
(k) Media may serve as a source of information that influences community perception

These problems can be overcome by sensitizing communities about common perceptions, misconceptions, and problems and encouraging their participation in malaria control and prevention campaigns.

Annex

I. Table of Dosages and Duration of Action

Below are the WHO recommended insecticides for indoor residual spraying against malaria vectors.

Insecticide compounds and formulations (1)	Class group (2)	Dossage (g a.i./m^2)	Mode of action	Duration of effective action (months)
DDT WP	OC	1-2	Contact	>6
Malathion WP	OP	2	Contact	2-3
Fenitrothion WP	OP	2	Contact and airborne	3-6
Pirimiphos-methyl WP & EC	OP	1-2	Contact and airborne	2-3
Bendiocarb WP	C	0.1-0.4	Contact and airborne	2-6
Propoxur WP	C	1-2	Contact and airborne	3-6
Alpha-cypermethrin WP & SC	P	0.02-0.03	Contact	4-6
Bifenthrin	P	0.025-0.05	Contact	3-6
Cyfluthrin WP	P	0.02-0.05	Contact	3-6
Deltamethrin WP, WG	P	0.02-00.025	Contact	3-6
Etofenprox WP	P	0.1-0.3	Contact	3-6
Lambda-cyhalothrin WP, CS		0.02-0.03		3-6

(1) CS: capsule suspension; EC = emulsifiable concentrate; WP = wettable powder
(2) OC: Organochlorines; OP = Organophosphates; C = Carbamates; P = Pyrethroids

Source: http://www.who.int/whopes/Insecticides_IRS_Malaria_ok.pdf