SOP: Indoor residual spraying of experimental huts for evaluation of insecticides

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Timeline

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1	30/10/2020	Angus Spiers	I2I
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Version Control[1]

[1] Historical versions of SOPs can be found on the I2I website (https://innovationtoimpact.org/)

Version	Date	Updated by	Description of update(s)
2	June-July 2022	Alex Wright, Katherine Gleave	Related documents, purpose, materials & equipment, data collection sheet information, health and safety, glossary of terms and references added.

Related documents

- I2I Best Practice SOP Library, 30 October 2020 (https://innovationtoimpact.org/)

1. Purpose

Indoor Residual Spraying (IRS) of experimental huts is required to test insecticidal efficacy and residual action of insecticides under semi-field conditions against wild population of mosquito vectors.

2. Background

IRS is used especially for control of malaria and Chagas disease vectors. However, where indoor residual spraying is used, it is essential that staff are fully trained in application techniques and maintenance of the application equipment. With good skills and high-quality application equipment, hazards to human health and the environment, as well as financials losses can be avoided.

3. Materials and equipment

3.1. Hut preparation.

- Petri dish
- 10 dead mosquitoes
- Bleach
- Spray bottle

- Broom
- Cotton wool
- 50 laboratory reared mosquitoes
- Plastic sheeting
- Chalk and ruler
- Sprayer
- Filter paper
- Rat glue/ rat trap
- 10% glucose-soaked cotton wool
- Two calibrated data loggers
- Mattress for sleeper
- Broom to clean

3.2. Calibration of sprayer and spraying huts

- Controlled flow valve (CFV)
- Water
- Bucket
- Stopwatch
- Data sheet
- Weigh scale if needed
- Aluminium foil
- Mixing bowl if needed
- Large graduated cylinder / measured and marked bucket
- Stopwatch and audible metronome
- Marker pen
- Label
- Waste disposal bags

4. Procedure

4.1. Pre-spraying preparation (KCMUCo)

4.1.1. Ensure that the moat around each hut is filled with water and check that there is no leakage.

4.1.2. Search rooms, verandahs, and exit traps for ants. If ants are found, follow SOP for removal of ant infestations from experimental huts. Ants can be monitored by placing 10 dead mosquitoes in an open petri dish in the experimental hut room. If they are not removed within 24hours it is okay to start the trial when ready.

4.1.3. Remove spiders, spider webs and lizards from the rooms and verandahs of all huts.

4.1.4. Repair holes in screened verandahs and fill any large cracks or holes in the walls.

4.1.5. Cover inside of eaves with plastic sheeting. Cut plastic sheeting to the right size so that areas of wall and ceiling that should be sprayed are not covered. Firmly attach sheeting.

4.1.6. Cover the area around and over the window traps with plastic sheeting. Cover the plastic with a layer of absorptive material such as Hessian sackcloth to prevent run-off from the plastic.

4.1.7. Cover the door of the hut.

4.1.8. Cover the baffles with plastic bags and tape the bag to the wall with masking tape.

4.1.9. Mark the walls with swath lines using chalk and a long ruler.

4.1.10. Where hut walls are 270-290 cm wide, four swath widths of 75 cm each with a 5 cm overlap should be marked out (75+70+70+70 = 285 cm).

4.1.11. Where the wall width exceeds or is below this range, consult with Study Director how to treat the incomplete swath (width < 75 cm), spray only complete swathes of 75cm and leave the incomplete swaths; after the spray has dried, fix plastic sheeting vertically leaving the incomplete swath to be sprayed; then spray the incomplete swath.

4.1.12. Mark the ceiling similarly. Each swath on the ceiling is broken into two sections so that four swaths are on each half of the room.

4.1.13. When spraying the ceiling the compression sprayer should be positioned in the center of the hut, and the operator should spray towards the walls so that the insecticide does not settle on the applicator.

4.1.14. To determine the swathe width, fill the sprayer with the same volume of water as will be used during the actual IRS applications, fit the sprayer lid and turn the handle to lock the sprayer.

4.1.15. Using both hands, operate the pump to pressurize the spray tank. Pump the tank until the pressure has reached 4 bar (58 psi) on the pressure gauge.

4.1.16. Attach the guidance pole to the sprayer lance using a strong adhesive tape. The pole (wire) should extend about 40 cm beyond the nozzle.

4.1.17. Hold the lance of the sprayer (keep 45 cm distance between from a test wall inside an experimental hut, spray one swath and then measure the width of the swath it produces using a measuring ruler.

4.1.18. Repeat this process three times and obtain the average swath width. The average swath width should be ~75 cm. To ensure that your number of spray swaths will cover the entire wall, you can adjust the guidance pole to change the distance of the sprayer nozzle from the wall and, therefore, the spray swath width.

4.1.19. Repeat steps 1.7 and 1.8 where adjustments of spray swath width are required.

4.1.20. To check spray quality, Whatman no. 1 filter papers are fixed at different positions in the huts covering walls and ceiling. Four filter papers measuring 5 cm x 10 cm are attached to the wall with a foil backing at randomly selected positions. The position of each filter paper must be marked so that cone bioassays are not performed on parts of walls where the filter papers have been stuck.

4.2. Spray calculation (CREC).

4.2.1. Calculate surface area of the hut.

4.2.2. Using a measuring tape, measure the width and the height of the huts to calculate the surface area of the hut. The wall heights should be measured in at least two points to account for variations in the height during construction. Surface area (S(m2)) = area of 4 walls + area of ceiling – areas of hut not to be sprayed

4.2.3. Calculate the amount of insecticide solution required per hut

4.2.4. The amount of insecticide solution needed can be calculated as follows: Volume to be sprayed per m^2 x surface area of hut. NB: The WHO 40 ml/m2 if there is no Control Flow Valve or 30 ml/m2 with a CFV of 1.5 bar. If the surface area of one hut is $30m^2$ we require 30 x 40 = 1200mL of insecticide solution.

4.2.5. Calculate the amount of insecticide required for each hut.

4.2.6. The amount of insecticide required for each hut to attain a target dose depends on the surface area and the concentration of insecticide in the formulation. It should be calculated as follows:

$$Vi_{(ml)} = \frac{S_{(m^2)} \times TD_{(mg/m^2)}}{Di_{(mg/ml)}}$$

Where;

Vi(ml) = Volume of insecticide required in ml

S(m2) = Internal Surface area of hut

TD (mg/m2) = Target dose in mg/m2

Di (mg/ml) = Insecticide concentration in mg/ml (available on insecticide container)

NB: where the concentration of the insecticide comes in a different format or as a percentage, be careful to convert this to mg/ml before applying the above formula.

The following calculation should be done when dealing with powdered formulations:

The quantity of insecticide (Q) in gram is = Target dose (g/m2)/ purity(%)* surface (m^2)

After determining how much insecticide is required per hut add an excess of at least 30% to account for loss of insecticide during application. For example, if a 100ml of insecticide formulation is required, then use 100ml+30% = 130ml. Note also, compression sprayers may not operate

correctly unless they have at least 1 liter of additional insecticide in them – this will avoid air being sucked into feed line if sprayer is tilted during operation.

4.2.7. Calculate the volume of water (solvent) required per hut for preparing insecticide solution.

4.2.8. The volume of water required per hut can be calculated as follows: **Volume of water= Insecticide solution required per hut- Volume of insecticide per hut**.

4.2.9. After determining how much water is required per hut, also add an excess of at least 30%. For example, if 1200mL of water is required per hut, the final volume of water (1200mL + 30%)= 1560mL.

4.3. Calibration of sprayer (KCMUCo)

4.3.1. Ensure sprayer has all correct parts and they are tightly screwed on. Check if there is any damage to the 1.5 bar Controlled Flow Valve (CFV) (the red valve). Replace the CFV and the nozzle if there is any obvious damage to these. Do not spray without a CFV unless Study Director gives written approval for this. Note: if no CFV is used, the discharge rate from sprayer will be >650 mL/min and the spray deposit rate will be 40 mL/m2.

4.3.2. Ensure the correct equipment identification number from the compression spray tank is being used, especially if multiple tanks with multiple AI are being used.

4.3.3. Usually a sprayer has a total tank capacity of 11.4 L. Fill the tank with 4-5 L clean water, fit the lid and lock it in position by turning the handle of the lid.

4.3.4. Operate the pump using both hands and with a foot on the foot rest (where fitted). Pump until the tank pressure is 4 bar (58 psi). Check that the tank is holding pressure by listening for any hissing sound of escaping air. If air is escaping, tighten up the part where air is escaping and replace parts if necessary.

4.3.5. Press the lever (trigger) briefly to make sure that spray is emitted from the nozzle in an even fashion without streaks or leaks. It should form an even flat fan shaped spray.

4.3.6. Calibrate the spray tank by spraying into a clean bucket for one minute, timed with a stopwatch. After the minute is up, measure this water using a 1L measuring

cylinder (well calibrated and of high quality). Repeat this process three times and record the results. Take an average value. This value with a 1.5 bar CFV is usually around 550 mL/min, with an acceptable range of 500 – 605 mL/ minute. Check the specification for the brand of the compression sprayer used.

4.3.7. Record information on the data sheet and have the Study Director approve calculations before spraying.

4.4. Determination of sprayer lance speed.

4.4.1. The correct application of the insecticide during spraying will require that the correct amount of insecticide is deposited per m^2 on the experimental hut wall. This requires moving the spray lance along the wall at a set speed (lance speed). The lance speed depends on the flow rate of the sprayer, the volume rate and the area of one spray swath.

4.4.2. Calibrate the flow rate of the compression sprayer.

4.4.3. Once you have determined your flow rate and swath area, use the following formula to determine the lance speed per swath:

Lance speed (s) = (Swath area (m^2) × Volume rate(ml/m^2) ÷ flow rate (ml/s)

e.g. Area of 1 wall swath = band width x average wall height = 71cm× 190cm = 1.349m^2

Volume rate = 30 ml liquid to be sprayed /m^2 (WHO recommendation)

Volume per swath = 1.349 × 40

Flow rate = 550 ml/60s (multiply by 60 to get flow rate / second)

Therefore:

Lance speed = (1.349 × 40)/ 880 (flow rate) × 60 = 3.68 seconds per wall swath.

4.4.4. NB: Prior to spraying the hut with insecticide, the spray team should practice on a test wall several times using water to see if they can maintain a constant lance speed for each swath. The most accurate individual should be selected as the sprayman for the study

4.5. Spraying huts (CSRS and IHI)

4.5.1. Prepare the insecticide spray liquid according to the manufacturer's instructions. With some products the insecticide may be mixed separately in an appropriate container (e.g. bucket) and poured into the sprayer.

4.5.2. Insecticides packaged in water soluble sachets, tablets for direct application and insecticide granules and other more soluble formulations may be added directly into the water filled tank.

4.5.3. For solid insecticide formulations that are not packaged in sachets, weigh the required amount on aluminum foil using a weighing balance wearing hand gloves. Add the contents to a mixing bowl (dedicated for insecticide use) and rinse off the foil to ensure no insecticide material is left. Add water a little at a time, mixing continuously to provide a uniform consistency. Pour into the sprayer and add water to make up the required volume

4.5.4. For liquid insecticide formulations, use a clean calibrated measuring cylinder to measure the volume of insecticide required and pour this into the spray tank and add water to make up the required volume.

4.5.5. WHO recommends loading 7.5L volume of liquid (insecticide + water) in a sprayer tank for IRS operations. However, considering that 1–2 huts may have to be sprayed per dose, lesser volume may be prepared to avoid wastage of insecticide. In that case the initial volume of liquid in the tank should be no less than 4 L (if about 1 liter liquid will be consumed per hut and that about 1.5–2 L liquid should remain in the tank at the end of the procedure to prevent air being sucked in).

4.5.6. Once the required volume of insecticide mixture has been transferred into the sprayer, fit the lid and turn the handle to lock the sprayer.

4.5.7. Before pressurizing the sprayer, weigh the sprayer on a calibrated balance (Note: the sprayer will then be weighed after spraying one hut to determine the volume of insecticide solution sprayed (assuming 1Kg weight = 1L volume)).

4.5.8. Using both hands, operate the pump to pressurize the spray tank initially to 2-3 bar pressure.

4.5.9. Agitate the spray pump for a few seconds to mix the liquid. Pressure in the pump will not allow the lid to open. Now pressurize until 58PSI (4 bar) pressure. Check that the sprayer pressure is at the desired level and that the tank is holding pressure.

4.5.10. Begin spraying at the bottom corner of the wall to the right of the door. If the spray operator is right-handed, go to the right, if left-handed, start spraying to the left of the door and go to the left.

4.5.11. Start spraying by moving the sprayer lance steadily from base of wall up to the junction with the ceiling.

4.5.12. To ensure the correct swath width, keep the nozzle tip about 45 cm away from the wall. Lean forward slightly as you spray the top of the wall and move back as you bring the nozzle downward so as to maintain the correct distance between the nozzle tip and the wall at all times while the application is being made.

4.5.13. Using a stopwatch or audible counter (e.g. metronome), time your spray speed to cover one meter every 2.2 seconds (4.5 seconds for a 2 meter high wall).

4.5.14. Move a step to the right equal to the width of the spray swath (75 cm in the case of 8002E nozzle tip, allowing a 5 cm overlap), and spray from the top of the wall to the base. Continue this procedure across each hut wall, until you reach the starting point at the front door.

4.5.15. Agitate the spray tank every two to three minutes to ensure the insecticide remains mixed.

4.5.16. Re-pressurize the tank when the pressure gauge falls below 25 psi.

4.5.17. Where using a palm thatch ceiling, spray the palm thatch after spraying the wall. The palm thatch can either be laid flat on the ground and sprayed or hung on a test

wall outside the hut and sprayed in the same manner as the hut wall depending on the availability of the latter. Ensure to maintain the same spray speed as for the spraying of the hut walls.

4.5.18. Once dry the palm thatch should be replaced on the ceiling of the hut.

4.6. Post-spraying procedure (KCMUCo)

4.6.1. Once spraying is complete, leave the hut door open for ventilation for 24 hours.

4.6.2. The sprayer should be weighed to determine the volume consumed. and the volume of insecticide solution left in the tank should be measured using a measuring cylinder and the amount of insecticide solution used recorded.

4.6.3. Any unspent insecticide liquid is then sprayed on an outer eave of a house or disposed of according to national regulations.

4.6.4. The spray equipment should then be washed thoroughly following the appropriate SOP and prepared for the next insecticide treatment. Never leave the sprayer unwashed between IRS applications, as dried insecticide residues may be difficult to remove (leading to cross-contamination during the next study) and may also damage the sprayer and nozzle.

4.6.5. Leave the filter papers to dry on walls and then remove them using metal forceps and store each one individually in aluminium foil. Cut the filter papers in half so that one part can be sent for chemical analysis and the other half kept at the facility. Put the foil in a labelled plastic bag with necessary details (e.g. the study number, insecticide name, dose, code, hut code, location etc). Store the papers at +4 ± 2 °C until they are sent for analysis. Filter papers should be sent for analysis within 1 month of spraying.

4.6.6. After the ventilation period, remove all the plastic sheeting and place into the designated chemical waste storage.

4.7. Collection and reporting of data

4.7.1. Ensure the following data is recorded in the data collection sheets.

- Protocol code
- Date hut resurfaced

- Date of spraying
- Insecticide code
- Substrate
- Number of huts to be sprayed
- Surface area of the huts
- Calculation of target active ingredient and application rate (signed by study director)
- Constant flow valve (CFV) used

5. Health and Safety

For GLP-compliant laboratories, the following should be installed in the laboratory and field prior to Semi-field IRS:

5.1. Field materials

- Spill kit for truck
- Mobile emergency shower
- Mobile emergency eye wash

5.2. Personal protective equipment (PPE)

- Spray suit coveralls
- Respirator mask (fit-tested for the specific individual spraying)- check AI MSDS for filter requirements
- Gloves
- Goggles and/or full-face Visor
- Over boots

6. Glossary of terms

AI	Active Ingredient

CFV	Controlled flow valve
CREC	Centre de Rescherches Entomologiques de Cotonou
CSRS	Centre Suisse de Recherches Scientifiques
GLP	Good Laboratory Practice
I2I	Innovation to Impact
IHI	Ifakara Health Institute
IRS	Indoor Residual Spray
KCMUCo	Kilimanjaro Christian Medical University College
MSDS	Material Safety Data Sheet
PPE	Personal Protective Equipment
RH	Relative humidity
SOP	Standard Operating Procedure
WHO	World Health Organisation
WHOPES	World Health Organization Pesticide Evaluation Scheme

7. References

WHOPES guidelines- Testing mosquito adulticides for indoor residual spray and treatment of mosquito nets

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