

Indoor Residual spray (IRS) in Malaria Control

1. Vectors of Malaria

In India malaria is transmitted by nine vector species, six are of primary importance. These are:

<i>Anopheles culicifacies</i> :	Transmits malaria in rural and peri-urban
<i>Anopheles fluviatilis</i> in foothills	Areas in plains In hills and f
<i>Anopheles stephensi</i>	In urban areas
<i>Anopheles minimus</i> <i>Anopheles dirus</i>	In north eastern states
<i>Anopheles sondaicus</i>	In Andaman and Nicobar Islands
<i>Anopheles annularis</i>	
<i>Anopheles philippinensis</i>	
<i>Anopheles varuna</i>	

Of these *An.culicifacies* is responsible for the transmission of 60-70% and *An.fluviatilis*, 15-20% new cases of malaria in our country. Control of malaria in India is actually control of *An.culicifacies* as each year 60—70% of the allotted budget is spent for control of malaria in those areas where *An.culicifacies* is the vector species for malaria transmission.

The understanding of the transmission of malaria is further complicated by the existence of species complexes of cryptic species or sibling species or isomorphic species in this team and also in other malaria vectors. Except for *An.stephensi* all other malaria vector exist as species complexes comprising several sibling species that result in considerable impact on the transmission of malaria including susceptibility to commonly used insecticides in public health programme.

2. Vector Control:

Intervention measures to restrict the transmission of malaria by controlling the vector population form the main part of the vector control. Effective vector control strategies are based on four facts:

- (i) Knowledge and understanding of vector biology
- (ii) Surveillance of vector species
- (iii) Incrimination of vector species
- (iv) Public education and implementation of effective control measures.

Vector control programme in India, as in the case with many anti-malaria programme elsewhere, in the world, mostly rely on usage of natural and synthetic chemical molecules, which have potential to kill the target insects.

Presently different formulations of synthetic chemical insecticides are in the use for vector control. Wettable powder (WP) formulations are used for indoor residual sprays while emulsion concentrate (EC) formulations are used for larval control. For Indoor Residual spray (IRS) insecticides in use are DDT 50% WP, malathion 25% WP and synthetic Pyrethroid (WP). Synthetic Pyrethroids include deltamethrin 2.5% WP, Cyfluthrin 10% WP, lambdacyhalothrin 10% WP, alphacypermethrin 5% WP, Etofenprox 10% WP and Bifenthrin 10% WP. Synthetic pyrethroid insecticides are also used for impregnation of bed nets.

3. Indoor Residual spray (IRS) : Most of the insecticides having residual effect are sprayed indoors, so that mosquitoes after having bite on an infective person will rest in the house and will pick up sufficient insecticide particles sprayed on the walls and other indoor surfaces of the house and its longevity will be reduced so much so that it does not survive to become infective. In areas where the vectors are strongly endophilic, i.e. they tend to rest indoors, indoor residual spraying of human dwellings can give very effective control. Vectors that are exophilic i.e. they tend to rest outdoor but tend to feed or rest indoors briefly, can be effectively controlled by indoor residual spraying with insecticides that have good airborne effect. In areas where vectors are strongly exophilic and/or exophagic, i.e. they rest and bite outdoors, other control methods, such as use of insecticide treated mosquito nets or exterior space spraying (for emergency control), should be considered.

In practice, the effectiveness of house spraying for malaria control depends on adherence to the specified criteria of the insecticide and application procedure, public acceptance of spraying, the availability of well maintained equipment, adequately trained spraying personnel, efficient supervision and strong financial support. The size of the area depends on local circumstances and is influenced by the distribution of malaria and malaria vectors; distance from important breeding sites, the flight range of the vectors and demographic features:

3.1 Target area: Generally, all the interior walls and ceilings are treated. In addition to permanent human dwellings, field huts where people sleep during the planting or harvesting season should be sprayed, depending on local vector behaviour. The underside of furnitures, back of the doors, outside caves and porch may need to be treated. It should be noted that the residual effect of insecticides may be short on some surfaces, e.g. porous mud walls, oil painted wood and alkaline white wash.

3.2 Selection of Insecticides: Several factors need to be considered in the selection of an insecticide spraying, including availability, cost, residual effectiveness, safety, vector susceptibility and excito -repellency. There are large number of insecticides, which are used as adulticides for indoor residual spray. These are DDT, Malathion and different formulations of synthetic pyrethroids.

The choice of insecticide for areas under the vectorial influence of *An.culicifacies*:

This species is a vector for malaria all over India. It is a complex sibling species– A,B,C, & D. All sibling species are efficient vectors of malaria except sibling species “B”. A genetic variant of sibling species “B” transmits malaria only in Rameswaram islands. Sibling species were found to differ in their response to insecticides and also in the rate of development of resistance to different insecticides. Based on these observations, the following recommendations have been made in Malaria Action Programme (MAP), 1995 for indoor residual spray:

- Areas where species ‘A’ is predominant: Malathion 25% WP
- Areas with species ‘B’ and ‘ C’ : In most of the areas these Species have already developed resistance to malathion. Pyrethroids use.

In areas where observations about sibling species ‘A’, ‘B’ and ‘C’ are inconclusive, use DDT ensuring total coverage in Time and Space before switching over to Malathion or Pyrethroids.

The other main vectors of malaria i.e., *An.fluviatilis*, *An.minimus* and *An.dirus* are still susceptible to DDT. However, susceptibility status should be continuously monitored and if the tests show development of resistance coupled with loss of epidemiological impact of spray operations, the following strategy should be adopted for change of insecticide.

Resistant to	Alternative insecticide
DDT	Malathion
DDT and Malathion	Synthetic Pyrethroids

3.3 Change of Insecticide:

If the change of insecticide is warranted, the state Govt. should support their choice of alternative insecticide by documentation of data on vector resistance studies and field observations on epidemiological impact of spray in

respect of insecticide in use. The change of insecticide will always be decided in mutual consultation between State Programme Officer for NVBDCP, ROH&FW and the Dte. Of NVBDCP with concurrences of State and Central Govts. The proposal for any such change of insecticide should follow the following steps:

- (i) State Govt. submits the proposal for change of insecticide to Dte. Of NVBDCP in the month of January-February. All technical data on vector resistance, epidemiological impact of the current insecticide in use, along with financial outlay, quantity of alternative insecticide chosen, with comparative cost difference for spray operation should be included in the proposal. The proposal should be discussed in the annual action plan meeting in Dte.of NVBDCP.
- (ii) Mutual consultations between the State Programme Officer NVBDCP, ROH&FW and Dte. of NVBDCP in the month of March-April and report prepared in this regard for submission to Technical Advisory Committee for approval under the chairpersonship of DGHS, GOI.
- (iii) Approval of MOH&FW should be obtained in the month of April-May.
- (iv) Insecticide should be procured for next year's spray operations and fixing of delivery schedule should be ensured so that the insecticide reaches the periphery by May-April next year i.e. well before starting the first round of spray operation.

4. Insecticide formulations used under NVBDCP

The following formulations/compounds are used under the NVBDCP for control of malaria:

4.1 DDT (Dichloro – diphenyl – trichloroethane):

In India DDT has been in use for malaria control since 1946. Recently there has been a tendency to curb the use of DDT due to its persistence in the environment. It is a fact that if DDT is applied in agriculture, it contaminate water resources, enters the biochain and at each step of the biochain, it gets more concentrated (bio-magnification) till it reaches human beings. In human body, it is stored in the body fat and is excreted in the milk. Therefore it reaches the infants right from the time of birth. Since DDT persists for a long time in the community, there has been apprehension that it will produce adverse impact on human metabolism and growth. However, in spite of extensive use of DDT in agriculture, no adverse reaction of DDT on human health has been reported so far.

A study group on WHO has recommended that at this stage there is no justification on toxicological or epidemiological grounds for changing current policy towards indoor spraying of DDT for vector-borne disease

control. DDT may therefore be used for vector control, provided that all the following conditions are met.

- a) It is used only for indoor spraying
- b) It is effective
- c) The material is manufactured to the specifications issued by WHO
- d) The necessary safety precautions are taken in its use and disposal.

Govt. of India has constituted a mandate Committee on DDT which reviews the use of DDT in public health and decides its quantity to be released for the vector borne diseases control programme every year.

DDT has an added advantage. It is comparatively cheaper than the other insecticides and even in those areas where resistance to DDT has been recorded in studies with WHO test kits, the epidemiological impact of good spray operations is seen because of its excito-repellent action.

Requirement of DDT:

150 MT per million population for two rounds of spray is required. In areas where third round is proposed in selected villages, additional requirement of 75 MT per million population should be estimated.

4.2 Organophosphorous compounds: Malathion 25% WP is used under the programme in areas with DDT resistance. The disadvantage of organophosphorous compounds is that unlike their use in agriculture where a farmer uses the organophosphorous compound for crop protection only once or twice a year, the spray squads engaged in spraying residual insecticide in the human dwellings work with these compounds for periods extending up to 6 or 7 months. This long exposure results in acute toxic symptoms and if not controlled properly may lead to mortality. Therefore, the spray staff engaged in spraying of organophosphorous compounds are to be provided with more elaborate protective garments and their blood cholinesterase level is to be checked periodically to assess the toxic impact of the compound. These compounds are also toxic to domestic pets.

Under Indian conditions, three rounds of spray with organophosphorous compounds are given as against two rounds of spray with DDT.

In case of OP poisoning, the patient should be transported as soon as possible to a doctor to receive an **antidote**. Organophosphate poisoning, **2-4 mg of atropine** should be given intravenously (for children 0.5 to 2 mg according to weight). Depending on symptoms, further doses of 2 mg should be given every 15 minutes for 2-12 hours in severe cases. Automatic injections are available for administration of atropine.

Requirement of Malathion25% WP:

900 MT per million population for three rounds of spray are required. If in some areas a further round is required in selected villages, 300 MT per million population for the special round for the population of selected villages only

4.3 Synthetic Pyrethroids:

These are new insecticides introduced for control of vector borne diseases in India. The cost of these insecticides is much higher than the cost of DDT and Malathion. Currently there are five insecticides of this group registered with Central Insecticide Board for use in the programme. These are (i) Deltamethrin 2.5% WP, (ii) Cyfluthrin 10% WP, (iii) Alphacypermethrin 5% WP (iv) Lambdacyhalothrin 10% WP and (v) Bifenthrin 10 WP.

In treating pyrethroid poisoning vitamin E oil preparations can be given for prolonged paraesthesia. Only in cases of definite allergic symptoms should corticosteroids be administered. On occurrence of convulsions after severe intoxication, intravenous injection of 5-10 mg Diazepam (or other benzodiazepine derivatives) should be given.

Requirement of Synthetic Pyrethroids:

- (i) Deltamethrin 2.5% WP: 60 MT per million population for two rounds of spray. In some areas, where a further round is required in selected villages, additional requirement of 30 MT per million for the population of selected villages is estimated.
- (ii) Cyfluthrin 10% WP: 18.75 MT per million population for two rounds of spray and 9.38 MT per million population for selected villages which would require special round/third round of spray.
- (iii) Lambdacyhalothrin 10% WP: 18.75 MT per million population for two rounds of spray and for a special round or third round of spray in selected villages, 9.38 MT per million population may be estimated.
- (iv) Alphacypermethrin 5% WP 37.5 MT per million population for two rounds of spray.
- (v) Bifenthrin 10% WP : 18.75 MT per million population for two rounds of spray and 9.38 MT per million population for selected villages which would require special round/ third round of spray.

4.4 Insecticide formulations and dosages for IRS-

S.No.	Name of Insecticide	Preparation of suspension in water	Dosage per sq.metre of active ingredient	Residual effect in weeks	Area to be covered by 10 lit.of suspension to get correct dosage
1.	DDT 50% wp	1 kg/10 Lit	1 gm	10-12	500 sq.m
2.	Malathion 25% wp	2 kg/10 Lit	2 gm	6-8	250 sq.m
3.	Deltamethrin 2.5% wp	400 gm/10 Lit	20 mg	10-12	500 sq.m
4.	Cyfluthrin 10%wp	125 gm/10 Lit	25 mg	10-12	500 sq.m
5.	Lambdacyhalothrin 10% wp	125 gm/10 Lit	25 mg	10-12	500 sq.m
6.	Alphacypermethrin 5%wp	250gm/10 Lit.	25 mg	10-12	500 sq.m
7.	Bifenthrin 10% WP	125g/10 litre	25 mg.	10-12	500 sq.m.

4.5 Insecticide Resistance in Malaria vectors:

Presently insecticides belonging to different groups, namely, organochlorine (DDT), organophosphate (Malathion), and synthetic pyrethroid are used for public health spray. Insecticides belonging to the carbamate group have yet not been introduced for public health sprays in India. Strategy for the changes in the insecticides has always been reactive. Successive changes in insecticide were made after the failure of the control by the ongoing insecticide intervention. A subsequent change in the insecticides has lead to sequential selection pressure of insecticides resulting in multiple insecticide resistant malaria vectors. Malaria vectors in India are resistant to DDT alone or double resistant to HCH or triple resistant to DDT, HCH, malathion and quadruple resistant to DDT, HCH, malathion and Deltamethrin (synthetic pyrethroid). HCH has been phased out of the programme in 1997. Of the six principal vector species, two, namely *An.culicifacies* and *An.stephensi* have shown wide spread resistance. Other vector species are mostly susceptible to these insecticides. Development of resistance to synthetic pyrethroid warrants a caution of impending possibility of wide spread resistance to other compounds of this group that are introduced in public health programme for indoor residual spray as well as insecticide treated bed nets.

4.6 Strategies of Delay/Avoid the onset of Resistance:

The most important aspect of the management of resistance is to either avoid or delay. The onset of resistance by effectively manipulating or influencing the factors responsible for the development of resistance. The methods include avoidance of use of insecticide, that induce broad-spectrum resistance mechanisms and confer cross resistance to chemically related and un-related insecticides and sequential use of insecticides in rotation is preferred.

Possible ways of avoiding development of insecticide resistance in field

- Avoid indiscriminate use of insecticides
- Avoid use of insecticides that simultaneously select resistance to other chemically related insecticides.
- Avoid use of insecticides that induce development of more than one type of resistance mechanism of broad spectrum of resistance.
- Avoid use of the same insecticide both against adults and larvae.
- Use of non chemical control methods, e.g. biopesticides, larvivorous fish.
- Use of synergist with insecticides to reduce physiological resistance.

4.7 Insecticide spray operations:

The indoor residual spray of human dwellings is as important for malaria control in the community, as is the early case detection and prompt treatment for an individual cure, therefore, it is essential that residual insecticidal spray should be planned and implemented with sound technical skill under expert guidance. **It should not be entrusted to non-technical personnel like contractors, voluntary bodies etc.** In the revised approach to malaria control, it has been decided to spray human dwellings and mixed dwellings. **Cattle sheds are not to be sprayed** with a view to conserve insecticide, improve coverage of human dwellings and the present diversion of mosquitoes from sprayed cattle sheds to human dwellings.

4.8 Planning for spray operations:

The planning of spray operations will be done by the District Malaria Officer. He involves the Medical Officer incharge of the PHCs in this process. The epidemiological data should be thoroughly analyzed in this process. A meeting of Medical Officer incharge PHCs should be convened by CMHO/DMO for this purpose.

Under the MPO, the spray operations are to be carried out in all area with API 2 or above. However, the priority of spray will be given to High Risk areas all over the country. Therefore, in “high risk” areas the population of ‘subcentre’ qualifying under the criteria laid down by the expert committee is considered. The population is obtained from the epidemiological data collected from each of

the PHCs of the district. The Medical Officer incharge of PHC should bring this information in the meeting at district HQ in the following format.

The District Malaria Officer should consolidate the information for the district in the following format

PHC and sub-centres of “High risk” areas for spray operations

S.No.	Name of high risk PHC	Population of PHC	No. of high risk sub-centres in PHC	High risk population for spray	Remarks

In sub-centres with API 2 above (excluding the high risk sub-centres) population of qualifying sub-centres only to be considered for spray in a PHC is segregated in the following format :

S.No.	Name of the PHC	Population of PHC	Number of sub-centres having API 2 & above	Population of sub-centres having API 2 & above qualified for spray	Remarks

While planning for spray, the epidemiological data of preceding three years are considered for selecting the population to be protected.

4.9 Spray Technique

The required quantity of insecticide should be issued to the squads each day by the supervisor after checking balance stocks available from previous day's supplies. The insecticides used under the National Vector Borne Diseases Control Programme (NVBDCP) are available as wettable powders.

The preparation of the spray suspension is made just before the start of the spray operations every day. It is important that the suspension is made correctly so that the correct dosage is applied on the sprayed surfaces. The procedure for the preparation of the suspension is the same irrespective of the insecticide. However, the quantity of the insecticide used per 10 litres of water will depend on the insecticide used.

The required quantity of the insecticide is measured with a plastic mug and poured into a 15 litre bucket. A paste is made with a small quantity of water. The remainder of water is then poured slowly into the bucket and the insecticide water mixture is stirred vigorously to obtain a uniform suspension. The suspension is then poured into another bucket through a cloth sieve to remove any particulate matter that might clog the nozzle of the spray pump.

The barrel of the stirrup pump is put in the bucket containing the spray suspension. One man operates the pump and the other man sprays. The spray lance should be kept 45 cms (18 inches) away from the wall surface. The swath should be parallel. Spray is applied in vertical swath of 53 cm (21 inches) wide. Successive swaths should overlap by 7.5 cm (3 inches). Spray is done from roof to floor, using downward motion, to complete one swath; then stepping sideways and spraying upwards from floor to roof. Do not let the spray drip to the floor. Spraying is done on inner surfaces including eaves and roofs.

The discharge rate should be 740 to 850 ml per minute. To obtain the above discharge rate, the pump man should give 20 to 26 strokes per minute with 10-15 cms plunger movement at a pressure of 10 PSI (0.7 kg/sq.cm) at the nozzle tip. Spraying into a bucket for one minute and measuring the quantity of the suspension in a graduated mug should check the correct discharge rate (740 to 850ml/minute). The nozzle tip should be discarded if the discharge rate exceeds 850 ml per minute.

If the spray stops due to a blockage in the nozzle, the nozzle cap be unscrewed to remove the blockage and replaced with a new one. The blocked nozzle should be put in a container with water for a few hours before the blockage is removed with a finer wire.

A good quality spray should lead to uniform deposit on walls and other sprayable surfaces. This is easy to verify for DDT and malathion sprays as the insecticide deposits are clearly visible. Deposits of synthetic pyrethroids are visible on wooden structures. The supervisor through physical verification should verify the quality and coverage of spray randomly.

It takes about 5 minutes to spray a house with an average surface area of 150 sq. metres. A daily summary of spray operations should be maintained by the field supervisor and verified by the health workers showing the areas covered, percentage room coverage and insecticide consumption in the tables as below:

Villages Selected For Intervention Measures – Spray Operations

Spray Operations At Subcentre On -----					
Village	To be Sprayed		Sprayed		Locked/Refused
	Houses	Rooms	Houses	Rooms	

Daily Consumption Record Of Insecticide

Spray Operations At Subcentre On _____			
Insecticide Issued (Qty.wp)	Balance insecticide available from previous day	Number of buckets (5 litres)	
		Prepared	Consumed

4.10 SUPERVISION, PROCESS AND PERFORMANCE INDICATOR

Supervision of spray operations is a very important activity to ensure that spray operations are carried out according to correct technical procedures, which is essential for taking corrective action, and achieve the programme goals. Supervision is carried at all levels of programme implementation. It can be concurrent or consecutive. A stratified sample should be taken up for supervision.

Concurrent supervision

The following should be checked during such inspections:

- Date of advance notification and the maintenance of time table for spray operations
- Turn out of spray crew
- Nozzle tip discharge rate
- Conditions of spray pumps
- Preparation of insecticide suspension
- Actual spraying operation including the technique, speed and coverage etc.
- Extent of refusal to accept spray and the numbers and percentage of locked houses
- Maintenance of spray records
- Consumption of insecticide as determined by the quantity issued and stock in hand
- Date and time of checking of the squad by Inspectors/ Supervisors and other supervisory personnel and their remarks, if any
- Arrangements for mopping up
- Future programme and time schedule

Consecutive supervision

The following is to be checked in consecutive supervision

- Evidence of insecticide deposit on sprayable surface particularly on the ceiling and wooden material like windows etc.
- Dispersal of the insecticide deposits on the walls to verify uniformity of deposits
- Number of rooms in each house sprayed satisfactorily, partially and not at all
- Percentage of refusals and locked houses
- Factors responsible for not spraying any area as elicited through enquiries from the residents
- Attempts made for mopping up operation in the event of high refusal
- Extent of mud plastering on the walls, if any and other relevant matters.

4.11 Community participation

Involvement of Panchayats in successful indoor residual insecticide spray is an essential aspect of the programme. Panchayats/village/ local bodies/ village heads/ Block Development Officers/ Mahila Mandals, religious groups etc., are to be informed about the spray schedule at least before a fortnight. This advance information must be mopped up by Surveillance Workers/Malaria Inspectors/ District Malaria Officer so as to facilitate the villagers to extend full cooperation in getting actual spray inside of human dwelling with the objective of full coverage of targeted population.

It is not the insecticide but the supervision and re-supervision of the spray operations, which matter in the control of vector borne diseases. Ensure high coverage of insecticide spray in terms of time & space.