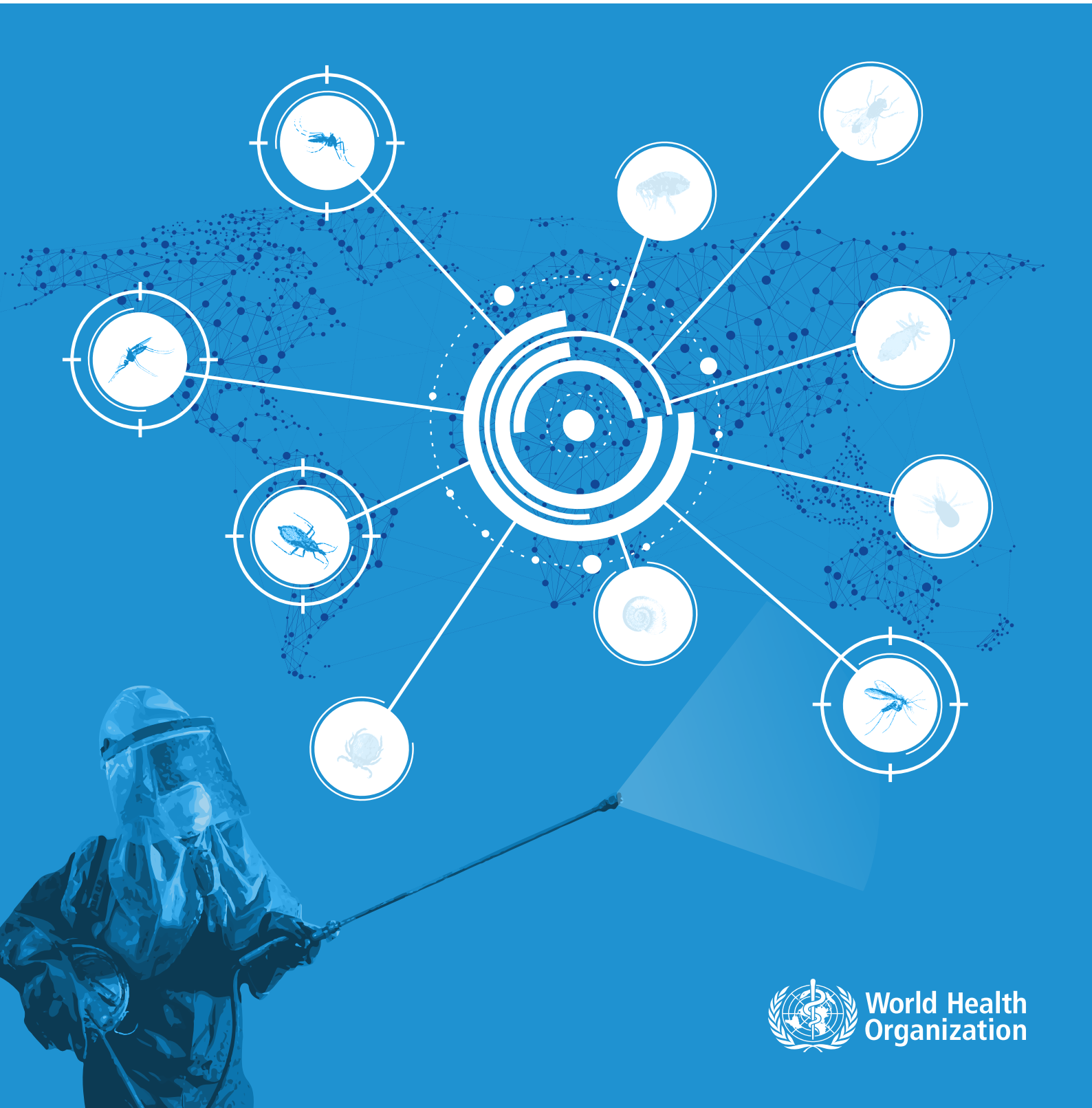
Operational manual on indoor residual spraying

Control of vectors of malaria, *Aedes*-borne diseases, Chagas disease, leishmaniases and lymphatic filariasis



World Health Organization

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Contents

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Abbreviations

AI	active ingredient
CFV	control or constant flow valve
CS	capsule suspension
EC	emulsifiable concentrate
DDT	dichlorodiphenyltrichloroethane
FAO	Food and Agriculture Organization of the United Nations
GIS	geographic information system
GPS	global positioning system
IEC	information, education and communication
IRS	indoor residual spraying
M&E	monitoring and evaluation
NGO	nongovernmental organization
PPE	personal protective equipment
SC	suspension concentrate
SC-PE	polymer-enhanced suspension concentrate
VCP	vector control product
WG	water-dispersible granules
WG-SB	water-dispersible granules in sealed water-soluble bag
WHO	World Health Organization
WP	wettable powder
WP-SB	wettable powder in sealed water-soluble bag

Glossary

The definitions given below apply to the terms as used in this document; they may have different meanings in other contexts. Some definitions listed have been taken or adapted from other World Health Organization (WHO) guidance, which may be subject to amendment *(1,2)*.

bioassay	In applied entomology, experimental testing of the biological efficacy and/or effectiveness of a treatment (e.g. infection, insecticide, pathogen, predator, repellent) by deliberately exposing insects to it
endophagy	Tendency of vectors to blood feed indoors *Note: Contrasts with exophagy*
endophily	Tendency of vectors to rest indoors *Note: Contrasts with exophily; usually quantified as the proportion resting indoors; used in assessing the effect of indoor residual spraying*
evaluation	The episodic assessment of any change in targeted results that may be attributed to the programme, project or intervention. It aims to link a particular output or outcome directly to a programme, project or intervention after a certain period of time has passed.
formulation	The combination of various ingredients (insecticide active ingredient, formulants, additives, emulsifiers, etc.) designed to render the product useful and effective for the purpose claimed and for the envisaged method of application
geographical reconnaissance	Censuses and mapping to determine the distribution of the human population, household locations and other features relevant for vector-borne disease transmission in order to guide interventions *Note: Geographical reconnaissance provides the basis for selecting field centres and depots, designing schedules and itineraries of operations, planning deployment of transport and assessing completion of planned activities. For indoor residual spraying, this is essential for the enumeration of housing units, sprayable structures and surfaces.*
house	Any structure other than a tent or mobile shelter in which humans sleep
household	The ecosystem, including people and animals, occupying the same house and the accompanying vectors
indoor residual spraying	Operational procedure and strategy for vector control involving spraying interior surfaces of human dwellings or other buildings that are common resting sites for vectors with a residual insecticide to kill endophilic vectors

indoors	Inside any shelter likely to be used by humans or animals, where vectors may feed or rest *Note: Where indoor-resting vectors can be targeted for indoor residual spraying*
insecticide	Chemical product (natural or synthetic) that kills insects. Ovicides kill eggs; larvicides (larvacides) kill larvae; pupacides (pupaecides) kill pupae; and adulticides kill adult vectors. *Note: Products used for vector control are assessed and listed by WHO Vector Control Product Prequalification (3). Active ingredients used in the formulation of prequalified vector control products are evaluated to ensure compliance with WHO specifications. WHO does not approve active ingredients.*
insecticide, contact	Insecticide that exerts a toxic action on vectors when they rest on a treated surface; the insecticide is commonly absorbed via the feet (tarsi), but can be absorbed through contact via other means.
insecticide dose	Amount of active ingredient of insecticide applied per unit area of treatment (mg/m^2) for indoor residual spraying
insecticide, residual	Insecticide that, when suitably applied to a surface, maintains its insecticidal activity for a considerable amount of time through contact and/or fumigant action
insecticide resistance	Property of insects to survive exposure to a standard dose of insecticide; may be the result of physiological or behavioural adaptation *Note: The emergence of insecticide resistance in a vector population is an evolutionary phenomenon due to either behavioural avoidance (e.g. exophily instead of endophily) or physiological factors whereby the insecticide is metabolized, not potentiated, or absorbed less than by susceptible vectors.*
monitoring	The routine tracking of key elements of programme/project performance (usually inputs and outputs) through record-keeping, regular reporting and surveillance systems
prequalification	Process to ensure that health products are safe, appropriate and meet stringent quality standards for international procurement *Note: Health products are prequalified by an assessment of product dossiers, inspection of manufacturing and testing sites, quality control testing in the case of vaccines and medicines, validation of the performance of diagnostic tests and verification that the products are suitable for use in the destination countries.*
spray round	Spraying of all sprayable structures in an area designated for coverage in an indoor residual spraying programme during a discrete period *Note: Depending on the residual activity of the insecticide and the dynamics of vector-borne disease transmission, one or more spray rounds may be required each year in the same area.*

sprayable structure	In the context of a vector control programme, a unit (house, animal or other shelter, latrine) suitable for spraying or required to be sprayed *Note: In house-spraying operations, this is usually implemented by indoor residual spraying.*
sprayable surface	The inside surfaces of all structures that are of an appropriate material type for residual spraying
spraying campaign	Comprises one individual spray round of indoor residual spraying in a defined location *Note: Spray campaigns may be split into more than one phase, with a pause in operations for a planned period of time.*
spraying frequency	Number of regular applications of insecticide by indoor residual spraying per house per year *Note: This will differ depending on the disease transmission pattern, residual efficacy of the product used and the aim of spraying, such as to interrupt transmission or to prevent seasonal increases in vector densities and vector-borne disease.*
spraying interval	Time between successive applications of insecticide
spraying programme	Comprises all of the planning and operations for indoor residual spraying within the strategic period. Planning is usually conducted on an annual basis, which may encompass more than one spray round.
spraying, complete	Spraying aims to cover all sprayable surfaces within a structure and is not targeted to specific sections or portions of sprayable surfaces (e.g. lower part of walls). *Note: This differs from selective spraying.*
spraying, focal	Spray coverage by indoor residual spraying of houses or other buildings in a geographical area selected based on parameters other than administrative (e.g. district or health zone) boundaries, such as a focus of malaria cases or a cluster of dengue cases
spraying, reactive	The use of indoor residual spraying in the houses of a confirmed case and neighbours at approximately the same time as part of a designated response *Note: The size of the radius of implementation of reactive indoor residual spraying should be determined by the behaviours and likely flight range of local vectors.*
spraying, selective	Spray coverage is targeted to specific sections of sprayable surfaces to take into account vector resting preferences, such as spraying to a maximum height from the floor (e.g. 1.5 m for *Aedes aegypti*). *Note: This differs from complete spraying.*

spraying, targeted	Spray coverage is targeted to specific populations, geographical areas, households, structures, sprayable surfaces or portions of sprayable surfaces. *Note: This is a broad term that needs to be carefully defined when used by a programme. Selective indoor residual spraying is one type of targeted spraying.*
susceptibility	In a population of insects, the liability to be killed by a particular insecticide
vector	An insect that transmits a pathogen from one organism to another
vector control	Measures of any kind against pathogen-transmitting vectors, intended to limit their ability to transmit the pathogen to humans *Note: Ideally, vector control results in reduction of transmission rates, by reducing the vectorial capacity, to a point at which transmission is interrupted.*
vector density	The number of female insects in terms of any collection unit (e.g. per hour, per trap, per house, etc.)
vectorial capacity	The number of new infections that the population of a given vector would induce per case per day at a given place and time, assuming that the human population is and remains fully susceptible to the disease

1. Introduction

This operational manual is designed to provide guidance on the establishment, management, implementation, reporting and evaluation of safe and effective IRS campaigns within the context of a locally adapted and sustainable vector control programme. Earlier versions had a scope limited to IRS against *Anopheles* for prevention and control of malaria *(4,5)*. In 2023, the document was extended significantly to include guidance on IRS for other vector-borne diseases also, in recognition that IRS can potentially impact on multiple diseases and in line with the *Global vector control response 2017–2030 (6)*. Updates were also made to reflect current World Health Organization (WHO) recommendations, standards and best practices for IRS. Substantive content was drawn from materials provided by the United States Agency for International Development/United States President's Malaria Initiative/Abt Associates.

This is the first attempt to expand WHO guidance originally developed for IRS against malaria to other vectors. A heavy focus has remained on routine IRS operations in residences using hand compression sprayers. It is expected that later iterations of this document will be adapted for greater consideration of focal and reactive IRS, as well as control of other disease vectors beyond mosquitoes.

This manual forms a companion document to the *WHO guidelines for malaria (7)*, draws on content from the *Operational manual on leishmaniasis vector control, surveillance, monitoring and evaluation (2)* and aligns with the *Manual for indoor residual spraying in urban areas for Aedes aegypti control (8)*. Other related WHO resources include *Lymphatic filariasis: a handbook of practical entomology for national lymphatic filariasis elimination programmes (9)* and *Technical document for the implementation of interventions based on generic operational scenarios for Aedes aegypti control (10)*. Companion documents such as this manual are made available in electronic form to enable rapid update as soon as warranted by new WHO recommendations or guidance.

This manual is divided into four key sections. The first section introduces the concepts of IRS and the purpose of the manual. The second outlines the requirements for establishing and managing an IRS programme. The third details operational aspects of how to conduct household spraying. The fourth highlights the importance and components of monitoring and evaluation (M&E) for IRS activities. Useful resources are available in the references, with example forms available in the annexes.

The information provided can support:

- development or refinement of national IRS strategies;
- development or update of IRS operational guidelines and procedures;
- development or update of training materials;
- assessment of delivery and coverage of IRS operations; and
- assessment of spray quality and impact of IRS operations.

The key audience for this document is therefore vector-borne disease control programme managers and staff, and implementing or private-sector partners at the national, provincial/state or local levels, who are responsible for the design, planning or implementation of vector control operations.

1.1 Background on indoor residual spraying (IRS)

Vector control is a key intervention for the prevention of a range of vector-borne diseases *(6)*. For some of these diseases, vector control is critical for transmission reduction and eventual interruption to ensure elimination and prevention of re-establishment of transmission. IRS involves applying residual insecticide to potential vector resting sites on the interior surfaces of human dwellings or other buildings where vectors are likely to come into contact with the insecticide. IRS is sometimes also applied in structures used for tethering animals if adult vectors are likely to rest there for a significant part of their lifecycle. In some countries, the principles of IRS have been extended or modified to treat other surfaces that are external to buildings. While this is not a WHO recommended intervention, this manual may provide useful guidance to countries using this approach.

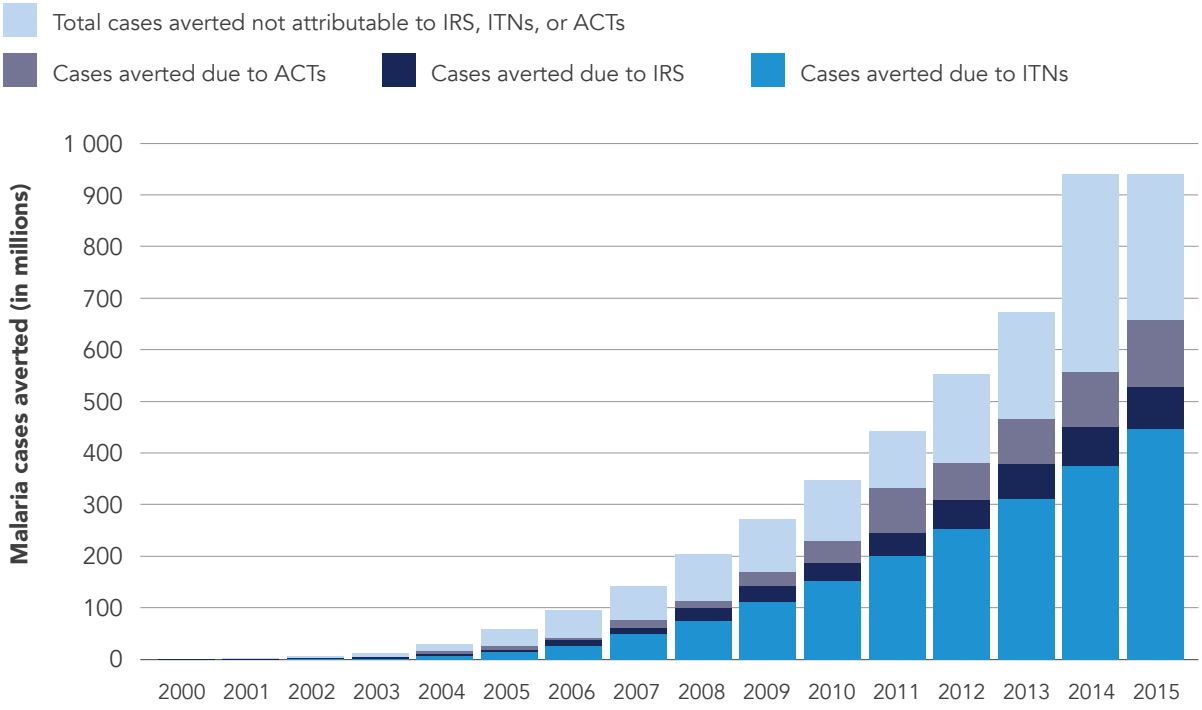
The main aim of IRS is to kill vectors before they are able to transmit pathogens to humans. When carried out correctly, IRS has historically been shown to be a powerful intervention to reduce adult vector density and longevity for mosquitoes, sand flies and triatomine bugs. This reduction in vector density and longevity can significantly reduce the transmission of vector-borne diseases.

IRS was the primary malaria control method used during the Global Malaria Eradication Campaign run from 1955 to 1969. While the campaign did not achieve its stated objective to end malaria transmission and eliminate reservoirs of infection globally, 37 of the 143 countries that were endemic in 1950 were free of malaria by 1978, and there was a sharp reduction in the burden of disease in other countries *(11)*. IRS contributed to around 10% of the estimated 633 million malaria cases averted in Africa due to interventions between 2000 and 2015 *(12)* (Fig. 1). A systematic review and meta-analysis of IRS for malaria control with 38 articles, including 81 reports, found that most studies showed a protective effect of IRS on the risk of malaria, regardless of the malaria incidence rate and countries' GDP *(13)*. IRS is therefore one of the two interventions recommended by WHO for large-scale deployment against malaria *(7)*, the other being insecticide-treated nets.

The spraying of residual insecticides has been shown to reduce densities of endophilic phlebotomine sand flies and is one of the primary methods used for leishmaniases control worldwide *(2)*. For control of *Aedes* mosquitoes, a massive campaign coupled IRS with larval source management to eliminate *Ae. aegypti* and yellow fever transmission from 18 South American countries and some Caribbean islands between 1947 and 1962 *(14)*, and a recent systematic review and other research have shown the effectiveness of IRS for dengue control *(15,16)*. Experience in the Americas indicates that IRS with high levels of household participation reduces human–vector contact and is a cost-effective method of preventing new cases of Chagas disease *(17)* that can lead to local vector elimination, although reinfestation and insecticide resistance have been challenges.

Even with historical impact and evidence of effectiveness, the use of IRS against diseases other than malaria has been limited by the need to allocate substantial human, infrastructural, institutional and financial resources for operations.

Fig. 1. Predicted cumulative number of malaria cases averted by interventions in sub-Saharan Africa, 2000–2015 (adapted from *(12)*).



ACT: artemisinin-based combination therapy; IRS: indoor residual spraying; ITN: insecticide-treated mosquito net

1.1.1 Rationale

IRS is most effective in controlling indoor resting (endophilic) vectors. The effectiveness of IRS arises from the fact that many key vectors are endophilic and/or feed indoors (endophagic). For instance, when searching for blood meals, vectors enter human dwellings or animal shelters where they may rest on the walls, ceilings or other interior surfaces before and/or after feeding on the hosts. Sometimes vectors feed outdoors, but rest indoors. When a vector susceptible to a particular insecticide comes into contact with it on a sprayed surface for a sufficient period of time, the vector absorbs a lethal dose of the insecticide, which kills it or reduces its lifespan. This results in a progressive decline in overall vector density in the sprayed area. Of those vectors that remain alive, a smaller proportion may survive the length of time required for pathogens to develop or multiply inside the insect host. The reduction of vector population density and longevity reduces their vectorial capacity, thereby contributing to a decrease in pathogen transmission in areas that have been sprayed.

IRS may provide some protection to individuals in a household by reducing vector–human contact through repelling vectors and/or reducing the number of vectors entering a house. However, once vectors have entered a dwelling or animal shelter, IRS does not markedly prevent blood feeding; the greater impact is on vector survival and, therefore, potential transmission of a pathogen. As the proportion of correctly sprayed structures increases in an area, the likelihood of vectors seeking refuge on a treated surface rises. At high enough community coverage, the survival of the mosquito population as a whole is affected and transmission of disease within a community may be reduced. (By contrast, some other vector control interventions, such as the use of insecticide-treated nets, provide an additional physical barrier to inhibit vector feeding, thereby providing protection to the individual net user.) WHO therefore recommends that IRS be deployed on a large scale as a community-level intervention *(7)*.

1.1.2 Goals

There are five basic goals for an IRS campaign:

1. To protect as many individuals as possible in the target area, with particular emphasis on protecting vulnerable groups (spray coverage).
2. To achieve spraying of a high number of spray units and structures in the target area (spray acceptance).
3. To ensure that enough houses are sprayed each day of operations to keep the spray campaign on schedule (spray progress or efficiency).
4. To ensure that spray operators use the correct procedures and techniques to deposit the right amount of insecticide on all sprayable surfaces (spray quality).
5. To monitor spray coverage, acceptance, progress and quality, and, where possible, the efficacy and effectiveness of the campaign to inform improvements for subsequent campaigns (spray M&E).

1.1.3 Conditions

Specific conditions need to be met for IRS to be an effective intervention in a given target area or population.

In general, IRS is considered appropriate in an area where:

- the majority of the vector population feeds and/or rests indoors;
- people or animal hosts mainly sleep indoors at night (relevant for night-biting vectors) or spend time indoors during the day (relevant for day-biting vectors);
- the vector-borne disease transmission pattern and other conditions are such that the human population can be protected by one or two rounds of IRS with an effective insecticide per year;
- the majority of structures and surfaces that are common vector resting sites are suitable for spraying; and
- community acceptance of spraying is good, which enables high access rates for teams to spray structures.

WHO recommends that the list of WHO-prequalified vector control products (VCPs) be relied upon for the selection of IRS products to be used in spray campaigns *(18)*.

1.1.4 Purposes

The ways in which IRS is deployed can differ depending on the intended purpose, and include:

- routine large-scale spray campaigns as part of planned prevention and control activities;
- targeted spraying in identified areas to protect populations at high risk or in transmission foci in pre-elimination settings;
- targeted spraying to protect populations in areas with ongoing transmission affected by a humanitarian emergency; and
- reactive spraying in houses or structures of confirmed cases and neighbouring locations at approximately the same time, with the radius of implementation determined by likely contact between humans and vectors, i.e. within the vector's flight range.

This focus of this manual is on providing guidance for comprehensive planning of routine spray campaigns, for which lead times for planning and implementation are many months. Further guidance is required on operations for other spray purposes, the conditions and constraints of which may differ from those of routine spraying.

1.1.5 Approach and modifications

For control of *Anopheles* vectors of malaria, the traditional approach to IRS usually includes the following features:

- Total: All sprayable dwellings or structures in the target area are sprayed.
- Complete: All areas of all sprayable surfaces are covered.
- Sufficient: The required dose of an insecticide is uniformly applied to all target surfaces.
- Regular: Spraying is repeated at appropriate intervals to ensure that sufficient insecticide residue is available for the full duration that protection is required, i.e. throughout the entire transmission season.

Modifications to traditional IRS have been made by national vector control programmes to account for different vector species and their resting behaviours (Annex 1). Targeting is often undertaken, in which certain populations, structures, rooms or sprayable surfaces are prioritized during spraying. Selective spraying is a type of targeting in which only specific sections or portions of sprayable surfaces are sprayed, such as to a maximum height from the ground based on certain vectors having a strong preference for resting at lower heights.

For instance, IRS is based on local information on the resting behaviour of key vector species as follows:

- for *Anopheles* species that feed on animals, spraying associated animal sheds that are in close proximity to human dwellings;
- for *Ae. aegypti*, selectively spraying walls up to 1.5 m height, behind and under large furniture, under light furniture, and on the backs and fronts of curtains;
- for *Ae. aegypti*, prioritizing spraying in bedrooms, living rooms and hallways; and
- for phlebotomine sand flies, selectively spraying walls up to 2 m height.

Targeting spraying in this way can improve efficiency and save money by reducing application time and insecticide volume *(19)*. Sufficient evidence is required to appropriately guide the strategic planning and training for targeted spraying. It is also essential to confirm that any modifications to IRS will not negatively impact entomological efficacy. Annex 1 provides a comparison of a routine spray campaign against *Anopheles* spp. to prevent malaria versus a spray campaign against *Ae. aegypti* to prevent dengue.

Some vector-borne disease programmes include spraying of the outside walls of domiciles or spraying in associated outdoor harbourages. Some may undertake additional spraying of eaves when the spray operator is located in an exterior position. However, these activities are beyond the scope of this document, which focuses on the application of residual insecticides to indoor surfaces.

1.1.6 Key components of effective implementation

For an IRS campaign to be effective, it must be properly planned and managed. This requires adequate national programme capacity, with sound policies, standardized procedures and effective systems in place. Effective IRS requires:

- adequate information on local vectors, especially insecticide susceptibility status and indoor versus outdoor feeding and resting behaviours;
- adequate political commitment;
- enabling policies and standardized operational, technical and logistical procedures;
- adequate programme and health system capacity to ensure that the spray application is of good quality, is well timed and results in high coverage;
- engagement of community leadership and residents' acceptance of spray operations;
- adequate and sustainable financial, logistical and human resources;
- adequate health and environmental safeguarding strategies;
- local registration or supply of authorized insecticides that are effective against local vectors; and
- judicious use of insecticides, including use of an insecticide resistance management approach, whereby insecticides with different modes of action are rotated on a schedule that is programmatically feasible, with the aim of reducing selection pressure for insecticide resistance *(20)*.

Requirements for effective IRS are expanded on in section 2.1.

1.1.7 Coverage targets

High coverage of targeted populations, households, structures, rooms and sprayable surfaces is a key requirement to ensure effectiveness of IRS. While there is a strong theoretical foundation for requiring high coverage of IRS, there is limited knowledge of the quantitative relationship between the level of community coverage and the resulting reduction in vector-borne diseases. Therefore, it is not possible to stipulate a specific IRS coverage rate that will ensure adequate effectiveness across all settings.

To maximize impact, IRS spray campaigns should strive to achieve high coverage in target areas. In general, it is recommended that resources and commodities be quantified to provide full coverage of the population at risk. In reality, coverage is unlikely to reach 100% due to various health system inefficiencies or inadequacies. Many countries, therefore, set an operational target of achieving at least 80% coverage of eligible structures in the target area (e.g. administrative area, focus or cluster). Coverage at this level should be seen as a minimum requirement to provide the community-level protection conferred by IRS. Other coverage targets can be set by the control programme depending on the specificities of the campaign, such as for high-risk areas or vulnerable population groups *(8)*.

1.1.8 Programmatic options

A number of options are available to vector-borne disease control programmes and their implementing partners, including the timing and frequency of spray rounds; targeting of populations, households, structures, rooms or spray surfaces; choice of insecticide products; selection of spray machines and equipment; programmatic targets; the design of M&E components; and data collection and analysis tools or systems.

Insecticide products currently prequalified or available for IRS include six classes of AIs grouped according to four modes of action *(21)*, based on their primary target site in the vector. WHO-prequalified products have been assessed for their safety, quality and entomological efficacy, which includes the evaluation of their mortality effect on mosquitoes when applied to a range of interior surfaces of dwellings commonly found in malaria-endemic areas. The latest information should be accessed on the WHO website *(18)*.

Pesticide application equipment that is compliant with WHO guidelines should be used *(22)*. When procuring spray equipment, a testing certificate issued either by the International Pesticides Application Research Centre (Ascot, United Kingdom of Great Britain and Northern Ireland) prior to 2017 or by the International Pesticides Application Research Centre (Harper Adams University, Newport, United Kingdom of Great Britain and Northern Ireland) from July 2019 should be requested from the supplier. The latter centre has been testing pesticide application equipment through a Memorandum of Understanding with WHO, effective as of July 2019.

These various options are discussed in more detail throughout this document.

2. Establishment and management of an IRS programme

2.1 Requirements for effective IRS

To be effective, IRS should aim to reach the highest possible coverage of the targeted spray area with sufficient spray frequency to maintain protection for the required duration (section 1.1.4). IRS effectiveness is dependent on the quality of spray operations. Successful IRS campaigns require a high level of political commitment with dedicated human, logistical, transport and financial resources. Timely and good-quality delivery of IRS operations depends on strong programme leadership, adequate organizational and planning capacity, and a well established management system. The required capacity includes skills for the collection of baseline information, detailed proposal development, thorough planning, sound management of insecticides ensuring occupational and environmental safety, robust training, strong community engagement, rigorous implementation, strict supervision, careful M&E and timely reporting.

Sound management of an IRS programme requires the development of operational plans. Planning must consider current epidemiological and entomological conditions and other factors that affect geographical variability or seasonality, such as rainfall patterns. Timeliness is a key factor in obtaining maximum benefits from IRS. For routine spraying, the spray should be applied over the shortest period of time just prior to the onset of the rains and before the peak transmission season. This is to ensure fresh deposits of insecticides at times when the number of mosquitoes is still low and would normally start to increase. For reactive application, such as in outbreaks or in humanitarian emergencies, rapid commencement of spraying is imperative. Capacity for focal spraying should be maintained even when transmission is interrupted in elimination settings in order to ensure timely response to imported cases. Operational plans should be reviewed annually, and the IRS strategy adapted and optimized according to changing conditions.

As part of planning and managing operations, measures to ensure the safety of spray operators, the community and the environment must be factored in. Depending on the national and local requirements, environmental assessments may need to be conducted to ensure that planned spray campaigns comply with relevant laws and regulations. Proper management and handling of insecticides is supported by providing adequate infrastructure and equipment and ensuring optimal staffing capacity. A well trained core of skilled environmental or public health officers, field entomologists and epidemiologists will be required. The spraying itself can be delivered by trained field staff. Recruitment from within the local community can support motivation and retention of spray operators. These spray operators require back-up and supervision to support the implementation of the spray campaign. Thorough training on the correct application procedures not only ensures the safety of staff and residents, but also ensures that insecticide is not wasted or underutilized and that the dosage applied to surfaces maximizes residual impact against vectors.

Community awareness and engagement are other critical factors that influence the effectiveness of IRS programmes. Acceptance by the local population contributes to attaining a high level of coverage and maintaining it over repeated spray rounds. Operational plans should include community engagement activities by implementing well designed, context-appropriate community education, communication and mobilization campaigns. Households should be well informed about the programme, aware of its benefits and informed in advance of the necessary preparations required for a safe and successful spray campaign.

The M&E of an IRS programme is key to determining whether the operations are proceeding as planned and whether the programme is meeting its objectives and having the desired impact in controlling the target disease(s). An M&E plan should be established prior to the deployment of IRS, with appropriate systems established or maintained to support M&E of the intervention. Results should be communicated to community leaders to ensure that they are aware of progress and outcomes.

When introducing IRS in a country for the first time, it is practical to start with a pilot area of a geographical size that is, at a minimum, consistent with the smallest implementation unit envisioned for the programme, such as a district. Once operations in the pilot area have been successfully conducted, they can be expanded to other districts in a step-wise manner to enable the programme to gain experience in developing the necessary operational capacities, infrastructure and systems for an efficient large-scale operation. At the outset, it is likely that there will be a shortage of field-experienced IRS coordinators and supervisors, and it is therefore advisable to seek technical assistance from well established programmes in other countries or regions, or to draw on private-sector expertise.

As pilot areas scale up, IRS coordinators and supervisors will be able to support more areas in the planning and implementation of IRS. In countries where IRS operations are ongoing, the focus should be on improving quality before any scale-up of coverage is considered. This should be accomplished through post-spray campaign reviews that analyse the timing of implementation, coverage (including reasons for refusals), quality of the intervention, and impact on vectors and diseases. The information generated in a post-season review provides essential lessons for adapting and improving planning and management for the next spray campaign.

2.2 Organization and delivery of IRS campaigns

This section provides information on a typical IRS round, operational plans, financial budgeting and recommendations for staffing structures. Subsequent sections address the other aspects introduced above.

2.2.1 Management cycle

An effective IRS programme is based on a well defined order of operations depending on the purpose of the spray campaign (see section 1.1.4). For routine IRS, this is linked to:

- the transmission season of the target vector-borne disease, such that IRS operations are completed shortly before vector abundance increases; and
- the annual health planning and financial budgeting cycles.

The IRS management cycle is an effective framework that outlines activities at different stages of planning, implementation and review of the spray campaign. It

provides an outline of the particular steps that should be included in an operational management plan and, by doing so, provides guidance for IRS programme managers on the timely management of operations.

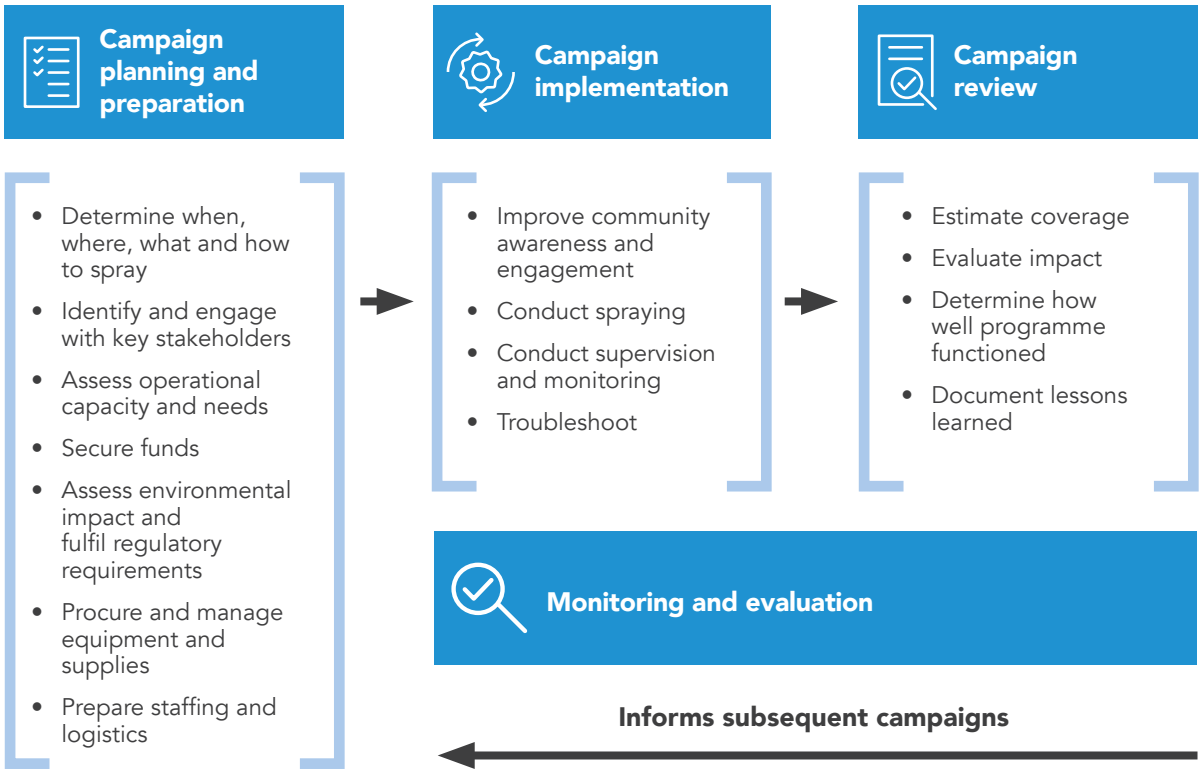
2.2.1.1 Phases of an IRS campaign

An IRS campaign can be broadly broken down into three phases (Fig. 2):

- **Campaign planning and preparation:** This includes determining where and when to spray and what the current operational capacity to deliver IRS may be, conducting a needs assessment, and preparing for IRS operations to ensure timely availability of all requirements including staff, equipment, supplies and logistics.
- **Campaign implementation:** Sometimes referred to as the "attack" phase, at this stage, spraying is under way and there is constant supervision, monitoring of programme progress, identification of issues and troubleshooting.
- **Campaign review:** Data generated from this evaluation phase is used to determine how well the programme functioned, and to estimate what proportion of the target population was protected by IRS and the impact on vectors and disease. These data form the basis of the annual review of operations and are used to inform the next year's operations (during planning and preparation).

M&E is conducted throughout campaign implementation and informs campaign review.

Fig. 2. Overview of IRS spray campaign phases



Further details on actions within each of these stages is provided in Tables 1, 2 and 3 below and in the respective sections.

Table 1. Planning and preparation

Action	Components
Conduct baseline or annual situation review for proposed spray areas	• vector-borne disease burdens and trends • vector ecology and insecticide resistance • environmentally or agriculturally sensitive or protected areas that should not be sprayed • assessment of coverage achieved during past spray campaign(s) • estimation of coverage of new IRS programmes
Conduct initial assessment or update geographical reconnaissance information	• target areas • populations at risk • target housing units, structures and surfaces to be sprayed
Conduct assessment of operational capacity and needs	• human resources • infrastructure for spray camps equipped with wash areas for equipment and personnel, soak pits and/or evaporation tanks, waste disposal arrangements, storage, stock control • transport • equipment and supplies, such as insecticides, sprayers, tools and spares, personal protective equipment (PPE) and vector insecticide susceptibility test kits
Calculate financial requirements and secure sufficient funds	• human resources • equipment, consumables, insecticides and susceptibility test kits • transport and logistics • safety requirements • storage requirements • waste management requirements • accommodation (or camping) requirements • data collection and management requirements • training requirements • overall administration costs • medical aid in contingencies
Conduct environmental impact assessment and development of pesticide management plans	• environmental impact assessment • pesticide management plans
Procure necessary resources	• equipment (spray pumps, spare parts, PPE etc.) • consumables • insecticides • transport • camping equipment for spray teams, if required
Manage stock	• establishment of stock • plans for stock management and storage
Plan for environmental protection	• establishment of safety and environmental health management and risk mitigation plans
Establish waste management facilities	• spray camps, soak pits and/or evaporation tanks • waste disposal facilities
Develop implementation plan	• daily average number of houses or sprayable surface areas to be treated by the spray operator (daily output of spray operator) and number of work-week days • community engagement schedule for pre- and post-spray • spraying schedules, both for individual areas and for completion of the whole spraying round • establish follow-up/mop-up spraying plans

Action	Components
Organize staffing, transport, commodities and delivery logistics	• assessing the status of and planning for transport and fuel, and developing mitigation plans for breakdowns and shortages • arranging for spray team transport, as well as transport for team leads and supervisors for their supervision duties • establishing finance and accounting systems for field operations, including systems for worker payments (e.g. bank accounts and mobile banking) • preparing district and subdistrict sites for storage and base operations, including facilities for liquid waste disposal
Plan IRS-related information, education and communication (IEC) for areas targeted for spraying	• developing IEC plans and messaging • informing, educating and mobilizing local authorities and communities
Establish staff tasks	• mapping out responsibilities at all levels and calculating the number of staff required (nationally, subnationally and on the ground, e.g. spray operators, team leaders and supervisors) • establishing an organizational chart • creating job descriptions and clear terms of reference, based on activities to be undertaken • preparing salary structures and working conditions, codes of conduct and reporting structures for all staff involved in the spray programme • recruiting and training of spray teams • preparing supervision schedules and supervision checklists including those relating to pesticide management and environmental compliance
Develop and establish an M&E plan	• preparing a plan for the collection, accounting and disposal of empty insecticide sachets and containers • conducting entomological routine collection activities • assessing the quality of the IRS product through pre- and post-shipment quality control sampling with testing for all specifications (not just the active ingredient (AI)) • assessing IRS coverage and spray quality • preparing reporting systems and appropriate reporting forms and checklists • tracking progress towards achieving the activities and objectives

Table 2. Campaign implementation

Action	Components
Distribute equipment and supplies	• managing insecticides, sprayers, PPE and other consumables
Improve community awareness and engagement	• engaging with community leaders • implementing IEC activities
Implement IRS, including concurrent supervision and M&E	• conducting spraying • updating baseline and, during operations, routine entomological data from areas targeted for IRS • monitoring IRS implementation, including supervision, data recording and reporting • conducting follow-up/mop-up activities • conducting quality control assessments of spraying • documenting, managing and troubleshooting issues

Table 3. Campaign review

Action	Components
Compile and assess M&E data	• reporting and reviewing coverage, quality and timing achieved in spray areas • reporting and reviewing the residual efficacy of insecticides used • reporting and reviewing entomological monitoring
Document lessons learned	• documenting what went well and what did not go well • formulating recommendations for subsequent spray rounds

2.2.2 Plan of action

The management cycle of operations should be supported by a detailed Plan of Action, with support from partners as appropriate. The Plan of Action is the equivalent of an annual work plan. This should include the actions listed above for each of the phases of a campaign. The Plan of Action needs to have the required financial and human resources investment to enable timely establishment of systems and structures, procurement of commodities, and recruitment and training of personnel. IRS implementation requires good coordination and careful tracking, with clear deadlines to facilitate the completion of activities before the start of the vector-borne disease transmission season. Throughout the planning process, technical goals need to be within the scope of the financial and human resources available. The Plan of Action can be used as a checklist to ensure that all areas of the programme are in place or have been duly considered. An example of a generic timeline for implementation of IRS has been provided (Annex 2).

The Plan of Action is usually developed by experts from the Ministry of Health in the areas of epidemiology, entomology, human resources, finance and logistics, and also in collaboration with other ministries, such as agriculture and the environment, as well as national pesticide regulatory authorities, partner nongovernmental organizations (NGOs) and private-sector entities. There must be open communication between the IRS programme, the rest of the health system and the community. A multisector national IRS advisory committee may provide a useful mechanism to support the operations and ensure that a Plan of Action is established well in advance.

2.2.3 Financial planning

The annual cycle of IRS operations requires preparation of detailed financial plans (budgets), often accompanied by funding proposals based on estimated needs for all operations throughout the phases of the IRS campaign. Securing finances and procuring commodities must be planned at least 6–12 months in advance. The budget must be sufficient to cover all identified activities – from the establishment of management plans and associated meetings through to the final reporting and review. The Plan of Action may be useful for determining the costs to consider.

Where IRS is being established, costs should be estimated both for initial pilot districts and for the planned roll-out to cover all target areas. If a programme is considering implementation of IRS beyond the current year, the potential long-term costs of insecticides, spray application equipment and its maintenance, and retention of permanent IRS staff should be considered.

Countries implementing IRS programmes should rotate the class of insecticide on a schedule that is programmatically feasible (e.g. every two years) to manage the increasing challenge of vector resistance to insecticides. The costs of these different products should be taken into account.

A contingency fund, generally estimated as 10% of the overall budget, should be included. There are numerous examples of programme failure due to underestimation of the required insecticide quantities, number of personnel or fuel costs, or when the expected staffing support from partners did not materialize. An example of a capital and operational budget for IRS has been provided (Annex 3).

Programmes should aim to optimize resources for vector control, including, where possible, through collaboration with other ministries, civil society and the private sector to enable efficient and cost-effective IRS operations. The plan should include identifying sources of funds and in-kind contributions (such as warehousing and transport), whether from central, provincial/state or local government budgets, or from other sources.

2.2.4 Organizational structure

To run an effective IRS campaign, it is essential for there to be sufficient personnel with adequate skills to establish, manage and implement all IRS operations. The structure of the campaign and its associated human resources needs may vary with how the programme is managed (e.g. centralized or decentralized) and will depend on the planned time frame for completing the spray round and the attributes of the target areas to be sprayed, such as accessibility, size and terrain.

In most country settings, the vector-borne disease control programme directs and coordinates the IRS operations. However, the structure and organization of campaigns may range from centralized programmes with operations managed at the national level, to decentralized programmes in which operations are managed at the provincial/state or district levels. Responsibility for planning and decision-making and other aspects of vector-borne disease control depends on the administrative structures of the Ministry of Health and different levels of government. Responsibility for implementation may be localized at the district level, regionalized or completely vested in the Ministry of Health, or may be shared at the district level with local government structures, such as local councils, municipalities and town boards.

For all programmes, it is important to develop organizational charts, often accompanied by organograms illustrating the staffing structure, the relationships between staff and their duties. In establishing the human resources needs and staffing structure, the specific activities to be undertaken at each administrative level should be identified and then particular roles matched to fulfil those needs.

2.2.4.1 Typical responsibilities at the national level

The vector-borne disease control programme manager coordinates the overall programme implementation with responsibilities largely delegated to a national vector control or IRS coordinator working with the national entomologist. The national coordinator may be supported by personnel experienced in data management and analysis, finance and logistics. Policies for requirements such as pesticide registration and compliance with environmental regulations, as well as labour policies for hiring temporary workers, need to be in place. A central

entomology laboratory is usually essential for analysing vector species and determining insecticide resistance status. A national vector control advisory committee and/or national research institutions may offer extra support and advice. In countries with smaller populations or in decentralized structures, the responsibility for vector control may be vested in environmental health officers.

2.2.4.2 Typical responsibilities at the provincial/state level

The provincial/state vector-borne disease control officer and an IRS officer coordinate the implementation of the IRS programme across districts and help to put national strategic plans and guidelines into practice.

2.2.4.3 Typical responsibilities at the district level

The district health officer, district vector-borne disease coordinator or district IRS coordinator oversees the implementation of all IRS operations and activities within the district. At the operational level, IRS activities are managed through the subdistrict field coordinators and spray team group leaders.

The Ministry of Environment and Ministry of Agriculture representatives should ideally be included in the district supervision teams to provide oversight on the management of insecticide use and disposal. Likewise, country environmental protection agencies will be useful for providing or organizing training on the proper handling and disposal of chemical waste.

A vector control officer should be designated as the IRS focal person at each administrative level. Technical support in entomology and epidemiology should be made available during the planning and M&E of district IRS operations. The IRS focal points should be supported by a national vector control or IRS vector control technical advisory committee and a network of research and academic institutions with an insectary and entomology laboratory.

2.2.4.4 Typical responsibilities at the community level

Village- or community-level responsibilities draw on local knowledge and capacity to ensure that accurate information and access are provided to spray teams in a timely and unrestricted manner. Other responsibilities may include the selection of spray operators from the community, management of spray equipment and supplies, such as provision of storage facilities and security for IRS logistics and equipment, provision of IEC to community members and reporting of coverage rates.

An example of the IRS structure and associated roles at different levels is summarized below (Table 4), and examples of IRS organograms at different levels are provided in Annex 4.

Table 4. Example of IRS task allocations at different levels (based on a four-tier system for routine operations coordinated by the Ministry of Health)

National/federal	Provincial/state	District/municipality	Village/suburb/community
• Developing an IRS policy • Developing IRS guidelines • Developing IRS proposals and national Plans of Action, including establishing an M&E plan • Establishing and maintaining multisectoral cooperation • Establishing organizational structure • Aligning responsible authorities for product registration and oversight of spray campaigns, including environmental compliance and human safety, across national and local levels • Budgeting and securing finances • Managing finance and accounting systems • Establishing and managing technical advisory committees, and planning and managing technical meetings at the national level • Estimating infrastructure, commodities, human resources and transport needs • Defining specifications for equipment, insecticide products and commodities • Conducting central procurement and commodity quality control • Managing central stores and stock control • Distributing commodities nationally	• Developing provincial Plans of Action • Managing all IRS operations in target districts • Supporting district entomological monitoring, sourcing other data (epidemiological, demographic, operational) and managing data • Providing estimates for operational requirements of insecticide products, equipment, human resources and logistics at the provincial level and developing budgets • Developing and evaluating IEC materials • Coordinating and supervising district operations and supervisors • Undertaking cascade training and performance evaluation of district supervisors • Receiving and distributing commodities to districts • Establishing provincial stores and managing stock	• Developing district or municipality Plans of Action • Estimating operational needs, such as staffing, commodities, transport and logistics • Budgeting and managing operational costs and finances • Recruiting, managing and supervising field personnel • Overseeing district stores and stock control • Receiving and distributing commodities for community implementation • Training and assessing field staff • Ensuring security and proper use of insecticides, equipment and transport, including disposal of chemicals and contaminated materials • Implementing day-to-day running of IRS operations and undertaking quality assurance checks • Implementing IEC activities • Undertaking equipment inventory and repairs	• Developing community spray plans (for district/municipality approval) • Identifying appropriate community-level staff • Mapping structures as part of geographical reconnaissance • Participating in the collection of basic entomological data • Issuing/receiving, caring for and managing insecticides, equipment and other commodities, and ensuring safe disposal of waste products • Conducting IEC in target villages/areas • Supervising and/or implementing spraying

National/federal	Provincial/state	District/municipality	Village/suburb/community
• Developing staffing terms of reference and codes of conduct, and hiring national-level staff • Identifying training needs, developing training curricula and training subnational coordinators • Establishing and maintaining national databases of geographical reconnaissance, entomological and operational capacity data • Providing technical support subnationally for all operations • Providing support and technical advice for baseline and routine data collection, analysis and interpretation • Monitoring and coordinating all IRS activities carried out by the provinces/states and related agencies, and providing feedback for remedial action as needed • Undertaking national evaluation activities, analysing data and reporting for annual reviews • Planning operational research (when required) and collaborating with research institutes and universities • Undertaking annual programme reviews	• Conducting or supervising equipment repairs • Monitoring and reporting of district progress and acting to intervene as necessary • Collecting, collating and analysing baseline and routine data from districts and reporting findings to national level • Reporting IRS coverage and quality in IRS districts to the national level • Holding biannual programme review meetings with district leadership	• Conducting/updating geographical reconnaissance (including selection of villages/areas and households to spray), managing data and reporting to the province • Running vector sentinel sites (vector ecology, bioassays, susceptibility studies), managing data and reporting to the province • Providing regular reports on operational progress in the field • Designing mop-up plans and ensuring that they are undertaken • Monitoring, evaluating and reporting field operations (integrating with established systems, where possible)	• Overseeing/conducting quality assurance • Reporting the number of structures sprayed and amount of insecticide used daily to the supervisor and at the end of the operation to the district • Reporting adverse events due to IRS, such as to the community health centre
Responsible: national IRS coordinator, national entomologist, data manager, financial manager, logistician	**Responsible:** provincial/state IRS coordinator, provincial/state entomologist	**Responsible:** district IRS coordinator, district environmental health officer, entomology technician, data manager and data entry officers, district IRS logistician (stores control) and equipment technician, district finance and payroll officer	**Responsible:** supervisor, storekeepers, spray operators, including one team lead

2.2.4.5 Vector control technical advisory committee

Establishing a specific advisory committee or subgroup of an existing committee may be useful for providing support on policy, technical and programmatic issues related to IRS. The group could also be used to provide guidance on the selection of districts for IRS, insecticides and equipment, and on the monitoring of coverage rates, as well as provide support for spray round reviews and programme evaluations. The IRS advisory committee can include members of the national vector control unit, national IRS coordinators and vector control officers within relevant departments. Representatives from other sectors, such as ministries of the environment and agriculture, including those responsible for product approval/licensing, the private sector (who may support IRS as part of workplace protection programmes) and the academic sector (who can help with programme reviews and evaluations, for example) may also be included. If such a committee is established, it should meet regularly during the preparatory planning period for each spray round to ensure timely preparation and then as frequently as necessary during the spray campaign to review progress against the originally set timeline. The committee's role should include identifying and proposing solutions for problems that arise in the field and taking corrective action if needed. Once the spraying has been completed, the committee should meet to support the programme evaluation.

2.3 Environmental protection and human safety

In establishing an effective IRS programme, it is essential to have in place a well designed human safety and environmental protection plan.

2.3.1 Sound management of insecticides and environmental impact assessments

All insecticides pose inherent risks and their safe use requires establishment of an insecticide management system with regular M&E checks built in (see section 5).

Sound insecticide management is the regulatory control, safe and proper handling, supply, transport, storage, application and disposal of insecticide products to minimize adverse environmental effects and human exposure. A compendium of guidelines and other resources has been produced by WHO and the Food and Agriculture Organization of the United Nations (FAO) *(23)*, and further information is available from manufacturers of particular insecticide products.

2.3.1.1 National insecticide registration and WHO prequalification

The registration of VCPs may fall under the responsibility of the ministries of health, agriculture and/or environment. Product registration is intended to ensure that products comply with the national legislation and regulations to support their use. The WHO prequalification programme includes a comprehensive assessment of individual VCPs through a standardized procedure aimed at determining whether the product meets WHO prequalification requirements for quality, safety and efficacy. This is for the purpose of providing guidance to interested United Nations agencies and WHO Member States in their procurement decisions. In many cases, countries may rely on WHO prequalification assessments as the basis for national

registration. Some national regulatory authorities may require additional data and assessments to support national registration.

For WHO prequalification, WHO develops and provides generic models that can be used for human health risk assessment of VCPs. These documents are referred to as generic risk assessment models. Generic risk assessment models consider both adults and children of all age groups, as well as people in the following categories:

- those handling products and preparing for application of the product;
- those applying the products; and
- residents who may be exposed post-treatment.

In characterizing risk, estimates of exposure to the AI are compared to acceptable exposure levels, as defined in the hazard assessment. Risk is considered across all exposure scenarios. The purpose of risk characterization is to examine the probability of adverse effects occurring during the use of the insecticide under defined exposure conditions. A risk–benefit analysis in which the risks of potential toxicity are compared to potential health benefits (e.g. disease prevention) may be needed in some cases.

Guidelines and additional information on the procurement of public health pesticides, lists of prequalified products and national pesticide registration are available from WHO and FAO, including the *Guidelines for procuring public health pesticides (24)* and a toolkit *(25)*.

2.3.1.2 National environmental assessment for insecticide application

Before procuring or using insecticides for vector-borne disease control, in most countries, an environmental assessment may be required to comply with national and local regulations. This is often scheduled to take place 4–6 months before the commencement of spray operations. In general, the assessment includes descriptions of the affected environment and species present, in particular those that may be threatened/endangered, the local species habitats, the soil type, water bodies and economic activities in the area. Details of the proposed insecticidal product(s) are provided, such as current registration status; eco-toxicological hazard of the AI(s); supporting ecological risk assessments based on use and environmental exposure scenarios; availability and effectiveness of other pesticides or non-chemical alternatives to IRS; availability of appropriate and safe application equipment; provisions made for training personnel to ensure safe insecticide use; and requirements for insecticide distribution, storage, use and disposal. The assessment details the environmental impact of spraying on the area, which should be weighed by programmes against other interventions or the likely human health consequences of not implementing IRS. The mitigation measures and conditions required to avoid, minimize and/or offset environmental impacts from IRS should be included.

2.3.1.3 Safe handling of insecticides

Insecticides should always be handled and applied with the understanding that all pesticides are inherently toxic. The safe and effective use of insecticides requires correct handling, application and safe disposal of waste and used containers. The product label is usually the first reference for guidance on handling the formulated pesticide product. Safety instructions must be followed by all those who handle or

come into contact with insecticides to avoid risks of elevated exposure for spray operators, household residents, pets and domestic animals, and the environment (see further details on occupational exposure below).

Best management practices should be established and regularly monitored throughout IRS operations regarding:

- storage, labelling and transport of insecticides and equipment;
- disposal of insecticides and other consumables; and
- occupational exposure and safety (for all points of handling, application or disposal of chemicals).

Health monitoring and insurance

Spray programme managers should consult and abide by local health and safety worker regulations and other applicable laws. In some countries, health insurance and/or health monitoring of spray operators may be required. This may include regular medical examinations or health checks.

For instance, in areas where IRS with malathion is applied for vector control, monitoring of acetylcholinesterase levels among spray operators is required after each round of spraying. Guidelines for personal protection when handling and applying pesticides are available and should be followed *(26)*.

Household occupant exposure risk

As well as ensuring the safety of programme staff, the safety of occupants of sprayed houses and their neighbours should also be ensured. Plans should detail how safety measures will be implemented and how risks will be mitigated. Informational campaigns, sensitization and mobilization activities are critical to ensure the safety of residents (see section 3.6).

3. Planning and preparing for IRS

3.1 Determining where, when and how often to spray

In general, IRS can be implemented in most eco-epidemiological settings, as long as the conditions outlined in section 1.1.3 are met. For efficient and effective implementation and maintenance of the programme, the requirements outlined in section 1.1.6 must also be fulfilled, and it should be ascertained that IRS is expected to have no harmful effects on the environment. Establishing and implementing an IRS programme requires considerable political and financial investment. Therefore, applying IRS in an informed and strategic manner is critical. Most programmes target IRS to specific areas, and usually commence with pilot implementation to confirm feasibility and impact before scaling up the spray programme.

The implementation of a spray campaign from start to finish in a given area over a defined period of time is called a spray round. The timing between rounds and their frequency is critical to achieving maximum impact against the target disease(s) and depends on the seasonality of vector populations and disease transmission, which in turn is related to weather, especially rainfall, humidity and temperature.

Spray rounds should ideally be completed before vector abundance increases and therefore prior to the start of the transmission season of the target disease(s). In many settings, vector abundance increases shortly after the onset of the rains (e.g. *An. gambiae* mosquitoes). However, the seasonality of vector abundance should be assessed based on local entomological data to determine whether this is the case for the specific target vector(s) of the area. For example, abundance of triatomine bugs is largely driven by temperature rather than by rainfall.

If vector abundance is found to increase following the start of the rains, the spray round should be completed as close to but prior to the first rains. The seasonality of onset of the rains often varies from one part of a country to another. Monthly surveillance data should be analysed and areas stratified to ensure that those areas with earlier rains and/or critical areas are prioritized.

While the schedule for routine spraying should ideally be fixed each year to occur prior to the expected peak of vector density and should not be subject to major changes, some adjustment may be needed under special circumstances (e.g. a weather anomaly such as a major flood event). It is critical to work with the meteorological department to understand weather-related risks and events during the period planned for spray operations.

If reactive IRS is being used in response to an outbreak, upsurge or humanitarian emergency, the most critical issue will be rapid implementation. For focal IRS in low transmission settings, capacity for rapid response will need to be maintained throughout the year. Plans should be in place to ensure that a vector control team

overseen by the district or municipality coordinator is available and ready for rapid deployment.

Logistical and human factors are also key considerations when planning IRS. Once the rains begin, roads often become impassable for spray teams, and residents may be reluctant to place their belongings outside in preparation for the spray. Programmes need to ensure that there are adequate numbers of spray operators to complete the spray round within the stipulated time.

Considerations of the residual efficacy of the product chosen in the specific setting should guide the frequency of spray rounds. Spraying should be timed with the aim of ensuring that insecticidal deposits remain active throughout the transmission season (i.e. IRS is not applied too early and thereby fails to provide coverage for the whole transmission season). Product formulations can provide different durations of residual efficacy on different surfaces. Ideally, the selected products will provide residual efficacy for at least three months after application on the predominant substrate(s), with the desired duration of residual efficacy being one year or longer.

For instance:

- In areas with perennial transmission, optimal coverage of IRS should be maintained year-round. This may require two rounds of spraying, for example, once every six months. However, some insecticide formulations have been shown to last beyond six months, in some areas and on some surfaces.
- In areas with one transmission season, one spray round annually before the period of transmission should be sufficient to impact vector-borne disease transmission.

If the transmission pattern exhibits bimodal peaks, spray rounds should target the peaks. Information on WHO-prequalified IRS products should be sought on the WHO website *(18)*.

3.1.1 Sources of data for decision-making

Decisions on whether, where and when to deploy IRS in an area depend on a number of factors falling under the following broad characteristics of an area:

- epidemiology
- entomology
- demographics (population data)
- structures (location, density, type)
- ecology
- environment
- health service capacity
- financial resources.

Features of an area can be assessed using data assembled from active on-site surveys and/or desk reviews of readily available information, including routine health facility surveillance reports, survey data (e.g. census results) and research studies. This information is essential to guide IRS operations and should be regularly validated and updated, such as through rapid field assessments and geographical reconnaissance (see section 3.1.2). In addition to guiding decisions as to where and when to spray, some of these data can also be used as baseline measurements against which the programme can later be monitored and evaluated (see section 5).

3.1.1.1 Epidemiological data

Epidemiological data can be used to determine the disease burden and seasonality in an area. Key epidemiological indicators often monitored are:

- disease or pathogen prevalence, determined through cross-sectional population-based surveys; and
- disease or pathogen incidence, determined passively through facility-based records and calculated monthly or annually.

Routine vector-borne disease surveillance data from health facilities should be accessed and tabulated by relevant administrative category, such as by district or primary health centre, to generate monthly and annual figures. Disease/pathogen incidence should be calculated both in total and by age group. Where feasible, and where sufficient financial and human resources are available, passive facility-based incidence data can be complemented by community-based prevalence surveys for the target vector-borne disease(s). Mortality data can also be sourced from health facility records and used to assess disease burden in an area. Epidemiological data should be considered in the context of past or current interventions, including for the prevention, diagnosis and treatment of vector-borne diseases.

Systematic collection and analysis of such data will enable the stratification and prioritization of areas for disease control. Thresholds for stratification of disease transmission intensity and appropriate interventions to apply are usually set by the individual country based on epidemiology, geography, cost and available budget. For example, some countries may decide to apply IRS only in those areas assessed to be of moderate and high transmission intensity. The thresholds and stratification should be reviewed regularly based on the latest data and feedback from the field to identify or update priority target areas as a means to maximize efficiency and impact. Analysis of these indicators by month can also be used to assess when transmission peaks and thus guide the timing of the IRS operations. Within strata where IRS may be appropriate, a key consideration is what target area and IRS coverage levels are logistically feasible.

For reactive IRS, mapping of case locations or likely locations of infection can assist in identifying high-risk areas for prioritized implementation *(8)*.

The following summarizes where IRS may be appropriate based on disease endemicity. This has been generated from existing WHO recommendations and guidance *(6-10)* as well as expert opinion and may be subject to update.

Examples of epidemiological criteria for selection of IRS target areas

Malaria

- Regular rounds of IRS are applied in areas with ongoing malaria transmission or where incidence exceeds a certain threshold.
- Reactive IRS is applied in specific situations, such as in areas with an outbreak of malaria, affected by an humanitarian emergency or where there are reports of a high level of *Plasmodium falciparum* drug resistance.
- Focal IRS is applied in low transmission settings, such as in active foci of transmission (or in some instances, in malaria-free areas with high risk).

Visceral leishmaniasis

- Regular rounds of IRS are applied in areas with anthroponotic transmission where phlebotomine sand fly vectors are peri-domestic and there has been:
  - at least one visceral leishmaniasis case reported at any time in the village/community in the preceding three years; or
  - at least one visceral leishmaniasis case reported three years after no case was reported in that village/community, or occurrence of one new post kala-azar dermal leishmaniasis case (a sequela of visceral leishmaniasis), detected during routine disease surveillance.
- Reactive IRS is also applied during an outbreak of the disease, such as when the threshold is exceeded in an endemic area or when the disease is introduced or becomes re-established in a non-endemic area.
- Annual planning for IRS should consider provisions for newly detected visceral leishmaniasis/post kala-azar dermal leishmaniasis case foci according to the criteria described above. Factors related to the reservoir host should also be considered.

Cutaneous leishmaniasis

- Regular rounds of IRS are applied in areas endemic for anthroponotic cutaneous leishmaniasis.
- Reactive IRS is applied in specific situations, such as when a new cutaneous leishmaniasis case is detected in a village/community that had reported no cases in the preceding three years.

Aedes-*borne diseases*

- Regular rounds of IRS are applied prior to the transmission season in endemic areas or in areas of historical transmission for dengue, chikungunya or Zika virus disease.
- Reactive IRS is applied in households, workplaces or other public spaces with a confirmed or suspected case and within a certain radius (e.g. 50–100 m), or at the nearest neighbours and other high-risk properties.
- Note that barrier or harbourage spraying in outdoor peri-domestic spaces may also be undertaken, but is beyond the scope of this guidance document.

Chagas disease

- An initial spray round of IRS is applied in areas endemic for Chagas disease and with triatomine infestation rates over 5% in baseline surveys.
- A second spray round is conducted in areas where triatomine infestation rates are over 5% in post-spray surveys, with all households in the area targeted for spraying.
- Spraying can also target peri-domestic areas, especially if chicken coops, pig pens or other potential refuges for triatomine bugs are present (e.g. firewood, bricks, adobe, tiles in courtyard).

Lymphatic filariasis

- Regular rounds of IRS are applied, often through malaria or dengue control activities, in areas where lymphatic filariasis co-circulates and vectors are *Anopheles* or *Aedes* spp.
- Reactive IRS may be used in areas endemic for lymphatic filariasis where therapeutics are not widely available or accepted.
- Note that IRS (and insecticide-treated nets) may be prioritized to communities where lymphatic filariasis is co-endemic with malaria and loiasis, in combination with biannual albendazole mass drug administration.

Disease prevalence and incidence data can also form the baseline against which the impact of IRS can be evaluated as part of broader programmatic reviews.

3.1.1.2 Entomological (vector) data

The key entomological determinants of IRS effectiveness are vector species present and their:

- insecticide susceptibility status;
- seasonal density and distribution; and
- resting and feeding behaviour.

IRS is particularly effective in areas where the vectors have a strong preference for feeding and resting indoors (i.e. are endophagic and endophilic). Some vectors that feed indoors but tend to rest outdoors (exophilic) can also be controlled if they rest indoors, even very briefly, after feeding. Likewise, there are situations in which the human population tends to sleep outdoors at night, but the vector rests indoors during the day in houses or cattle sheds and can thus be controlled by IRS. There are, however, some situations in which the vector is strongly exophagic and exophilic, both feeding and resting outdoors, and rarely comes into contact with an indoor wall surface. In these cases, IRS may not be effective.

Entomological surveys can identify the primary and secondary (if any) vector species responsible for transmission in a given area. If data exist on specific traits associated with these species (either locally or regionally), knowing the species composition can help to determine the appropriateness of IRS for that setting. For example, if the key malaria vector species in an area is determined to be *An. gambiae s.s.*, it is likely that the majority of the population will rest indoors to digest their blood meal; therefore, IRS would be an appropriate intervention.

In order for IRS to be applied at the correct time for maximum impact, seasonal changes in vector density and transmission potential need to be established and assessed in relation to meteorological and environmental data that could affect the logistics of the spray operations. For some vector systems, such as for leishmaniases, reservoir host–vector interactions are strong determinants of human risk and should also be considered.

Accurate susceptibility of the vectors against the insecticides available for IRS should be assessed as per standard procedures *(27)*. Insecticide resistance is a critical challenge currently facing vector control efforts, and knowledge of the resistance status of the key vectors is central to the planning and implementation of an effective IRS programme *(20)*.

An entomological monitoring plan that also considers insecticide resistance should be established. For the purpose of IRS, this should aim to determine the appropriateness of an area for spraying and support decisions on where, when and what to spray. In addition to vector identification, feeding and resting behaviour and insecticide susceptibility status, programmes should also monitor the duration and effectiveness of IRS application. Currently, this is done by means of the standard WHO cone bioassays (see section 5.5).

Where it is not possible to conduct entomological surveys prior to implementing IRS, data can be used from sentinel sites that are proximal to that area and have similar eco-epidemiological characteristics.

Additional information

Entomological data may provide further insights to assist in evaluating the impact of the IRS campaign and can be collected at baseline and periodically thereafter. Such data include the time of host seeking, preference for feeding indoors or outdoors, preference for feeding on humans or on animals, age of the vector population (often assessed through parity rates for mosquitoes), human-biting rates, human blood indices, sporozoite rates and entomological inoculation rates. If gathering these data is beyond the capacity of the vector-borne disease control programme, these can be assessed in collaboration with national research and academic institutions.

Section 5 includes further details on entomological indicators and methods of assessment, with supporting materials available from WHO *(28)*.

3.1.1.3 Ecological considerations

A number of ecological variables have an impact on vector bionomics and therefore influence the intensity of vector-borne disease transmission and the effectiveness of IRS. These variables include topography, altitude, the presence of permanent water bodies, temperature, humidity (wet, dry and winter seasons) and rainfall (duration and intensity). Depending on the targeted vector-borne disease(s), epidemiological and entomological data should be evaluated in relation to relevant meteorological and environmental data, especially on rainfall and temperature. This provides further guidance for prioritizing areas to spray and for identifying the best time to spray and the number and timing of spray rounds.

3.1.1.4 Environmental safety determinants

Agricultural practices need to be taken into account when selecting areas for IRS, including certification for organic farming, export of pesticide-free crops or practices such as silk-worm cultivation in Asia. Consulting and achieving consensus with environmental agencies and agricultural ministries regarding where it would be appropriate to spray considering these environmentally sensitive areas is vital. Inclusion of representatives from these ministries in vector control technical working groups can enhance informed decision-making.

Once an area has been tentatively selected for IRS and prior to procurement of insecticides, most countries, programmes and implementing partners require that environmental assessments be conducted and safety reviews be carried out to ensure safe pesticide management and delivery of IRS (see section 2.3.1). Programmes must ensure that they comply with applicable standards and procedures for pesticide storage, delivery, usage, stock control, recording and reporting (see sections 3.4 and 3.5).

3.1.1.5 Health services determinants

Adequate health service capacity is important for the successful establishment and implementation of an IRS programme. It is therefore necessary to assess the status of the following elements:

- the health system's organization at the community, district/state, regional and national levels, and its ability to implement or support an IRS programme;
- health financing for insecticides, equipment, transport and operational costs (taking into account the anticipated period of deployment); and
- human resources capacity in vector control and entomology for planning, implementing and managing an IRS programme.

3.1.1.6 Human population data

To select areas for spraying, it is essential to gather information about the population in the proposed target area. Population information is usually captured during geographical reconnaissance (see section 3.1.2) or can be sourced from the latest population census data, inter-census surveys and demographic health surveys, as well as from local government records and health facility records. Information may also be sought from other major community-based programmes, such as the Expanded Programme on Immunization, or insecticide-treated net distribution data.

These primary and secondary data sources should be used to provide:

- names of relevant administrative areas (e.g. province, region, state, district, ward, village – terms used may vary by country) broken down to the lowest levels;
- names of major urban centres or target villages/communities;
- population numbers by administrative area and by rural and urban distribution;
- population structure by age group (under or over 5 years, male or female);
- population distribution and density; and
- average household size (number of people per household).

Other data that can inform the appropriateness of an area for spraying may include transport routes and ease of access. Poor or non-existent roads, widely dispersed housing or the presence of physical barriers, such as rivers and mountains, can be major obstacles for spray teams trying to reach all households.

3.1.1.7 Structure data

Once a potential target area has been identified for IRS, detailed information on structures should be collected. These data are usually collected by means of geographical reconnaissance (see section 3.1.2) and other house-to-house surveys (see section 5.5).

Structures beyond residential households should be considered, such as other locations where people regularly spend nights. These can include:

- boarding school dormitories;
- health centre or hospital wards with inpatient capacity;
- hotels and rest houses;
- religious or other community centres where regular evening gatherings are held; and
- fishing and farm huts.

For spraying against those vectors that bite during times that people are not within their houses, other structures beyond the primary household should be considered for spraying and hence must be included in surveys. These may include:

- school rooms or buildings;
- shop houses;
- religious or other community centres where regular daytime gatherings are held;
- markets;
- health centres; and
- other public gathering places.

Data requirements during structure surveys include:

- number and type of structures;
- average number and type of rooms per structure type (e.g. sitting room, bedroom, kitchen, dining room, bathroom, toilet, animal shelter);
- average size of one room (in square metres of sprayable surface area);
- type of materials used for construction of walls and ceilings (e.g. mud, thatch, brick, bamboo, corrugated iron); and
- name of head of household and number of residents.

These data provide information on the total sprayable areas, enabling quantification of supplies needed. In order for the IRS programme to be successful, target structures must have suitable surfaces for treatment and the correct insecticide formulations for those surfaces must be selected. Traditional housing made of mud, clay or wood may require different formulations compared to modern houses that are made of brick or concrete and are often painted.

3.1.1.8 Spray locations and surfaces

"Sprayable surface" is defined as the inside surfaces of all structures that are of an appropriate material type for residual spraying and that therefore should be sprayed. This is based on the known resting sites of the vector species targeted, as well as the anticipated use of the structures (Table 5). While resting sites may include locations outside in the peri-domestic environment, these are not included in the scope of this guidance that focuses on the spraying of indoor surfaces.

Table 5. Examples of spray targets based on known common resting locations of different vectors

Disease	Vectors	Indoor resting locations appropriate for spraying	Indoor locations inappropriate for spraying
Malaria	*Anopheles* spp. mosquitoes	Walls, eaves (not exposed to rain), ceilings of sleeping structures, inside walls of detached latrines, inside walls and ceilings of animal shelters.[a] Verandahs or under-floor areas of raised houses (not exposed to rain) may also be included.	Non-sleeping structures (shops, schools), metal roofs, kitchens,[b] rooms housing people who cannot be moved[c]
Dengue, chikungunya or Zika virus disease	*Aedes* spp. mosquitoes	Lower portion of walls (up to 1.5 m) of houses – especially for *Ae. aegypti*, under and behind furniture, front and back of curtains, inside cupboards	Upper portion of walls and furniture (above 1.5 m high), kitchens,[b] bathrooms with tiled walls, rooms housing people who cannot be moved[c]
Leishmaniases	*Phlebotomus* spp. or *Lutzomyia* spp. sand flies	Lower portion of walls (up to 2 m)[d] of houses and animal shelters (especially cattle sheds),[a] kitchens[b]	Rooms housing people who cannot be moved[c]
Chagas disease	*Triatoma* spp. bugs	Walls – and especially cracks in walls	Kitchens,[b] rooms housing people who cannot be moved[c]
Lymphatic filariasis	*Anopheles* or *Aedes* spp. mosquitoes[e]	As above for relevant vector(s)	As above for relevant vector(s)

[a] Appropriate where vectors are zoophilic and proven to rest in animal shelters

[b] Kitchens are generally omitted from spray operations (to reduce the risk of contaminating food stuffs and cooking implements), unless there is evidence that these are preferred vector resting sites. Additional safety precautions and acceptance by the community are required if kitchens are to be sprayed.

[c] For instance, sick or elderly residents.

[d] Sand flies are likely to come into contact with the lower 2 m of surfaces while negotiating their upward movement and are likely to rest at or below 2 m after blood feeding. However, in areas where malaria and leishmaniases are co-endemic, the IRS strategy should align with the requirements for malaria by spraying the full height of walls, eaves, ceilings, etc.

[e] *Culex* spp. are vectors in some areas, but there is limited evidence of IRS impact on species of this genus.

The average sprayable surface area of structures and number of households in the target areas must be calculated to estimate the total number of square metres of surface to be sprayed and hence the amount of insecticide needed. This information must therefore be obtained prior to insecticide quantification and procurement.

An estimate of the average sprayable surface is usually determined using a representative sample of 5–10% of the total households in the target area(s). The type of all the structures that comprise the household (main houses, animal shelters and other buildings) should be noted, and surfaces areas measured and recorded. Depending on the resting sites of the target vector, this could include the inside walls, ceiling, doors, windows, curtains (front and back), inside cupboards, and underneath or behind furniture. When selective spraying will be undertaken, such as for *Aedes* spp., it is essential to calculate the actual areas to be sprayed, rather than the total wall and ceiling area.

The proportions of the different types of structures and average sprayable surfaces should be estimated. If applicable to the targeted spray area, structures can be classified using a simple system to assist in estimating the quantity of the specific

insecticide formulation to be used in IRS operations and in determining the logistical requirements of the programme. For instance, traditional or modern (formal) classifications widely used for malaria IRS are as follows:

- A traditional or rural house/structure is constructed from materials readily available in the local area (e.g. mud, thatch, sticks, rough lumber, bamboo, wooden planks). These frequently have very few internal partitions and their internal walls are seldom finished with plaster or paint in most rural areas.
- A modern or urban house/structure is frequently constructed from finished lumber, cinder block or brick, with multiple internal walls that have often been plastered with cement and/or lime to give a smooth finish or have been painted.

Types of sprayable surfaces

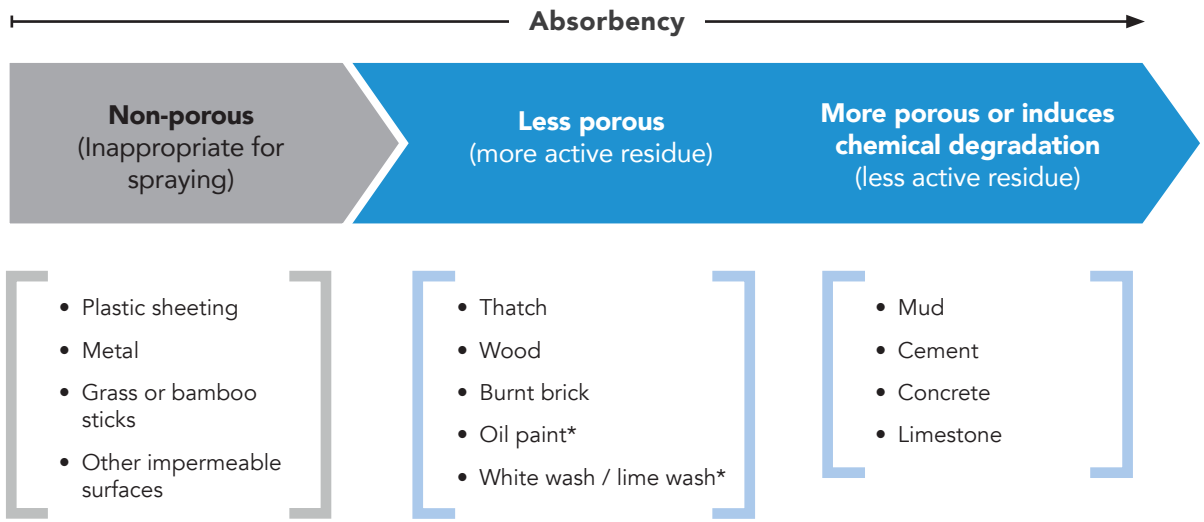
The persistence of an insecticidal AI sprayed on a surface varies with the type of insecticide, the product formulation and the type of surface. The residual efficacy of insecticides on absorbent surfaces can be 10–20% less than on non-absorbent surfaces. Most insecticides exhibit longer residual efficacy on wood and thatch than on mud. Mud surfaces, cement blocks, concrete and brick tend to absorb the insecticide, and certain types of mud may also induce chemical degradation.

It is important for there to be a clear understanding of the predominant surfaces that require spraying in the target area, and to ensure that the right amount (application rate) of the recommended concentration is sprayed based on the common surface types.

Some impermeable surfaces, such as plastic sheeting, may not be suitable for spraying, as the insecticide runs off leaving little residual effect (Fig. 3). Grass walls and those with bamboo sticks with wide gaps and metal ceilings are also not appropriate for spraying. To optimize potential residual efficacy, where available, label instructions guiding dilution and spray volume based on surface type should be followed.

The number of structures that are ineligible for spraying due to factors such as wall composition, structure use/type and so on should also be noted. This can be recorded as part of the reference number painted on the door of each structure or noted on the house spray cards.

Fig. 3. Relative absorbency of different surface types



* Note: paint or other substances applied to a surface will change its absorbency

Annex 5 provides an example of a sprayable surface recording form for baseline estimation of insecticide quantification needs.

3.1.1.9 Additional data

Collecting data on human population movement and the "permanency" of structures can be used to determine the appropriateness of IRS for an area. Settled populations that remain in one location for a good part of the year are more accessible than nomadic or mobile populations that migrate seasonally to fields or forests. Achieving high coverage of IRS in an area where the population is highly mobile often requires repeated follow-up (mop-up) spraying, which would need to be taken into account. The movements of people in and out of sprayed areas for the purposes of planting, harvesting, cattle grazing and other seasonal activities can also result in people moving from "protected" homes to those that have not been sprayed.

Temporary shelters that may be unsuitable for spraying are often used during seasonal activities or during periods of heavy rains or floods. Similarly, the construction materials used for housing within camps for displaced persons or refugees may not be conducive to spraying. Access to populations affected by complex humanitarian emergencies and natural disasters must be considered *(29)*. "Incomplete houses" also pose a challenge for IRS, as do those that are structurally "open" with few walls.

Knowledge of reservoir hosts is essential when seeking to control phlebotomine sand fly vectors, as this is a key factor in determining transmission dynamics of leishmaniases. For instance, in the Middle East, control interventions for leishmaniases often target reservoirs rather than vectors.

Social factors, such as the willingness of a community to accept IRS and to cooperate with a spray programme, are of critical importance when selecting target areas. Sometimes households are receptive to IRS during initial spray rounds when the vector-borne diseases or intense mosquito biting are perceived as problematic, but are less receptive when transmission has been reduced. The need to empty the house of many of the residents' belongings before spraying against *Anopheles* has also been reported to decrease the acceptability of the intervention over time.

Cultural and behavioural patterns in relation to housing must be considered. In some communities, outdoor sleeping is common in the hot and humid season, a time when mosquitoes are also abundant and active. Furthermore, individual households may re-plaster or whitewash walls, or re-thatch ceilings after spraying, thereby reducing vector exposure to the insecticide and necessitating repeat spraying.

3.1.2 Geographical reconnaissance and mapping of structures

Geographical reconnaissance is the method through which more granular data on demographics, village/community and structure distribution, structure type and local terrain can be collected, mapped and enumerated via on-site surveys before the spray campaign *(30)*. It encompasses censuses and mapping to determine the distribution of the human population and other features relevant for disease transmission in order to guide interventions (adapted from *(1)*). During this operation, houses and other sprayable structures can be allocated unique

identifying numbers to support the tracking and monitoring of IRS interventions throughout the course of the spray campaign.

Data captured through geographical reconnaissance operations provide the basis for key aspects of vector control operations planning, implementation and evaluation, such as selecting field centres and depots, allocating resources, designing deployment schedules and itineraries, monitoring intervention progress and assessing the completion of planned activities. It can also be used to define, as accurately as possible, the geographical limits of endemic vector-borne disease transmission and to assess epidemic potential, as well as to support routine disease surveillance activities. Geographical reconnaissance also allows for verification and/or updating of data collected through desk records or from other sources.

Precise information on the extent and number of structures in a target area informs resource needs, and the mapping of other public infrastructure, environmentally sensitive areas and road or access networks can support logistics planning. This enables the identification of locations that are environmentally compliant and safe, with adequate access, to serve as operation sites, stores, soak pits and wash areas, and helps to identify where essential resources, such as water supplies, may be located. Geographical reconnaissance data and supporting maps can be used to aid in the establishment of detailed schedules and itineraries for spraying and surveillance personnel, and the planning of transport routes and needs. During and at the end of the spray operations, these census and mapping data can be used to assess the progress and completion of the planned activities. Geographical reconnaissance may also provide more granular information on the geographical limits of vectors and disease-endemic or epidemic areas, enabling more precise IRS targeting.

Geographical reconnaissance should be conducted before IRS is implemented (Fig. 4). However, if it is not financially or practically possible before the first spray round, full geographical reconnaissance may be conducted during the first round and updated during subsequent rounds. The need and scope of geographical reconnaissance will vary from country to country and programme to programme, depending on the availability of data from other sources and on financial resources available to close data gaps.

Before undertaking local geographical reconnaissance, it is necessary to check what core geographical data may already be available in the country. Geographic information systems (GIS) in a given country may already be established in other government agencies and NGOs working in health, statistics, agriculture, environment, public works and so on. The vector-borne disease control programme(s) should collaborate with these institutions to prepare operational and risk-based maps (both spatial and temporal) using available data. This type of database and mapping is an excellent resource to support effective targeting of IRS.

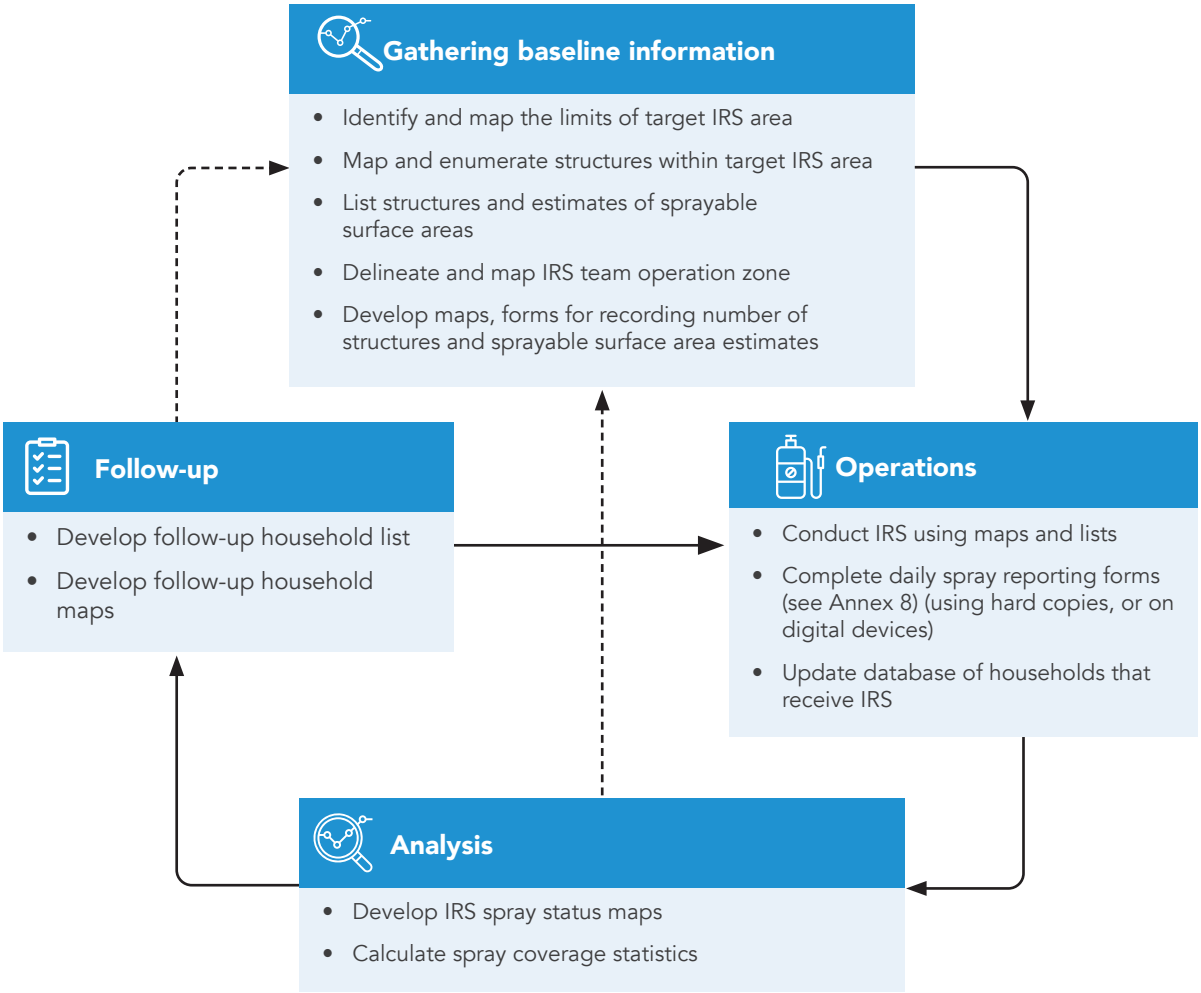
In addition to the data detailed in section 3.1.1, important information for developing IRS operational plans that is contained in such geographical databases includes:

- administrative boundaries (national, subnational);
- population by administrative level (to village or suburb level where available);
- location and elevation of villages or suburbs (including names and codes);
- location and type of health infrastructure;
- location and type of schools and other public infrastructures;
- location of roads (and other access routes), rivers, lakes and forests;

- location and type of safe water points;
- indicator data, such as population subgroups (age, sex, risk group);
- spatial distribution of target structures;
- location of protected or environmentally sensitive sites, such as national parks and wetlands; and
- population activities, such as farming.

All these data should be time-stamped and their source recorded.

Fig. 4. Geographical reconnaissance and mapping to support the IRS management cycle



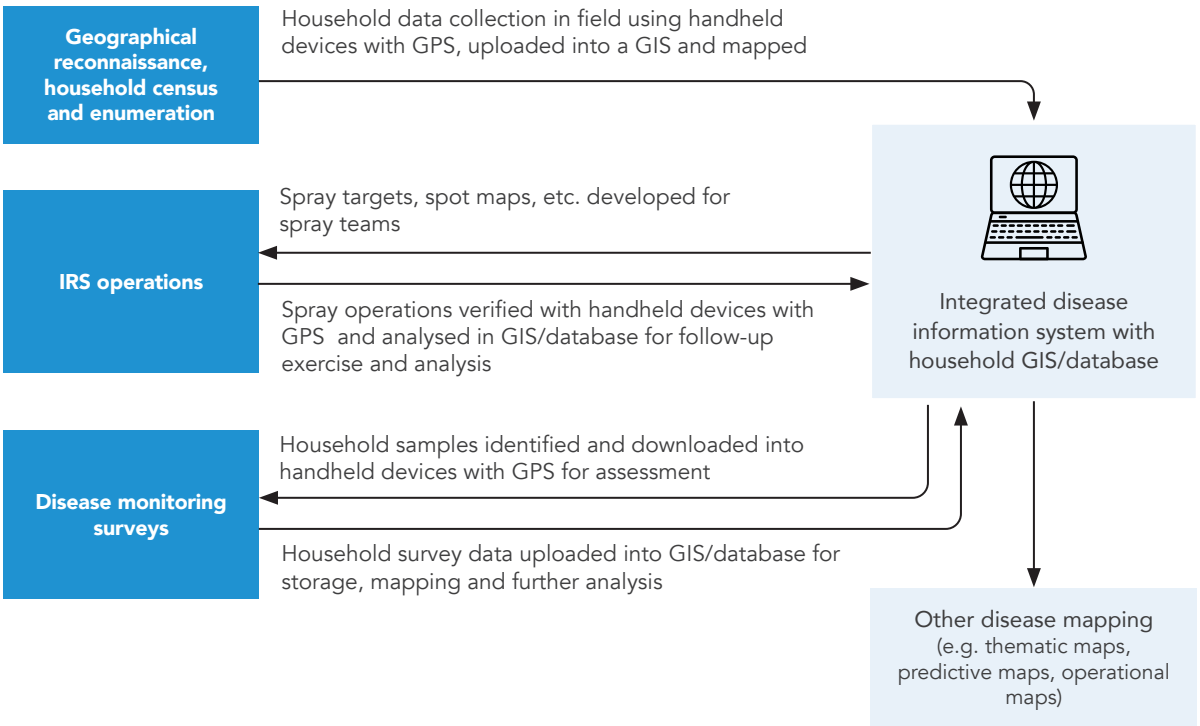
3.1.2.1 Mapping tools and technologies

Maps significantly help operational planning and guide spray teams to the structures to be sprayed each day. A range of tools and technologies are available to support mapping activities, ranging from published paper maps to digital GIS. However, the fundamental principles and the need for accurate and up-to-date basic information remain the same *(13)*. Topographical maps are often available from the surveyor general's department or from local government planning departments. These maps show administrative boundaries, roads, villages/suburbs, water sources, mountains and other useful features and greatly facilitate geographical reconnaissance. Satellite imagery and other base maps can, in general, be downloaded from free services

such as Google Earth, Google Maps and OpenStreetMap, with more detailed maps and images available from other online services. These can be integrated with handheld devices fitted with global positioning systems (GPS) to map structures and local features.

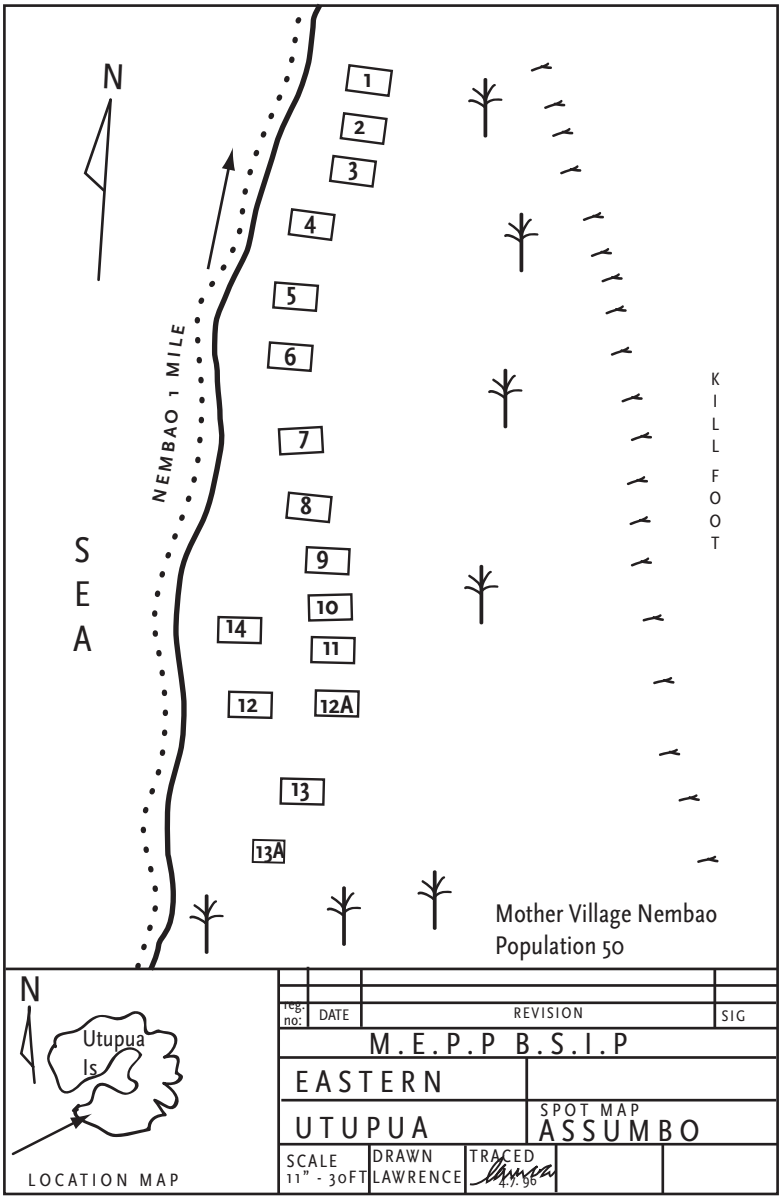
During geographical reconnaissance, households can be rapidly georeferenced, mapped and issued with a unique identifier in the field using integrated handheld electronic devices, such as smartphones and tablets, fitted with GPS. Census questionnaires detailing the structures and their characteristics and the previous spray history in an area can be completed and linked to these georeferenced locations on the electronic devices or carried out using traditional paper questionnaires. Electronic devices are advantageous due to the fact that they can be pre-programmed to navigate through questionnaire skip patterns and to adjust question wording for specific situations. Survey results can be cleaned and downloaded quickly after fieldwork is carried out. Data can be added to base maps to provide detailed geographical reconnaissance information on the target IRS areas, thereby assisting in many aspects of operations. This integrated approach to the collection, storage, analysis and mapping of relevant disease data enables relatively easy, accurate and quick assessment, planning, monitoring and reporting of a number of vector control and elimination interventions (Fig. 5).

Fig. 5. Integrated approach to information systems (adapted from WHO Solomon Islands, unpublished report, 2008)



Field teams can also develop hand-drawn local maps in target areas during the geographical reconnaissance. Images of localized areas can be downloaded from online resources and structures marked on them. Alternatively, with the aid of a compass, patterns of the structures or houses to be sprayed, together with their access routes, can simply be marked on a sketch map and locations for field camps can be identified (Fig. 6).

Fig. 6. Example of a sketch map for IRS planning (adapted from WHO Solomon Islands, unpublished report, 2008)



3.1.2.2 Household identification

The specific structures to be sprayed in an area should be delineated with clear unique identification numbers. This will form the basis of the geographical reconnaissance within the boundaries of broader areas targeted for IRS, and provide a platform to support the M&E of spray coverage The number, type and size of structures should be identified, mapped and recorded. Each household should be given a reference number to be painted or labelled on a door or a wall and should be issued with a house spray card so that spray operators can determine where and what they have to spray. This also enables spray team leaders to better supervise the work.

3.1.2.3 House spray cards

A house spray card can be issued to each household at the time of the geographical reconnaissance to facilitate recording of the details of each spray operation (Annex 6). The card details the location of the household (the various administrative levels and the geolocation), assigns a household code and records the head of the household. The card is completed with the details of the spray activities during every spray round. Some countries may now be entering this information into a computer, tablet or smartphone, rather than using a physical card.

3.2 Spray teams, training and supervision

In order to achieve high coverage of houses identified as being eligible for spraying with timely implementation (ideally less than two months per spray round), programmes must include an adequate number of IRS teams, each of sufficient size and with appropriate training, field supervision and district coordination, as outlined below.

During the planning stage, the number of spray teams required should be calculated based on the time available to conduct spray operations, the total number of housing structures or units to be sprayed and the number of structures that can be completed by one operator in one day. This should take into account the travel distance between structures and the actual size of the sprayable surface per structure.

Spray teams may be allocated specific areas to spray in each district. This is done to ensure that every village/suburb is covered and that teams do not have unmanageably large areas to spray, which could lead to spray operators being so dispersed that supervision and re-supply become challenging. Detailed spraying schedules showing planned movements, activities of spray teams, the site of IRS camps and areas for IRS should be mapped out.

It is important for community leaders and local authorities to be consulted when preparing these schedules. In some cases, the targeted spraying areas will be close enough to the homes of spray operators, such that they can carry out their work during the day and return to the central depot or operation site, clean and store their equipment, and return to their homes at night. Involving operators from the local community, rather than strangers from another part of the country, will improve acceptance and compliance and reduce the cost of transportation and accommodation.

3.2.1 Spray teams

To estimate the number of spray operators required to undertake a spray campaign, the number of structures to be sprayed should be divided by the average number of structures that a spray operator is estimated to be able to spray in a day, divided by the length of the spray campaign. In cases where households are both easy to access and near to each other, one spray operator should be able to spray 8–10 structures per day. This may be as high as 15 per day in some locations, but as low as five per day in areas where structures are scattered and separated by long walking distances and/or when structures are very large.

For example, if there are 100 000 structures to be sprayed, an operator can spray eight structures per day on average, the campaign should be completed in six weeks and teams work six days per week, then about 350 operators are needed. This assumes that there are no holidays during the spray period. The number should be adjusted for holidays and should be increased by 5% as a buffer to allow for staff absences and unforeseen events that require additional labour.

A *single spray team* is one unit that consists of:

- *one team leader* whose function is to supervise the work of the spray operators belonging to the team, to record and report on the households and housing rooms/units to be sprayed and to list those missed that require follow-up/mop-up spraying;
- *5–7 spray operators*, with smaller teams highly preferable in cases where the personnel are less experienced and require greater supervision or where the areas to be covered are spread over a wide geographical area;
- *one community mobilizer*, usually a paid temporary worker who communicates with local leaders and who also informs the residents that the spray is about to take place so that they can make the necessary preparations;
- *one driver* for operations where a motor vehicle is used, who should be trained in driving a bus or truck capable of safely and comfortably transporting 14–20 people, insecticide, equipment and the required amount of water; and
- *one group leader/supervisor* to coordinate 3–5 spray teams.

The recommended number of spray teams per district or operational area depends on the size of the district, its population density and how many structures need to be sprayed during the spray campaign. The spray technique – such as complete or selective spraying – should be taken into consideration. Spray teams should be instructed to locate and treat all sprayable structures that have been identified as targets, including those beyond residential households.

Spray team leaders and group leaders or supervisors must check that the amount of insecticide sprayed on walls is sufficient and that spraying is completed according to the recommended standards.

3.2.2 Spray operators

The operator should be a responsible person who can work under minimum supervision. Spray team members have a duty to act in a professional manner towards each other and to maintain good relations with the local community members. For this reason, spray operators can be drawn from their own communities and vetted by the community members. Their behaviour and demeanour should be beyond reproach. A "code of conduct" for spray operators and team leaders is included in Annex 7 *(26)*.

Spray operators are in general temporarily employed for just 2–3 months and drawn from a community within the district to be sprayed. The period of employment covers both training and implementation of the spray operation. District and subdistrict coordinators, in consultation with community leaders and local authorities, can recruit spray operators and train them to handle insecticides safely and to accurately apply insecticides according to standard operating protocols under local conditions. The contracts for these operators may be done through the Ministry of Health or any local authority. In some situations, an implementing partner (such as a bilateral donor, NGO or private-sector company) takes responsibility for IRS.

Spray operators should:

- be at least 18 years old;
- be physically fit and healthy;
- be physically able to perform the work;
- not have any underlying conditions that may cause IRS to pose a threat to their health (such as asthma or high blood pressure);
- be able to read and write the national language (so they can read the label and follow emergency procedures if needed); and
- be able to operate the sprayer.

Women who are breastfeeding or are pregnant should not be recruited as spray personnel to avoid potential pesticide exposure and to avoid physical strain while carrying the spray tank. In addition, any woman who is identified as being pregnant during the campaign should be reassigned to duties other than spraying.

3.2.3 Training for IRS coordinators and spray teams

A successful IRS campaign depends on the application of an adequate and uniform dosage of insecticide on all possible resting places of the target vector(s) (see Table 5). This requires recruitment and appropriate training of spray operators, team leaders and group leaders or supervisors, as well as subdistrict and district coordinators. Each position must have a clear job description outlining the roles and responsibilities and reporting lines. All personnel must be familiar with their terms of reference and tasks. Training packages and performance evaluations can be developed based on the required activities and expectations of each role, as needed. Further guidance on the licensing of public health pest control operators is available *(31)*.

3.2.3.1 Institutional training for IRS coordinators

Formal IRS cascade training for national, provincial/state and district/municipality IRS coordinators should be conducted by the Ministry of Health and implementing partners as short practical courses and workshops. Generic IRS training resources for these training of trainers courses are available through WHO, with comprehensive materials developed through the United States President's Malaria Initiative *(32)*.

Training could include the following topics, depending on the target audience:

- what IRS is, why, where and when it is used;
- the importance of and strategies for community engagement;
- principles and requirements for safe and appropriate pesticide management;
- the role of baseline entomological surveys;
- conducting geographical reconnaissance and census of spray areas and houses or structures;
- insecticides used for IRS and related safety precautions;
- the need for and appropriate use of PPE;
- responding to spills and other incidents;
- spray application equipment, its maintenance and inventory;
- waste minimization and management processes;
- conducting house spraying;
- tracking, supervising and monitoring spray rounds;
- reporting on progress and performance of an IRS campaign; and
- developing an IRS Plan of Action.

Training of trainer and cascade training should include a gender component, covering issues such as:

- general guidelines for respecting co-workers in a gender-sensitive context;
- what constitutes sexual harassment;
- construction of appropriate facilities for the sanitary and privacy needs of women and men;
- observation of protocols regarding shared and gender-specific sanitary facilities;
- respect for privacy at operations sites when cleaning up;
- the investigative/corrective/punitive measures that will be taken if sexual harassment is discovered or reported; and
- the formation of all-women teams if appropriate.

3.2.3.2 Field training for spray operators, team leaders and group leaders

The technical skills of spray operators, team leaders and group leaders (and potentially subdistrict supervisors, depending on roles) must be updated regularly. The first-line group leaders should be trained to carry out the same tasks as the spray operators. In addition, they should be trained to carry out geographical reconnaissance, record keeping, reporting, public relations and sessions on basic health messaging related to vector-borne diseases and IRS. This will enable them to provide adequate and appropriate supervision.

Vector-borne disease control programmes should establish field training centres strategically placed in the districts for this purpose. Field training of all spray operators must be provided at least annually, and preferably immediately before the beginning of each spray round.

The annual practical training of spray operators should focus on developing the necessary skills for adequate spraying, especially spray timing, spray pattern, swath overlap, and personal and environmental safety.

The training course should be subdivided into several sections and take place over 5–7 days. No time limit should be set for the length of time to complete each individual section, as this will vary according to the trainee's readiness and skills. However, 3–5 days should be dedicated to the practical portion of the training.

The purpose of spray operator and supervisor training should be to ensure that all personnel involved in IRS understand their tasks and responsibilities and are made aware of their responsibility to their colleagues, the environment and the community. They undergo training to enable them to grasp the concepts of:

- what IRS is, why, where and when it is used;
- the principles and requirements for safe and appropriate pesticide management;
- the need for and appropriate use of PPE;
- the use of spray equipment, its handling, care, transport and storage;
- how to dismantle and reassemble a sprayer for maintenance purposes;
- how to prepare the sprayer;
- sprayer pressurization and calibration;
- how to explain the objectives of the IRS programme to residents, providing instructions for before, during and after spraying, and how to answer any questions asked;
- the sequence of spraying in a house; and
- how to complete the house spray cards and required daily reporting forms.

3.2.3.3 Training wall

The practical training of spray operators preceding each spray round includes, among other activities, the spraying of a training wall with water. The IRS training wall helps operators to focus on two areas: how to maintain the exact distance from the nozzle tip to the surface being sprayed, and how to spray at the correct rate and keep up the speed of application over the surface to ensure application of the correct dose.

To accomplish training for full wall spraying, the following steps should be undertaken:

1. The trainer marks an area 3 m high and 6.35 m long, divided into nine bands – the first one 75 cm wide and the remainder 70 cm wide. The spray nozzle will provide a spray swath, or spray pattern, that is 75 cm wide if it is kept at a distance of 45 cm from the wall.
2. To practise keeping the nozzle 45 cm from the wall, a wooden or plastic extension is fitted to the lance. The length from the nozzle tip should be 45 cm.
3. The spray operator stands directly in front of the wall, with right arm extended and body inclined towards the surface while raising or lowering the right arm so that the end of the extension remains in contact with the surface.
4. The spray operator starts at the top corner of the wall and sprays at a uniform rate, moving downwards to the bottom. He/she takes one step to the right and continues spraying from the floor upwards. The next swath should overlap with the previous one by about 5 cm.
5. At the end of each swath, the spray operator stops the flow of insecticide and steps 1 m to the right.
6. The spray operator continues in this way until the entire area of 19 m^2 is covered. Each swath of 3 m in height should be covered in about seven seconds (or if 2 m, should be covered in five seconds). Nine swaths of 3 m should therefore take one minute to spray.

The approach can be adapted where selective wall spraying will be undertaken, such as for *Aedes* vectors (Annex 1).

3.2.3.4 Spray training practice

During the training, spray operators should be familiarized with working under field conditions. This may include practising how to spray different rooms, wall heights or wall sections (complete versus selective spraying). It should also cover spraying of ceilings, wall cracks (for spraying against triatomine bugs), under or behind furniture, or on the front and back of curtains (for spraying against *Aedes* mosquitoes), as appropriate. This could be done by identifying some houses and structures near the training site to do so, or by having sample furniture to practise spraying.

3.2.4 Supervising spray teams and spray operations

To be successful, IRS requires guidance and support from team leaders, IRS supervisors and IRS coordinators. Training will be required to ensure that this is in line with standard operating procedures and that accurate corrective guidance or action can be provided. This support and supervision should be provided routinely and consistently throughout the spray round. Depending on the duration of the

round, supervision should generally be provided daily by the team leader, weekly by the IRS supervisor, and monthly by the IRS district coordinator through the collation and review of data (Annex 8, Annex 9, Annex 10), with periodic review of specific processes (Annex 11, Annex 12). Inspections should be carried out using standard forms and checklists to ensure uniformity and accuracy (Annex 13, Annex 14).

Spray operators and teams should be constantly monitored to ensure that safety precautions are being adhered to, team tasks are on schedule, the spraying of surfaces and individual structures is of high quality, and targeted eligible structures are not being missed. Daily reporting forms can be cross-checked against household and structure information collected during geographical reconnaissance.

3.2.4.1 Purpose of supervision

The overall purpose of supervision is to ensure that high-quality IRS is delivered without human and environmental risk, and that high coverage is achieved. The role of a supervisor is to solve problems and to offer support, not to criticize or find fault. The main objectives of supervision are to:

- ensure that the spray team movement schedule is strictly adhered to and the agreed target numbers of houses to be sprayed per day are maintained;
- ensure proper use of PPE and safe handling of insecticides;
- ensure proper use of spray equipment;
- take immediate corrective measures on the spot in the case of technical deficiencies, such as spray application techniques or equipment deficiencies;
- motivate, stimulate, encourage and advise on effective functioning of the fieldwork and good communication with residents and community leaders;
- ensure good teamwork for total coverage of the areas to be sprayed;
- ensure that strict discipline and standard operating procedures are maintained;
- assess, evaluate and encourage the work output of the teams;
- make constructive and feasible recommendations to improve the quality, coverage and timely implementation of operations; and
- report on team outputs and follow up as necessary.

Scheduled spot checks on all spray teams enable assessment of quality and work performance and monitoring of coverage. Feedback on operational deficiencies should be given to the team leader and IRS field supervisors so that they can take remedial measures. Safety compliance and the functioning of equipment must be checked regularly.

Provincial and district IRS coordinators, disease control officers and entomologists should conduct field visits to supervise IRS, note operational problems and correct them on the spot using the same standardized checklists. To improve management, supervision, tracking and reporting of spray teams, the use of a mobile phone system should be considered to enable efficient communication.

3.2.4.2 Supervisory tools

Supervisory tools include forms, reports, records, graphs and charts to monitor operations. Tools and checklists for staff supervision need to be simple, clear and short – ideally, no more than one page in length. The checklists provided in Annex 13 list items to be checked as part of a typical supervision process.

An IRS supervision inspection checklist (such as that provided in Annex 14) is intended to be used as a supervision tool to verify country programmes' preparedness to safely implement IRS and minimize environmental contamination. This checklist is divided into sections to cover all the different stages of an IRS operation: inspection of (i) pre-spraying store/soak pit; (ii) spraying activities; and (iii) post-spraying wash-up/waste disposal activities. The checklist can be used to verify that spray operators have access to and have been trained to use PPE to ensure their safety; the sites used for IRS operations have a well managed warehouse, including a soak pit or soak away that is used for progressive rinsing of spray tanks and washing of PPE; and plans are in place for the handling and disposal of chemical waste to minimize or avoid environmental contamination.

At any stage of assessing IRS operations, feedback should be provided and should highlight areas that require attention. The feedback should also propose solutions and recommendations to the IRS district coordinator or supervisor, who should ensure that corrective measures are taken.

3.3 Selection and procurement of insecticides

Insecticides used in public health vector control are usually contact insecticides that are considered either residual or non-residual. Residual contact insecticides are stable, organic chemicals that, when applied, remain toxic for a given period (usually several months) to insects alighting on or walking over that surface. By contrast, a non-residual insecticide, such as that used for space spraying, provides a short-duration effect.

Selection of insecticides for IRS is guided by the characteristics of the insecticides, including the duration of residual efficacy on common surfaces; the susceptibility status of the local vectors; and the epidemiology of the target disease(s), especially the duration of the transmission season. It should also be aligned with the vector control strategy and the insecticide resistance monitoring and management plan, if available *(33)*. It is essential that insecticide selection and procurement be made in a timely manner to enable spray operations to be conducted as per the established schedule.

3.3.1 Considerations for selection of insecticides

The characteristics of the insecticide, including the desired effects on the target vector, must be considered when selecting insecticide(s).

3.3.1.1 Resulting effects on insects

Appropriate insecticides for IRS use any mechanism to reduce vectorial capacity so as to provide community protection to individuals *(34)*. Different insecticides may have different effects on the particular species of insect vectors through one or more types of action:

- repellency
- irritancy (excito-repellency)
- killing
- blood-feeding inhibition
- reduced fecundity.

Insecticides with low excito-repellency and that kill vectors quickly are generally thought to be most effective for use in IRS. This is because vectors will be more likely to rest on surfaces treated with insecticides with these actions until a lethal dose has been taken up and will die before biting additional hosts, thereby reducing transmission.

3.3.1.2 Vector susceptibility

For IRS to be highly effective, vectors must be susceptible to the insecticide selected. Insecticides may lose their efficacy if the target insects develop insecticide resistance. Development of resistance is a common result of insecticide use and the resulting selection pressure on the insect population. Studies of insecticide resistance should be conducted on samples of the target insect population collected from the areas targeted for spraying. Guidance on how to monitor insecticide resistance in mosquito vectors is available *(27)*. If possible resistance is observed in bioassays, tests should be repeated to confirm the presence of resistance and programmes should select another insecticide to which cross-resistance is unlikely *(20)*. To mitigate against the emergence of resistance, programmes should plan to rotate insecticides with different modes of action at pre-set time intervals, such as every one to two years, irrespective of resistance frequencies in the vector population.

3.3.1.3 Residual efficacy

The most important quality of a residual insecticide used for IRS is its long-acting bioavailability on a given surface. Insecticides should remain toxic to vectors that come into contact with the surface over a sufficiently long period to prevent the need for frequent reapplication, which is costly and time-consuming. Ideally, bioavailability should remain for a period long enough to cover the vector-borne disease transmission season. A minimum duration of residual efficacy of three months is needed for residual insecticides, with a desired duration of residual efficacy of one year or longer *(35)*.

3.3.1.4 Appropriate formulation

Insecticides are not applied in their pure form. They are combined with various ingredients in a formulation designed to render the product effective for a specific purpose and for the envisaged mode of application. The insecticide selected and its formulation should fully comply with its WHO specification parameters *(36)*. The formulated product should enable long-lasting toxicity of the insecticide(s) once applied, be stable during transport and storage, mix well with water to enable application and be suitable for use in spray equipment. Optimum effectiveness of IRS (i.e. providing the desired residual toxicity) is affected not only by the insecticide formulation, but also by its appropriateness for the type of surface being sprayed. For instance, wettable powders (WP) and water-dispersible granules (WG) are best suited to very porous surfaces such as mud walls, whereas suspension concentrates (SC) and emulsifiable concentrates (EC) are more effective on finished cement, finished wood or timber, or painted surfaces, especially those to which oil-based paints have been applied. Further details on the pros and cons of different formulations are provided below (section 3.3.2.3).

3.3.1.5 Safety

Insecticides are inherently hazardous. VCPs – including those with novel AIs and new formulations – are under continuous review by WHO. Many have already been used safely and effectively in many countries around the world to control vectors, and some for decades. The WHO product evaluation process involves assessment of efficacy testing data, human risks with occupational exposure and specifications for quality control. WHO hazard and human risk assessments of insecticides ensure that the formulations do not pose unacceptable risks to humans, animals and the environment when handled and applied according to label instructions. It is essential to check whether the formulated product meets WHO specifications and is WHO-prequalified. WHO conducts human health risk assessments based on the AI and declared uses of products as part of the prequalification assessment. WHO does not generically approve or accept AIs because the potential risks associated with their use are specific to the formulation and directions for use. Therefore, WHO cannot comment on the potential risks to human health posed by VCPs that have not been evaluated through the prequalification process.

Steps to mitigate accidental contamination and spills should be implemented prior to commencing spray operations (see section 2.3).

3.3.1.6 Access and availability

In selecting the specific product or products to be used for the spray campaign, the registration status of the product in the country, product eligibility for funding/ procurement by international organizations and partners, and the availability of products to be supplied by the manufacturer should be considered. Managers of the spray campaigns are encouraged to contact the manufacturers of products early in the planning process to determine whether preferred products are or may become available. Manufacturers of IRS products are encouraged to submit applications to WHO to participate in the prequalification process *(3)*, to proactively seek country registration where products are needed to support spray campaigns, and to undertake other activities aimed at facilitating access.

3.3.1.7 Community acceptability

Residents have found some insecticide formulations to be less acceptable due to their peculiar smell or because they leave unsightly deposits on the sprayed surfaces. The acceptability of formulations may vary by location and can undermine spray operations in situations where there are low rates of household compliance in allowing spray operators to access indoor spaces. The application of the formulation by IRS should be acceptable to the community. This implies that the application is not offensive to the residents in ways such as generating strong or foul odours or visible stains on the walls and should not cause any irritancy or skin sensitization *(34)*.

3.3.1.8 Cost and cost-effectiveness

The unit prices of different insecticidal products may vary by location and will depend on the programme scale. The overall cost of the insecticide needed will also depend on the dosage to be applied and the frequency of application. Programmes should monitor the costs of IRS operations according to standard cost categories (i.e. operations, labour, equipment, PPE, insecticide and administration).

Costs can then be calculated per unit structure sprayed or per unit of population protected as part of a more detailed resource prioritization exercise.

3.3.1.9 Availability

Timely availability of sufficient stock of insecticides to enable spray operations is essential. Supply time frames and the necessary in-country regulatory and clearance requirements should be considered.

3.3.2 Insecticide products

Having considered the factors in section 3.3.1, and assuming multiple product options remain, programmes may then need to further consider the specific AI and formulation type as part of the product selection process. Programmes should rely on those products for IRS that are prequalified by WHO *(18)* and application equipment that meets WHO standards *(22)*. Both insecticide and spray equipment should comply with national regulatory and environmental safety standards. Detailed guidelines for good pesticide management, including procurement, quality control, transport, storage, use and disposal, are available from WHO *(26)*.

3.3.2.1 AIs

Insecticidal AIs currently used for IRS fall into six insecticide classes, which are grouped according to four modes of action based on their primary target site in the vector. As of July 2023, IRS products prequalified by WHO include five of the six classes (with no organochlorine product prequalified) *(18)*. Examples of AIs contained in prequalified IRS products are listed below.

- **Sodium channel modulators**
  - Pyrethroids: alpha-cypermethrin, deltamethrin, lambda-cyhalothrin, etofenprox, bifenthrin
  - Organochlorines: no prequalified products available

- **Acetylcholinesterase inhibitors**
  - Organophosphates: pirimiphos-methyl
  - Carbamates: bendiocarb

- **Nicotinic acetylcholine receptor competitive modulators**
  - Neonicotinoids: clothianidin

- **GABA-gated chloride channel allosteric modulators**
  - Meta-diamides: broflanilide

There may be IRS products in current use or that have been used in the past that contain AIs not listed above (e.g. the organochlorine dichlorodiphenyltrichloroethane (DDT), the organophosphate malathion, the carbamate propoxur). However, there are no IRS products with these AIs currently prequalified by WHO, which means that no product has been assessed by WHO for its efficacy, safety and quality, and no inspection of manufacturing sites has been conducted.

There may be various formulations with the AIs listed above that are sold by different manufacturers under different trade names. These trade names should not be confused with the AI. The use of trade names is generally to be avoided, since

a product may be registered under different trade names in different countries and may therefore be unfamiliar to programme managers.

Programme managers should ensure that the product procured and received is aligned with their selection or expectation and is authorized for use by the national pesticide regulatory authority.

3.3.2.2 Use of DDT for IRS

As of July 2023, there were no organochlorine IRS formulations prequalified, including DDT *(18)*. However, use of DDT for IRS does occur in some countries. Practical information for use of DDT for IRS is included in the *Guidelines for malaria (7)*, with selected text provided or adapted below.

Unlike the other five insecticide classes covered by WHO's recommendation for IRS, DDT has been classified as a persistent organic pollutant. As such, its production and use are strictly restricted by an international agreement known as the Stockholm Convention on Persistent Organic Pollutants *(37)*. The Convention's objective is to protect both human health and the environment from persistent organic pollutants. When the Stockholm Convention was established in 2004, it provided an exemption for the production and use of DDT for disease vector control, mainly because of the absence of equally effective and efficient alternatives at the time. The recent expansion of products available for IRS and overall expansion of vector control interventions has provided additional options.

WHO actively supports the promotion of chemical safety and, together with the United Nations Environment Programme, shares a common commitment to the global goal of reducing and eventually eliminating the use of DDT, while minimizing the burden of vector-borne diseases. DDT use for malaria vector control has declined over the years and WHO supports continuation of this trend.

In some areas, the use of DDT may be warranted. The decision to use DDT for malaria vector control needs to be based on a detailed analysis that considers all other potential options for vector control and provides clear reasoning for choosing DDT over the other options. WHO considers DDT to be a last resort, not a first choice. If DDT is selected, it should be used under strict control measures and only for the intended purpose. Its use requires that the conditions set by the Stockholm Convention be met, including additional reporting (see section 3.3.5).

Effective use and safe storage of DDT rely on compliance with well established and well enforced rules and regulations, in accordance with national guidelines and following the WHO technical guidance provided in this manual. Where DDT is deployed, it is essential for adequate resources and technical support to be in place to ensure the sound management of this persistent organic pollutant.

When considering the use of DDT, programmes should take into account the additional reporting requirements to the Stockholm Convention, additional environmental assessment procedures that may be required (e.g. the need in some programmes for a public comment period), and additional procedures for disposing of empty containers and other contaminated waste, such as through the use of evaporation tanks (see section 3.5.4). In terms of insecticide resistance, there is cross-resistance with pyrethroids in some situations; in other situations, the vector may be resistant to pyrethroids and to carbamates, but still susceptible to DDT. As with

all insecticides, there needs to be careful monitoring of insecticide resistance and a robust plan for insecticide resistance management *(20,33)*. In addition, there needs to be good stock management through stringent accounting, secure storage and close supervision to prevent illicit diversion and use, especially for agriculture.

3.3.2.3 Insecticide formulations

IRS insecticides are applied as end-use formulations. The duration of residual action can vary according to the types of indoor surfaces sprayed.

As of 1 July 2023, the formulations of insecticides prequalified by WHO for IRS include:

- capsule suspension (CS)
- emulsifiable concentrate (EC)
- suspension concentrate (SC)
- polymer-enhanced suspension concentrate (SC-PE)
- water-dispersible granule (WG)
- water-dispersible granules in sealed water-soluble bags (WG-SB)
- wettable powder (WP)
- wettable powder in sealed water-soluble bags (WP-SB).

The major characteristics of the different formulations and their impact on IRS are described below (Table 6).

WP and CS formulations are the most commonly used insecticides for IRS on porous surfaces (e.g. mud and thatch walls) in traditional buildings in rural areas. EC, SC and CS formulations are generally used for spraying impervious and painted surfaces on modern buildings because they are less likely to leave visible residues or stains. EC formulations are generally less suitable for use on porous surfaces.

CS and the recently introduced SC-PE formulations have shown longer residual activity than WP, WG and SC formulations, especially on porous surfaces. Packaging WP and WG formulations in single-dose, sealed water-soluble bags increases the safety and ease of handling of these products and obviates the need for measuring small quantities in the field.

Table 6. General characteristics of different IRS formulations prequalified for public health vector control

Formulation type	Description	Examples of appropriate surfaces	Other common features relevant for IRS
WP and WG with or without SB packaging	• The AI is formulated with an inert powder containing wetting and dispersing agents • Forms a suspension in water	More porous surfaces, e.g. • mud bricks • concrete walls	• Easy to transport, store and use • Less effective on plastic sheeting, canvas tents, oil-based paint • May leave visible deposits on sprayed surfaces • Spray tank needs occasional agitation/ shaking • Without SB packaging, risk of exposure to dust and spills during dispensing and mixing
EC	• The AI is dissolved in an oil-based solvent with emulsifiers • When mixed with water, forms a milky white oil-in-water emulsion composed of finely suspended droplets containing the insecticide	Less porous surfaces, e.g. • finished cement • finished wood • painted surfaces	• Easy to mix with water • Few visible deposits • High concentration of AI in formulation • Strong smell • Absorbed by porous surfaces • High dermal absorption increases risk for operators • Flammable
SC and SC-PE	• Contains small crystalline particles of AI suspended in a liquid (usually water)	Less porous surfaces, e.g. • finished cement • finished wood • painted surfaces	• Less effective on plastic sheeting • Less visible residues than with WP and WG • Spray tank needs occasional agitation/ shaking
CS	• The AI is encapsulated in microscopic polymer capsules • Capsules form a suspension in water	All surface types, including: • wood • mud/cement walls • painted cement walls • cloth	• Capsules release the insecticide slowly after spraying, extending the compound's residual life • Spray tank needs occasional agitation/ shaking

3.3.3 Estimating insecticide requirements

In estimating the amount of insecticide needed for spray operations, the application rate must be known. The application rate is the amount of AI of the insecticide applied to a unit of surface area, expressed in grams per square metre (g/m^2). The correct application rate is one of the most important issues in an IRS programme.

Programme managers should review the product label in full. Application rates and dilution rates will be provided in the directions for use. If the target application rate of AI, the dilution rate and/or the amount of product needed is not clear, programme managers should consult the manufacturer. If application rates vary depending upon the surface, programme managers may need to incorporate this into their calculations.

To estimate the amount of insecticide required for an IRS spray round, the following is needed:

N: number of houses to be sprayed (expressed as the percentage of modern and traditional structures);
S: average sprayable surface per house in m^2 (modern and traditional structures);
C: concentration of AI in the formulation (% AI); and
Y: target dosage, expressed in g/m^2 (application rate), of insecticide to be used on each type of structure according to the product's label.

Once this information is gathered, **Q**, the total quantity of insecticide needed (g) is calculated as shown below:

$$Q = \frac{S \times Y \times 100}{C} \times N$$

Note: When the full quantity of insecticide needed is calculated, programmes may want to consider the addition of a buffer of 3–10% to overcome any possible shortages. This buffer is most relevant for new spray areas, while in areas where repeat spray rounds have been implemented, there are generally better data to inform quantification. With the move to subnational rotation of more costly insecticides, inclusion of buffer stocks has become the exception rather than the norm to avoid left-over stock and associated disposal costs.

Example 1a: Determine the amount of insecticide formulation required to treat 11 607 formal structures (households) with an average sprayable surface area of 300 m^2. The insecticide formulation selected is lambda-cyhalothrin 10% WP. The dose to be applied (application rate) is 0.025 g of AI per square metre.

$$Quantity\ (Q) = \frac{300 \times 0.025 \times 100}{10} \times 11\ 607 = 870\ 525\ g$$

Therefore, 870.5 kg of insecticide formulation is required to spray 11 607 structures or households. With a 10% buffer stock of 87 kg, the total amount of lambda-cyhalothrin required is **957.5 kg**.

Example 1b: Determine the amount of insecticide formulation required to treat 6250 traditional structures with an average sprayable surface area of 125 m^2. The insecticide formulation selected is DDT 75% WP. The dose to be applied (application rate) is 2.0 g of AI per square metre.

$$Quantity\ (Q) = \frac{125 \times 2.0 \times 100}{75} \times 6\ 250 = 2\ 083\ 333\ g$$

Therefore, 2083.3 kg of insecticide formulation is required to spray 6250 structures or households. With a 10% buffer stock of 208 kg, the total amount of DDT required is **2291.3 kg**.

3.3.4 Insecticide procurement and quality control

Pesticide procurement is a highly specialized and complex subject. WHO has published guidelines for procuring public health pesticides *(24)*. Public health VCPs should only be procured if they are WHO-prequalified and if they are registered for use in the country in question (see section 2.3.1). These guidelines cover the

basic principles and stages that are important in the procurement of public health pesticide products, including planning, selection of appropriate high-quality products, procurement, legal and technical requirements, quality control and administrative requirements.

Quality control for all insecticides procured is important in terms of the concentration of AI, the level of impurities, and, especially in the case of WP formulations, the quality of the suspension when mixed in a sprayer, which may vary from one procurement to the next. Programmes should verify that pre-shipment quality control has been undertaken, so that a substandard product does not arrive in country. These laboratory analyses check to see whether the product conforms to the required specifications with respect to not only the amount of AI, but also all the physical and chemical properties of the product. These analyses are usually undertaken by the manufacturer of the product.

WHO provides guidance to national health authorities and offers assistance through designated WHO collaborating centres on the quality control of insecticides. Guidelines are available for the quality control of public health pesticides and their distribution and use *(38)*.

3.3.5 Reporting annual consumption of insecticides

WHO encourages all countries using insecticides for IRS to submit annual reports on the class, compound, formulation, concentration and quantity used. This enables WHO to monitor and plan support for countries in terms of insecticide specifications and use. It also enables both individual countries and WHO to advise the industry of changes in the size and needs of the market, and of the priorities for research and development. For malaria, this information is submitted to WHO via electronic reporting forms that are distributed every year as part of the World Malaria Report data collection. For other vector-borne diseases, this information is collated through periodic initiatives *(39)*. An example annual reporting form on insecticide usage is provided in Annex 15.

DDT use and reporting

All countries that are signatories to the Stockholm Convention on Persistent Organic Pollutants and that either produce or use DDT for IRS for the control of malaria or other vector-borne diseases are required to report on its use every three years. Guidance on the use of DDT and associated reporting requirements is available on the website of the Stockholm Convention (http://chm.pops.int/Home/tabid/2121/Default.aspx).

3.4 Selection, procurement and management of spray equipment and other materials

To ensure the quality of the spray operations and minimize human and environmental exposure, the use of quality equipment and materials is essential. Equipment should be procured and delivered in time for training and preparation for field operations. Core requirements are hand compression sprayers with adequate spare parts and protective clothing for spray operators. Other materials will also be needed for spray teams in the field.

To improve the management, supervision, tracking and reporting of spray teams, the use of VHF radio communication or a mobile phone system for district coordinators, supervisors and group leaders should be considered.

3.4.1 Hand compression sprayer

Hand-operated compression sprayers complying with WHO specifications should be used to apply insecticides *(22)*.

A hand compression sprayer (Fig. 7) generally consists of:

- a cylindrical spray tank of steel or durable plastic with a lid for holding the spray mixture;
- a hand-operated air pump with a two-pronged handle and locking device to pressurize the tank;
- a pressure-release safety valve/device to prevent the tank from over-pressurizing and to enable easy depressurization;
- a footrest attached to the tank to keep it steady while pressurizing it;
- a shoulder strap or straps fitted with the tank, at least 5 cm wide and adjustable in length for comfort and ease of carrying;
- a hose, resistant to the chemicals used in pesticide formulations attached at the top of the tank to a dip-tube;
- a dip-tube mounted in the tank with an O-ring gasket (if the gasket is damaged, air may leak from the tank);
- a trigger valve with a cut-off valve that permits the operator to close the system;
- a straight lance;
- a control or constant flow valve (CFV) to ensure that the output of the spray nozzle remains constant as the pressure in the spray tank decreases during spraying;
- a nozzle holder on the body of the spray tank (ideally to hold the nozzle with a CFV);
- an air pressure gauge fitted on top of the spray tank (in most models) to measure the tank pressure while pressurizing the tank; and
- a nozzle assembly comprising a fan nozzle tip, body, protector (cap) and filter with housing (to filter out particles too large to pass through the nozzle).

Note that for spraying under or behind furniture, as is required for *Aedes* vectors, an angled nozzle tip (e.g. with a 120-degree elbow) (Fig. 8) or a flexible lance extension will also be needed.

Fig. 7. Cutaway diagram of two examples of hand compression sprayers that meet WHO equipment specification guidelines (bottom diagram is adapted from an illustration provided by Goizper Group)

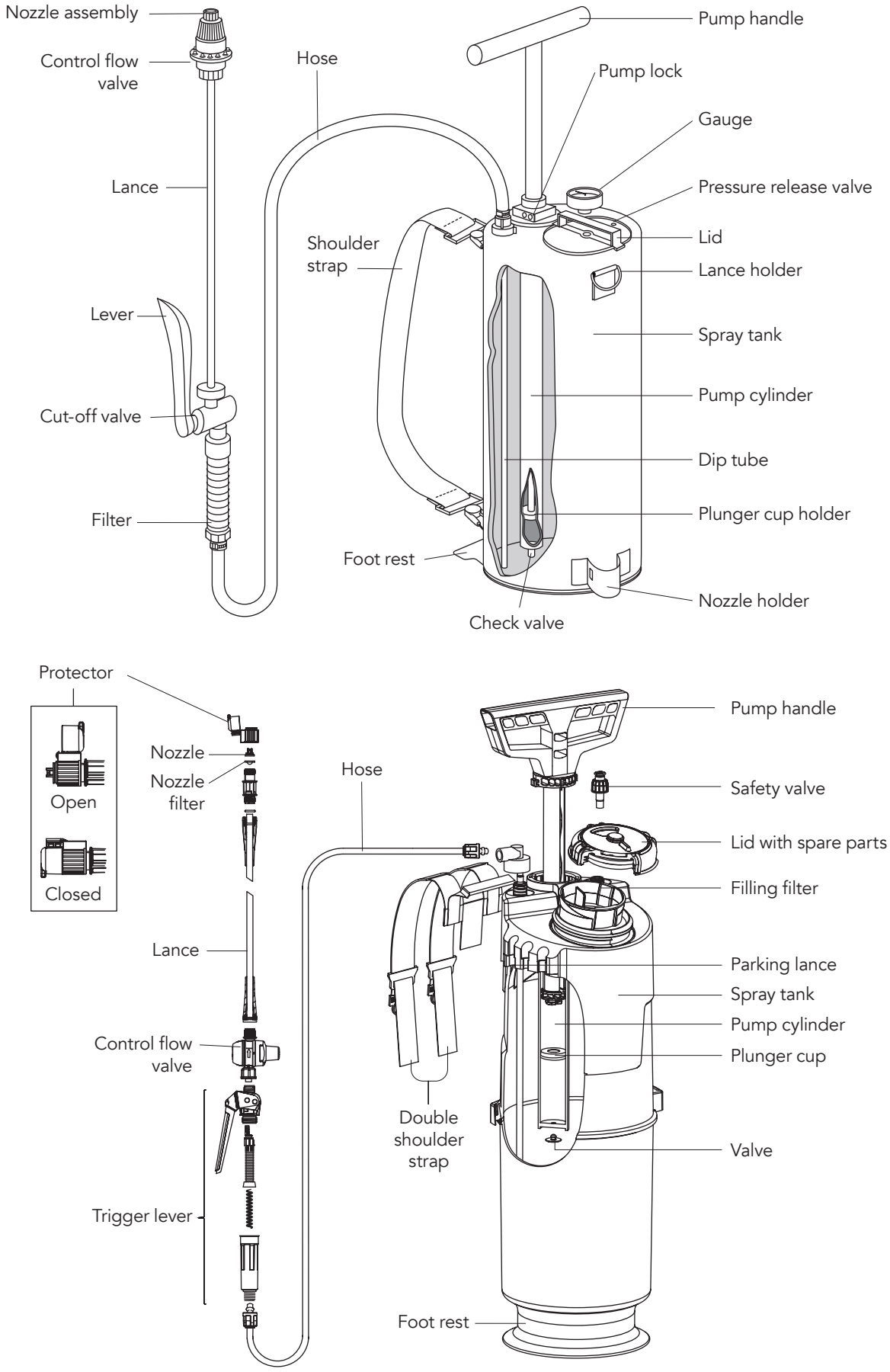
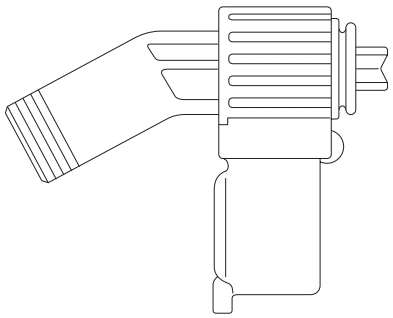


Fig. 8. Diagram of an angled nozzle



Other accessories may be necessary, such as an additional lance to extend the length of the lance to spray higher areas of the walls and ceilings. The lance should be able to be parked when not in use to protect the nozzle. A filler filter may also be installed inside the tank to enable the filtering of water during filling.

Most tanks have four openings on the top: a large one for filling, which is fitted with a removable cover, and openings for the air pump, discharge system and pressure gauge. The tank is pressurized using the hand pump (plunger) attached to it. The compressed air forces the liquid out of the tank via a hose with a cut-off valve, a lance and a nozzle. The plunger seal may be made of leather or rubber and must be resistant to the chemicals used in insecticide formulations.

Hand compression sprayers that can hold up to 8 L of water (meaning that their total tank capacity is about 11.4 L with 3.4 L left as space for air) are suitable for IRS application with the use of a CFV. The total weight when filled with 8 L of spray liquid is less than 12 kg. When filled with 7.5 L of spray liquid, one tank load is enough to spray a 250 m^2 area.

Certain programmes may have in their stocks sprayers with a larger tank size of 15 L and often without a CFV. These sprayers can hold 10 L of liquid but are not preferable from an ergonomic perspective due to the heavier load on the back of the spray operators. Programmes should gradually replace such sprayers with sprayers that have a tank size of about 11.4 L and a CFV.

3.4.1.1 Nozzles

> **Note:** 100 kilopascals (kPa) = 1 bar = 14.5 pounds per square inch (psi). For sprayers, the standard pressure units used are bars or psi and therefore both are provided throughout this document.

The nozzle is one of the most important components of the sprayer. It should deliver a precise amount of spray suspension per minute at a certain pressure to maintain a uniform spray pattern and swath width. The selection of the nozzle depends on the insecticide and where it is to be sprayed.

Flat fan nozzles are recommended for hand-operated compression sprayers for IRS. These are designed to produce an 80-degree swath width and are available in hardened stainless steel, ceramic embedded in plastic body or polyacetal materials. The 8002E flat fan nozzles (referred to as 8002 nozzles) are the standard to be used. The 8002 nozzles usually emit 550 mL of liquid per minute through a CFV at a standard 1.5 bar (22 psi) pressure (though this can differ between sprayers). At a spraying speed of 2 vertical metres on a wall per five seconds (24 m/min), this will produce the correct application of 30 mL of suspension per square metre of surface area.

Without a CFV, the 8002 nozzles normally emit 650 mL/min at 2.0 bar (29 psi), 800 mL/min at 3.0 bar (44 psi), and around 900 mL/min at 4.0 bar (58 psi) tank pressure, with an estimated 40 mL of suspension/m^2.

A 8001E nozzle is sometimes used for the application of synthetic pyrethroids/carbamates or organophosphates to non-absorbent substrates, such as tiles or painted surfaces *(40)*.

3.4.1.2 CFVs (flow regulators)

CFVs are currently a standard specification for hand compression sprayers for IRS to ensure an even discharge as the tank pressure drops and avoid a decrease in flow rate over time. The CFV should be attached to the nozzle tip or built into the lance assembly.

A 1.5 bar (22 psi) CFV is recommended for compression sprayers for IRS. A 1.5 bar CFV reduces the output and ensures uniform flow such that walls are uniformly sprayed at 30 mL/m^2. Applying this volume, the suspension discharge rate and the insecticide dose rate (AI/m^2) remain constant as the pressure in the spray tank drops from around 4.0 bar (58 psi) to 1.5 bar (22 psi) over time.

The use of a CFV reduces the amount of water needed by 25% per tank load. When a CFV is not used, 10 L of suspension is needed to treat a 250 m^2 surface area (discharge rate: 40 mL/m^2). When a CFV is attached, the same area can be treated with just 7.5 L of suspension (discharge rate: 30 mL/m^2). By inference, this means that sachets of insecticide designed to treat 250 m^2 of wall surface with 10 L of liquid can be diluted in 7.5 L of water and therefore sprayers with smaller tank sizes can be used. In addition, using a CFV set at a low pressure, the risk of inhalation of spray droplets is reduced relative to the initial pressure of 4.0 bar (58 psi) when the spray tank is fully pressurized and there is no CFV.

3.4.2 Sprayer spare equipment and parts

Application equipment should be maintained, checked and calibrated before each use. The sprayer manufacturer's instruction book provides information on the correct maintenance procedures. A maintenance plan or replacement schedule for field equipment should be developed. Any leaking, worn or damaged components should be promptly mended or replaced before use. In particular, nozzles should be checked for wear frequently and replaced as necessary, as nozzle life is highly dependent on the type of formulation used (e.g. WP causes greater erosion), water quality (e.g. presence of erosive particles) and material of the nozzle (e.g. steel, ceramic).

Spray operators should always carry sufficient spare parts for the equipment. In addition to spare nozzles, programmes should stock other spare parts, especially gaskets, springs, lances and shoulder straps, which can be prone to wear and damage. Spare CFVs may also be needed. Tools for changing the parts, such as a wrench or spanner set, are required. Spare part kits are available from the manufacturers. Spare parts and a system for sprayer maintenance and repair must be included in the annual procurement and planning.

Repairs may be carried out by persons who are not trained in pesticide use and application; however, these individuals must be fully protected, even when working on clean ("decontaminated") equipment. All repairs to spray equipment should be

noted. Care must be taken to ensure that any repairs do not cause further damage, such as by ensuring that hard materials are not used to clean nozzles.

Section 4.3.1 gives further details of how to check the sprayer and fill the tank so it is ready for use in the field.

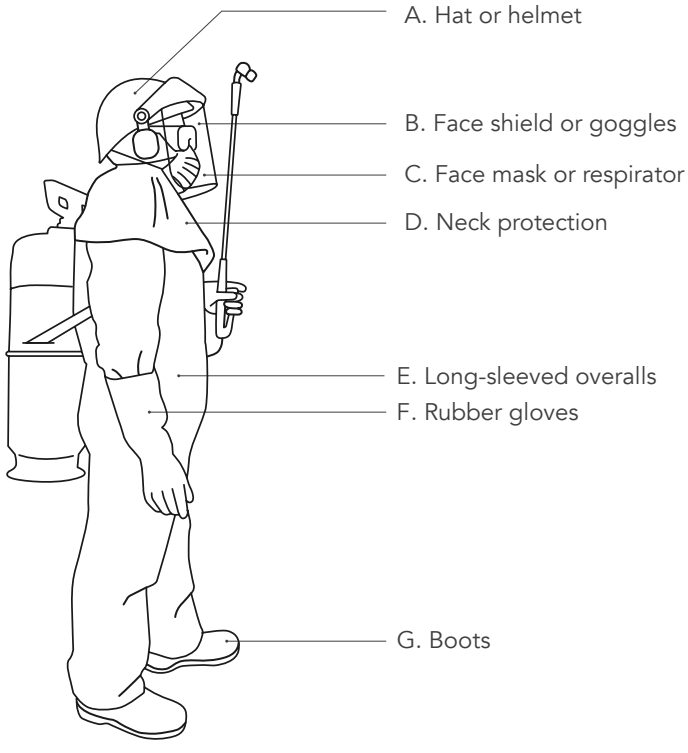
3.4.3 PPE for spray operators

Spray teams must be provided with good-quality PPE appropriate for IRS. PPE must be procured and delivered with sufficient lead time to equip teams when they start training and preparing for field operations. It is essential that all protective clothing and gear be bought before every season to ensure that it is the right size and comfortable for use by spray operators. A minimum of two sets of overalls should be provided for each spray operator. Detailed WHO/FAO guidance on the use of PPE for IRS is available *(26)*.

PPE for IRS (Fig. 9) includes:

- headcover, such as a broad rim hat or plastic helmet, to protect the head, face and neck from spray droplets;
- neck scarf, mutton cloth or light cloaks to protect the neck from spray:
- full face shield or goggles to protect the eyes and face against spray fall-out and splashes;
- face mask/respirator to protect the nose and mouth from airborne particles of the spray fall-out and to avoid inhalation;
- long-sleeved overalls worn outside of boots to prevent skin contact with spray;
- rubber gloves that are resistant to the chemicals in use to shield the hands;
- non-absorbent boots that protect the feet; and
- raincoat for use to protect the spray operator only when it is raining (and not to be used during spraying).

Fig. 9. Spray operator PPE



The exact PPE specifications depend on the formulation being applied. When spray is applied with a tank pressure of up to 4.0 bar (58 psi), a face mask/respirator is essential. When the sprayer is fitted with a 1.5 bar (22 psi) CFV and the spray is applied at 1.5 bar (22 psi), the proportion of inhalable droplets is significantly lower; however, a mask or face shield is required even in a well ventilated area. A face shield is more comfortable to wear and avoids the need for goggles (Fig. 9). Dust masks and surgical masks should not be used, as they do not provide adequate protection against pesticides.

Some masks can be washed and carefully dried for reuse, but disposable masks should be disposed of after one day of use or earlier if they are contaminated; operators must not breathe through a contaminated mask. If a respirator is used, the dates and duration of use must be recorded and the cartridge replaced as recommended by the manufacturer.

Gloves are necessary when preparing the spray liquid using concentrated formulations and when spraying the walls, even when using insecticides in sachets where the probability of contamination is low.

PPE should not be stored near non-work clothes or near food and should not be kept at home. It should be stored separately from insecticides and application equipment to prevent contamination.

3.4.4 Other materials for spray operators

The spray operator should also be provided with the following:

- map of area showing the houses or structures to be sprayed;
- notebook and records;
- bag/satchel for carrying insecticide bottles or sachets;
- muslin cloth for straining dirty water;
- plastic sheeting to cover objects;
- wet wipes for cleaning face shields;
- buckets to carry water; and
- calibrated measuring containers (if insecticide is not packaged in sachets).

Other equipment for spray teams may include tents, camp beds, sleeping mats, mosquito nets, soap, cooking utensils and lighting, if field camps are being set up.

3.5 Transport, storage and waste management

There is potential for exposure and environmental contamination throughout all stages of insecticide handling, from the point that they arrive in the country to their eventual application and the disposal of waste from spray operations. It is therefore essential for measures to be put in place and monitored regularly to minimize this risk. Safety standards must be set for insecticide:

- packaging
- transport
- storage
- application
- disposal
- spill response.

3.5.1 Packaging

Packaging of chemicals should be sufficiently robust to withstand any extreme transport, handling, storage and climate conditions to which the insecticides may be exposed. Packaging should be rigid, leak-proof, weather-, tamper- and rat-resistant, and labelled appropriately.

Insecticides should be kept in the original packaging and containers for transfer into sprayers on site. Spray charges (or the quantity of insecticide needed for one sprayer) should be pre-packed to facilitate easier transport, handling and efficient filling of the sprayers. IRS products should be ordered as sachets commensurate with the operational capacity of the sprayers used by the programme (i.e. 7.5 L or 10 L). For solid formulations (e.g. WP, WG), water-soluble sachets that can be placed directly in the spray tank are preferred. Insecticides should never be decanted into food containers, drinking bottles or unmarked containers, as this may result in accidental exposure of others. If a container is damaged and/or the insecticide is leaking, the product should be emptied into a clean replacement insecticide-approved container that is fully labelled.

3.5.2 Transport

IRS campaigns require the necessary materials and supplies to be procured and delivered in time and personnel to be safely transported to and from their sites of operation. Most damage to insecticide containers, and therefore potential exposure, occurs during their transport, loading and offloading. To ensure staff safety and avoid pesticide spills, the vehicles used must be safe and in good operating condition. All vehicles for transport of insecticide or spray teams should be inspected for their suitability before use and checked frequently to ensure that they meet safety standards. Insurance for vehicles should be obtained to provide coverage in the case of accidents. Transport vehicles should be decontaminated thoroughly as soon as spills or leaks are seen. They should be equipped with a spill response kit that includes a bucket of sand, sawdust or soil, a shovel and a brush (see section 3.5.5), with a fire extinguisher also included.

Licensed literate drivers should be employed. They should be trained on the properties and hazards of the insecticide(s) they are handling and what to do in an emergency. They should receive training on how to prevent contamination and spillage and have the means to contact emergency numbers in the case of an accident. Protective equipment should be provided to drivers. First aid kits should also be available in the vehicles (see section 4.1.3).

Insecticide containers should be loaded in such a way that the risk of damage and movement is minimized. At regular points during transport, in particular over long distances and uneven surfaces, the containers and the vehicle should be checked for leaks or spills. Similarly, during offloading, all containers and vehicle surfaces should be checked. Any spillage must be responded to immediately, ensuring thorough decontamination of the vehicle's surfaces. Torn or unreadable labels should be replaced.

Spray personnel are typically transported via pick-up truck or minibus. If pick-up trucks are used, hand bars and benches to accommodate the teams will provide better safety and comfort. In general, the minimum requirement is one or two vehicles per district to service 5–10 spray teams. When transporting spray teams to the spray areas, pesticide containers should be transported separately from food

and drinks and be well secured in vehicles. Sprayers can be placed between the legs of personnel to minimize the risk of spillage.

It is preferable that vehicles being used during the spray operations are not used for other purposes, in particular food transport. If the vehicle is to be used for another purpose, it should be thoroughly cleaned. If it is used exclusively for the IRS operations, then cleaning can be conducted after all spray operations for that round have finished.

In some countries, road access is very limited and/or poor and structures for spraying can only be accessed by foot or by smaller motorized vehicles such as mopeds, or even in certain cases, by boats, donkeys or bicycles. It is advised that this form of transport be used with caution and special care to avoid pesticide spills. This type of transportation should be authorized by the country in which the spray operations are being conducted.

3.5.3 Storage and field camps

To avoid adverse impacts on human health or the environment and to ensure the security of IRS equipment and commodities, storage facilities must meet specific standards. Insecticides should always be stored securely, away from livestock, separate from food and drinks, and locked away to prevent access by children and unauthorized persons. Storage is required at the district level where insecticides and spray equipment, along with other supplies, equipment and records, are kept. These facilities may also be used for the storage of waste chemicals ahead of proper disposal. Insecticides and their waste should not be stored with other commodities. However, if this is unavoidable, then they should be stored in a clearly marked separate section.

Small-scale storage facilities are often necessary in cases in which several spray teams will move around different areas over the months of the operation, or because of access limitations and distances of some spray sites. These temporary field camps should be sited at strategic locations. In addition to storing spray team commodities, these camps may be the location of wash areas. Some of these field camps may also become permanent storage, equipment repair and training facilities for districts and provinces. There may be further steps required for these smaller facilities, located close to communities, to ensure their security and restricted access.

3.5.3.1 Siting of storage facilities

Insecticide storage facilities should be sited:

- away from schools, health facilities, animal feed depots and residential homes (at least 100 m away);
- away from community pedestrian access routes;
- away from water courses, areas with high water tables prone to flooding, and domestic or animal water supplies; and
- in an accessible location for transport and emergency exits.

The storage facility should have visible hazard signs on its exterior in the local language(s) to indicate that hazardous pesticides are being used and access is

restricted to authorized persons. Warnings prohibiting smoking and open flames should be clearly displayed, accompanied by appropriate symbols.

3.5.3.2 Design of building

Storage facilities must be large enough to accommodate all insecticides, both those for deployment and waste products (and other equipment if necessary), while still allowing easy access to commodities. Storage facilities must be lockable and their structure well maintained. They must also be well ventilated and temperature-controlled to ensure that pesticide vapours do not build up and that indoor temperatures do not reach dangerously high levels. Floors should be impermeable (e.g. made of concrete) such that insecticide spills are not absorbed and to facilitate decontamination. Pesticide containers should be placed above ground level, such as on wooden pallets, and not directly on the floor to prevent them getting wet. No liquids should be stored above dry materials. Containers should not be stacked at heights that may result in toppling or prevent their accessibility by stock managers. Floors and access routes to containers must be kept uncluttered.

3.5.3.3 Other insecticide storage facility requirements

Stores should be provided with fire extinguishers (powder or carbon dioxide, not water) that are regularly checked and serviced. Supplies of sand or dirt to cover and absorb spillage should be available, along with brushes and pans to sweep these up. Water and detergents should be provided. There should be visible notices providing the names and contact details of those responsible for the store and whom to call in case of emergency.

3.5.3.4 Stock control

All storage facilities require a good stock control management system. This includes having a current inventory of all items, assigned stock control numbers and a stock tracking system to account for commodities received, stored and issued. This should be accompanied by an audit system. Store stock control must ensure that old stock is used before similar new products that have recently been purchased. Detailed organization and management of stock can be found in the FAO *Pesticide storage and stock control manual (41)*.

3.5.4 Waste minimization and management

To ensure safety when disposing of insecticide containers and other contaminated consumables, a set of standard practices must be established and operations regularly checked. Further information on human safety and environmental protection can be found on the WHO website *(42)* and in the compendium *(23)*.

Options for minimizing waste are presented below (Table 7).

Table 7. Waste minimization management guide

Ways in which insecticide waste can be generated	Ways to minimize waste generation or disposal
Surplus insecticide or spray solution	Ensure proper planning of needs. Preferably order insecticide to cover only one year's needs (including buffer) at a time rather than stockpiling. Prepare only enough insecticide to spray the area to be covered each day. Encourage use of all mixed insecticide before the end of the day. Do not leave the spray mixture in the sprayer overnight.
Sprayer leakage contaminating absorbent material	Maintain well, check frequently and mend rapidly all sprayers to avoid spillage.
Little or no agitation (especially with DDT) resulting in sediment in pump that requires disposal	Agitate the mixture constantly during spraying to avoid sedimentation.
Sprayer washing and rinsing	Implement the progressive rinse method using appropriate containers and recycle rinse water for the next day's use.
Chemical fall-/bounce-off during spraying	Use correct spray technique.

3.5.4.1 Solid waste management and disposal

Solid waste is generated during IRS operations, which requires correct disposal. This includes materials that have not had contact with pesticides (such as non-insecticide packaging, paper, etc.) and those that are potentially contaminated, having been in contact with chemicals (such as empty insecticide sachets or containers, damaged PPE, used cleaning equipment, materials such as sawdust used to clean up spills, and contaminated soil from accidental spills).

Uncontaminated waste can be disposed of as standard municipal waste. However, contaminated waste needs to be disposed of in an environmentally sound manner. Insecticide management practices should always include steps to minimize waste by recycling and disposing of empty sachets or containers through special incineration. This should be done at appropriate facilities designed for this specific purpose. Burning in a conventional open fire will not destroy any residual insecticides and may generate environmentally toxic emissions *(43)*.

Disposal of contaminated waste

All the contaminated solid waste should be collected in a central storage facility while awaiting disposal by qualified staff. Certain types of IRS waste, such as empty sachets and respirators, are collected on a daily basis, while other types (e.g. gloves and covering sheets) are collected periodically. Solid waste from IRS activities should not be allowed to accumulate and should be disposed of at the end of each seasonal spray schedule, wherever possible. Different countries have different approved approaches to contaminated waste disposal, which may include burial, incineration or removal by registered contractor. Empty insecticide containers should be cleaned out, as far as is practicable. This should be done away from water sources, with disposal as indicated on the label. In some cases, the effluent can be

recycled and used for subsequent spraying (see section 3.5.4.2). Glass containers should be smashed and steel drums and metal and plastic containers punctured (other than aerosol containers) and crushed to ensure that they cannot be reused, before being sent to a central location for disposal.

Safe and secure storage

As with the storage of insecticide products, the waste storage facility must be lockable, with a roof in good condition, have adequate ventilation, be accessible and be located away from flood-prone areas.

The storekeeper is responsible for maintaining an accurate inventory of all IRS waste. Empty insecticide sachets and inventories of empty sachets returned to supervisors should be tracked daily. A final audit of used insecticide sachets and containers should be undertaken to ensure that each empty sachet has been collected and has not been diverted for unauthorized use.

3.5.4.2 Effluent waste (rinse water or wash liquids)

IRS supervisors and team leaders are responsible for ensuring that their teams follow the progressive rinse method and recycle the water used for washing sprayers. They also need to ensure that insecticide spills are cleaned and contaminated materials are disposed of through incineration. Special attention should be given to preventing the contamination of food and the floor areas of houses where children and animals would be especially exposed.

At the end of each day, spray equipment should be washed at the spray camp. The resultant rinse water should be collected in a bucket or closed container and can be used to prepare the spray suspension on the following day as the IRS operations continue.

Once the spray campaign has been completed, the rinse water and any container rinse that has not been added to the spray pump should be disposed of in:

- soak pits for biodegradable insecticides (e.g. waste from pyrethroids, carbamates and organophosphates);
- evaporation tanks for non-biodegradable insecticides (e.g. waste from DDT); or
- mobile soak pits, which can be used in remote areas, where it is impractical for teams to return to a central location for clean-up *(44)*.

3.5.4.3 Site considerations and layout

Sites for locating IRS cleaning and waste facilities require wash areas, progressive rinse areas, a soak pit and/or evaporation tank. In selecting these sites, it is important to consider soil, topography, groundwater and proximity to water bodies (rivers, lakes and wetlands), with a view to avoiding potential contamination of groundwater with insecticides. In general:

- avoid areas with a high groundwater table and areas prone to flooding, and choose sites away from bore holes and schools, whenever possible; and
- avoid locations near crops, surface water, animal enclosures, beehives and public buildings such as schools, whenever possible.

All staging areas used for washing spray equipment and PPE are required to have a wash area that drains into a soak pit or evaporation tank. Pits or tanks should therefore be located downhill from the progressive rinse area and the wash area so that run-off from this facility is directed into the pit or tank. This avoids potential spills that may be caused by transporting effluent to the pit and reduces the risk of environmental contamination. All areas used for washing spray equipment and PPE must be impervious.

In general, most facilities should be located adjacent to the storage facilities, where they can be more easily protected and monitored. Due to access limitations and the distance of some spray sites, it may be more feasible to place a small facility in an appropriate area near the site.

The entire structure should be fenced off to block access to animals and unauthorized personnel. The fence can be simple (single-gated) made from tree branches and/or barbed wire or other cross-structures. The fence can also serve as a temporary hanging place for washed clothes (that have not been exposed to insecticides) to sun dry.

Hazardous warning signs must be posted in the area to further caution the public.

3.5.4.4 Wash areas

Wash areas are where PPE and any materials used to cover household items are washed with detergent and water.

- If biodegradable insecticides are being used (e.g. pyrethroids, carbamates or organophosphates), the wash area can be constructed either next to or within the soak pit. If located next to it, the effluent should run into the soak pit.
- If non-biodegradable insecticides are being used (e.g. DDT), a tarpaulin should be used to capture all effluent and direct it into the soak pit. The wash area should be a cemented bay that drains into the evaporation tank.

Hanging lines for drying overalls should be erected directly over the washing areas. Any PPE deemed to be insufficiently clean and/or too worn to be reused should be collected in large plastic bags and disposed of in accordance with national requirements, if any. If no system is in place, it is recommended that used PPE be returned to the retailer for return to the manufacturer. If recycling schemes exist in the country, the material of the used PPE can be recycled.

A separate wash basin should be provided for daily washing of the spray operators' face and hands.

3.5.4.5 Soak pit

A soak pit is a specially designed hole in the ground for disposing of biodegradable waste (Fig. 10). A properly sited and well constructed soak pit protects the environment from contamination, while allowing pesticides to degrade and become harmless. A concrete curb should be built around the soak pit to contain effluent and divert run-off from the surrounding area.

Due to the distance and access limitations of some spray sites, it may be more appropriate to create a scaled down version of a soak pit located near the site or to use a mobile soak pit (see details below).

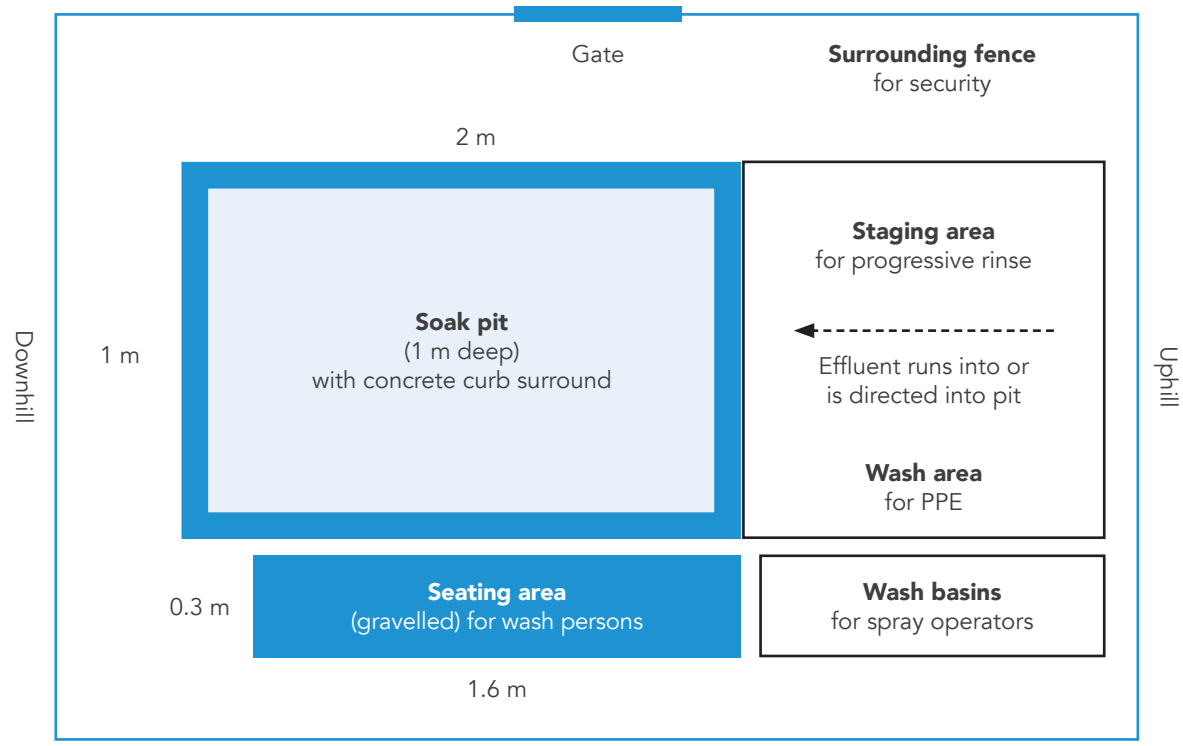
Standard design and construction

A soak pit measuring 2 m by 1 m by 1 m is usually sufficient to absorb the effluent produced by 20–30 spray operators for the duration of the spray operations. The pit walls should be lined with plastic sheeting to prevent seepage of chemical effluent through the side walls. The bottom of the pit should be lined with 1–1.5 bags of sawdust, covered with 1.5–2 bags of hard coal or charcoal, and covered with a layer of stone aggregate and small gravel to create a filter that is 1 m in depth. As the effluent percolates through these materials, the pesticides are filtered out and degrade before reaching the surrounding soil. Unless the soak pit becomes clogged with foreign matter and will not drain, it should remain effective for three years, at which time it can be excavated so that the sawdust and coal can be replaced.

Decommissioning

At the end of their useful life, soak pits can be decommissioned and the sites restored to their former condition by filling in, levelling and planting the area with appropriate local vegetation. There is no need to extract the coal stones and gravel before doing so. It is advised that, after restoration, the soil should be sampled to test for pesticide contamination.

Fig. 10. Example layout for a soak pit



3.5.4.6 Evaporation tank

An evaporation tank is a sealed tank for the disposal of effluent from non-biodegradable liquid pesticides such as DDT. These tanks allow for collection of such waste near the site of application until safe disposal of solid waste can be carried out at a facility equipped to handle this category of waste *(40)*.

Standard design and construction

An evaporation tank should hold approximately 15 750 L (based on the amount of effluent produced each day minus evaporation rates), which should be sufficient to allow for disposal of effluent from 20–30 DDT spray operators. The tank should be designed to have maximum surface area to promote evaporation. The tank should be constructed with impervious concrete, sunk into the ground, with sides raised 20–30 cm above the ground to prevent overflow, and covered with a lockable wire mesh. The tank should also be fitted with an overflow drain to allow for drainage during the rainy season once the operations have been completed and the tank has been cleaned of residue.

Once evaporation is complete, the dried DDT residue is collected and disposed of, together with the other solid DDT waste.

Proper use

- After a spray round, all sand, sludge and pesticide residue remaining in an evaporation tank should be scooped out, placed in a sealed container, placed with empty sachets and disposed of according to the country's protocol for solid waste disposal. Efforts to minimize chemical waste and ensure its disposal should follow international standards (see section 3.5.4).
- If it rains during the spray operations, the tank should be covered with a tarpaulin to prevent extra rainwater from flooding the tank and causing overflow.
- If the water level in the tank comes within 15 cm of the drainage hole, liquid should be siphoned into plastic polytanks (around 4000 L) for temporary storage, until it can be added back to the tank.

Decommissioning

If evaporation tanks are to be decommissioned, all insecticide residue should be removed before the tank is dismantled. The site should be restored back to its natural state to the extent possible once IRS activities have been discontinued.

3.5.4.7 Mobile soak pit

One or more mobile soak pits may be used as an alternative to a permanent soak pit or evaporation tank for DDT *(42)*. A mobile soak pit is a transportable water filter designed to reduce insecticide concentrations from IRS wash water following the end-of-day equipment decontamination. It consists of a plastic bucket filled from bottom to top with layers of screen, foam, screen, granulated activated charcoal, screen and foam. The layers filter out large particles, and the activated charcoal can remove both insecticide and soap from rinse and wash water, enabling the reuse of the purified water the next day as dilution water for the spray tanks. These soak pits are designed for use by a maximum of five spray operators and can be temporarily installed at predetermined locations along spray routes.

At the end of the spray campaign, the activated charcoal can be incinerated at temperatures > 110 °C.

3.5.4.8 Disposal of obsolete (date-expired) insecticides

Insecticides should not be allowed to expire. Proper planning, quantification and stock management should be in place to minimize the risk of generating surplus stock. Store stock control must ensure that old stock is used before recently purchased similar new products, using the principle of "first-in, first-out". Occasions will arise, however, when it will be necessary to dispose of pesticide concentrates. This is usually because the stock is outdated and has been found to be unusable, because the product is no longer registered for the original purpose or because vector resistance has emerged.

Safe disposal should be in line with national authority guidelines (often decided by ministries of health, agriculture or the environment) according to the available disposal facilities in the country and in compliance with international conventions relating to the international transport of pesticides. FAO has provided technical guidelines to inform this process *(45)*.

If only a few kilograms or litres of pesticide are involved, they should be collected and sent to the central location for disposal by qualified personnel. Storekeepers should not become directly involved with pesticide disposal. Pesticides are best disposed of by burning them in a special incinerator at temperatures of 1100–1300 °C. If such equipment is not available in country, expired insecticides should be returned to the supplier or passed on to a specialist disposal agent selected by the national authorities.

Solid waste from DDT can be disposed of in an approved in-country incinerator that meets DDT disposal requirements *(45)*. If no in-country incinerator exists, the waste must be transported out of the country to a certified facility. Once incinerated, the remaining ash residue must be treated as toxic waste and be disposed of according to the requirements for disposing of toxic ash residue.

The useful life of the expired insecticides can sometimes be extended beyond their label expiry date, such as by confirming expected efficacy through re-testing of samples by the original manufacturer and other registered quality control centres. National authority guidelines should be followed in this regard.

3.5.5 Spill response

There will occasionally be spills, even in the best run programmes. These can be the result of natural disasters (e.g. flash flooding, fires, earthquakes, or cyclones); vehicular accidents of any type that result in damage to the vehicle or its contents; accidents involving equipment for moving pesticides within a store; or other unforeseen occurrences (e.g. falling from a transport vehicle due to rugged conditions). Complete decontamination and effective disposal may be very difficult to achieve.

Protocols should be established on how to handle exposure to and/or spillage of pesticides. If such an event should happen, staff must be wearing protective clothing and bystanders should be kept at a safe distance from the contaminated site. If spillage occurs, access should be restricted and the spill covered with earth or sand, with no attempt made to wash away the spill with water or other liquids. Contaminated materials should be placed in containers for collection and central disposal.

A fully stocked spill response kit should be available that includes:

- absorbent sand, sawdust or soil
- a shovel
- a long-handled brush with stiff bristles
- a short-handled brush and pan.

A first aid kit should also be available (see section 4.1.3). It is essential that all staff have the means to contact supervisors or emergency numbers in case of such events.

3.6 Advocacy, communication and community engagement

The public needs to be kept well informed to ensure full support and cooperation with any IRS activities. IRS programmes should always have an effective advocacy and public health promotion component to ensure widespread acceptance and support at household and community levels. This requires an ongoing dialogue between those coordinating IRS programmes and community and local government leaders, together with other sectors such as agriculture and education. Professional guidance should ideally be sought from health educators, health promoters and social scientists to develop appropriate advocacy, communication and community engagement strategies and to conduct IEC campaigns before the start of each spray round. Focus group sessions should be held to define how IRS is justified to the public, to anticipate areas of concern and to develop key messages.

3.6.1 IEC campaigns

The higher the percentage of houses completely sprayed with residual insecticides, the better the protection afforded to the entire community. For a spray programme to be successful, people must be informed of the benefits of protection against pathogen-carrying mosquitoes that is provided by IRS.

IEC campaigns should be carried out before spray operations are launched countrywide or in specific districts in order to raise awareness about IRS, facilitate community mobilization, ensure acceptance of IRS and encourage participation in IRS operations at the family and household level.

IEC campaigns use simple messages that are consistently reinforced through different media. Educational materials, such as pamphlets, posters and cartoons, need to be produced and widely distributed. Where possible, these should be supported by radio and TV coverage. Public address systems in target communities can also be used.

3.6.2 Community participation

Every effort must be made to enlist the cooperation of each household. This requires obtaining agreement of community leaders and residents before initiating an IRS programme in a locality. Prior to spraying, team leaders must contact community leaders to inform them of the planned spray operations and that IRS team members will be visiting the villages or suburbs to provide more detailed information and then to conduct the spray. As close to the planned spraying date as possible, a member of the IRS team should travel to the target location to provide specific information regarding the planned spraying.

Target groups for community engagement include:

- traditional leaders
- political leaders
- religious leaders
- civil society leaders
- women's group leaders
- youth leaders
- school-aged children
- teachers
- community health volunteers or health workers.

There should be opportunities for community members to debate issues, seek advice and arrive at a consensus of opinions and approaches. Any dates of special importance to the community, such as market days, should be noted to inform planning of spray operations. Meetings organized by community leaders to explain the procedures and benefits of an IRS programme should be one of the tools used. It is important that the IRS staff explain to community leaders and residents the objectives of the IRS programme and outline to them the benefits, safety precautions, potential post-spraying side-effects and actions required by community members.

Key messages during meetings with community leaders and members could cover:

- when, where and how the spraying will be conducted;
- why it will be conducted, including how insecticide application impacts specific vector-borne diseases;
- the expected duration of effectiveness and the importance of not re-plastering, painting or washing the walls during that period;
- that the insecticides used are not hazardous to humans, dogs, chickens, cats or other domestic animals, if the precautions outlined by the spray operator are followed;
- that the spray operators will not spray places used for storage of food such as rice, yams or corn;
- that spraying does not harm walls, ceilings and furniture;
- that spray operators are responsible people who will take care of people's property;
- the need for the participation of residents in preparing their houses for spraying and complying with instructions, including by providing water (where relevant) and preparing household items in advance of spraying;
- the importance of waiting outside after spraying is complete, until the insecticide is dry (usually about one hour), to reduce the risk of skin and eye irritation. In some circumstances where there is high humidity, drying may be delayed and residents may be requested to remain outside for longer, up to two hours;
- the importance of continuing to use other vector control interventions, if these are available;
- specific instructions on what community and household actions are required before, during and after spraying;
- where to seek advice and assistance if any problems are experienced, such as side-effects; and
- any associated evaluations that will require community cooperation (such as vector surveillance) and if any follow-up visits are planned.

3.6.3 Instructions for the community

Directly in advance of the spray campaign, local spray operators should be employed or a local community leader or member should accompany spray teams to secure full resident cooperation. Specific instructions to residents should be developed and discussed in advance and translated into local languages as needed.

Instructions should include the following:

Before spraying:

- if needed, collect and make available at least 15 L of clean water for mixing of insecticides in the sprayer and for any other use by the spray team during spray operations;
- prepare houses for spraying by:
  - covering items (e.g. water, foodstuffs and other consumables, cooking utensils, light furniture, bedding and clothing, toys); or
  - if relevant:
    - moving these items outside;
    - moving those items that cannot be taken out of the structure away from the walls, such as to the centre of the room, to enable easy access for the spraying of walls and furniture; and
    - taking down pictures, wall hangings and posters that can be removed.

On the day of spraying:

- do not be present where pesticides are being mixed, in particular children and pregnant and breastfeeding women;
- allow spray teams to enter their houses and associated sprayable structures;
- ensure that all residents remain outside the house at least 10 m away during spraying and for an hour or more after completion of the spraying while the insecticide dries;
- similarly relocate pets and domestic animals, caged or leashed, away from the house;
- notify the spray team if there are any rooms or structures that cannot be sprayed, for example, if there are sick or elderly residents that cannot be moved out of the house; and
- do not prepare food in close proximity to the house during spraying.

After spraying:

- ensure that all occupants and animals remain outside until the sprayed walls and other surfaces have dried, which usually takes about one hour;
- sweep floors free of residual pesticide and insects killed from the spraying, and dispose of the swept material immediately in a latrine pit or by burying it in a hole;
- ensure that other residents, in particular children, pregnant women and animals, enter the house only once the sprayed surfaces have dried and the dead insects have been swept up;
- open doors and windows for ventilation for at least 30 minutes, as any residual odour will dissipate as the insecticide dries and the room is ventilated, and should not be cause for concern;
- if skin irritation is experienced, wash with soap and water; for eye irritation, flush eyes with water; for respiratory irritation, leave the home for fresh

air; if accidentally ingested, contact programme staff or go to the nearest health facility;
- do not re-plaster or wash sprayed walls after spraying and until the peak vector-borne disease transmission season is over; and
- continue using other preventive measures, such as insecticide-treated nets, to protect against vector-borne diseases.

In this way, members of the community understand what they need to do to facilitate the operations, including how to prepare their homes and other structures in advance of the spraying and cooperate during and after spraying. The information provided must be as simple as possible and the use of technical words must be minimized.

4. Spray campaign implementation

Once the necessary planning, procurement and training has been completed in preparation for IRS, and the community has been sensitized to the planned operation so that refusals are minimized and houses are prepared before spray teams arrive, the actual house spraying operation can begin. This phase of the IRS operation involves ensuring that safety measures are in place; preparing insecticide solutions in the spray tanks; spraying the targeted structures; and recording which structures have been sprayed and which have not. Adequate supervision is important to ensure that each step is performed efficiently and to the highest standards.

4.1 Safety precautions

Supervision of IRS operations and regular M&E are required to ensure that the spray operators apply the relevant health and environmental safeguards following international best practices and standards. There is a risk that spray personnel may be exposed to insecticides at a number of different stages of the handling, spraying or storage of insecticides, such as:

- while opening the package;
- while mixing the insecticide formulation with water;
- while loading the sprayer;
- while maintaining and washing the equipment after spraying;
- during spraying, especially in high, overhead places;
- through spillage; and
- during disposal.

At each stage, measures must be in place to minimize this risk. The following are considered essential practices for spray operators and other handlers of insecticides:

- Eating, drinking and smoking while applying pesticides must be strictly forbidden.
- Spray operators should be provided with drinking water and encouraged to hydrate frequently. Gloves should be removed and hands and face washed with soap and water before drinking any liquids.
- If the skin is contaminated with pesticide, spray operators must wash immediately with soap and water; if pesticide gets into the eyes, they should immediately flush their eyes with plenty of water. In the case of ingestion, see guidance in section 4.1.3.
- The number of work hours for operators should be restricted to avoid exhaustion, preferably not exceeding six hours. Applying pesticide in the cooler hours of the day should be considered, when it is more comfortable to wear protective equipment.
- Water should be readily available before and after spray operations for washing hands and good personal hygiene should be practised. After spray operations, spray personnel should wash their faces and hands at a minimum. If feasible, spray personnel should fully wash.
- First aid directions should be available in the event of an accident or unplanned exposure.

Before starting any spray programme, it is essential for staff to be aware of the risks of exposure and how to minimize these. This applies not only to spray operators, but to all staff who may handle the insecticides or who are maintaining sites where insecticides are stored or disposed of. All personnel should read, or have read to them, the label information. Understanding the label information, including the hazards of handling the insecticide and the protective measures required, is essential for minimizing the risks associated with that chemical. Extensive pre-spray training for pesticide applicators and operators is essential, and, in some countries, personnel must obtain a certificate of competence to apply pesticides in order to ensure that IRS is conducted safely and effectively.

Prior to starting any spray operations, all staff must be reminded of and follow key safety procedures that should have been covered in training. These include to:

- read the label carefully and understand the directions for preparing and applying the insecticides, as well as the precautions listed to avoid inhalation and direct skin contact with the insecticides;
- know the first aid measures and antidotes for the insecticides being used;
- use protective clothing while handling and spraying insecticides (including while preparing spray equipment);
- use dedicated equipment for measuring, mixing and transferring pesticides;
- wash gloved hands before removing the gloves and remove concentrated liquid pesticides from a gloved hand (as some solvents gradually penetrate a glove);
- mix insecticides in a well ventilated area, preferably outdoors;
- where possible use pre-packaged insecticides with the appropriate quantity of water in the sprayer;
- rinse containers for liquid insecticides properly;
- inform the team leader or supervisor if their body comes into contact with the insecticide;
- regularly check the integrity of the spray equipment;
- always depressurize the sprayer before opening the lid;
- always depressurize the sprayer when transporting;
- never clear blocked spray nozzles by blowing with the mouth;
- do not eat, drink, smoke or use mobile phones while handling and spraying insecticides;
- wash hands and face with soap and water after spraying and before eating, smoking or drinking;
- shower or bathe at the end of every work day and change into clean clothes;
- wash overalls and other protective clothing at the end of each work day in soap and water and keep them apart from the rest of the family's clothes;
- change clothes immediately if they have become contaminated with insecticides;
- keep two sets of protective clothing that are different colours to avoid using the same uniform as the previous day; and
- inform the supervisor immediately if feeling unwell.

4.1.1 PPE

The main purpose of PPE is to minimize human exposure to a pesticide by keeping pesticides away from the body. However, PPE does not provide a 100% guarantee that a person will not have some exposure. All staff who handle insecticides and spray equipment, including those involved in their transport, storage, maintenance and disposal, should be provided with appropriate protective gear depending on the product being used.

Chronic exposure risk for spray operators is minimized by the wearing and regular washing and changing of protective clothing when handling insecticides and during all spray operations. Spray operators must always be provided with personal protective devices and clothing, including hat or helmet, face shield or goggles, face mask or respirator, neck protection, long-sleeved overalls, rubber gloves and boots (see section 3.4.3).

A minimum of two sets of protective clothing (overalls) should be provided to each spray operator. Ideally, these should be different colours for use on different days to indicate which have been washed after a day's spraying. Extra care must be taken when spraying organophosphates.

To avoid contamination of domestic areas and potential exposure of people and animals, the washing of work clothing and PPE should be conducted away from where families wash and shower. The clothing should be kept in a separate place from those of the family. Boots worn during pesticide use should not be worn when returning home.

4.1.2 Resident safety

The safety of occupants of houses targeted for spraying and their neighbours should also be a priority. At the time of spraying, the risk of exposure can be minimized by ensuring that safety precautions, as outlined in section 2.3, are followed.

4.1.3 Insecticide poisoning and first aid measures

Failing to follow correct procedures during spray operations can result in undesired exposure to insecticides or accidental insecticide poisoning. Below are some of the signs and symptoms of insecticide poisoning:

- general – extreme weakness and fatigue;
- skin – irritation, burning, excessive sweating, obvious staining;
- eyes – irritation, burning, excessive running, blurred vision, narrowing or widened pupils;
- digestive system – burning in mouth and throat, excessive salivation, nausea, vomiting, stomach cramps or pains, diarrhoea;
- nervous system – dizziness, confusion, restlessness, headaches, muscle twitching, staggering, slurred speech, fits or convulsions, unconsciousness; and
- respiratory system – breathing with difficulty, wheezing, coughing, chest tightness and pain.

In the event of an accident, exposure or if there are signs or symptoms of pesticide poisoning, first aid treatment is immediately required. A member of the team should be trained in first aid with a first aid kit, and a supply of clean water should also be made available. The kit should be checked regularly and instructions for use should be in the appropriate language. The first aider should be conversant with the insecticide(s) being used and the emergency procedures in the event of an accident and should have copies of all the latest product labels. Specific procedures to follow are often given on the product label or can be sourced from the insecticide manufacturer and/or supplier.

First aid kits should include:

- adhesive bandages or plasters
- gauze, tape, cloth bandages
- antibiotic cream
- eye wash
- hydrocortisone cream/calamine
- pain killers.

Key actions to implement are to:

- immediately move the patient away from pesticides and any contaminated areas;
- remove any contaminated clothing and PPE safely (considering both the patient and the first aider);
- wash exposed parts of the body with soap and plenty of clean, cold water without contaminating others;
- cover the patient with a blanket or clean clothes;
- if the eyes have been exposed to the insecticide, wash them immediately with ≥ 500 mL of clean water and gently irrigate the eyes for at least 15 minutes; and
- keep the patient in the "recovery position", on their left side with their neck extended until professional medical aid can be given.

The routes of entry, possible prevention and general first aid measures are tabulated below (Table 8).

Table 8. Prevention and treatment of poisoning

Route of entry	Prevention/protection	First aid measures
Skin	Use proper application techniques. Use gloves and protective clothing. Clean protective equipment before reuse.	Remove contaminated clothing and wash skin with soap and water.
Eyes	Use eye protection (face shield or goggles).	Flush eyes with clean water for at least 15 minutes.
Respiratory system	Avoid inhalation of fine dust and mist by using face mask or respirator.	Move to fresh air.

If the patient has ingested toxic pesticides, medical attention is needed immediately. A list of local emergency contacts should be available, including appropriate medical facilities with access to poisons information. The doctor should be given the label of the pesticide(s) to which the patient was exposed.

Immediately following ingestion, the patient should not be given any water or milk, as this will push the pesticide on into the bowel, where it will be absorbed more quickly. If the patient is unconscious, nothing should be given by mouth. If the patient is fully conscious and seen within 10–15 minutes of ingestion, as a general rule, vomiting should not be induced to try to remove some of the pesticide (unless the label says to do so). Vomiting a potentially corrosive pesticide, or any product that could damage the lungs (as indicated on the label), can be dangerous. In addition, it could delay transport to a hospital.

Local health units and hospitals should be provided in advance with simple information on the side-effects of insecticides being used in the area and on the recommended treatment and management of pesticide exposure *(5)*. In addition, facilities should be encouraged to stock treatments.

The key products or antidotes that should be available for treatment are:

- topical vitamin E (tocopherol acetate) for skin exposure;
- topical anaesthetic for eye exposure; and
- atropine, diazepam or phenytoin for ingestion exposure.

In cases of exposure, whether it be with spray personnel or residents, a report should be compiled of the incident. A description of the event should be provided with the date, time, location, person(s) involved and the insecticide to which the individual(s) was exposed. Details of treatment and management should be provided in the report. Programmes should follow country regulations regarding who should receive the report and timelines for submission.

4.2 Daily spray operations

4.2.1 Pre-spray communication

On the day of spraying, one member of the spray team should alert residents that the team is in the area and will be visiting their households, so that they can make the necessary preparations ahead of the spray team's visit.

IRS teams should always maintain a positive approach when communicating with community leaders and residents. As observed in the code of conduct *(26)* (Annex 7), the spray teams are "the face" of the Ministry of Health and, as such, they have a duty to always act in a professional manner and to maintain good relations with the community.

4.2.2 Routine of the spray team

The daily routine of a spray team typically includes the following:

- The spray team leader checks the spray team every morning to verify that all team members are wearing clean PPE and provides them with a briefing of where they will be spraying that day.
- Each spray operator prepares their hand compression sprayer for review and inspection by the spray team leader, including measurement of discharge rates when applicable.
- The spray team leader ensures that the spray operator has all the necessary equipment and that the equipment is in good working order.
- The spray team leader checks the amount of insecticide in numbered sachets that each spray operator requires for the day and ensures that operators have all the necessary information and recording forms for the day's work.
- The spray team then proceeds to work using the transport assigned. Sprayers should be depressurized before transporting. All sprayers should be secured upright in the vehicle to prevent accidental damage during transport between field camps and spray sites.

- Upon arrival in the assigned spray area, the spray team leader allocates a number of houses to each spray operator and the spray operations begin.
- Upon completion of the day's work, the spray team leader ensures that each spray operator properly and safely disposes of any remaining insecticide in their sprayer following the progressive rinse method, and that they thoroughly clean their sprayer at a designated wash point.
- The spray operators clean and store their PPE for use the following day and clean themselves appropriately.
- The spray team leader checks on insecticide use, the return of empty sachets and the removal of contaminated PPE. Daily recording forms are collected and the leader conducts an end-of-day debriefing.

4.2.3 Tasks of the spray operator

4.2.3.1 Preparing the spray charge

There is a standard series of procedures for the spray operator to prepare the insecticide mixture (the "charge") to spray. The following four steps should be followed to ensure safe and proper preparation.

Step 1: Wear protective clothing and gear
The first step is for the spray operator to put on protective clothing and gear. Spray operators must be aware that they are at occupational risk when using insecticides. It is their responsibility to ensure that they use protective clothing, as detailed in section 2.3. This includes during the preparatory phase each morning prior to the start of spray operations.

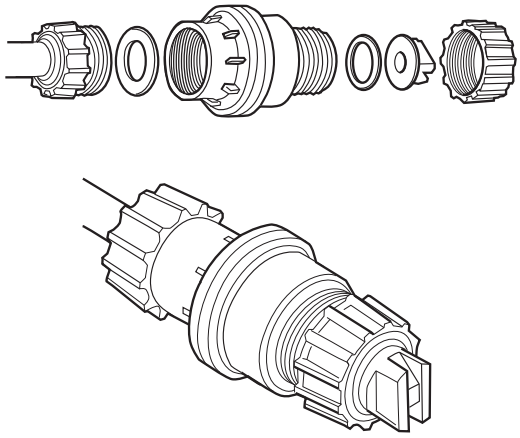
Step 2: Check the sprayer
Faulty sprayers may result in poor application, over- or under-application, and personal or environmental contamination. Before starting daily spray operations, the equipment must be checked. The sprayer should be examined to ensure that all component parts are present, assembled correctly and in good condition. The sprayer should then be checked with clean water to see whether it operates properly and to ensure that there are no leaks in the lance hose, its connection, the nozzle or the on/off valve. The discharge rate should also be checked periodically to calibrate the nozzle, as described below.

Examine assembly
The correct assembly of a hand compression sprayer in shown in section 3.4.1. The CFV may be built in to the lance assembly or may need to be fitted (Fig. 11) following one of the options below:

- Between the lance and the nozzle: Remove the nozzle tip and cap. Fit a washer, if not present, into the end of the CFV that is screwed onto the end of the lance. Then, with another washer if necessary, screw the nozzle body, tip and cap back onto the CFV.
- Between the lance and the trigger valve: Screw the CFV into the trigger. Then, screw the lance to the CFV.
- For other lances: Remove the nozzle body. Fit a washer, if not present, into the end of the CFV that is screwed onto the end of the lance. Then, with another washer if necessary, screw the nozzle body, tip and cap back onto the CFV.

Ensure that the correct type of nozzle is fitted to the CFV and lance, i.e. a flat fan nozzle with an 80-degree swath (8002 nozzle). Check that it is not damaged, worn or clogged by calibrating, as outlined below.

Fig. 11. CFV assembly



Calibrate the sprayer nozzle
One important step when checking the sprayer is to calibrate the nozzle. Operators should calibrate their sprayers regularly to ensure the correct discharge rate and to detect any problems with the flow rate that could be due to a worn out nozzle or malfunctioning CFV. Ideally, nozzles should be calibrated about once a month or after spraying every 200–300 spray units.

The nozzle should be calibrated by following the steps below (while wearing protective clothing (see section 2.3)):

- Pour clean water into the tank (never fill the tank more than three quarters full).
- Fit the lid and lock it in position by turning the handle.
- Operate the pump using both hands and with feet on the footrest. Pump until the tank pressure is around 4.0 bar (58 psi) or until the maximum pressure is reached. This is the working pressure. Every full stroke gives about an extra 1 psi. If present, the pressure gauge should show an increase as it is pumped.
- Check that the tank is holding pressure. Listen for the hissing sound of escaping air.
- Check to make sure that there are no leaks along the lance and hose, especially where the hose joins the tank, and the trigger on/off valve.
- Operate the trigger on/off valve to make sure that the spray is emitted from the nozzle.
- Check the discharge rate by opening the trigger or on/off valve for one minute, collect the discharge and measure the amount in a measuring jug.
- Repeat this step three times and calculate the average discharge per minute.

Sprayers with a 1.5 bar CFV
With the above procedure, if there is a 1.5 bar (22 psi) CFV and a new high-quality nozzle fitted, the nominal discharge of an 80-degree flat fan 8002 nozzle should be around 550 mL ± 10% per minute. However, this may differ between sprayer and nozzle models so the manufacturer's specifications for each should be checked. The spray decomposition pattern should be uniform.

In general:

- If the discharge rate exceeds the expected value for a new nozzle by more than 10% then the nozzle tip is considered to be worn.
- If there is no spray coming out of the nozzle or if the discharge rate is lower than the expected value for a new tip by more than 10%, it is likely that the nozzle is clogged.

A spray deposition pattern that is not uniform (as checked by spraying against a contrasting surface, such as a dry wall) can also indicate that a nozzle is worn or clogged. Clogging is most likely due to a blockage in the nozzle or the screen filters (rather than in the CFV) since the orifice on the nozzle tip is smaller.

The opening of a nozzle is very small and must not be damaged. If the nozzle is clogged, it should be immersed in a container of water for several hours before using a very soft toothbrush to remove the blockage. Nozzles must not be cleaned with a hard pin or piece of wire, or by blowing through it.

After cleaning or replacement, repeat the calibration and check the spray deposition pattern to determine if the issue has been resolved. If it is determined to be worn or damaged, the nozzle must be replaced with a new 8002 nozzle.

Sprayers without a CFV
The same steps are followed for calibrating compression sprayers not fitted with a 1.5 bar CFV, except that pumping should stop at 3.0 bar (44 psi) pressure in the tank. At this pressure, the correct discharge of an 8002 nozzle should be 800 mL per minute.

Check tank lid
The tank lid should be checked to ensure secure closing and correct opening:

- To close the tank, insert the cover vertically onto the tank, lift it and fit it into the tank opening; turn the handle across the width of the opening.
- To open the tank, push down the air-release valve by turning the handle on the cover; the cover will become loose once the air pressure is released and the tank reaches atmospheric pressure.

Having checked the sprayer, depressurize the tank by rotating the lid handle so that it stops on the pressure release button valve on top of the lid. During this process, hold the handle to prevent the lid from falling into the tank. Empty out the clean water used for calibrating the sprayer.

Step 3: Mix the insecticide and fill the spray tank
Spray operators must follow the instructions on the product label to ensure safe and correct mixing, handling and application of insecticides. The insecticides should be mixed outdoors or in a well ventilated area, away from community members.

While in the field, the insecticide sachets or containers should be kept in sachet holders or in drums or cartons away from moisture, heat and direct sunlight.

In general, insecticides come in pre-measured sachets for ease of use. In some cases, however, insecticides may need to be measured out by the IRS team. To mix the product, the following items are required:

- appropriate PPE;
- pre-measured and factory-packed sachets or plastic bottles or a measured quantity of the insecticide formulation (one chemical charge for filling one spray pump);
- functioning sprayer; and
- bucket with clean water.

Spray operators should identify a suitable flat, level and hard surface on which to place the sprayer. The insecticide may be mixed separately in a bucket and poured into the sprayer. Water-soluble sachets, tablets and insecticide granules can be added directly to the water-filled tank; this reduces the hazards associated with handling and mixing the insecticide in a separate container. The following provides instructions on how to mix insecticides in the sprayer.

Sprayers with a 1.5 bar CFV
Add clean water to the tank. A sachet or bottle with enough IRS formulation to spray a 250 m^2 area will require a **7.5 L** tank mix for a compression sprayer **fitted** with a 1.5 bar CFV, discharging at a rate of 550 mL ± 10% per minute. When using a 1.5 bar pressure (1.5 bar CFV), measure 7.5 L of water. The first 4 L of this water should be added to the tank and the pre-packed insecticide in a sachet or pre-measured quantity of insecticide should be added to this. The remaining 3.5 L of water should then be added to the mixture.

Sprayers without a CFV
Add clean water to the tank. A sachet or bottle with enough IRS formulation to spray a 250 m^2 area will require a **10 L** tank mix for a compression sprayer **not fitted** with a 1.5 bar CFV, discharging at a rate between 760 mL and 790 mL per minute. The pre-packed insecticide in the sachets or plastic containers or the measured quantity of insecticide formulation should be added directly to the spray tank, the sprayer lid should be closed tightly and the contents mixed by agitating the sprayer. The tank must then be filled with the remaining water to make the required total amount of mixture. The tank may have a mark indicating the maximum level of liquid; for most standard sprayers, this is 10 L.

Step 4: Shake and pressurize the spray tank
The lid should be fitted and the tank slightly pressurized, then shaken to mix the insecticide well. Shaking is done by grasping the sprayer by the pump shaft and the bottom end of the tank. The tank should not be held by the strap, nor should it be swung back and forth while on the shoulder. Formulations that have been prequalified by WHO should remain in suspension for at least 60 minutes without further shaking.

Now, slowly depressurize the tank, add the remaining 3.5 L of water, close the lid and pressurize to a sufficient level to commence spraying. It is important for adequate tank pressure to be maintained throughout spraying if there is no CFV attached.

- If the pressure is too high, the flow rate will be too high and cause run-off from the wall, which may increase spray bounce-off and contribute to early damage of the nozzle aperture.

- If the pressure is too low, the spray angle will be too narrow and the operator may try to compensate by reducing the distance of the nozzle from the wall, thereby altering the swath width and spray deposit on the wall.

For sprayers that are **not fitted** with a CFV, it is important that operators repressurize the sprayer to keep the pressure within 1.7–4.0 bar (25–58 psi) until the tank empties. As the volume of suspension liquid in the sprayer decreases during spraying, more pressure strokes will be required to return it to its required pressure.

The following steps should be followed to pressurize the tank (Fig. 12):

Sprayer with a 1.5 bar CFV
When the tank pressure decreases below 1.5 bar (22 psi), the CFV will close. The tank should be repressurized to use the remaining spray, if any. Note that to spray 7.5 L of suspension at 550 mL per minute, it usually takes 13–14 minutes.

- Put one foot on the footrest and unlock the pump plunger. Pull the plunger all the way up with both hands and then push it downwards, using full, even strokes. A full stroke gives about 1 psi.
- Pump strokes should be even and regular from top to bottom (short irregular strokes make more work and less pressure input per stroke).
- It may not be necessary to pump to 4.0 bar (58 psi) for the sprayer to work again, especially if there is a small amount of spray left in the tank.

Sprayer without a CFV
Use the pressure gauge (manometer) to monitor the pressure in the compression sprayer.

- Pump as above and continue until it registers a pressure of about 4.0 bar (58 psi). The upper and lower operating pressure limits are usually 4.0 bar (58 psi) and 1.7 bar (25 psi), respectively.
- Check the pressure by looking at the manometer, which usually shows the "operational pressure range" with a colour band.

Pressure should not be checked by:

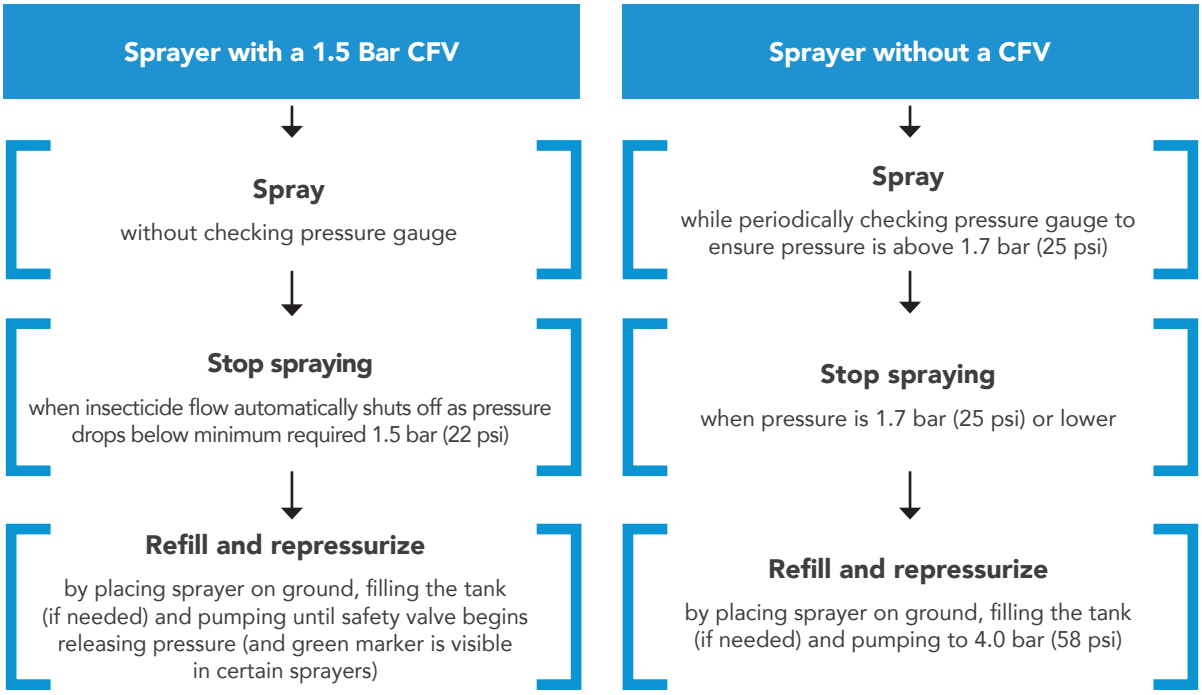
- the amount of fluid discharged;
- the appearance or width of the fan-shaped spray; or
- the time of last pumping.

Always release the pressure when the sprayer is not in use, for example:

- when the operator stops for long breaks (e.g. for lunch); and
- when the sprayer is being transported.

It will usually be necessary to repressurize and shake the sprayer once or twice before it is empty.

Fig. 12. Simple schematic of how to maintain the correct pressure for sprayers with and without a CFV after initially pressurizing the tank



Step 5: Carry and store the sprayer

The sprayer should only ever be carried by the shoulder strap(s) and never by other parts such as the cover handle. Spray operators should always check and adjust the strap(s) for comfortable carrying and handling.

For sprayers with a single strap, during spraying, the sprayer should be placed on the front, hanging under the left shoulder with the upper part of the sprayer forward. The sprayer is held with the left hand on top. This position allows for:

- quick unloading for placing on the ground for repressurizing; and
- easy handling in narrow passages and rooms.

When the sprayer is not in use, the sprayer should be placed on the back of the left shoulder in an upright position with the strap in front and the hose collected under the sprayer lid handle.

For sprayers with two straps, during spraying, the sprayer can be carried on the back with both straps over the shoulders for comfort. If needed, the sprayer can also be carried with just one of the straps over one shoulder, as described above.

When the sprayer is not in use, the sprayer should be placed in an upright position with the lance placed in either of the positions on the parking lance and the hose placed in the holder.

4.2.3.2 Applying the insecticide

Insecticide application rate

The dose being applied affects the residual efficacy of the insecticide. The insecticide suspension must be sprayed evenly and at the recommended application rate over all sprayable surfaces to ensure maximum efficacy. The amount of insecticide that is sprayed on a surface is determined by several different factors. Factors that are influenced by the spray operator during spraying and that need attention during training and supervision are:

- distance from the nozzle tip to the surface being sprayed: this should be kept consistent at 45 cm;
- speed of movement of the nozzle over the surface: this should be five seconds to spray a 2 m x 75 cm swath (i.e. each linear metre covered should take 2.2 seconds) but should increase if the nozzle is closer to the surface being sprayed, such as when spraying underneath or behind furniture; and
- air pressure in the sprayer:
    - For a sprayer with a 1.5 bar CFV, spray is applied at a constant flow rate so long as pressure is above the minimum required.
    - For a sprayer without a 1.5 bar CFV, this should be maintained at 1.7–4.0 bar (25–58 psi).

If the standard spraying procedure is adopted, the spray liquid will be applied at a rate of **30 mL/m² or 1 L per 33.3 m²**. This amount of suspension normally stays on the surface without run-off.

It should be noted that on smooth non-absorbent surfaces (such as painted brick walls), it is even more important to apply insecticide with a hand compression sprayer that includes a CFV in order to achieve a discharge rate of 30 mL/m^2, instead of a higher rate that will lead to high run-off and wastage.

Factors that are not directly influenced by the spray operator, but that require attention during preparation for actual spraying are:

- the concentration of insecticide in the suspension; and
- the nozzle tip aperture size.

Insecticide spray strategy

The following lists the key considerations in conducting the spray. There are a number of good practices that should be kept in mind:

> **Total coverage:** Spray teams and spray operators must find and spray every single spray unit in the target area that is relevant for the target vectors (see Table 5). For night-biting anthropophilic vectors such as *Anopheles* spp., only those buildings in which people sleep regularly should be sprayed. These may include houses, health centres or hospitals, boarding school dormitories, hotels and rest houses, and fishing and farm huts. For day-biting vectors such as *Aedes* spp. any buildings in which people gather and spend significant time during peak vector biting times should be sprayed. These may include schools, shop houses, markets, churches, health centres and other buildings.

Sprayable structures: Within each spray unit, all structures of relevance should be sprayed. Detached kitchens (after food stuffs and cooking implements have been removed) and latrines can be sprayed if known to be common resting sites of vectors and if residents permit spraying there. For zoophilic vectors, animal shelters (such as cattle sheds) with roofs may be considered sprayable structures, but open pens and corrals should not be sprayed.

Sequence of rooms for spraying: If the household has multiple floors, operators should start with the upper floor and move towards the lower floors. In general, in households with multiple rooms, operators should always start with the back rooms and move towards the front of the house. Kitchens or areas within houses used to prepare or store food should not be sprayed, to the extent possible. Rooms from which immobile persons cannot be shifted should not be sprayed.

Where there is evidence of a strong resting preference of the target vector in certain room types, these should be prioritized for spraying. For instance:

- for *Aedes* vectors, the order of priority of room types for spraying can be:
  - bedrooms
  - living room
  - hallways or corridors
  - bathrooms (without ceramic tiles)
  - rest of the house.

Sprayable surfaces: These will depend on the target vector and may include:

- for *Anopheles* vectors:
  - all inside walls;
  - doors and window frames;
  - inside eaves and openings;
  - ceilings, rafters and beams; and
  - wall hangings, posters, pictures and other items permanently affixed to walls (if permission given by residents);

- for *Ae. aegypti*:
  - exposed areas of walls;
  - curtains (front and back);
  - under and behind large furniture (e.g. wardrobes, cupboards, tables, beds);
  - under light furniture (e.g. chairs);
  - other difficult-to-reach surfaces, such as underneath elevated floorboards; and
  - verandas.

Wall surfaces made of tiles, enamel, metal or glass should not be sprayed. The underside of tin/metal roofing should not be sprayed, as this surface can reach high temperatures during the day, which may significantly reduce the duration of effectiveness of the insecticide. However, the underside of thatch roofing and dark and damp places where mosquitoes, triatomine bugs or sand flies rest may be sprayed.

When spraying a room, operators should start with the walls and then move to spraying underneath and behind large furniture. Finally, the light furniture and other sprayable surfaces should be treated.

Complete or selective spraying: In complete spraying, all sprayable surfaces within a structure must be sprayed and no sprayable areas should be left out, missed or forgotten. For instance, for *Anopheles* vectors, the full wall area is usually sprayed, as is the ceiling if it is considered a sprayable surface.

In selective spraying (sometimes called "targeted IRS"), spraying is limited to certain areas of sprayable surfaces for which there is evidence that high proportions of the vector populations rest there. For instance:

- for *Ae. aegypti*, which predominantly rests at lower heights, spraying is applied up to 1.5 m only;
- for phlebotomine anthroponotic sand flies, which are highly likely to come into contact with or rest on the lower portion of walls, spraying is applied on walls up to 2 m.

Spray procedure

The steps below should be followed by spray operators to ensure good practice during spraying.

Step 1: Inspect the structures for spraying

On arrival at the house for spraying, the spray operators should greet the residents, explain the purpose of the visit, and then request permission to enter the rooms accompanied by a member of the family. Operators should then check that the necessary preparations have been made. For instance, for spraying against *Anopheles*:

- All household items that can be moved have been removed from the house and are located at least 10 m away, especially food, water and their containers, and cooking utensils.
- Heavy furniture has been moved away from the walls.
- Other items have been moved to the centre of the room and covered.
- Wall hangings and other items on walls have been removed.
- There are no occupants or animals inside and animals have been secured outside.
- All residents and animals are at least 10 m away from the house during spraying.

If items remaining in the rooms to be sprayed have not been covered, operators should be equipped with plastic sheeting to do so. For spraying in densely populated urban areas or where rapid reactive or selective spraying are implemented, it may not be feasible to remove items from households or shift heavy furniture prior to spraying. This should be determined in advance, with clear and consistent instructions provided to spray operators.

Step 2: Apply the insecticide

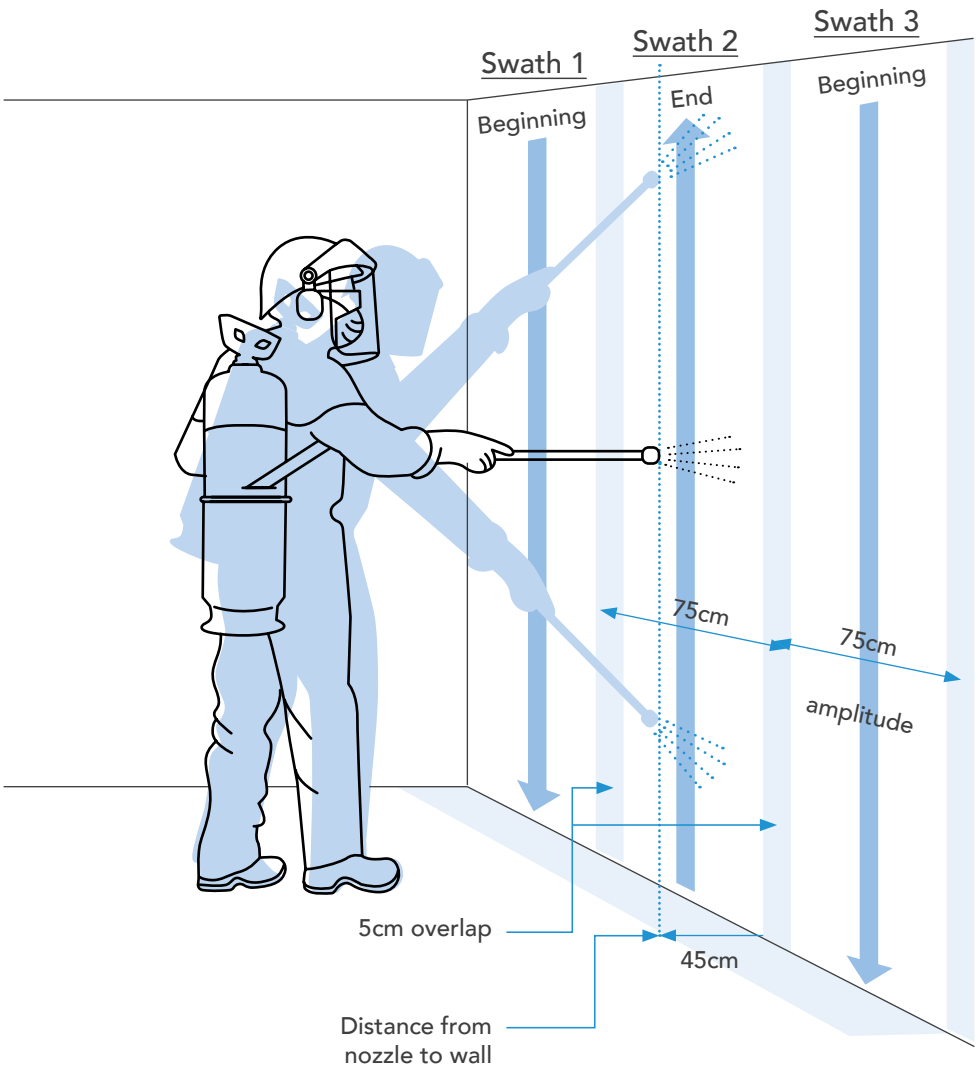
General spray technique

Once the inspection of the house is finished, spraying can start. Keeping the correct distance and angle of spraying is critical for depositing the correct concentration of insecticide on the sprayed surfaces. To commence spraying, spray operators should:

- lift the sprayer using the shoulder strap and position the strap on the shoulder and tank under the armpit so that the pressure gauge is visible; adjust the strap if needed;

- support the hose and lance in one hand, enter the room to be sprayed and face the door;
- maintain a body position of about 1 m from the surface to be sprayed;
- maintain a distance of 45 cm between the spray nozzle and the surface to be sprayed to provide a spray swath that covers 75 cm (Fig. 13);
- always begin spraying at the top of the swath, moving down:
- after the first swath, take a step sideways to get to the middle of the next swath and cover the second swath from bottom to top, ensuring that there is a 5 cm overlap between adjacent swaths (Fig. 13) in order to achieve even coverage (as there is usually reduced deposit at the edges of the spray pattern);
- maintain a smooth comfortable action with the hand and elbow with the arm fully extended when spraying the top of a vertical surface, bent at the elbow towards the waist at a 90-degree angle with the lance horizontal at the middle position, and extended downwards when spaying the lower section; spray operators may need to lean forwards as they spray at a higher point (such as on a wall) and move back as they bring the nozzle downwards; and
- maintain a uniform spraying speed of five seconds for a 2 m long (75 cm wide) swath or almost four seconds for a 1.5 m long swath to provide the correct target dose.

Fig. 13. Correct distance between the spray nozzle and spray surface and correct swath direction and overlap (adapted from *(8)*)



The correct footwork should be maintained together with the hand spray speed to generate the correct rhythm. Obstacles, such as chairs, tables and cupboards against walls, can impede progress and cause interruption of or deviation from a regular spray pattern. It may be necessary for the spray operator to adopt different postures while maintaining the basic distance and speed.

A uniform speed of spraying is required to provide the correct target dosage. Timing may be aided by mentally counting "one thousand and one, one thousand and two, one thousand and three", and so on. Adjust the mental counting procedure according to the local language.

If the arm moves too quickly, less spray will be applied, resulting in a lower amount of insecticide deposited than the recommended concentration. This will reduce insecticidal activity and greatly impact the efficacy of the operation. It might also contribute to the emergence of vector resistance if inadequate concentrations are repeatedly applied. Conversely, if the spray speed is too slow, there will be an overdose of insecticide, resulting in wastage and unnecessary extra costs.

During spraying, agitate the sprayer at regular intervals (such as every 10 successive swaths) while checking the pressure gauge. Ensure that the pressure does not drop below 1.7 bar (25 psi) for sprayers without a 1.5 bar CFV (repressurization will be required below this level). One pump stroke generally adds 1 psi to the tank pressure. For sprayers with a 1.5 bar CFV, the pressure gauge does not need to be monitored regularly because it will continue to operate and only stop when the pressure falls below 1.5 bar (22 psi).

Walls
Usually interior walls are the surfaces that are sprayed first and have the highest surface area to be covered. When spraying walls, spray operators should start from the doorframe and move in a clockwise direction around the room.

Eaves and openings
If part of the spray strategy, the house eaves and areas around openings such as doors and windows need special attention. Spray operators should:

- start spraying the inside of the eaves, beginning from above the door from the outside;
- move around the house spraying the outside eaves, taking care to avoid insecticide fall-out;
- make sure that there is an overlap between the wall and the roof; and
- upon completion of the eaves, spray around the window openings and air vents.

Doors and windows
Total coverage cannot be achieved without spraying the sides of all doors and windows of the targeted structures. In particular:

- when doors and windows open inwards, both sides need to be sprayed;
- when doors open outwards, only the interior surface needs to be sprayed;
- the doorframe must be sprayed, beginning from the left or right bottom corner;
- the portion of the wall covered by an open door (i.e. behind the door) must be sprayed; and
- once sprayed, the door should be opened to let adequate lighting into the room for the rest of the spray operation.

Ceilings
Spraying the inner roof and ceilings, rafters and beams requires horizontal spraying. If ceilings are included in the spray strategy, spray operators should:

- spray the ceiling or underside of the roof after the walls have been sprayed;
- wear a headcover/hat when spraying the roof or ceiling, and use an extended lance if needed;
- ensure that goggles are in place and well sealed around the edges:
- avoid exposure to spray fall-out by directing the lance at an angle from the body so that any spray liquid that drops from the ceiling does not drip on the operator; to avoid being covered in spray mist while spraying, the operator needs to walk backwards rather than forwards;
- for distance and timing of spraying, follow the method outlined above for spraying of walls;
- ensure that the pressure is at 4.0 bar (58 psi) before spraying the roof for those programmes still using compression sprayers without a CFV, or above 2.0 bar (29 psi) when using a sprayer fitted with a 1.5 bar CFV;
- spray horizontally from the farthest point inside the room until arriving back at the starting point;
- move up to the next swath and spray around the room; and
- spray the supporting beams last.

In houses without a ceiling, the inside of the roof may be too high to spray with the standard lance provided with the sprayer. Such houses should be visited by two spray operators, one who is equipped with the standard lance and is responsible for spraying the walls, and another who has a sprayer on which the lance is fitted with a lance extension. The nozzle and CFV are unscrewed from the lance, the extra straight lance is screwed onto the lance and the nozzle and CFV screwed back onto the end of the lengthened lance. This enables spray to be applied with the nozzle at a greater height, so that the inside of a roof can be treated. The same nozzle type as that used for spraying rooms should be used.

Curtains
Where the target vectors commonly rest on curtains (such as some *Aedes* vectors), the curtains should be sprayed on the back and front. The height of spraying can be limited (e.g. to a maximum of 1.5 m or 2 m from the floor, depending on the vector). To spray curtains:

- open out, or extend, the curtains as much as possible;
- pay attention to folds to ensure as uniform a spray pattern as possible; and
- apply the same technique as for the walls.

Under or behind large furniture (e.g. wardrobes, cupboards, tables, beds)
Where target vectors commonly rest under, behind or within large furniture (such as some *Aedes* vectors), the items should be sprayed. This may include hard-to-reach areas (e.g. under a bed or within cupboards), so a flexible swan neck extension or angled spray wand may be needed. To spray large furniture:

- remove any bedding, including pillows and blankets; if the mattress cannot be removed, it must be covered with plastic;
- introduce the lance below the wardrobe to reach the deepest side of it (nearest the wall or farthest away);
- orient the inclined nozzle towards the wardrobe to ensure that the spraying jet is on the target surface;
- to the extent possible, keep the nozzle about 30 cm away from the surface (this may not always be possible);

- spray at twice the speed required for wall surfaces, i.e. spray at one second per metre;
- apply swaths progressively to ensure that the entire target surface is covered, noting that the swaths will be narrower; and
- stop spraying when the nozzle reaches the edge of the wardrobe.

Under light furniture (e.g. chairs)
Light furniture should be sprayed after completing large furniture:

- turn the furniture over to expose the target surface;
- start spraying from the upper side to the lower side of the target surface;
- adapt the spraying distance from the nozzle to the object, depending on the width of the object;
- with the nozzle 45 cm away from the surface, spray with a speed that covers 1 m in 2.5 seconds;
- if the distance from the nozzle to the target surface is less than 45 cm, increase the spraying speed to one second per metre; and
- ensure that the target surface is covered uniformly.

Wall hangings, posters, pictures and other items on the wall
Items hanging on walls may also require spraying if they cannot be easily removed. To do so:

- determine whether the items are kept permanently on the wall or not;
- spray over items that are fixed on the wall for the long term;
- if the item can be lifted off the wall, also spray its underside and the wall surface under it; and
- for immoveable household items positioned close to the wall, introduce the lance between the wall and the object to spray. (Note that it may not be possible to maintain the correct distance).

Difficult-to-reach surfaces
The underside of floorboards of houses that are elevated or raised above the ground on stilts or posts provides an ideal resting site for many vectors. These areas must also be sprayed. An extension lance may be necessary for houses that are elevated high above the ground or that have high ceilings. In the Asia-Pacific region, flexible swan neck extensions are necessary for spraying the underside of floorboards.

Other structures
After completing the spraying of the sleeping structure, operators should spray the internal walls of other eligible structures. These may include toilets (pit latrines) or bathrooms that are detached from the house. Detached kitchens can also be sprayed after food stuffs and cooking implements have been removed (noting that these differ from internal kitchens, such as those in urban areas, which are generally not sprayed). Enclosed poultry runs and animal sheds may also be sprayed after ensuring that all animals have been taken out and secured. The inside of granaries or any rooms where agricultural products are stored **should not** be sprayed unless these spaces are empty at the time the spray is being conducted.

When operating the sprayer, if any of the following are experienced, then spraying should stop and the issue should be reported to the team leader or supervisor:

- leaks
- blockages
- worn nozzles (signified by irregular and uneven flow patterns).

Stop spraying if anyone enters the house or if people or animals come within 10 m while eaves are being sprayed.

Step 3: Post-spraying communication
Spray operators or another assigned member of the spray team should deliver the key information, education and instructions to residents, as outlined in section 3.6.3. These details should be developed or adapted in advance to ensure consistency across phases of the campaign.

4.2.4 Spray data recording and reporting

The spray operator should ensure that household information is filled in accurately before leaving the site. For structures that may have been missed or where the household head or residents were absent, plans should be made to revisit those households for mop-up spraying while the spray team is in the area. If household lists are available, unsprayed houses or structures should be recorded and highlighted for follow-up. If GIS is used, locations of unsprayed houses can be mapped to guide mop-up logistics.

To aid the mop-up operation, sprayed structures should be marked and/or house spray cards should be completed. Structures that were not sprayed can be prominently marked with a different colour/sign to facilitate identification during the mop-up operation.

Example of a marking code:

> 16 (R) T1, 01/01/2022
> 16 – spray operator number
> (R) – refused
> T1 – team number
> dd/mm/yy – visit/spray date.

4.2.4.1 House spray cards

As described in section 3.1.2.3, an IRS house spray card containing location details of a household may be issued during the geographical reconnaissance activities (Annex 6). On the day of spraying, this card should be completed with the date of spray, who conducted the spray, who was resident in the house or building at the time of the spray, and the numbers of people and structures or rooms per spray unit that were sprayed. Locked houses, rooms and households whose residents refused IRS should be marked appropriately.

4.2.4.2 Routine reporting forms

Spray operators, spray team leaders and IRS district coordinators should use standard reporting forms to report, supervise and monitor IRS implementation.

A daily reporting form (Annex 8) is completed by a spray team member. This may be a person who is not currently spraying to avoid the need to manage spray equipment and PPE while completing reporting forms. The persons responsible for reporting should ensure that household information is filled in accurately before leaving the site. Information, such as locked rooms, refusals, sachets or number of

spray charge(s) used, should be recorded in a daily spray operator record form or book and entered into digital tools if in use.

Completed daily reporting forms must be presented at the end of the day to the spray team leader. It is the responsibility of the team leader to check that data have been correctly entered and to summarize this information at the end of each working day. Information from the daily reporting forms can be used to check the performance of individual spray operators by examining:

- the number of households sprayed per operator versus their target;
- the amount of insecticide used versus the expected amount based on the households sprayed; and
- the number of households that refused spraying and the reasons why.

This will help programme managers and supervisors to identify if there are issues, such as the pace of spraying or insecticide use versus what is expected, which may indicate where re-training or closer supervision is needed, or in the case of high refusals, where better community engagement is required.

A weekly reporting form (Annex 9) should be maintained by the IRS district supervisors and district IRS coordinators. Each coordinator tracks around 4–10 spray teams and measures the weekly progress in relation to the total planned target for the spray round. A monthly reporting form (Annex 10) is used by IRS district coordinators to monitor progress on IRS spraying coverage for the spray round in the district in relation to the total planned target (see section 5.3). Provincial and district coordinators should conduct random sample surveys of one in 10 households to cross-check the validity of the reported coverage, the quality of spraying and residents' perceptions.

4.2.5 Daily cleaning and waste management

When spraying has finished for the day and before removing any protective clothing, the following procedures should be followed:

- All empty chemical containers and sachets should be counted and recorded.
- All partially filled containers or remaining sachets should be counted, recorded and returned to the supervisor.
- All spray equipment should be cleaned.

4.2.5.1 Cleaning of spray equipment

The spray equipment requires daily washing. The spray mixture should not be left in sprayers overnight, as the suspension will start to cake and block the filters and hose. The chemicals may also damage the components of the sprayer and reduce their lifespan (e.g. seals or valves may stick and disintegrate).

The progressive rinse method is used to rinse and clean spray pumps. This method entails washing the spray pump using a series of plastic containers, which are alternately either empty or filled with clean water. The rinse water is saved and used the next day for making up the spray solution. This saves and recycles water, and less effluent is produced, thereby reducing the quantity of water that reaches the soak pits and/or evaporation tanks and minimizing the risk of environmental contamination. Rinse water **must not** be disposed of into the environment (see section 2.3).

Triple rinse or progressive rinse method

This method uses a series of barrels for washing. Wide and deep barrels that allow submersion of the entire spray pump (such as those with a 200 L capacity) are suitable. Seven 200 L barrels are placed in a line (Fig. 14). Barrels 1, 3, 5 and 7 are left empty and barrels 2, 4 and 6 are filled with clean water.

The following steps are undertaken for a triple or progressive rinse (while wearing full PPE) at the end of the day:

- Spray teams return to their staging areas and depressurize sprayers on a sloped surface that leads to a soak pit (located away from water sources).
- Pour left-over insecticide into barrel 1, allowing the container to drain for at least 30 seconds.
- Add 1–2 L of water from barrel 2 to the sprayer until it is about one quarter full.
- Close the sprayer and pressurize it to approximately 2.0 bar (25 psi); shake, rotate and invert it to rinse all interior surfaces.
- Discharge through the lance, CFV and nozzle for one minute into barrel 3.
- Depressurize the sprayer, remove the lid and pour the remaining contents into barrel 3, allowing the container to drain for 30 seconds.
- Repeat the process two more times, using water from barrel 4 to rinse and empty into barrel 5; then, rinse with water from barrel 6 and empty into barrel 7.
- Fully drain the spray tank and wipe the interior walls of the tank.
- Drain the discharge assembly by holding it pointed downwards with the spray control valve open.
- Dismantle the trigger and nozzle assembly, and clean all components in a dish or bucket of water from barrel 6. Add the resulting rinse water to barrel 7.
- Clean the outside of the sprayer, including the straps.

Upon completion of these stages, the sprayers will have gone through a triple rinse procedure that produces clean sprayers and rinse water. The rinse water generated in this fashion must be kept in the rinse containers and **never** disposed of in the environment. It can be reused the next day in the following way:

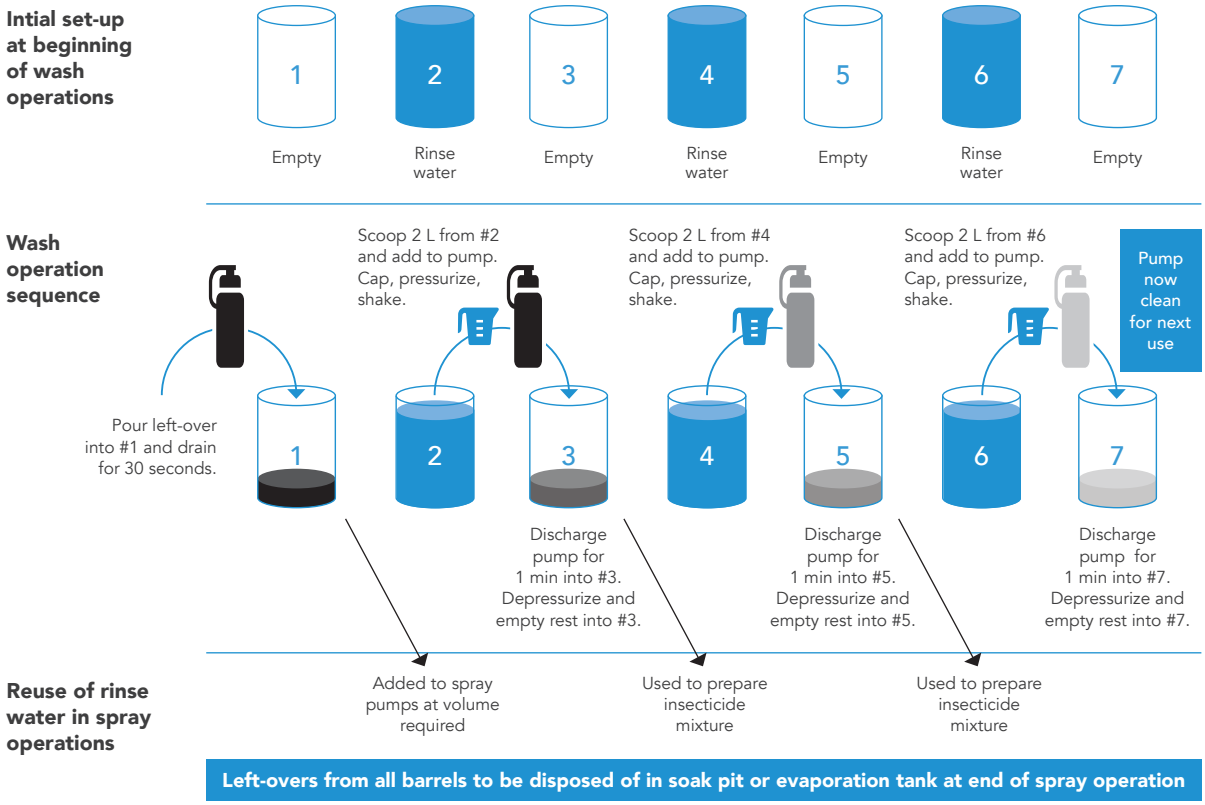
- Left-over pesticide in barrel 1 is added to spray pumps at the volume required.
- Liquid from barrels 3 and 5 is then used to prepare the pesticide.
- Liquid remaining in barrel 7 contains diluted contaminants and can be disposed of in a soak pit or evaporation tank.

A simplified approach can be used where needed, as follows:

- Empty left-over insecticide into a sealable container and keep for use the next spray day.
- Add 1.5 L of clean water to the used compression sprayer. Shake it and drain the wash liquid (rinsate) into a bucket.
- Repeat the rinse and drain process twice more, adding rinsate to the bucket.
- Add a final 1.5 L of clean water and shake it. Pressurize to 2.0 bar (25 psi) and then spray for one minute to discharge water into the bucket to clean the assembly.
- Depressurize, open the tank and drain the remaining water into the bucket.
- Wipe out the tank and wash the outside. Disassemble the strainer and nozzles and rinse with clean water. Clean the outside of the sprayer, including straps.
- Ensure that the pumps are dry and clean before storing.

The cleaning process continues on a daily basis until the spray season ends. Any remaining liquid in any containers should then be disposed of in the soak pit or evaporation tank, depending on the insecticide used.

Fig. 14. Overview of the seven-barrel triple rinse or progressive rinse method



4.2.5.2 Checking and storing equipment

After triple-rinsing the tanks:

- sprayers should be checked for any faults that may have developed and these should be reported to the team leader;
- cleaned sprayers should have the lid removed and be put in an inverted position to drain off any water and allow for air circulation; lances should hang from the D-ring on the tank with the trigger valve kept open; and
- sprayers should be returned to storage, making sure that they are kept dry. If possible, they should be stored in an inverted position with the cover assembly loose.

4.2.5.3 Removing PPE and personal washing

After doing all the above, spray operators should wash gloves and boots and remove PPE in general in this order:

- all head and face protection (masks/respirators, shields/goggles)
- overalls
- boots
- gloves.

Then, spray operators should do the following:

- Wash used protective clothing in detergent (at the operations site over a soak pit. Contaminated clothing must not be taken home).
- Wash their whole body thoroughly using soap, paying particular attention to exposed areas such as hands and face.
- Dispose of washing water and rinse water safely, using a toilet or bathroom with a soak pit or soak away.

At the end of the spray round, all wastewater should be decontaminated following the appropriate methods recommended by national and international guidelines for safe disposal of chemical waste, and disposed of in a soak pit or evaporation tank or through another approved method.

4.3 Spray equipment inventory and maintenance

Spray equipment and insecticides are expensive items; insecticides must be used economically and sprayers should be handled and maintained carefully. A weekly, or at minimum monthly, inventory of equipment should be conducted during spray operations. The final inventory at the end of the spray round should indicate any necessary repairs, replacements or other requirements.

Daily cleaning at the end of each day, following the steps provided in section 4.2.5, is essential. Routine daily cleaning of equipment and weekly and monthly maintenance schedules during the spraying period will help to:

- ensure that equipment is ready to use when next needed and continues to be fully functioning; needs for repair identified during cleaning should be addressed immediately, rather than when preparing for the next spray day/ campaign;
- ensure more efficient application by maintaining the quality of nozzles and other parts, in turn ensuring optimal insecticide spray delivery; and
- avoid equipment leakage, in turn preventing contamination of the spray operator, other people, animals and the environment.

Standardizing hand compression spray pumps and operator calibration procedures will also contribute to prolonging the life of the spray equipment. All spray supervisors, team leaders and spray operators should be able to dismantle and reassemble the sprayer without assistance. Efforts should be made to provide adequate facilities and equipment for field preventive maintenance and for repairing hand compression sprayers. Each spray team should have a designated spray operator to conduct basic field preventive maintenance and repair of spray equipment. For more complex repair, the designated technician should be called upon.

Maintenance and checking of spray equipment should be carried out not only when something in the sprayer breaks or when some obvious fault is noticed, but must be a regular activity. Spray pumps need to be checked periodically for the pressure valve, CFV, residue in tank, clogging of nozzle and so on.

At the end of a spray campaign, all spray equipment and associated items (e.g. tools, spare parts) should be cleaned and stored safely in a central location. An inventory should be prepared of the materials needed to replace items lost or

damaged during the spray season. Equipment should be protected during transport to avoid damage to the tanks and other components. The following should be done to maintain and store equipment between spray rounds:

- Inspect each sprayer for damage and repair if necessary. Each spray machine can be completely disassembled and all parts cleaned and dried, if preferred.
- Put a small amount of oil on the leather cup of the pump plunger and on the threaded fittings. (Note that oil and aromatic solutions must never be used on the rubber or plastic components of a sprayer.)
- Remove and clean the "in-line" filter.
- Store compression sprayers upright and separate from other field equipment.
- After storage, check each sprayer to make sure it is in working order before it is sent back to the field.

Example checklists for monitoring effective cleaning and maintenance of sprayers in the field have been provided (Annex 11, Annex 12).

To maintain and repair compression sprayers during and after each spray round, the programme needs to ensure that it has designated equipment technicians and provide them with workshops and appropriate tools at designated centres. At each store or operation site, at least one technician should be identified and given extra training on equipment maintenance. Routine maintenance of the equipment includes repair, servicing and calibration. The technicians prepare a report that includes information on the quantities of sprayers in a state of disrepair that will need to be replaced. The report will also advise on the quantities of spare parts that need to be procured. This should be acted on to ensure that all necessary parts are available for the subsequent spray round.

4.3.1 Spare parts and maintenance tools

A maintenance kit with adequate tools and spare parts should be available for all spray teams. The periodicity of maintenance and parts replacement can be more frequent depending on usage and the age of the equipment. Programmes can enlist the spare parts needed most often, such as gaskets, valves and nozzles, and order them in advance to avoid disruption of IRS operations. When ordering from the manufacturer or a local supplier, the sprayer model, part name and identification number should be given.

Basic tools required include a spanner set or two crescent or adjustable wrenches; one Phillips and one flat-head screwdriver; and two pairs of pliers. For certain sprayers, a universal tool kit may be supplied with the sprayer.

An illustrated manual for each type of sprayer should be supplied by the manufacturer and should be made available to each spray team. This manual provides:

- a description of the equipment;
- operating instructions;
- maintenance instructions;
- information on how to solve most problems; and
- a list of spare parts.

4.3.2 Troubleshooting the spray equipment

It should be expected that issues will be faced during spray operations, and the necessary preparations and spare parts should be available to address these issues. The most common sprayer faults and potential solutions are provided below (Table 9).

Table 9. Common issues with sprayers and potential solutions

Common issues	Potential solution(s)
Control valve does not shut off	Clean O-ring and seating surface on control valve. Replace O-ring if worn.
Leaks where wand joins control valve	Clean O-ring in lance and sealing surfaces. Replace O-ring if worn.
Tank does not pressurize when handle pumped	Lubricate plunger cup with petroleum jelly (not oil). Replace plunger cup.
Leaks where cap joins wand	Clean O-ring on wand and sealing surfaces. Replace O-ring if worn.
Leaks where pump seals at tank	Clean gasket sealing surfaces or replace gasket.
Air leaks at hose connection	Ensure gasket is tight. If O-rings are used, clean sealing surfaces or replace O-rings; re-attach hose. (Do not use plastic as a replacement for O-rings or gaskets on the trigger handle, as this will affect its structural integrity and may damage it.)
Liquid or air enters pump cylinder	Clean check valve sealing surface or replace check valve.

5. Monitoring, evaluation and review

M&E refers to a process by which data are collected, analysed and reported to provide the information necessary for effective programme planning and management. M&E is a continuous process that occurs throughout the lifecycle of a programme, providing oversight of its implementation and results. M&E facilitates the understanding of the cause-and-effect relationship between implementation and impact, and can guide the implementation of the spray strategy, assess its effectiveness, identify how the strategy should be improved and account for the resources used. Monitoring activities and evaluation activities have separate functions, although there is some overlap between them (Table 10). M&E activities only make sense if the findings are certified by the relevant authority and followed by adequate response mechanisms.

Table 10. Key features of M&E

Monitoring	Evaluation
• Regular systematic process of measuring project performance and documenting progress against set targets and benchmarks while the project is ongoing • Often involves the tracking of inputs, processes and outputs. Outcomes and impacts may also be included as monitoring activities • Enables the programme's stakeholders to understand whether the programme is proceeding according to plan, achieving its objectives and utilizing its resources efficiently, and whether adjustments are needed	• More comprehensive assessment of a programme, entailing a process of determining the programme's worth or significance as systematically and objectively as possible • Involves the periodic rigorous assessment of longer term outcomes and impacts that can be attributed to the programme, strategy or intervention • Can be used to demonstrate the value of the programme, strategy or intervention • Can be used to provide lessons for future programmes or policies

5.1 Purpose

Through M&E, the performance of vector-borne disease control programmes can be measured at all levels to provide the basis for accountability and evidence-based decision-making. IRS campaigns are usually assessed by employing a number of M&E activities. A toolkit for IRS M&E has been developed for kala-azar and tested in three countries *(46)*, and a broader M&E conceptual framework is available for neglected tropical diseases *(47)*. To track progress against goals, data should be gathered about spray operations each day.

M&E procedures should be established such that errors and deviations from planned activities can be identified and corrected at an early stage. When spray operations are being carried out, monitoring activities need to be conducted to verify that all the eligible structures have been sprayed and that the intervention

is being delivered at a high quality. Post-spray data quality audits are also used to verify the quality of spray data.

At the end of the spray campaign, data are collated, analysed and reported to determine whether the programme was carried out according to plan, met its objectives and had the desired impact in controlling the target disease(s). These data also enable an evaluation of costing compared to what was budgeted and, in some cases, an estimation of cost-effectiveness or value for money. These findings can be used to inform future spray operations, providing data for determining how to improve the programme and whether to continue IRS in those areas targeted for spraying in the next round. The collected data are useful for planning and financing subsequent IRS spray rounds and for updating local census and mapping records.

M&E procedures should be planned, clearly communicated and applied consistently and transparently. M&E activities are the joint responsibility of vector-borne disease control programme managers at the national or subnational levels, IRS coordinators, group team leaders and field supervisors.

In order for the programme to be reviewed in this way, a well designed and managed M&E plan must be implemented from the start of spray operations.

5.2 M&E plan

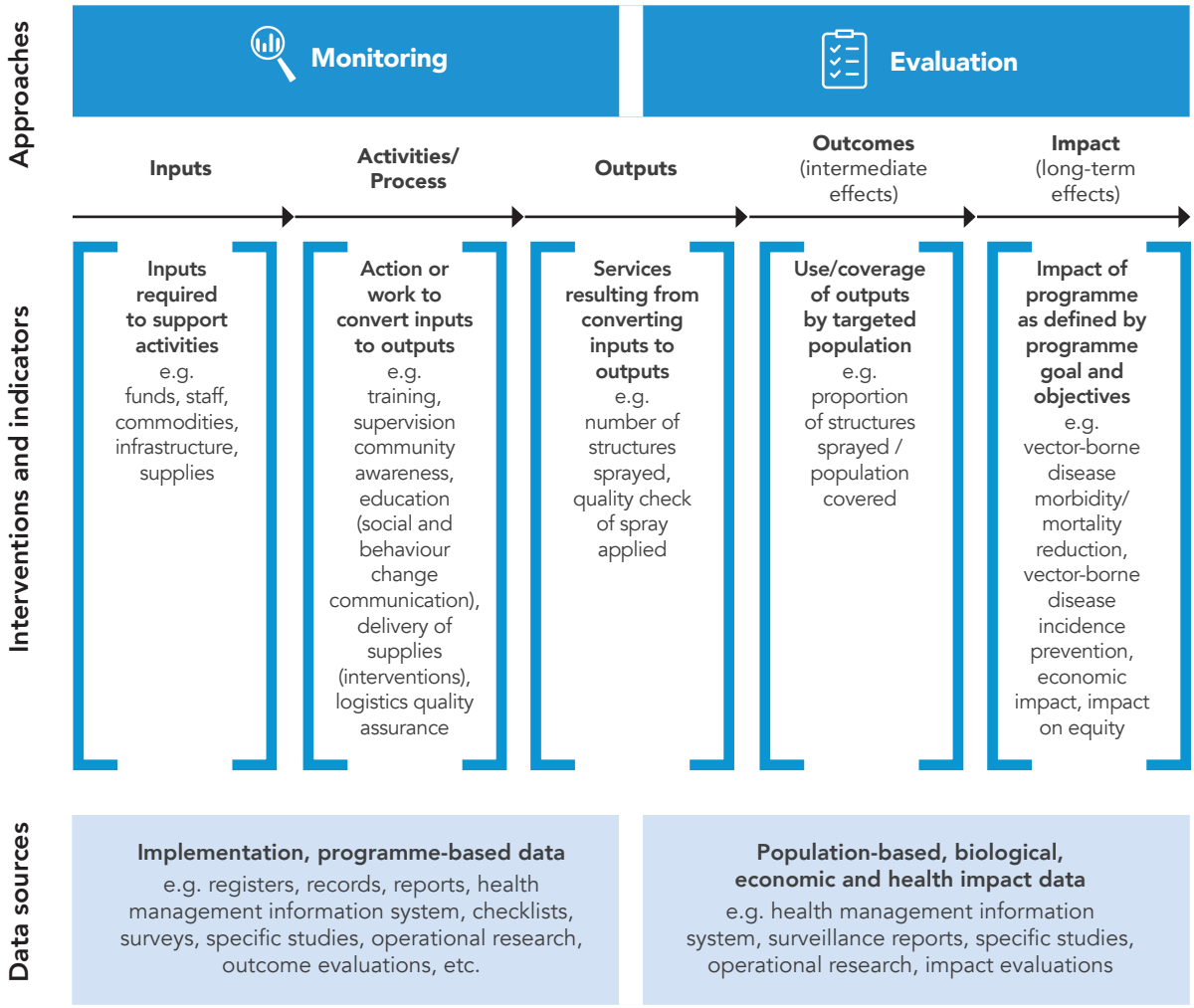
During the development stage of an IRS programme, it is essential to develop a robust M&E plan describing all the M&E activities. The process should be led by the programme manager, but may need to involve other stakeholders depending on the country-specific implementation arrangements. The programme, and the M&E activities, may need to be adapted as the programme evolves, depending on the results of the data collected or any changes in strategy.

A comprehensive M&E plan includes:

- a description of the programme objectives and procedures of implementation;
- the expected results of the programme;
- the data (indicators) that are needed and how they will be collected (sources and systems for collection) and analysed;
- plans for demonstrating programme performance, outcome and impact;
- details of how the information will be used, in particular how the data will inform programmatic decisions;
- how the results will be disseminated;
- how the plan will be implemented (including a description of roles and responsibilities and needs for human resources and capacity-building); and
- how the programme will be accountable to all stakeholders at all levels.

When designing an M&E plan, a framework is often used to depict the components of a programme and the sequence of steps/processes that go into achieving the desired outcomes of the programme. The framework can be used to select and plan activities, as well as to define the targets, expectations, different levels of performance and desired results of the planned activities. It can help to develop programme goals and measurable objectives, and aid in the identification and selection of appropriate indicators to measure the progress and impact of the programme. One example is a logic model that identifies and illustrates how programme inputs, processes, outputs and outcomes feed into impact (Fig. 15).

Fig. 15. Example of a logic model for M&E for an IRS campaign



Indicators

Part of designing an IRS programme is the identification of key indicators that can provide information on the performance or impact of a programme or intervention and the establishment of methods and systems to collect such information. An indicator is a variable that measures one aspect of a programme, project or health outcome. It serves to measure the value of change over time in meaningful units, enabling comparison between a baseline value and a future value. Indicators provide vital information for a programme/project by signalling the need for corrective management action, evaluating the effectiveness of various management actions and providing evidence as to whether or not the objectives of the programme or project are being achieved.

The WHO reference manual on malaria surveillance, monitoring and evaluation *(28)* provides further information on appropriate systems and indicators for monitoring and evaluating IRS for the prevention and control of malaria, although these can be adapted or added to for other vector-borne diseases. M&E indicators for integrated vector management have also been provided *(48)*.

5.3 Monitoring of programme performance

Timely and accurate data collection, reporting and use of the collected data is a critical element of monitoring an IRS programme to determine whether the planned activities, outputs and immediate outcomes are progressing according to plan and to rapidly identify when objectives are not being met and corrective action is required. All activities of a spray programme can be monitored with checks built in – from the assessment of management plans and plans of action to the implementation of the spray programme and data recording and analysis. Targets and/or expectations for particular activities must be developed at the outset of a programme.

Key activities to monitor, record and compare against targets set at the outset include:

- funds spent;
- quantities of commodities and equipment procured;
- logs of transport used;
- details of community outreach and awareness activities conducted;
- number of staff recruited;
- training undertaken and completed and number of staff trained;
- records of supervision;
- daily, weekly and monthly reporting on:
    - number of structures sprayed and the proportion of the population covered;
    - amount of insecticide used;
    - problems encountered in implementation (including documentation of refusals or post-spraying plastering of walls) and proposed solutions;
- quality of data recording; and
- quality of IRS at sentinel sites or villages.

Examples of data that can be collected as part of monitoring are provided below (Table 11). Additional data collection forms may be required by other personnel responsible for tasks associated with IRS, such as equipment and supply storekeepers.

Table 11. Data collection forms that can be used

Data collection form	Data entered by	Actioned
House spray card	Spray team member (e.g. spray operator)	Held by household to record IRS activity over multiple spray rounds
IEC mobilization form	Community mobilizer (or spray team member)	Submitted to IRS coordinator or social mobilization and communication officer
Daily reporting form	Spray team member	Submitted to spray team leader
Daily/weekly reporting form	Spray team leader	Submitted to group leader and/or subdistrict supervisor
Monthly reporting form	Group leader and/or subdistrict supervisor	Submitted to provincial/state/district IRS supervisor

Data collection form	Data entered by	Actioned
Checklist for cleaning the sprayer in the field	Spray team leader or group leader	Addressed with spray operators to immediately implement remedial action
Checklist for maintenance of sprayers	Spray team leader or group leader	Addressed with spray operators for remedial action and submitted to maintenance team
Supervision checklist for team or group leaders	Spray team leader or group leader	Addressed with spray operators for remedial action and submitted to IRS subdistrict or district supervisor
Supervision checklist for supervisors	Subdistrict or district IRS supervisor	Addressed with team or group leaders for remedial action and submitted to IRS coordinator
Supervision inspection checklist	Subdistrict IRS supervisor, national programme staff or external evaluator	Submitted to IRS coordinator or national vector control coordinator

5.3.1 Quality management

One important aspect of monitoring is quality management, which includes quality assurance and quality control (Table 12). These activities should form an integral part of the national programme's strategy.

Table 12. Key features of quality assurance and quality control

Quality assurance	Quality control
• Selection and implementation of systematic and well planned activities that will support quality execution of the programme • Aims to prevent delivery of substandard services or products and ensure accurate reporting	• Checks that the project is following its standards, processes and procedures, and that the project produces the required deliverables • Used to verify that the outcomes are of quality • A reactive means by which quality is gauged and monitored

When outputs and impacts have not met targets, it may be due to a variety of factors related to implementation that could have been managed as part of a thorough quality assurance/quality control system. Such factors may include inadequate procurement planning, poor quality of deployed products, incorrect application of the intervention and failure to achieve high coverage. Quality assurance and quality control efforts should be continuous, systematic and independent.

For IRS, the key planned activities that can assure quality both before and during operations include:

- sourcing only IRS products prequalified by WHO for deployment against vectors;
- requesting the supplier/manufacturer to provide a certificate of analysis for each batch of the product actually being supplied;
- conducting pre-shipment inspection and sampling according to WHO guidance and/or International Organization for Standardization standards, performed by an independent sampling agent;

- testing upon receipt in country (post-shipment quality control testing) if specific risks related to transport have been identified or specific concerns over potential product performance justify this additional expense;
- ensuring that quality equipment is sourced;
- including in tenders conditions for free-of-cost replacement of commodities that fail quality control checks and cover disposal of failed lots;
- storing equipment and insecticides in facilities that meet conditions specified by manufacturers;
- conducting post-market surveillance to monitor quality over time in order to ensure that products and equipment continue to conform to their specifications and/or their recommended performance set by WHO;
- ensuring that equipment is well maintained and repairs are made as needed;
- using established protocols for all activities;
- conducting high-quality training for all staff engaged in field implementation of vector control interventions;
- conducting high-quality and regular supervision, monitoring and follow-up of field operations;
- using well designed data capture methods and tools that support accurate and timely data collection; and
- planning for periodic testing of the quality of IRS operations, such as through bioefficacy monitoring of sprayed surfaces (see section 5.5).

For the procurement of insecticides, further information is provided in section 3.3.

Quality control checks form part of the evaluation of a programme. These require adequate reporting and assessment and should be linked to planned quality assurance activities. For example, these may include:

- testing the insecticides imported for adequate levels of toxicity against target vectors;
- checking the application rates of equipment;
- monitoring the climate conditions of storage facilities;
- carrying out assessments of trained staff;
- reviewing supervision reports;
- assessing protocol compliance;
- checking data accuracy; and
- assessing the bioefficacy and quality of the spray.

Example of assessing spray data quality

A few days after a village or suburb has been sprayed, an M&E supervisor visits a random sample of households to spot check data recorded by spray operators. During the visits, the supervisor interviews residents and checks their IRS house spray card, on which the date of spraying and the unique household identification number should have been recorded. Other responses from residents are recorded on a data collection verification form, which is then compared to the data recorded by spray operators.

The data collection verification form helps the M&E team to validate that the information collected by spray operators is accurate. If supervisors identify discrepancies between the information provided by the residents and the data collected by the spray operators, they can re-train staff to reinforce proper data collection practices. The verification form may also be used to identify instances of fraud or theft of insecticide.

5.3.2 Monitoring indicators

Key programme or process monitoring indicators for IRS that should be monitored throughout the spray campaign are provided below (Table 13).

Table 13. Key IRS programme monitoring indicators (adapted from *(28)*)

Indicator	Definition	Calculation or explanation	Recommended method/tools	Use
Population reached with spray campaign participation information	Proportion of the population that was reached with messages providing campaign dates and guidance on how to benefit	**Numerator:** Number of people interviewed that claim to have received messages providing campaign dates and guidance on how to benefit from the campaign **Denominator:** Number of people interviewed	Cross-sectional surveys after registration	Identify population that may be missed during the campaign in order to better direct targeted social and behaviour change activities Identify effectiveness of community engagement and social and behaviour change activities
Number of structures sprayed and not sprayed	Number of eligible structures sprayed and not sprayed	**Count:** Number of eligible structures sprayed by teams and the number not sprayed	IRS routine reporting forms completed daily and weekly (during spray operation)[a]	Monitor progress of spray teams on a daily and weekly basis
Number of people covered	Number of people in structures that were sprayed	**Count:** Number of people living in structures that were sprayed by teams	IRS routine reporting forms completed daily and weekly (during spray operation)[a]	Monitor progress of spray teams on a daily and weekly basis

Indicator	Definition	Calculation or explanation	Recommended method/tools	Use
Quality of spraying	Proportion of mosquitoes that died within a fixed period of time after being exposed to a wall sprayed in the last 24 hours	**Numerator:** Number of mosquitoes that died within a fixed period of time after being exposed to a wall sprayed in the last 24 hours **Denominator:** Total number of mosquitoes exposed to the sprayed walls	WHO cone bioassays on sprayed walls	Ensure good-quality spraying. Low mosquito mortality could have a number of causes, such as suboptimal IRS product, errors during mixing, lack of capacity of spray operators or population washing the walls after spraying. Causes should be investigated.
Volume of insecticide used per day	Volume of insecticide used per day	**Volume:** Amount of insecticide used per day, expressed in sachets or bottles, or the unit of packaging of the product	IRS routine reporting forms completed daily and weekly (during spray operation)	Evaluate whether adequate product doses were applied to sprayed walls (compared to expected amount based on the number of structures sprayed) Identify where teams require re-training on application procedures
Reasons for structures not being sprayed	Frequency of each reason provided for a structure not being sprayed		IRS routine reporting forms (completed during spray operation)	Understand population acceptability of the campaign Understand bottlenecks to achieving the expected IRS coverage, inform mop-ups and better plan future campaigns

[a] Information collected during geographical reconnaissance prior to spraying can also be useful.

5.4 Evaluation of IRS programmes

The ultimate goal of a vector control intervention is to reduce the vector-borne disease burden in the target area. Evaluating a vector control intervention involves a rigorous assessment in an attempt to attribute impact against the target disease(s) to the intervention. In an epidemiological sense, this impact would be the reduction of disease burden (usually measured as a decrease in incidence or prevalence). In an entomological sense, the impact of interventions on a vector population is evaluated. Programmes can use health management information system data, sentinel site data and other locally available case data to help assess the epidemiological impact of interventions, such as reduction of disease prevalence, incidence or mortality. However, attributing epidemiological impact on disease burden to IRS is often difficult when there are other ongoing control measures. Comparing baseline epidemiological data collected prior to the deployment of IRS (see section 3.1.1) to the data collected during the intervention may give an indication of trends in disease burden. More details on evaluating malaria vector control in terms of epidemiological impact are given in the WHO reference manual on malaria surveillance, monitoring and evaluation *(28)*, but many of the principles also apply to other vector-borne diseases.

Entomological investigations can be used alongside epidemiological data where such data are available or can provide useful information on whether the intervention is having the desired effect on the local vector population and what reasons there could be for low impact.

An IRS programme can be evaluated in terms of its outputs, outcomes and impact (Fig. 15). However, there may be some overlap between the campaign evaluation and the indicators measured as part of the monitoring activities. The immediate outcomes recommended for reporting are related to the coverage of the IRS operations.

5.4.1 Outcome indicators

IRS spray programmes or campaigns should strive to achieve high coverage in terms of spraying all eligible structures so as to ensure maximum programme impact. In general, it is recommended that a programme quantify resources and commodities to provide full coverage of the population at risk. In reality, this approach is unlikely to result in 100% coverage due to various system inefficiencies, such as household heads or residents not being home at the time of spraying despite community sensitization activities.

Many countries set a target of achieving a minimum proportion of coverage of eligible structures, such as 80%. A target coverage level should, however, not be used for quantification purposes. For planning and procurement purposes, requirements to achieve 100% coverage of eligible structures should be used.

Programmes should establish these targets ahead of the start of a programme and use them as benchmarks for reporting. Coverage targets are primarily the percentage of eligible structures, households or population at risk for the vector-borne disease(s) that receive IRS. The percentage of structures sprayed in relation to the targeted number should be regularly calculated. Coverage below the predefined targets indicates that structures were missed, closed or were otherwise inaccessible during spraying.

Structures that were not accessible at the time of the spray team's visit need to be clearly marked and recorded to enable a targeted and efficient mop-up operation. Records need to be updated to capture additional structures sprayed during such targeted mop-up operations. Furthermore, surveys should be conducted to determine the extent of re-plastering after spraying in order to estimate the actual time over which the IRS is likely to be effective in the targeted communities. This information can also help to determine whether this intervention is appropriate in the setting and/or whether further community sensitization is needed to improve its effectiveness.

Programmes should focus on practical and measurable indicators. Information collected during geographical reconnaissance can be useful. The key immediate outcomes and measurable indicators to be evaluated during and after the IRS campaign are provided below (Table 14).

Table 14. Key outcome indicators relevant for IRS operations

Indicator	Definition	Calculation or explanation	Recommended method/tools	Use
Coverage of structures sprayed of those found	Proportion of eligible structures sprayed of those found[a]	**Numerator:** Number of eligible structures sprayed **Denominator:** Number of eligible structures targeted and found (i.e. visited by spray team)	IRS reporting forms (completed during spray operation)[b]	Identify areas that require mop-up Together with the reason for refusing IRS, can help to target social and behaviour change activities
Proportion of structures found of those targeted	Proportion of eligible structures found of those targeted for IRS	**Numerator:** Number of eligible structures found **Denominator:** Number of eligible structures targeted for IRS	IRS reporting forms (completed during spray operation)[b]	Understand operational coverage of the campaign
Coverage of structures sprayed of those targeted	Proportion of eligible structures sprayed of those targeted for IRS	**Numerator:** Number of eligible structures sprayed **Denominator:** Number of eligible structures targeted for IRIS	IRS reporting forms (completed during spray operation)[b]	Understand actual campaign coverage
IRS population coverage	Proportion of population protected by IRS	**Numerator:** Number of people living in sprayed structures **Denominator:** Total population in the target area	Household surveys[b]	Understand the real protection conferred by the campaign
IRS residual efficacy after implementation	Number of days during which more than 80% of susceptible mosquitoes died after exposure to sprayed walls through WHO cone bioassays	**Count:** Number of days during which mosquito mortality in cone bioassays[c] was above 80%	WHO cone bioassays on sprayed walls	Understand the duration of IRS efficacy and whether it is long enough to cover the targeted transmission period Compare or select insecticides that provide coverage throughout the targeted transmission period

[a] Some countries may report the proportion of rooms.

[b] Information collected during geographical reconnaissance prior to spraying can also be useful.

[c] Mortality observation time will vary with the insecticide sprayed (fast-acting = 24 hours, slow-acting = up to 72 hours).

For measuring the coverage of structures sprayed relative to those targeted, the method used to quantify eligible structures is important. If eligible structures are identified through a registration process, including geographical reconnaissance, this indicator will be sufficient to measure real campaign coverage. If eligible structures were calculated from census information, a household survey may be needed to calculate actual IRS coverage.

5.4.2 Entomological indicators

It is key to the success of an IRS programme to know the susceptibility status of the vectors to the insecticide in use and any alternatives considered for future use. As detailed in section 3.3.1, when selecting the insecticide(s) to be deployed, the susceptibility of mosquitoes within the area of deployment should be checked prior to spraying. After assessing baseline insecticide susceptibility of the major vector(s) in that area to the insecticide(s) in use or planned for future use as part of rotation, resistance to these insecticides should be assessed on an annual basis.

IRS operations can also be evaluated by assessing changes in the vector population, such as vector abundance and survival. Since the insecticide is delivered to indoor surfaces, it may be more effective at killing some vectors than others. Programmes may want to assess changes in species composition and/or behaviours that may occur in response to IRS, in particular as part of investigating the reasons for declining impact of spray programmes if this is not readily explained by other factors, such as the coverage or quality of spraying or insecticide resistance. As IRS kills vectors that rest on indoor walls or repels mosquitoes that enter houses, entomological effect can also be evaluated by measuring changes in indoor resting rates and vector exit rates. As population reduction of a particular vector is one expected outcome of IRS, it may also be expected that overall human biting rates will be reduced.

Descriptions of key indicators used to assess the entomological effectiveness of vector control tools, including IRS, are provided elsewhere *(28,48)*. Further details on insecticide resistance monitoring, including for resistance intensity and resistance mechanisms, are also available elsewhere *(27)*.

5.5 M&E methods and tools for data capture

A range of data sources can be used to monitor and evaluate IRS programmes, including routine information systems (e.g. health management information system), household and health facility surveys and sentinel sites or specific studies and research projects *(48)*. Agreement on the need for and scope of the proposed activities should be reached by all in-country stakeholders, including the national regulatory authority where applicable. These should follow WHO guidance. Further details on each of these methods or tools are provided below.

For monitoring IRS activities, routine reporting relating to IRS coverage should be undertaken by spray teams, with reports completed daily and data collated weekly and monthly. During spray operations, these reports are used to track and report on structure, household and population coverage indicators.

5.5.1 Documenting structures sprayed: house spray cards

As detailed in section 3.1.2, a house spray card can be one way to document the structure sprayed. These cards can be given to each household during the geographical reconnaissance and updated during every spray round. It includes the house location and identification number, number of residents at the time of spraying, number of rooms sprayed, date of spray, insecticide used, and names of the spray operator and team leader. This information allows spray teams to know what spraying has been done previously at an individual house and any issues encountered. An example IRS house spray card is provided in Annex 6. These can be adapted to be appropriate for spray units other than residential houses, such as health centres or schools, and can be provided to the relevant authority to retain.

5.5.2 Reporting IRS coverage and monitoring the performance of teams: routine reporting forms

Standard reporting forms should be used by spray operators, team leaders and district coordinators to report, supervise and monitor IRS operations, as detailed in section 5.3. In addition to reporting the number of structures sprayed and populations covered, these forms also document the amount of insecticide used and reasons for refusal. Daily reporting forms are completed by spray operators and submitted at the end of the day to the spray team leader, who compiles a daily or weekly overview and checks the performance of his/her spray operators. A weekly summary is maintained by the group leader or IRS subdistrict coordinator, who tracks several spray teams and measures their weekly progress in relation to the total planned targets for the spray rounds. The district coordinators prepare monthly reports on their district's spray operations to assess coverage, and these are submitted to the provincial/state/district IRS supervisor. Sample forms have been provided that can be adapted to the particular programme staffing structure and requirements (Annex 8, Annex 9, Annex 10).

5.5.3 Operational coverage: IRS household survey

District coordinators should conduct household surveys as part of their evaluation of operational coverage at the end of the spray round. These household surveys, when compared with the routine reports of the spray campaign, provide a figure for the actual coverage. These surveys can also be conducted as "representative" sample surveys and combined with periodic vector-borne disease indicator surveys and other health surveys, and with other broader demographic surveys such as demographic health surveys or multiple indicator cluster surveys, as long as all samples are drawn from the areas targeted for IRS. Information from geographical reconnaissance can also be leveraged to support operational coverage calculations, such as through the generation of household or structure checklists.

5.5.4 Entomological surveys

Field entomology teams are required to assess operational effectiveness in different areas and to manage sentinel sites in different ecological zones. These sites enable the teams to monitor and detect changes in trends in vector composition, density, behaviour and susceptibility. Entomological baseline surveys on vector density, distribution, human landing/biting and resting behaviours, and insecticide susceptibility should be conducted before IRS begins to ensure that the conditions are met for IRS to be suitable. This information should supplement the situation analysis through rapid review and collation of existing information from past programme records, other surveys and research studies. IRS coordinators should seek support to establish central and field insectaries. They should also collaborate nationally and internationally with research or academic institutions and with insecticide resistance networks to support the above areas of performance measurement.

5.5.4.1 Vector dynamics

The mosquito collection methods used to evaluate entomological indicators need to be selected based on the mode of action of the insecticide(s) used for IRS, which targets resting vectors. Details on specific methods for collecting mosquitoes for malaria surveillance are provided elsewhere *(28)*. Collection systems and sampling

regimes should be designed to provide enough replicates to ensure sufficient statistical power to detect the desired effect. Evaluation of the entomological impact of interventions may not be possible in very low transmission settings due to the low numbers of mosquitoes often collected.

Vector species

Prior to initiating an IRS programme, it is essential to know which vector species are present in the target area and to confirm that their preferred resting sites are indoors, indicating that IRS is an appropriate intervention. Efforts should be made to accurately identify the species present. Frequent collections are generally not necessary, unless more detailed investigations are required due to suboptimal impact of the intervention that cannot be explained by other factors.

Vector abundance and composition

Many methods exist for sampling vector populations to determine abundance, all tailored to the particular behaviour the vector is displaying at that time. These include indoor aspirations or knockdown collections using pyrethrum sprays of resting vectors, collection from baited traps and light traps, human landing collections and exit traps. Collectors should take into consideration the specific inherent biases for each collection method. The concurrent use of several different collection methods may overcome some of these biases and enable the sampling of populations of vectors that have different behavioural characteristics and occupy different habitats.

Insecticide resistance

Insecticide resistance monitoring is an integral part of every IRS operation. Standard WHO bioassays can be used to measure resistance frequency and to determine the resistance status of the local vector population. Monitoring should be conducted on an annual basis to test the insecticides currently in use or considered for use in IRS. In all cases, relevant WHO procedures for monitoring insecticide resistance should be followed *(27)*.

Human–vector contact

Human–vector contact (human biting rate) can be measured directly through human landing collections, or indirectly by testing a representative sample to determine the proportion of blood meals taken on humans by a vector species (human blood index).

5.5.5 Assessing IRS quality and determining residual efficacy of insecticides: WHO cone bioassays

WHO cone bioassays should be used to assess the quality of spray application and whether an adequate dose has been applied to kill vectors. They can also be used to determine the residual efficacy of the IRS if data for that formulation or surface type do not already exist, such as when a product is introduced for the first time in a geographical area. However, these bioassays may not be suitable for all IRS formulations and other methods may be needed.

Once the local residual efficacy of a product has been determined for an area, subsequent measurement of insecticide decay on sprayed surfaces should only be done to answer specific questions and if resources are available. Countries can make post-market surveillance a priority in cases in which there are no country-specific data on certain IRS products or there are anecdotal data on poor performance of certain products.

The assays require the use of vectors with confirmed insecticide susceptibility or with characterized resistance profiles, which are usually reared in insectaries. If insectary-reared vectors are not available, field-collected susceptible vectors or other vector species can be used. For mosquito-borne diseases, the cones are kept on the sprayed surface with mosquitoes for 30 minutes and the 24-hour mosquito mortality (or up to 72-hour mortality for slower acting insecticides such as neonicotinoids) is recorded after exposure. This is calculated as the number of mosquitoes that die during this post-exposure period divided by the total number of mosquitoes exposed in the assay. Tests should be conducted on 5–10 homes per week using three cones per home.

Further guidance on measuring IRS residual bioefficacy for mosquitoes is provided in the *Guidelines for testing mosquito adulticides for indoor residual spraying and treatment of mosquito nets (49)*. Indicators for this test are outlined above (Table 14).

More robust quantitative insecticide test kits are under development that use colorimetric assays to determine the amount of insecticide on the wall surface. This technique avoids the need for a susceptible strain of live mosquitoes.

5.5.6 Studying community acceptance and barriers to IRS deployment: community surveys

The information collected in the routine reporting forms during spraying can be used to assess community acceptance and reasons for refusals. Assessment of these data may indicate the need to conduct more in-depth community-level studies on the knowledge, attitudes and practices of residents of an area targeted for IRS. Such surveys are not required to run an IRS programme and should be undertaken only when a specific need is identified. This information can also be collected as part of other household surveys. The findings can help to guide the development of educational messages to improve programme performance.

5.5.7 Implementation research

When specific situations or problems require more rigorous examination than the tracking of standard indicators, it may be justified to initiate implementation research. Research priorities should be developed based on the issues observed, such as the suboptimal effectiveness of IRS, or based on operational challenges faced, such as changes in vector composition and behaviour or changes in programme organization and structure.

5.5.8 Data capture tools

To facilitate efficient recording and reporting of information, clear and simple data collection forms, entry forms, analysis tables and report templates should be developed. Hand-held electronic devices, such as tablets or smartphones, and computers with spreadsheet, database and mapping software can be used to speed up and improve the accuracy of manual data recording, storage, analysis and reporting. The use of digital tools for data capture will contribute to rapid, efficient and effective data management. There are numerous software applications available to support data capture and management; vector-borne disease control programmes should select software appropriate to their situation considering interoperability with other tools used by the relevant health authority.

WHO provides standard DHIS2-based data collection and visualization tools to help countries to collect monitoring data and integrate these with epidemiological data. DHIS2 tools can be used by field teams and by programme managers to collect data and visualize the findings to help inform decisions. The software is open-source and available on the WHO website *(50)*. The modules contain a set of standard data collection forms, automatically calculated indicators, data visualizations and thematic dashboards that enable the collection, visualization and interpretation of data on IRS and other vector control interventions in line with WHO recommendations. With these modules, countries can:

- collect data from the field, insectaries or laboratories, using mobile phones, tablets or computers, online and offline, with geolocation;
- integrate entomological and vector control data with epidemiological data and other types of relevant data (e.g. climatological data, stock data);
- calculate standard entomological indicators automatically; and
- develop custom visualizations (tables, graphs and maps) and dashboards to meet specific needs.

The modules are constantly improved to better meet country-specific needs, and expanded to include new procedures and methods for entomological surveillance and the monitoring of vector control interventions.

5.6 Review of annual IRS operations

5.6.1 Operational review

IRS operational reviews should be undertaken at the end of each spray round to determine whether all aspects of the operation have been carried out according to the Plan of Action.

There should also be a more comprehensive annual meeting held 1–2 months after the spray round has been completed to review the overall IRS operation, to ensure that programme targets and objectives have been achieved, and to outline adjustments and improvements for the next year's operations. Reports and presentations should be prepared by IRS coordinators at subnational levels. The national IRS coordinators and IRS vector control committee members should review these reports and provide feedback to subnational programmes on their performance.

Annual IRS reports should be prepared at all levels by IRS coordinators at the end of the spray round.

The following areas should be reported on:

- **coverage:** the percentage of target structures sprayed, reasons for refusals, numbers or proportions of houses that were re-plastered following spraying, and suggestions to address this in the future;
- **timing:** when insecticide was applied and whether this was an appropriate time in relation to the onset of vector-borne disease transmission;
- **equipment:** the performance of the spray equipment under operational conditions;
- **expenses:** resource utilization, including for training, salaries, per diems, spray equipment, insecticides, consumables and transport costs;
- **incidents:** summary of incidents, how they could have been prevented and suggested mitigation measures for the next spray round; and
- **lessons learned:** challenges faced, how they were addressed and suggestions for the next round.

These reports will provide valuable information for the planning and budgeting of the next round of IRS implementation in the same area or its geographical extension.

5.6.2 Strategic review

Following any IRS programme, an evaluation of outcomes and impact (from routine health systems data) should be produced. This should document results in terms of improved quality of delivery and coverage targets, entomological impact and changes in vector-borne disease incidence or prevalence. This can be used to improve future spray rounds and identify any needs for training or research activities.

Periodic programme strategic evaluations take place once a programme has been running over several transmission seasons. These evaluations bring together all operational information collected to enable assessment of the broader programme components, such as cost, policy, management structure and organization, effectiveness and efficiency of the intervention, and the programme's performance and sustainability. These evaluations help to identify trends and strengths and weaknesses that could be instrumental in making decisions about future expansion of interventions or reduction of target areas and objectives. These reviews therefore inform any necessary updates to the IRS strategy and operations based on past experience, lessons learned and the evolving situation.

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Annexes

Note: Examples are provided as templates to be adapted to the local context

Annex 1. Comparison of key features of malaria and dengue IRS campaigns

Feature	*Anopheles* malaria IRS campaign	*Aedes* dengue IRS campaign
Purpose	• Proactive large-scale spraying as part of routine activities • Targeted spraying in foci in low-transmission or elimination settings	• Proactive spraying in high-transmission areas • Reactive spraying in response to an imported case, outbreak or epidemic
Target vectors	• Indoor-resting (endophilic) *Anopheles* spp. that mainly bite humans at night and may also bite animals	• Indoor-resting (endophilic) *Aedes* spp. that mainly bite humans during the day[a]
Spray campaign timing	• Prior to the onset of the normal transmission season, usually before the wet season commences	• Proactive: at least three months prior to transmission peak • Reactive: as soon as outbreak or epidemic is detected
Spraying frequency	Depends on the residual efficacy of the selected IRS product in the specific setting • Needs to be sufficient to provide year-round coverage in areas with perennial malaria transmission	Depends on the residual efficacy of the selected IRS product in the specific setting • Proactive: one or two applications to cover the transmission season • Reactive: initial round for rapid response to an outbreak or epidemic, with the need for subsequent rounds determined by the progression of the dengue outbreak
Spray location	• Administrative areas, such as health zone or district	• Proactive: areas of historically high transmission or with vulnerable groups • Reactive: (i) specific distance from a confirmed case (e.g. radius depends on flight range of vector) or (ii) specific geographical area or lower level administrative area with a cluster of cases
Spray units	• Houses and other buildings where people regularly spend the night (e.g. boarding school dormitories, health centre or hospital wards with inpatient capacity, hotels and rest houses, fishing and farm huts)	• Primarily houses • Other buildings where people gather regularly and spend significant time during the day, if identified as high risk for transmission (e.g. school rooms or buildings, shop houses, churches, markets, health centres, other public gathering places)
Sprayable structures (within spray unit)[b]	• Mainly human dwelling(s) • Animal sheds that are in close proximity • Detached kitchens and latrines • Other sleeping locations	• Mainly human dwelling(s) • Detached kitchens • Other community spaces
Spray coverage	• Aim to spray all sprayable structures for every spray unit within the spray location	• Aim to spray all sprayable structures for every spray unit within the spray location

Feature	*Anopheles* malaria IRS campaign	*Aedes* dengue IRS campaign
Preparation	• Move portable items outside or cover (e.g. water, foodstuffs and other consumables, cooking utensils, light furniture, bedding and clothing, toys) • Move other items to the centre of the room • Remove non-permanent pictures, wall hangings and posters	• Cover items (e.g. water, foodstuffs and other consumables, cooking utensils, light furniture, bedding and clothing, toys)
Spraying sequence (within spray unit)	• Upper floor(s) then lower floor(s) • Start with back rooms and move towards front	• Upper floor(s) then lower floor(s) • Start with back rooms and move towards front
Priority rooms in houses	Depends on target vector resting preferences • Generally: all rooms (except those excluded, as below)	Depends on target vector resting preferences • Generally: bedrooms, living room, hallways
Excluded rooms in houses	• Internal kitchens or areas used to prepare or store food • Rooms from which residents cannot be moved	• Internal kitchens or areas used to prepare or store food • Rooms from which residents cannot be moved • Latrines are generally not sprayed
Sprayable surfaces	Depends on target vector resting sites • Usually includes: inside walls; doors and windows; inside eaves and openings (not exposed to rain); ceilings, rafters and beams; wall hangings, posters, pictures and other items on wall; under-floor areas of raised houses; inside walls of latrines; inside walls and ceilings of animal shelters	Depends on target vector resting sites • Usually includes: inside walls that are exposed (not covered); front and back of curtains; under and behind large furniture (e.g. wardrobes, cupboards, tables, beds); inside cupboards; under light furniture (e.g. chairs)
Sprayable surface types	Depends on the product (as per label) • Usually excludes: tiles, enamel, metal, glass, underside of tin/metal roofing	Depends on the product (as per label) • Usually excludes: tiles, enamel, metal, glass, underside of tin/metal roofing
Surface coverage	• Complete spraying of all sprayable surfaces	• Selective spraying[c] up to a height of 1.5 m

[a] Most common target is *Ae. aegypti*

[b] Note that spraying of outside walls of domiciles or associated outdoor harbourages may be undertaken for exophilic *Aedes* vectors (e.g. *Ae. albopictus*), but outdoor spraying is beyond the scope of this document

[c] Also called "targeted IRS"

Annex 2. Example of generic timeline for IRS programme activities

Activity	Months before, during and after IRS operations									
							Spray operations			
	−6	−5	−4	−3	−2	−1	1	2	+1	+2
IRS strategy meetings										
Conduct bimonthly meetings (strategy, pesticide selection, spray locations, timing of operations, etc.)	x		x		x		x		x	
Establish country technical IRS committee (involve relevant ministries and partners)				x						
Needs assessment (field visit)										
Environmental assessment	x									
Logistics, financial and administrative assessment	x									
Entomological and epidemiological data collection	x									
Draft environmental assessment	x	x								
Draft budget	x	x								
Environmental compliance										
Revise and approve environmental assessment and budget		x	x	x						
Environmental monitoring						x	x	x	x	x
Environmental compliance inspections						x	x			
Entomological surveillance										
Identify/train technicians				x						
Baseline survey					x					
Periodic surveillance						x	x	x	x	x
Logistics and procurement										
Issue requisitions	x									
Pesticide and equipment delivered					x					
Detailed planning and geographical reconnaissance		x	x	x						
Quality control/product delivery		x								
Logistics arrangements			x	x	x	x				

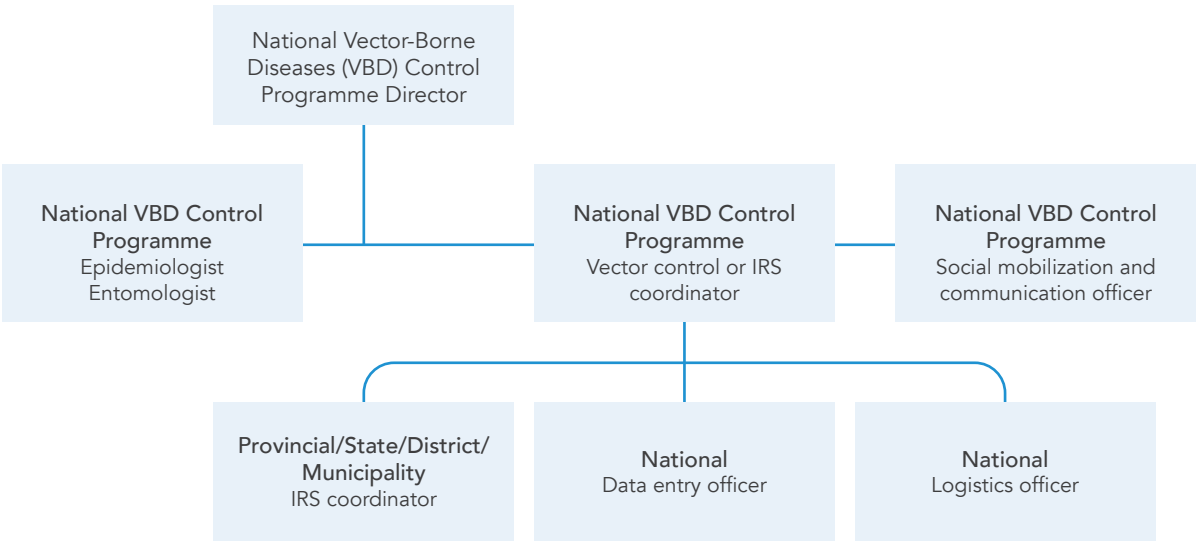
Activity	Months before, during and after IRS operations									
							Spray operations			
	−6	−5	−4	−3	−2	−1	1	2	+1	+2
Information, education and communication (IEC) activities										
Develop IEC materials		x	x							
Produce IEC materials				x	x					
Supervisor and implementer training						x				
IEC in coordination with IRS operations						x	x	x		
Post-spray survey									x	
IRS operations										
Geographical reconnaissance/ mapping			x	x	x					
Development of guidelines for spray operators (local language)			x	x	x					
Administrative and data management team training				x	x					
Supervisor and operator training						x				
Physician training (pesticide management)						x				
Medical checkup for spray operators						x				
IRS launch day setup						x				
Spraying operations							x	x		
Monitoring of coverage, acceptance, effectiveness and efficiency							x	x	x	
Inventory and operational assessment									x	
Post-operation plan										
Closing ceremony									x	
Maintenance of equipment									x	
Incineration of sachets (if required)									x	x
Medical checkup for spray operators									x	
Evaluation and analysis of all reports and data									x	
District meeting (open forum with community)										x
Debrief meetings with partners										x
IRS review and report									x	x

Annex 3. Example of capital and operational budgets for an IRS campaign

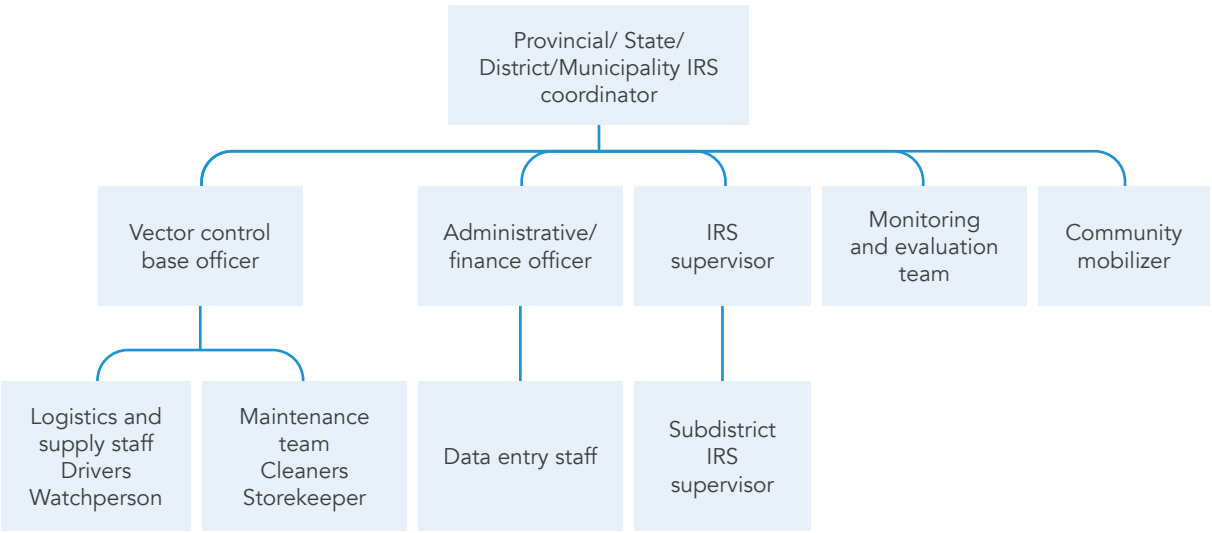
Item	No. of units	Unit cost	Total cost
Capital			
Baseline epidemiological and entomological review and survey			
Environmental impact assessment			
Compression sprayers			
Other equipment, spares and replacement parts			
Tool kits			
Protective sheeting to cover household goods			
Transport: trucks/boats for 3–4 spray teams			
Transport: supervisors' motorcycles			
Transport: coordinators' 4x4s			
Malaria camps – storage and base			
Recurrent			
Spray insecticides			
Salaries of spray operators for 4–8 weeks (adjust to minimum wage)			
Personal protective equipment (overalls, boots, gloves, hat, net protector, face shields/goggles)			
Collection and disposal of empty sachets and containers			
Travel and per diems for supervisors and coordinators for duration of the campaign			
Transport hire and fuel costs			
Annual training of coordinators and supervisors			
Annual training of spray operators			
Annual IEC and community mobilization materials			
Annual review of environmental compliance and pesticide management			
Monthly, quarterly and annual operations management meetings			
IRS data entry and summary report sheets			
Malaria prevalence surveys (optional)			
Entomological studies and sentinel sites			
Annual post-spray review and annual report production			

Annex 4. Examples of IRS operations organizational charts

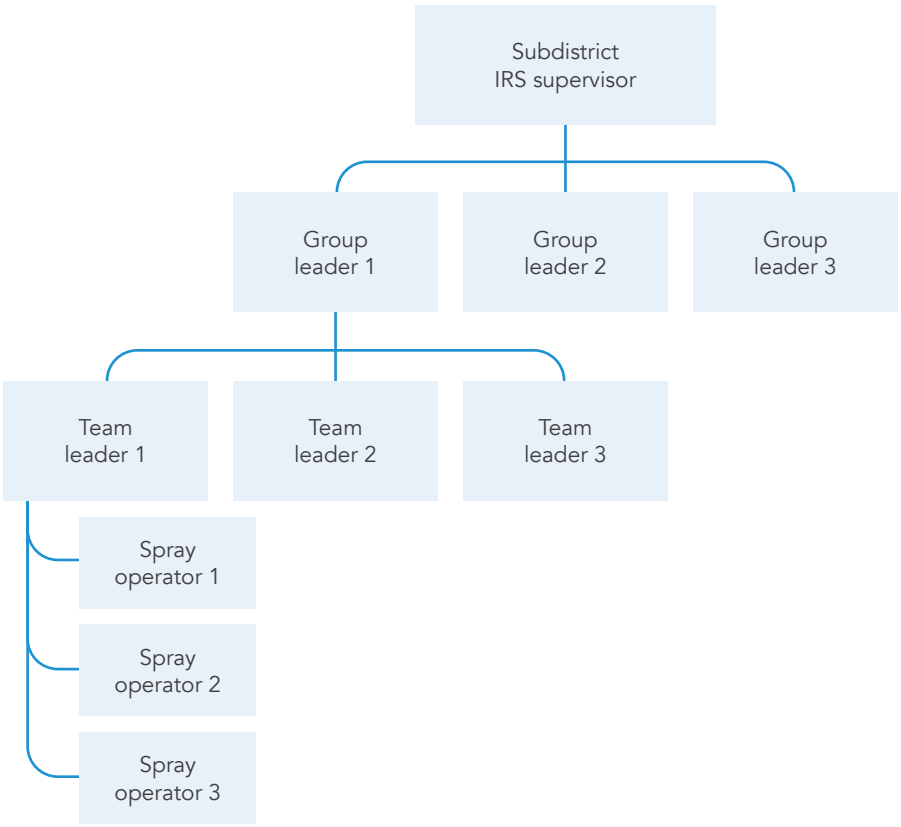
Example 1: Organization at central level



Example 2: Organization at provincial/state/district level



Example 3: Organization at subdistrict level



Annex 5. Example of sprayable surface recording form for baseline estimation of insecticide quantification needs

(This is for initial quantification purposes only and not for use in all IRS spray operations. Some components can be omitted depending on the target vector. This form is for complete spraying of all surfaces and should be adjusted for selective spraying as needed.)

Household number	GPS coordinates	Type of structure	Dimensions of surfaces								Total surface area (SQ metres)
			Eaves (WxL)	Room 1[a]	Room 2[a]	Room 3[a]	Room 4[a]	Large furniture (LxH) + (WxL)	Light furniture (WxL)	Detached kitchen or animal house[b]	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

[a] Room: (LxH)x2 + (WxH)x2 + ceiling (WxL) + curtains (WxH)

[b] Detached kitchen or animal house: (LxH) x 2 + (WxH) x 2 + ceiling (WxL)

Annex 6. Example of house spray card

Date card issued _____

District _____ Parish/Ward _____ Village/Suburb _____

Head of household _____ House ID No. _____ GPS: Longitude _____ Latitude _____

Date sprayed	Spray operator	Number of occupants		Number of rooms/units										Insecticide used	Amount of insecticide used	Spray checked
				Sprayed					Unsprayed					Locked or refused			
		Adults	Children	1	2	3	4	5	1	2	3	4	5			

Date _____ Comments _____

_____ _____

_____ _____

_____ _____

Annex 7. Example of code of conduct for spray operators

(Adapted from *(1)*).

The following code of conduct incorporates features of a code currently being used successfully in several malaria vector control programmes in sub-Saharan Africa. It is given here as an example for use in other programmes.

IRS team members, including spray operators and team leaders/supervisors, have a duty to always act in a professional manner and maintain good relations with the community. Team members' behaviour and demeanour should be beyond reproach. Spray team personnel should never say or do anything to each other or to a member of the community that will upset or offend local leaders, residents or their customs. Sometimes spray teams will be offered food. Accepting these gifts should be discouraged, as it may cause undue hardship to residents where food and/or water may be in short supply or difficult to obtain. Therefore, spray team members must provide their own food and/or snacks at all times and in all locations.

All members must agree to comply with the following:

Rule 1: Spray team members must wear their uniform properly and maintain it in clean, good working order.

Rule 2: Spray team members must properly wear their personal protective equipment while spraying.

Rule 3: Spray team members must be respectful and courteous towards residents and their property at all times.

Rule 4: Spray team members must never ask residents to provide food, money or water for their spray operators or activities.

Rule 5: Spray team members, particularly the team leaders, should give clear instructions to the residents so they can adequately protect themselves, their family members and domestic animals and pets from exposure to the insecticide applied. They should also instruct the residents to sweep the floor of the house and the ground around it to clear all dead insects over the course of two days after spraying and to put them immediately in a latrine pit or bury them in a hole.

Rule 6: Spray team members must comply with all directives given by their team leaders and programme managers.

Spray operators

Spray operators are often selected from the community and employed for a period ranging from a few weeks to a few months, depending on the complexity of the campaign. They are trained to apply insecticide. They should, under the jurisdiction of the Ministry of Health or other pertinent local authorities undertaking the IRS campaign, be at least 18 years old, be physically fit, healthy and able to operate the sprayer, be able to work with minimum supervision, and be able to read and write. If women are employed, they must understand that they must not be pregnant or lactating at the time of recruitment or become pregnant during any part of the spray campaign, and that pregnancy can be grounds for relocation away from active

spraying. Spray operators should be responsible persons who can communicate with residents. Once teams are selected, spray operators are trained in the proper insecticide application techniques, effective communication and record keeping.

Tasks and responsibilities of spray operators

- Report for duty on time and ready to work.
- Carry out instructions given by the team leader in a timely fashion.
- Report any problems to the team leader as soon as they arise.
- Respect local customs, laws and regulations.
- Keep his/her sprayer, tools, personal protective equipment, etc. clean and in good working order, and assume total responsibility for all the equipment under his/her care.
- Wear personal protective equipment as instructed while spraying and protect himself/herself and the environment from insecticide contamination.
- Apply all insecticides following programme procedures, protocols and directives, and be accountable for all insecticide sachets issued to him/her.
- Conduct comprehensive spraying of assigned homes as per the spray strategy.
- Maintain accurate records of his/her activities while on duty as a spray operator.
- Be courteous and respectful to residents and their property.
- Explain the purpose of spraying and the precautions being taken, and answer any questions posed by residents.
- Assist residents, if necessary, to move furniture and other belongings.
- Thank each resident for cooperating upon completion of the work, and answer or address any concerns that residents may have.

Tasks and responsibilities of team leaders and supervisors

- Assist in the training of spray operators and guide them in the proper completion of their duties. This should be done in accordance with the established procedures and protocols, and in a timely fashion.
- Ensure his/her team members have adequate supplies of insecticide, water, record cards, replacement personal protective equipment, etc.
- Continuously and routinely check his/her team members to make sure their equipment is kept clean and in working condition.
- Supervise his/her spray team members during spraying operations and ensure that their work is carried out according to instructions and following established protocols and procedures.
- Conduct sporadic checks on application equipment and nozzles so that appropriate discharge and application rates are maintained.
- Make appropriate corrections to methods or techniques not executed correctly by any of his/her team members.
- Carry out or supervise minor field repairs to sprayers and personal protective equipment.
- Ensure that zone maps are always available (or produced) and are updated as his/her team members progress between villages or suburbs.
- Ensure that all data recorded by team members are correct and accurate and rectify any deficiencies noted.
- Prepare daily progress reports accurately upon completion of daily spraying.
- Keep all spray personnel up to date and informed as to their progress and that of the campaign.

- Ensure that residents are notified of spray operations at least one day in advance.
- Contact community or municipality leaders before or as soon as his/her spray team enters the village or suburb.
- Verify that spraying has been conducted according to the established plan upon completion of the day's work.
- Report the progress of the team to the supervisor and include remarks on the work of each spray operator.
- Supervise the cleaning of application equipment at the end of the day's work.
- Carry out any other instructions given by his/her superior or any other senior programme officer.
- Ensure each team member in his/her team maintains a professional image and conducts himself/herself with cultural sensitivity.

Reference

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Annex 8. Example of daily reporting form for spray operators

District _____ Parish/Ward _____ Village/Suburb _____

Report date _____ Spray period covered by report from _____ to _____

Insecticide used: Compound _____ Formulation _____ Dosage concentration _____

Name and ID No. of Spray Operator _____

No.	Target household ID or head of household name	Target household GPS		No. of people in household		No. of rooms/structures/ units in household		No. of rooms/structures/ units in household unsprayed		No. of mosquito nets hanging[a]	No. of long-lasting insecticidal nets in use[a]
		Latitude	Longitude	Children	Adults	Traditional	Modern	Locked	Refused (see key)		
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
Total		N/A	N/A								

[a] Omit if not relevant.

Refused key and totals: SC: sick or elderly ☐ NB: newborn ☐ F: funeral ☐ NH: no one home ☐ R: refusal ☐ O: other ☐

Spray Operator daily summary

No. of insecticide sachets/pouches/bags/bottles issued for day: _____

No. of empty sachets/pouches/bottles returned at end of day: _____

Total used (issued-returned): _____

Remarks: _____

Signature: _____

Team Leader daily summary

No. of households sprayed: _____

% household coverage (sprayed houses/target houses): _____

% room/structure/unit coverage (sprayed/total in all sprayed houses): _____

Remarks: _____

Signature: _____

Annex 9. Example of daily/weekly routine reporting form for spray team leaders

District _____ Parish/Ward _____ Village/Suburb _____

Report date _____ Spray period covered by report from _____ to _____

Insecticide used: **Type 1:** Compound _____ Formulation _____ Dosage concentration _____

Type 2: Compound _____ Formulation _____ Dosage concentration _____

Name and ID No. of Spray Team Leader _____

Operations		Households			People			Rooms / structures / units			Nets		Insecticide use			
Day/ week	Spray operator	No. target households	No. of households fully sprayed (no refusal/ locked)	Proportion of target households fully sprayed (%)	No. of people in target households	No. of people in fully sprayed households	Proportion of target people in fully sprayed households (%)	No. of rooms/ structures/ units in target households	No. of rooms/ structures/ units sprayed	Proportion of target rooms/ structures/ units sprayed (%)	No. of mosquito nets hanging[a]	No. of long-lasting insecticidal nets hanging[a]	No. of insecticide sachets/pouches/ boxes/bottles used		No. of empty sachets/ pouches/ boxes/ bottles returned	
													Type I insecticide	Type II insecticide	Type I insecticide	Type II insecticide
Total																

[a] Omit if not relevant.

Spray Team Leader's remarks on operational problems and suggested solutions

Signature of Spray Team Leader _____

Annex 10. Example of monthly routine reporting form for district IRS coordinators

District _____ Parish/Ward _____ Village/Suburb _____

Report date _____ Spray period covered by report from _____ to _____

Insecticide used: **Type 1:** Compound _____ Formulation _____ Dosage concentration _____

Type 2: Compound _____ Formulation _____ Dosage concentration _____

Name and ID No. of District IRS Coordinator _____

Operations		Households			People			Rooms / structures / units			Nets		Insecticide use			
Week	Spray team	Total no. target households for spray round	Total no. of households fully sprayed (no refusal/ locked)	Proportion of target households fully sprayed (%)	Total no. of people in target households	Total no. of people in fully sprayed households	Proportion of target people in fully sprayed households (%)	Total no. of rooms/ structures/ units in target households	Total no. of rooms/ structures/ units sprayed	Proportion of target rooms/ structures/ units sprayed (%)	No. of mosquito nets hanging	No. of long-lasting insecticidal nets hanging	Total no. of insecticide sachets/pouches/ boxes/bottles used		Total no. of empty sachets/pouches/ boxes/ bottles returned	
													Type I insecticide	Type II insecticide	Type I insecticide	Type II insecticide
Total																

District IRS Coordinator's remarks on operational problems and suggested solutions

Signature of District IRS Coordinator _____

Annex 11. Example of checklist for cleaning the spray equipment and PPE in the field

Checklist for maintenance of spray equipment and PPE in the field

District _____ Parish/Ward _____ Village/Suburb _____

Spray Operator _____ Team Leader _____ Date _____

When is the sprayer cleaned?

- ☐ At the end of the day's spraying
- ☐ If changing from one product to another

What protective clothing is worn when cleaning the sprayer?

- ☐ Head: cover such as broad-rimmed hat or plastic helmet
- ☐ Neck: scarf, mutton cloth or light cloak on neck
- ☐ Face: full face shield or goggles
- ☐ Nose and mouth: mask or respirator
- ☐ Body: long-sleeved overalls
- ☐ Hands: rubber gloves
- ☐ Feet: non-absorbent boots

Is the correct cleaning procedure being followed?

- ☐ Empty the spray tank of spray mix into barrel 1 for progressive rinse
- ☐ Fill tank to about one quarter of its volume with clean water, close lid, pressurize and shake
- ☐ Discharge water for one minute into barrel 3 to clean hose, lance, CFV and nozzle
- ☐ Depressurize and empty rest of water from tank into barrel 3 (note safety measures and contamination)
- ☐ Repeat the process at least twice more using water from barrel 4 and empty into barrel 5, then using water from barrel 6 and empty into barrel 7
- ☐ Fully drain the tank and wipe interior
- ☐ Fully drain the discharge assembly and dismantle trigger assembly, cleaning lance filter in bucket of water
- ☐ Dismantle nozzle assembly, clean CFV, nozzle filter and nozzle components in bucket of water
- ☐ Clean outside of sprayer including the straps
- ☐ Do not drain sprayer onto waste ground but recycle the rinse water into progressive rinse containers
- ☐ Store sprayer by removing the lid and hang upside down to fully drain inside the store

WARNING! Do not dispose of left-over insecticide or rinse water into the environment – always use the progressive rinse method and recycle the rinse water.

Annex 12. Example of checklist for maintenance of spray equipment

Checklist for maintenance of spray equipment

District _____

Parish/Ward _____

Evaluator _____ Supervisor _____

Date _____

Checklist for maintenance schedules

1. Checklist for pre-spray checks

Visual checks of cleanliness of pump:		
Overall	☐ poor	☐ good
Strap	☐ poor	☐ good
Nozzle	☐ poor	☐ good
Fill with water, pressurize and check:		
Pressure gauge functioning	☐ Yes	☐ No
Pump pressuring smoothly	☐ Yes	☐ No
Pressure retained if left for five minutes	☐ Yes	☐ No
Trigger valve stops cleanly – no drips	☐ Yes	☐ No
No obvious leaks or drips at hose connections	☐ Yes	☐ No
No obvious leaks or drips around trigger	☐ Yes	☐ No
No obvious leaks or drips at nozzle	☐ Yes	☐ No
Strap pattern even	☐ Yes	☐ No

2. Checklist for periodic checks

All elements of the pre-spray checks (see above)

Dismantle pump and check:			
Condition of piston and signs of wear	☐ poor	☐ good	☐ very good
Condition of outlet valve	☐ poor	☐ good	☐ very good
Dismantle trigger valve assembly and check:			
Condition of trigger valve for wear	☐ poor	☐ good	☐ very good
Condition of seals or O-rings for wear	☐ poor	☐ good	☐ very good
Reassemble sprayer, fill with water, pressurize and measure:			
Flow rate at full working pressure	☐ poor	☐ good	☐ very good
Nozzle discharge pattern	☐ poor	☐ good	☐ very good

Two safety rules for dismantling and checking spray equipment

1. Always wear gloves and long sleeves when dismantling sprayers.
2. Always ensure that sprayer is not pressurized before dismantling.

Annex 13. Example of spray team leader's and IRS supervisor's checklist

Checklist for spray team leader and IRS supervisor

District _____

Parish/Ward _____ Village/Suburb _____

Team Leader _____ Number of spray operators _____

Estimate of number of target structures _____ Date _____

Initial observations:

What was the spray operator doing on your arrival? _____

Use of protective clothing? Overalls ☐ Boots ☐ Face shield/goggles ☐ Mask/respirator ☐
Headcover/hat ☐ Neck protector ☐ Gloves ☐

Procedure before starting to spray:		
Are the residents informed?	☐ Yes	☐ No
Are food items, water containers, cooking utensils covered/taken outside?	☐ Yes	☐ No
Are the residents outside during spraying and until 60 minutes after?	☐ Yes	☐ No
Are domestic animals outside during spraying and until 60 minutes after?	☐ Yes	☐ No

Spraying technique:		
Is the sprayer filled correctly?	☐ Yes	☐ No
Is the sprayer pressurized correctly?	☐ Yes	☐ No
For sprayers without a 1.5 bar CFV, is the sprayer pressure gauge checked frequently and pressure maintained within 1.7–4.0 bar (25–58 psi or 172–400 kPa)	☐ Yes	☐ No
Is the sprayer handled and carried correctly?	☐ Yes	☐ No
Is the sprayer shaken periodically before and during spraying?	☐ Yes	☐ No
Is the nozzle held at a constant distance from the target (45 cm)?	☐ Yes	☐ No
Is the nozzle moved at a constant speed over all surfaces?	☐ Yes	☐ No
Is proper footwork performed so that adjacent swaths overlap for uniform spray coverage?	☐ Yes	☐ No
Is the pressure released when the sprayer is not in use?	☐ Yes	☐ No
Is distribution of insecticide on wall adequate?	☐ Yes	☐ No
Is distribution of insecticide on roof/ceiling adequate?	☐ Yes	☐ No
Does spray operator spray behind and under furniture?	☐ Yes	☐ No
Does spray operator spray under the eaves?	☐ Yes	☐ No
Does spray operator spray behind the doors?	☐ Yes	☐ No
Does spray operator avoid environmental pollution?	☐ Yes	☐ No
Does spray operator eat, drink or smoke without first washing?	☐ Yes	☐ No
Does spray operator complete daily recording form?	☐ Yes	☐ No

Comments _____ **Feedback** _____

Residents _____ Positive _____

Community leaders _____ Requires attention/action _____

Proposed solutions/recommendations _____

Team Leader or District IRS Supervisor _____

Name and ID _____

Signature _____

Annex 14. Example of inspection checklists to assess readiness for quality, safe and effective IRS

Checklist 1: Pre-spray storeroom and soak pit inspection

Date of inspection: __ / __ / ____ Inspectors: Inspector 1: _____ Inspector 2: _____

Country: _____ Province/State: _____

District: _____ Village/Suburb: _____

GPS coordinates: Longitude _____ Latitude _____

Security and organization of central warehouse and district storage facility

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
1	Is the storage facility located at an adequate distance from schools, homes and water bodies/flood plains?	Yes	No	Facility located at least 100 m away from residential housing? _____	
2	Is the storage facility secured, including double locks on pesticide storage containers, all windows barred and doors secure?	Yes	No	Double lock on pesticide storage containers? _____ Windows secured? _____ Strong front door with double locks? _____	
3	Is the facility guarded 24 hours/ day with adequate lighting?	Yes	No		
4	Are guards equipped appropriately: boots, whistles, flashlights, phones?	Yes	No		
5	Is the storeroom well ventilated?	Yes	No		
6	If the storeroom is to be used to keep insecticides for a longer duration, does it have adequate ventilation and/or exhaust fans working?	Yes	No		
7	Is there adequate lighting inside the store?	Yes	No		
8	Are danger signs and appropriate hazard labels prominently displayed?	Yes	No		
9	Do the compression pumps meet WHO specifications for use in IRS?	Yes	No	Pumps fitted with 8002 nozzle? _____ Fitted with 1.5 bar CFV? _____	
10	Are technicians available to service compression pumps and fix dysfunctional pumps?	Yes	No		

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
11	Are the pumps kept dry and properly stored?	Yes	No		
12	Are the spray pumps properly maintained and is a stock of spare parts available?	Yes	No	1) Pumps serviced once a year _____ 2) Pumps and nozzles (8002) calibrated prior to spray round _____	
		Yes	No	3) Nozzles cleaned and tested regularly _____ 4) Spare 8002 nozzles available _____	
13	Is personal protective equipment (PPE) properly maintained?	Yes	No	1) Overall in good condition, cleaned and properly stacked _____ 2) Head gear and boots in good condition, cleaned and properly stacked _____ 3) Is PPE kept separately and away from equipment and insecticides? _____	
14	Is the store clear and free of rodents? (Rodents can damage sprayers by chewing hoses)	Yes	No	Rodent traps set in the store? _____	

Stock review and safety

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
1	Is there a system for recording stock, and are stock cards up to date?	Yes	No		
2	Are the available stock cards properly filled to enable tracking of stock?	Yes	No	Using stock cards, can warehouse supervisor indicate: a) quantity and age of remaining stock? _____ b) quantity of stock that has been used to date? _____	
3	Are stock items shelved in an orderly fashion on pallets, according to their type and expiry date?	Yes	No		
4	Does the storeroom have a leak-proof floor and a sump at the entrance to contain major leakage?	Yes	No	*The leak-proof floor should drain into a sump so that if the floor is washed, liquid can be collected for appropriate disposal.*	
5	If flood risk is unavoidable, what precautions are in place to mitigate the consequences?	Yes	No	1) Raised storage area _____ 2) Proper drainage in place _____	
6	Does the storeroom have a leak-free roof?	Yes	No		

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
7	Is storage capacity sufficient to store the total stock of insecticides at any time?	Yes	No		
8	Are insecticide containers (boxes, drums, etc.) stored on pallets and stacked in a manner that allows for inspection?	Yes	No		
9	Is the maximum storage height (2 m) for insecticide stacks maintained?	Yes	No	*If no, then containers must be restacked to bring them in line with the maximum storage height.*	
10	Are all insecticide containers checked to ensure that none are leaking?	Yes	No		
11	Is there a recording thermometer in the pesticide storeroom?	Yes	No	Logbook with regular record of temperature available? _____	
12	Are functional in-date fire extinguishers or fire-fighting equipment (e.g. bucket of sand) available?	Yes	No	Available: outside / inside the storeroom? _____ pesticide room? _____ transport vehicles? _____	
13	Is there a system for fire extinguishers to be tested and replaced before their expiry dates?	Yes	No	Are all fire extinguishers functional? _____	
14	Are pesticide labels securely fixed and legible?	Yes	No		
15	Are samples of pesticides taken for quality assurance/quality control analysis?	Yes	No	If no, is there evidence to show the quality of pesticides? _____	
16	Are any insecticides that are past their expiry date separated from operational stocks?	Yes	No	Expiry date of pesticides in inventory _____ /_____ /_____	
17	Is there any evidence of pesticide leakage or spillage (sign of dust or granules)?	Yes	No		
18	Are barrels or containers for waste available and are these clearly labelled?	Yes	No		
19	Are used sachets or bottles counted and stored neatly in boxed containers or barrels?	Yes	No		
20	Is soap and water available for hand washing after handling insecticides?	Yes	No		
21	Are antidotes to specific pesticides available nearby? *(Note: Not all pesticides have an antidote)*	Yes	No	Is there a plan for emergency evacuation to health facility in case of accidental poisoning? _____	

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
22	Do storeroom supervisors know the signs of poisoning specific to the pesticides being used, as well as the location of the nearest treatment facility?	Yes	No	Distance to nearest pesticide poison management centre _____	
23	Are pregnancy test strips in stock for female staff and have preparations been made for tests to be conducted at a nearby clinic or by a nurse?	Yes	No	*Pregnant or breastfeeding spray operators should be assigned tasks other than spraying*	
24	Is there an adequate number of supervisor checklists, inventory and monitoring and evaluation forms available?	Yes	No		

Health and safety issues

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
1	Are pesticide Material Safety Data Sheets (MSDS) readily available?	Yes	No		
2	Are there extra MSDS available for labelling transport vehicles and are drivers trained in the event of an accident?	Yes	No		
3	Is there a plan for maintenance of PPE?	Yes	No		
4	Are instructions provided for the correct use of PPE?	Yes	No		
5	Is there adequate PPE in the inventory for the number of operators expected? *(At least two pairs of overalls and one set of boots, gloves, headcover, neck protector, face shield/googles, face mask/ respirator per spray operator)*	Yes	No	Number of operators to work out of this centre _____ Number of full sets of PPE available _____	
		Yes	No	Number of available: overalls? _____ boots? _____ hand gloves? _____ headcovers? _____ face shields/goggles? _____ mask/respirator? _____	
6	Are first aid kits for the storeroom and for transport vehicles stocked with pain killers (e.g. aspirin), dressings (e.g. adhesive bandages, plasters, gauze, tape, cloth bandages), eye wash?	Yes	No	Number of transport vehicles expected to be used? _____ Number of fully stocked first aid kits? _____	

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
7	Is the emergency response procedure posted in the stockroom (including phone numbers) and on the notice board at the warehouse?	Yes	No		
8	Is the spill response procedure posted?	Yes	No		
9	Are emergency spill kits in place for vehicles and the storeroom (absorbent sand, sawdust or soil; long-handled brush with stiff bristles; shovel; short-handled brush and pan; fire extinguisher) and with instructions included?	Yes	No	Number of vehicles to work out of this operations centre? _____ Number of spill kits included in inventory? _____	
10	Is there more than one spray season of accumulated solid waste?	Yes	No	If yes, is there a plan in place for its disposal? _____ When will disposal take place? _____	
11	If present, are foods, medicines and other products stored separately from pesticides (to prevent contamination)?	Yes	No		
12	Is there someone trained in first aid, specifically in treating pesticide exposure?	Yes	No	If no, is there a plan to provide training? _____	

Soak pit and washing area

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
1	Is the soak pit located away from water bodies, steep slopes or flood-prone areas?	Yes	No		
2	Are the soak pit and surroundings cleared of vegetation and cleaned?	Yes	No		
3	Is the gravel on the soak pit adequate, well placed and able to act as a filter?	Yes	No		
4	Are the washing areas properly sloped to drain into the soak pit, with no leaks or cracks?	Yes	No		
5	Are clothes lines present and are they sufficiently strong?	Yes	No		
6	Are the clothes lines located above the soak pit or wash area?	Yes	No		

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
7	Are danger signs and appropriate hazard labels posted on all exposed sides of the soak pit?	Yes	No		
8	Is the soak pit sufficiently well built and is it correctly fenced, gated and locked?	Yes	No	Well built and fenced? _____ Gated? _____ Locked? _____	
9	Are showers and toilets with adequate privacy and drainage present at the site?	Yes	No	Separate facilities for men/women? _____	
10	Is there adequate clean water available for rinse management?	Yes	No	Available for: progressive rinsing? _____ washing PPE? _____ cleaning of operators? _____	
11	Is there a storage space for clean non-working clothes and are changing areas available to put on work clothes?	Yes	No		

Evaporation tanks (DDT and other non-biodegradable chemical waste)

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
1	Is the evaporation tank for DDT liquid waste well built, is it located away from water bodies and is the tank covered with wire mesh?	Yes	No N/A	Located downward side of rinse area? _____ Constructed of concrete? _____ Sunk into the ground with sides raised 20–30 cm high? _____ Covered with mesh wire? _____	
2	Is there any cover available in the event of rain?	Yes	No N/A	*Could be permanent shelter or temporary tarpaulins*	
3	Are the washing areas properly sloped to drain to evaporation tank, with no leaks or cracks?	Yes	No N/A	No leaks? _____ No cracks? _____	

Additional comments

Checklist 2: Spraying activities

Date of inspection: __ / __ / ____ Inspectors: Inspector 1: _____ Inspector 2: _____

Country: _____ Province/State: _____

District: _____ Village/Suburb: _____

GPS coordinates: Longitude _____ Latitude _____

Field site office / district storage facility

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
1	Are first aid kits for the storeroom and for transport vehicles stocked with pain killers (e.g. aspirin), dressings (e.g. adhesive bandages, plasters, gauze, tape, bandages), eye wash?	Yes	No	Number of transport vehicles expected to be used? _____ Number of fully stocked first aid kits? _____	
2	Is there someone trained in first aid, specifically in treating pesticide exposure?	Yes	No		
3	Are the storekeeper, spray operators and wash persons properly instructed to wear PPE and do they wear appropriate PPE?	Yes	No	Instructed or trained to wear PPE? _____ Do they wear appropriate PPE? _____	
4	Do spray teams have clean and complete PPE at the start of each work day?	Yes	No		
5	Are overalls washed daily at site and are they dried over the soak pit?	Yes	No		
6	When conveying equipment to the field, are all spray operators comfortably seated in vehicles with pumps well placed between their legs?	Yes	No		
7	Are the spray operators given a meal at the beginning of their work day?	Yes	No	*Meal should be provided if the spray operation is expected to last longer than eight hours a day*	
8	Do any of the female spray operators appear to be pregnant or breastfeeding?	Yes	No	Records for pregnancy test results observed on site? _____ Plans to do pregnancy test midway during spray season? _____ *Pregnant or breastfeeding spray operators should be assigned tasks other than spraying.*	
9	Is the "first in, first out" principle of insecticide use applied?	Yes	No	*Oldest inventory pesticides should be used first before reaching the expiry date.*	

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
10	Is the store well arranged (including the height of arranged items, allowance for free movement, proper stacking of items, appropriate ventilation)?	Yes	No		
11	Are warning signs and appropriate hazard labels correctly displayed (danger signs, insecticide safety notices)?	Yes	No		
12	Is a functional in-date fire extinguisher and other fire-fighting equipment available?	Yes	No		
13	Is there a thermometer to measure daily temperature in the store?	Yes	No		
14	Is the floor impermeable?	Yes	No		
15	If flood risk is unavoidable, what precautions have been taken to mitigate this fact?	Yes	No	Raised storage area? _____ Proper drainage in place? _____	
16	Is the roof leak-proof?	Yes	No		
17	Are lighting and ventilation adequate?	Yes	No	Is there visibility in the store day and night? _____ Are there windows that can be easily opened? _____ Are ventilators (e.g. fans, air-conditioners) available to allow air circulation? _____	
18	Are the surroundings of the store and soak pit clear of IRS solid wastes (empty sachets, masks, gloves)?	Yes	No		
19	Is the spray team deployed with an adequate number of pumps, including spare nozzles?	Yes	No		
20	Are all pumps fitted with a CFV?	Yes	No	If no, any plans to procure CFV? _____	

Spray tank preparation

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
1	Are the pumps filled using water from the previous day's progressive rinse?	Yes	No		
2	When the contents are mixed in the tank, is the tank shaken before being pressurized?	Yes	No		
3	Is the pump pressurized to 4.0 bar (58 psi)?	Yes	No		

Information dissemination and household preparation before spraying commences

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
1	Have the residents been instructed on what to do during and after the spraying operation?	Yes	No	Instructed: to exclude animals from the house _____ to keep the house locked up for a specified duration post-spray _____ on the importance of ventilation after the lock up period _____ on proper disposal of dead insects _____, etc.	
2	Have all residents been informed that if they have any reaction such as skin irritation, they should wash the affected area with soap and clean water and seek medical attention if the symptoms persist?	Yes	No		
3	Have all personal belongings, animals, sick or elderly persons, food/ water items and eating utensils been removed from the house?	Yes	No		
4	Have all immovable items been properly covered with polythene sheets?	Yes	No		

Observation of spray operators and adequacy of supervision in the field

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
1	Do spray operators correctly record household details?	Yes	No		
2	Are spray operators in full PPE (overalls, boots, face shield/ goggles, mask/respirator, hat, neck protector, gloves)?	Yes	No	If some spray operators are not in full PPE, what are the missing items? _____ Is there a plan to replace missing items? _____	
3	Is the mixing of the insecticide witnessed by household residents?	Yes	No	*In some areas, it is beneficial for residents to (safely) witness mixing to promote community confidence that insecticide is being used for spraying.*	
4	When liquid insecticide is used, are spray operators rinsing (x3) the bottle and adding rinse water to the pump?	Yes	No N/A		
5	Are spray operators spraying only the recommended surfaces?	Yes	No		

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
6	Do spray operators correctly apply spraying techniques?	Yes	No	*Operators should maintain the nozzle tip 45 cm from the wall, use vertical swaths, ensure a swath overlap of 5 cm, shake the pump can and observe the pressure gauge.*	
7	Are any spray operators observed eating/drinking/ smoking while at work?	Yes	No		
8	If spray operations last longer than six hours, is there a plan for spray operators to wash and drink water during a break?	Yes	No		
9	Is there adequate supervision during the operation?	Yes	No	Are supervisors alongside spray operators to monitor spray progress? _____ Is proper use of PPE observed? _____ Are supervisors cross-checking spray operators' data forms? _____	

Spray operators after spraying operations

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
1	At the end of the shift, are both full and empty sachets/ bottles returned, counted and recorded?	Yes	No		
2	Are empty sachets/bottles and used masks stored in separate designated and labelled containers in the store?	Yes	No		
3	Are seven barrels for triple-rinsing placed and arranged on impermeable ground or on a polythene sheet (in the case of permeable ground) along the wash bay?	Yes	No		
4	Do barrels 2, 4 and 6 contain enough water for triple-rinsing?	Yes	No		
5	Are pump left-overs emptied into barrel 1 and stored properly for the next day's use?	Yes	No		
6	Do spray operators correctly conduct triple-rinsing of pumps while wearing PPE?	Yes	No		
7	Are all used hand gloves, nose masks and empty sachets/bottles separated and consolidated in a waste storage room at the end of the day's work?	Yes	No		

	Mitigation actions	Findings		Comments / recommended actions	Completion date (if applicable)
8	Are all overalls, face towels and other cloth PPE handed over to the washers for washing?	Yes	No		
9	Are washed pumps arranged in the store in an orderly fashion?	Yes	No		
10	Do spray teams have access to end-of-day washing facilities (including soap and water)?	Yes	No	Is there adequate clean water available for washing? _____ Is soap available for washing? _____	
11	Do spray operators complete daily reporting forms (structures sprayed, stock received, used and returned)?	Yes	No	Are supervisors cross-checking data forms filled in by spray operators? _____	
12	Is the insecticide usage rate and average number of houses sprayed per spray operator within acceptable limits? *(At least 4–8 sachets and 10 houses/spray operator/day)*	Yes	No		

Additional comments

Checklist 3: Post-spraying activities, wash up and waste disposal

Date of inspection: __ / __ / ____ Inspectors: Inspector 1: _____ Inspector 2: _____

Country: _____ Province/State: _____

District: _____ Village/Suburb: _____

GPS coordinates: Longitude _____ Latitude _____

Observations on spray operation on arriving at field station / wash-up facility / progressive rinse

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
1	Is the wash site located near the field station/district storage facility?	Yes	No		
2	Are all spray operators wearing PPE when they return from spraying?	Yes	No		
3	Are all persons conducting the progressive rinse in full PPE?	Yes	No		
4	Are all wash persons wearing appropriate PPE?	Yes	No		
5	Are any spray operators eating, drinking or smoking?	Yes	No		
6	Are barrels 2, 4 and 6 filled with water?	Yes	No		
7	Are spray pumps triple-rinsed using the progressive rinse method?	Yes	No	Is the insecticide poured into barrel 1 used for spraying the following day? _____ If rinse in other barrels is kept clean, is the water used to reconstitute insecticides? _____ *Note: Pesticides poured into barrel 1 can be used for spraying the following day. If rinse in other barrels is kept clean, then the water can be used to reconstitute insecticide.*	
8	Are the outsides of the tanks rinsed off in the soak pit?	Yes	No		
9	Are the helmets, face shields/ goggles, gloves and boots rinsed off in the soak pit?	Yes	No		
10	Is PPE washed and then hung to dry over the soak pit or soak away?	Yes	No		
11	Are soak pits or evaporation tanks used to dispose of all contaminated water?	Yes	No		

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
12	Are the pump nozzles, filters and strainers cleaned with a soft (tooth) brush and water to remove particulates?	Yes	No		
13	Are the spray pumps hung upside down to dry?	Yes	No	*Spray pumps should be hung upside down after being washed.*	

Solid waste

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
1	Are empty sachets/ bottles inventoried and documented?	Yes	No		
2	Are all contaminated empty sachets/bottles (leaked and damaged containers) repacked and labelled appropriately, and put in storage?	Yes	No	*Not thrown on the ground, or buried or burned in an open pit*	
3	Are contaminated mouth/ nose masks stored with empty sachets?	Yes	No	Is chemical waste stored in a separate room? _____	
4	Are any other contaminated materials (e.g. cardboard, materials for cleaning spills) placed in a container?	Yes	No N/A	If no, is there a plan in place? _____	
5	Has worn-out and contaminated PPE that cannot be reused been cleaned and disposed of together with other waste materials?	Yes	No N/A	If no, is there a plan in place? _____	
6	Have DDT sachets been incinerated at a certified facility?	Yes	No N/A	If no, has such a facility been identified? _____	

Effluent waste soak pit (biodegradable insecticides, e.g. pyrethroid)

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
1	Is the soak pit located away from bodies of water or from flood-prone areas?	Yes	No	Is the soak pit at least 100 m from water bodies? _____	
2	If located on a slope, is there a berm to prohibit run-off from entering on the uphill side, and one on the downhill side to contain effluent run-off?	Yes	No		
3	Is the soak pit absorbing all the effluent waste?	Yes	No		

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
4	Is a puddle and/or run-off being created?	Yes	No		
5	Is there adequate gravel to act as a filter?	Yes	No	Is the soak pit surface clear of soil and vegetation? _____	
6	Is the soak pit area fenced and gated?	Yes	No	*Fence needed to keep children and animals out*	
7	Is there a danger sign and appropriate hazard labelling at the soak pit to keep out unauthorized persons?	Yes	No	If no, has there been adequate communication with the community so they understand not to enter the wash areas? _____	

Effluent waste evaporation tanks (DDT and other non-biodegradable chemicals)

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
1	Are evaporation tanks located away from bodies of water or flood-prone areas?	Yes	No	*Evaporation tank should be at least 100 m from water bodies*	
2	If located on a slope, is there a berm to prohibit run-off from entering on the uphill side, and one on the downhill side to contain effluent run-off?	Yes	No		
3	Are there cracks visible in the concrete?	Yes	No	If yes, is there a plan to seal the cracks to avoid seepage into the soil? _____	
4	Are there signs of evaporation?	Yes	No	Are traces of dried residue on the side of the tank above water visible? _____	
5	If not, do you see effluent contained safely elsewhere? (e.g. in polythene tanks)	Yes	No		
6	Is there any cover available in the event of rain?	Yes	No	*Could be permanent shelter or temporary tarpaulins*	
7	Is the evaporation tank fenced off and gated?	Yes	No	*To keep out children and animals*	
8	Is there a danger sign and appropriate hazard labelling at the evaporation pit to keep out unauthorized persons?	Yes	No	If no, has there been communication with community so they understand not to enter the wash areas? _____	

Effluent waste wash areas

	Mitigation actions	Findings		Comments / recommended actions *(mark with a Y or N where appropriate, or add detail requested)*	Completion date (if applicable)
1	Is there a concrete catchment area or tarpaulin spread out on the ground to catch all effluent?	Yes	No		
2	Can all effluent be easily drained into a soak pit or evaporation tank?	Yes	No		
3	Are the overalls hung out to dry on clothes lines over the wash area?	Yes	No		
4	Is the wash area fenced off and gated?	Yes	No	*To keep out children and animals*	
5	Is there a danger sign and hazard labelling at the evaporation pit to keep out unauthorized persons?	Yes	No	If no, has there been communication with community so they understand the dangers and that they must not enter wash areas? _____	

Additional comments

Annex 15. Example of annual reporting on insecticides used for vector control

Country: _____ Date _____

Completed by: Name _____ Email: _____

Position _____ Tel: _____ Fax: _____

Year	Compound	Class	Formulation	Concentration	Type of application	For control of	Amount of formulation used (kg or L)	amount of AI
2010	DDT	Organochlorine	75WP	75%	Indoor residual spraying	Malaria	1000 kg	
2011	Deltamethrin	Pyrethroid	25WG	25%	Indoor residual spraying	Malaria	1000 kg	

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