

Protecting the health and safety of workers in emergency vector control of *Aedes* mosquitoes

Interim guidance for vector control and health workers

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Contents

| | |
|-------------------------------------------------------|----|
| Introduction | 4 |
| Occupational health and safety measures | 5 |
| Planning for protective measures | 5 |
| Operator protection | 5 |
| Specific safety rules | 6 |
| Safety training | 7 |
| Personal hygiene | 7 |
| Storage and disposal of insecticides | 8 |
| Medical supervision | 8 |
| Management of acute poisoning with insecticides | 9 |
| Symptoms of acute poisoning | 9 |
| First aid and decontamination | 9 |
| Treatment | 10 |
| References | 11 |

Introduction

This document provides recommendations on essential measures to protect the health and safety of operators and other persons involved in emergency vector control of *Aedes* spp. mosquitoes, including space spraying of insecticides, larvicide application and, in some cases, indoor residual spraying. It is intended to be used by vector control managers and operators, public health workers, medical professionals, district health officers and ministries of health.

Space spraying involves dispersing a liquid insecticide into the air to create a fog or aerosol with droplets less than 30 µm in diameter (optimally 10–15 µm). It can be applied using thermal or cold fog methods to disperse the insecticide. Fogging machines can be hand-carried for spraying indoors or mounted on a vehicle for spraying outdoors. The insecticides recommended by WHO belong to the class of pyrethroids with or without a synergist (deltamethrin, lambda-cyhalothrin, permethrin + s-bioallethrin + piperonyl butoxide, and d-d, trans-cyphenothrin) and organophosphorus compounds (malathion). (1)

Indoor residual spraying is done using portable compression sprayers to apply a residual insecticide (e.g. bendiocarb, that belongs to the carbamate class) to selected indoor surfaces such as walls or under furniture. (2)

Larvicides are microbial pesticides, chemical insect growth regulators, spinosyns, benzoylphenyl urea compounds, and organophosphate insecticides applied into the breeding habitats of mosquitoes. (3) Liquid formulations are applied with hand-operated compression sprayers (the same equipment as used for indoor residual spraying) or with backpack sprayers, while solid (granule) formulations are applied by hand. (4)

The insecticides including larvicides used for vector control should be registered for use by the competent national authority.

Occupational health and safety measures

The main tasks associated with exposure of workers to insecticides are: opening containers; mixing and loading spraying solutions; spraying insecticide products with hand-carried or vehicle-mounted equipment; washing and maintaining spray equipment; and disposal of empty containers. Accidental exposure is most often associated with spills, splashes and leakages of insecticide in concentrated form.

The protection of the health and safety of workers involved in insecticide spraying requires a combination of measures for collective and personal protection and medical supervision.

Planning for protective measures

When planning for insecticide spraying operations, include the following protective measures:

- Identify relevant national regulations on pesticide purchase, use and application techniques.
- Identify sufficient numbers of machine operators and ancillary personnel according to the size and characteristics of the area to be treated.
- Consider workers' health and safety in the choice of application equipment and insecticide products. Obtain material safety data sheets for each product and identify after-sales services from the manufacturer such as training and disposal of insecticide containers. Spraying equipment must have safety guards to prevent operators from touching hot surfaces.
- Identify and provide the necessary personal protective equipment (PPE), work clothes, and personal hygiene facilities.
- Provide training to machine operators, ancillary personnel, and supervisors in safe working methods.
- Identify a medical expert trained in occupational health to provide advice on preventive measures and to carry out preliminary and periodic medical assessment of workers for early detection of toxic effects.
- Develop respiratory protection programmes for operations that require the use of respirators, including written standard operating procedures, regular training, fit-testing, fit-checking, maintenance, inspection, cleaning, storage and periodic programme evaluation.
- Calculate the correct flow rate for the product and delivery method in order to reduce the amount of insecticide used and the amount of unused product that must be disposed of.
- Organize operators into squads, in which each person knows precisely what his or her duties and responsibilities are.
- Organize first aid and emergency care procedures. (5)

Operator protection

The protection of workers' health and safety during applications of insecticides should include:

- Daily briefings on measures to protect workers' health and for safe work practices;
- Prohibition of smoking, eating and drinking during the application of insecticides and larvicides;

- Use of appropriate PPE;
- Use of correct maintenance procedures for equipment to ensure that no leakages occur during spraying operations;
- Re-calibrate spray equipment after 25 hours of operation, major maintenance or a change of product;
- Use of semi-closed automatic dilution machine for water-diluted sprays. (5)

The selection of PPE depends on the occupational health and safety risks associated with the different work tasks. The PPE must comply with national regulations on pesticide use and take manufacturers' recommendations into account.

When handling concentrated insecticide products, pouring out, mixing or preparing a spray liquid, and filling equipment wear:

- Cotton coverall covering the arms and legs (two sets should be provided per worker per day to allow for change in case of wetting);
- Rubber chemical resistant protective gloves;
- Hat with broad rim;
- Chemical goggles or face shield;
- Rubber boots. (4,5,6)

In addition to the above, when spraying with hand-held devices and operating vehicle mounted-foggers by hand, wear:

- Air-purifying half-mask respirator with organic vapour cartridge(s) in combination with filters for aerosols and particles, such as N95, R95, or P95 filter (respirator filters must be periodically changed in accordance with the manufacturer's instructions); and
- Ear muffs when working with noisy foggers (5,6)

When applying microbial larvicides and growth regulators, wear:

- Working clothes;
- Rubber gloves;
- Dust masks when handling formulations in granular form. (4)

Specific safety rules

For indoor spraying and fogging:

- Shut off all electricity at the master switch.
- Ask householders to shut all exit points except the main door and be outdoors before space spraying begins.
- Spray operators should start work from the rearmost room, moving backwards and away from the fog to minimize exposure.
- For small single-storey houses, the spray can be delivered from the front door or through an open window without having to enter every room of the house, provided that adequate dispersal of the insecticide droplets can be achieved.
- For large single-storey buildings, it may be necessary to apply the spray room by room, beginning at the back of the building and working towards the front.
- For multi-storey buildings, spraying is carried out from top floor to the ground floor and from the back of the building to the front. This ensures that the operator has good visibility at all times.
- A fog must be "dry" before being directed into a building. Test the fog by placing the machine on the ground and checking that the area immediately in front of the nozzle is not wetted by the fog. To

reduce the production of large wetting droplets, obtain the correct balance between flow rate and combustion temperature. This is usually done by reducing the flow rate. (5,6)

For outdoor ground fogging with vehicle-mounted equipment:

- In areas with narrow roads and houses close to the roadside, the spray should be directed backwards from the vehicle.
- In areas with wide roads and buildings far from the roadside, the vehicle should be driven close to the kerb and the spray directed at an angle (downwind) to the road rather than directly behind the vehicle.
- The nozzle of vehicle-mounted cold fog machines may be directed upwards at an angle when there are barriers that impede airflow e.g. boundary walls and fences. For vehicle-mounted thermal foggers, the nozzle should be directed horizontally.
- The vehicle should move upwind so that the fog drifts downwind away from it and the operators.
- As far as possible, the predetermined speed of the vehicle should be maintained. The spray must be turned off when the vehicle is stationary.
- The downwind side of the spray area should be treated first, working systematically from downwind to upwind areas.
- To avoid driving into the spray cloud, dead-end roads must be sprayed only on the way out. (5)

Safety training

Training in the safe use of insecticides should be provided to:

- **Medical specialists, entomologists, vector control personnel, engineers and safety supervisors:** mode of action of the pesticide; significance of diagnostic measures; recognition of signs and symptoms of toxic effects; when to refer a poisoned worker to a health care facility for treatment;
- **Field team leaders and other operators:** spraying techniques; safety precautions; use and maintenance of protective equipment and clothing; recognition of early signs and symptoms of poisoning; first-aid measures, including resuscitation.

Personal hygiene

Careful attention to personal hygiene is an essential component of the safe use of insecticides. Safety precautions depend largely on the correct use of personal protective equipment and personal hygiene, including washing, changing clothes and cleaning of equipment. Measures for personal hygiene should be organized along the following lines:

- Spraying staff should be provided with at least two sets of coveralls to allow for frequent changes.
- Washing facilities with sufficient water and soap should be made available in the field at appropriate locations.
- At the end of each day of spraying operations, staff should remove all working clothes, shower or bathe and change into clean clothes.
- Transport for staff at the end of each day of spraying operations should be arranged to avoid long delays in return to base for washing.
- Working clothes must be washed regularly - the frequency will depend on the toxicity of the formulation used. Domestic washing should be avoided to prevent household contamination with pesticides.
- Particular attention should be given to washing rubber gloves and to avoid wearing already contaminated gloves – this can be more dangerous than not wearing gloves at all.
- Spray operators must always wash their hands and face with soap and water after spraying and before drinking, eating or smoking. In case of skin contact with insecticide, wash affected area immediately with soap and water.

- Eating, drinking and smoking during fogging operation must be strictly forbidden.
- Working hours must be arranged so that exposure to insecticides does not exceed six hours per day.
- Operators should be encouraged to inform their supervisors immediately if they feel unwell. (4,7)

Storage and disposal of insecticides

All insecticides used in space treatments or larviciding should be stored in a safe, secure place and in accordance with manufacturer's label recommendations. Unused, diluted insecticide must not be left in the spray equipment after fogging or larviciding, or be stored. Unused diluted insecticide and empty containers and sachets should be disposed of in accordance with national guidelines and regulations and the recommendations of the manufacturer. Empty containers should be triple rinsed with the solvent being used (e.g. kerosene oil, diesel, water) and rendered useless before disposal. The rinsate should be used in preparing the subsequent spray liquid as applicable or disposed of in accordance with national guidelines. (4)

Medical supervision

Arrangements must be made to ensure that any exposed person can easily report any symptoms to a supervisor, who will then notify a medical officer. In particular, any unusual illness not associated with well-recognized signs and symptoms of poisoning by a specific insecticide should be noted and reported to the appropriate health authorities. Monitoring should be implemented to detect any subtle neurological effects in exposed persons, such as loss of ability to understand written material and to concentrate. In addition to clinical surveillance, quantitative biochemical tests can be carried out to assess the degree of exposure.

All operators should go through a preliminary health assessment to determine if there are any contraindications for working with the specific insecticides being used. The preliminary health assessment should consist of a physical examination, medical history, occupational history, comprehensive metabolic panel (blood sugar, electrolyte and fluid balance, kidney and liver functions), baseline cholinesterase RBC/plasma tests (for those using organophosphates and carbamates) and pulmonary function test (for those required to wear a respirator). Working with organophosphates and carbamates may cause complications of pre-existing peptic ulcer, bronchial asthma, anaemia, degenerative diseases of the central nervous system, chronic colitis, history or evidence of psychosis, and diseases such as myasthenia gravis and glaucoma, which are treated with cholinesterase-inhibiting drugs. (11)

Management of acute poisoning with insecticides

Symptoms of acute poisoning

The symptoms of acute poisoning after exposure to organophosphates or carbamates may not appear until after the person has left work and therefore may not immediately be associated with occupational exposure. The early symptoms of poisoning include excessive sweating, headache, blurred vision, narrowed pupils, weakness, dizziness, nausea, excessive salivation or bronchial secretion, vomiting, stomach pains, slurred speech and muscle twitching. Later, there may be diarrhoea, loss of reflexes and sphincter control, convulsions and coma. (4)

The symptoms of pyrethroid poisoning can include paraesthesia (a tingling, prickling sensation of the skin), particularly on the face and hands, irritation of the upper respiratory tract, salivation and, occasionally, allergic reactions. If pyrethroids are ingested, prominent digestive symptoms can occur such as nausea, vomiting and epigastric pain. In severe poisoning, patients can have fits and become unconscious. Death may occur due to respiratory paralysis. (10)

First aid and decontamination

Once poisoning has been diagnosed, the following information should be collected for the attending medical officer:

- name of the toxic substance (on packaging);
- amount and route of exposure (e.g. skin, mouth) if known;
- time of poisoning;
- reason for poisoning (intentional, accidental, overexposure while spraying); and
- any other relevant information. (4)

Any person administering first aid must be protected from the solvents and active ingredient by wearing gloves and an apron. First, respiration and pulse should be checked. If either is absent, resuscitation should be started. If the patient is unconscious, the airways should be freed by removing vomitus or other material from the mouth (including any false teeth), then tilting the head back and pulling the chin upwards. If mouth-to-mouth resuscitation is necessary, a clean handkerchief can be placed between the mouth of the patient and the mouth of the person giving first aid. If the patient is breathing and has a pulse but remains unconscious, he or she should be placed in the recovery position (i.e. lying on one side with the head tilted slightly downwards) in order to prevent any vomitus from entering the lungs. The patient should be transported in this position. No water or drugs should be given by mouth to an unconscious patient. (4)

All contaminated clothing should be removed to prevent further absorption. Affected skin should then be washed with soap and flushed with large quantities of water. If the eyes are contaminated, the lids should be gently opened with the fingers and the insides (conjunctivae) washed with clean running water for several minutes. Care should be taken that runoff from one eye does not enter the other eye. (4)

Decontamination of the skin and eyes should take place as soon as possible after exposure. Special medical treatment should be sought promptly after decontamination. Specific measures are needed for different groups of insecticides.

Treatment

There is no specific antidote for pyrethroid poisoning. Treatment is essentially symptomatic and supportive after decontamination to prevent further absorption. (10)

The management of acute poisoning with organophosphates and carbamates includes the following clinical interventions:

- Manage airway and assist ventilation as needed. If severe respiratory distress or SpO₂ <90, give oxygen.
- If hypotension or shock, give intravenous fluids rapidly. Titrate to maintain adequate urine output.
- Give atropine 1–3 mg intravenously as a bolus.
- Listen to lungs, take pulse, and measure blood pressure.
- Aim for clear lungs, stable blood pressure (>90 mmHg systolic), dry mucous membranes, and oxygen saturation of >95%.
- Recheck at five minutes. If no improvement, give double the initial dose of atropine. Dilated pupils and tachycardia alone should not be considered as end points.
- Continue to give doubling doses of atropine every 5–10 minutes until the patient is stable. If the lung crepitations persist after 3–5 boluses of atropine (doubling doses), consider that the patient may have aspirated.
- If blood pressure does not improve with atropine, consider giving fluid boluses and exclude metabolic acidosis.
- Once the patient has been atropinized, initiate an infusion of atropine (20% of the total dose required to atropinize) as an hourly infusion.
- Monitor for signs of atropine toxicity (agitation, confusion, hyperthermia) every 4–6 hours. If atropine toxicity develops, stop the infusion and restart at 70% of the last infusion rate once the toxicity settles.
- Monitor respiratory rate, pulse rate, and blood pressure. Prepare to intubate and if necessary ventilate.
- Give diazepam 5–10 mg intravenously for agitation, seizures, and fasciculations. Repeat dose as necessary.
- For organophosphates only, give pralidoxime, if available.(9)

All cases of acute or chronic poisoning of operators and other personnel resulting from occupational exposure to insecticides should be reported to the competent authority dealing with registration and compensation of occupational diseases and injuries according to the established national practice and regulations.

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