1.0 Dengue: A Major Public Health Concern

1.1 Background

Dengue fever (DF) and dengue hemorrhagic fever (DHF) are considered important re-emerging arboviral diseases in more than 100 tropical and subtropical countries of the world. The disease epidemiology is complex in nature and requires to understand variety of factors that include weather and environmental changes, vector species composition and behavior, population dynamics and degree of immunity among local population. A proper understanding of these contributing factors are extremely essentials for a more precise prediction of the location and time of high-risk events and finally to how to respond.

In Pakistan, dengue is the most rapidly spreading vector-borne viral disease during last decade threatening the millions of people due to prevailing peculiar socio-economic conditions and epidemiological situation. From 1995-2004 only 699 dengue cases were reported from 3 districts of Pakistan. During 2005-2011 numbers of confirmed cases and deaths dramatically increased to 55,946 and 539 respectively effecting 105 out of 146 districts/agencies/territories and since then, the disease has become widely accepted as one of the major public health problems in Pakistan.

*Aedes aegypti* and *A. albopictus* have been considered major vectors of dengue in Southeast Asia including Pakistan. Both species have been closely associated with human dwellings due to its breeding preference for clean water domestic habitats. In agreement with international data, the most attracted indoor breeding sites of *A. aegypti* and *A. albopictus* in Pakistan and their sequence is Underground Water Tanks, Earthen Pots, Buckets and Drums as shown in figure 1. Other internationally documented breeding places are jars, money plant bottles, pots, buckets, plastic cups, fountains, bird bath, ant-traps, wooden and metallic barrels, bottles, cisterns, tins, cemetery urns, tyres, and roof gutters. Less oftenly they breed in natural containers such as plant leaf axils, bamboo stumps, tree cavities, coconut shells and large snail shell and many more places where rainwater collects or is stored.
Similarly both species also exhibit a discernible demarcation in occurrence in different geographical areas of country. In Southern part of country (24-50 m above sea level) only A. aegypti is prevalent species where in Northern/submountainous areas (500-600 m above sea level with upper limit of 2500 m) of country, A. albopictus shows a significant dominance. However, in Central part of the country A. aegypti shows dominance while A. albopictus also shows reasonably high densities.

Similar to malaria vectors in Pakistan, overall both dengue vector species also exhibited a well define rising trend in population in post monsoon season (September to November). During 2005-2011, 95.53% caseload of country has been reported during these months and there was rapid decline in cases during/after December which indicated a possible positive correlation between vector densities and disease incidence.

1.2 Why Issue is Important

A good understanding of the vector(s) habits like breeding, feeding, resting, and timing/duration of transmission, is crucial in determining which intervention(s) is cost-effective and sustainable and also the timings of intervention(s). Since dengue vector has specific breeding sites that are mainly man-made and vectors are active during day times, therefore, vector control efforts should be mainly focus on Community-Based Environmental Management and Personal Protection Measures promoted through systematic and intensive Health Promotional Campaign. This is a key element in a successful dengue prevention and control program around the globe.

Currently, the use of chemicals for public health pests control is one of the major elements for any successful VBD control program worldwide and Indoor Residual Spraying (IRS) has always been given top priority particularly during the past few decades. However despite its importance, the use of chemicals particularly for indoor residual application has very little impact for long-term control of DF/DHF.
The use of insecticides should be discouraged for long term prevention and control of DF/DHF.

However, in many countries studies on control of A. aegypti have shown that thorough indoor treatment at an interval of 7-10 days with portable fogging applicators produced significant control of A. aegypti. Since the current vector control tools have certain/some limitations in terms of cost, delivery and long-term sustainability, therefore it is compulsory to select Time and Target-specific vector control intervention(s) based appropriate entomological and epidemiological evidences and vector control interventions must be carried out in both inter-epidemic and epidemic periods involving local communities.

In Pakistan like other developing countries, vector control is a very weak component of disease control program and implementation of VBD control programs is not coordinated among the different relevant sectors, resulting in a loss of prevention and control opportunities, and duplication and wastage of meagre resources.

In Pakistan currently there is no designated institute/department/cell for the control of vectors of dengue, leishmaniasis, and also bedbugs, ticks, human mites, fleas, houseflies etc in Pakistan. Only Malaria Control Program has a vector control component which is also not working properly due to human and logistic constrains. Pakistan since the commencement of global malaria eradication program solely dependent on use of chemicals for vector control, with indoor residual house spraying as the main intervention. However due to withdrawal of external support and less supports from government side particularly since late 1980’s vector control activities are being carried out on very limited scale and without effective guidelines and long term policies. Currently lack of trained entomologists, quality assurance, coordination among different line departments, and effective monitoring and evaluation mechanism for vector control interventions are the major challenges for the control of dengue and other VBDs which requires serious and systematic efforts to; (i) establish a separate “Dengue Control Cell” within the Ministry of Health as a part of overall health system strengthening; (ii) establishment of a functional intersectoral mechanism of coordination between all stakeholders for implementation of Integrated Vector Management approach; and (iii) regular capacity building programs. Operational research on insecticides resistance in dengue vector(s), characteristics of virus, vector(s) densities and bionomics between highly and low affected areas, rural and urban areas, frequency of host–vector contact and disease epidemiology is also
strongly recommended which ultimately leads to develop an evidence-based, community friendly and sustainable dengue management strategy in country.

1.3 Need of the Document

Since both dengue and malaria vectors have entirely different resting feeding and breeding habits in urban and rural settings respectively, therefore it is very important to understand that the “type, target site and timing” of intervention(s) are also different for both diseases. This document mainly deals with prevention of dengue vector mosquitoes during routine operations as well as during outbreaks or emergencies. Same guidelines can also be used for malaria vector control by changing the sequence and time of intervention(s). Table 1 shows a comparison of appropriateness of dengue and malaria vector control intervention(s) during routine and under outbreaks/emergencies situations. The ultimate goal of development of these guidelines is to provide practical help to local health authorities to interrupt the disease transmission by reducing vectors densities in local settings. The development of this document also has aim to strengthen provincial/district level capacities in entomology and vector control as well as the promotion of functional national mechanisms for inter-sectoral coordination and collaboration at all levels for cost-effective and sustainable dengue vector control interventions through active involvement of district governments and communities.

In long term this document will enable health planners and policy makers at all levels to make better informed-decisions in selection of more effective and sustainable vector-specific intervention(s) in their local settings, judicious and rationale use of insecticides and bednets for future dengue vector control operations in Pakistan.
### Table 1: Appropriateness of different vector control interventions for DENGUE & MALARIA under different disease scenario

<table>
<thead>
<tr>
<th>Disease Scenario</th>
<th>Adult Control</th>
<th>Larval Control</th>
<th>HE</th>
<th>IVM</th>
<th>Aerial Appli.</th>
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<tr>
<td></td>
<td>IRS&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Fogging</td>
<td>Personal Protection</td>
<td>Chem.</td>
<td>Biological</td>
</tr>
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<td>Routine</td>
<td>Indoor</td>
<td>Outdoor</td>
<td>ULV</td>
<td>LLINs</td>
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<td>Outbreak / Emergency</td>
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1. Indoor Residual Spraying

#### Notes:
- + = Least/No priority
- ++ = Low priority
- +++ = Moderate Priority
- ++++ = Top priority
2.0. Dengue Vectors Control Methods

After devolution, one of the major responsibilities of Directorate of Malaria Control (DoMC), Ministry of NHSCR-Government of Pakistan is to formulate uniform policy and guidelines and also to provide technical assistance to provinces for control of vector(s) of malaria. In the best interest of public heath, DoMC since 2006/07 also developing and circulating national guidelines for the control of dengue vectors. In present document DoMC recommends following main dengue vectors control methods and their sequence is;

2.1 Establishment of Dengue Control Cell

2.2 Establishment/Strengthening of Dengue Disease Surveillance System

2.3 Partnership Building

2.4 Health Promotion Campaign

2.5 Personal Protection Measures (PPM)
   2.5.1 Use of Repellents
   2.5.2 Use of LLINs
   2.5.3 Cloth Treatment
   2.5.4 Use of Protective Cloths
   2.5.5 Screening of House

2.6 Use of chemicals
   2.6.1 Larval Control
   2.6.2 Adult control
      2.6.2.1 Space spraying
         2.6.2.1.1 Thermal Fogging
            2.6.2.1.1a Indoor Thermal Fogging
            2.6.2.1.1b Outdoor Thermal fogging
         2.6.2.1.2 Cold fogging/ULV
         2.6.2.1.3 Aerial Application
   2.6.2.2 Indoor Residual Spraying (IRS)
   2.6.2.3 Selection of insecticides

2.7 Environmental Management (EM)
   2.7.1 Solid Waste Management
   2.7.2 Source Reduction or Habitat Alteration
2.8 Integrated Vector Management (IVM)

2.9 Biological Control

2.9.1 Use of Mosquitofish

2.9.2 Bacillus thuringiensis (B.t.i) and B. sphaericus

2.9.3 Synthetic Insect Growth Regulator (IGR)

2.10 Capacity Building

2.11 Operational Research

2.12 Technical Comments/Expert Opinion

2.12.1 Closure of Swimming Pools

2.12.2 Closure of Service Stations

2.13 References

Details of operational guidelines for implementation of these interventions are as under;

2.1 ESTABLISHMENT OF DENGUE CONTROL CELL

Keeping in view the rising trend of DF and DHF in Pakistan particularly since 2005/06, there is an urgent need to promote it as a “Priority/Notable Disease” among health officials and general public. For this purposes following important actions are recommended on priority basis;

- There must be a separate “Dengue Control Cell” within the provincial Ministry of Health as a part of overall health system strengthening.

- At federal/central level Directorate of Malaria Control (DoMC) should be given additional responsibility for policy formulation and guideline for dengue vector control and also to provide technical assistance to provinces and districts when and where required.

- Establishment of “Entomological Reference Laboratories Network” at national and provincial levels which act as Centre of Excellence for following functions;

  ➢ Exploration of vector mosquito fauna of the country.

  ➢ Up-gradation of entomological data of country (density, bionomics of vector mosquitoes).
- Regular conduction of insecticides resistance test in dengue vectors according to WHO standards.
- Monitoring of efficacy of interventions (IRS, larviciding, fogging etc).
- Monitoring of efficacy of LLINs at local level.
- Rearing of mosquitoes under 100% natural and laboratory conditions.
- Facilitation of operational research.
- Capacity building of district level vector control staff etc.,

- Technical Working Groups (TWGs) of entomologist should be an integral part of Dengue Control Cell at all levels (Federal, provincial and districts).

- Dengue Control Cell at both provincial and federal levels should adopt Integrated Vector Management (IVM) initiative which promotes and encourages;
  - Inter-sectoral mechanism for collaboration and coordination among not only all health sectors but also with other sectors like agriculture, irrigation, education etc in the country for effective and sustainable dengue vector control measures.
  - Vector Control Needs Assessment (VCNA) for dengue alongwith other VBDs to identify the total needs, available resources (provincial+donors etc), gaps and opportunities for vector control using the guidelines and tools developed by WHO for development of national and provincial plan of action.
  - The use of intervention(s) singly or in combination and reduce the reliance of any single intervention (use of chemicals).
  - Presence of a qualified and competent National Focal Person for vector control who understands the principles of IVM.
  - Also presence of a competent Provincial Focal Person (provincial senior entomologist) for better coordination with national focal points.

- To reflect IVM principles, provincial health department must re-profile existing vector control programs in an optimal distribution of essential functions over different levels (provincial & districts level).
• District government must allocate sufficient funds for dengue vector control interventions and develop *District Implementation Plan* (DIP) well before transmission period (preferably in February-March).

• *Research and Development* (R&D) wing should be one of the main components for promotion of research culture and finally to designed evidence-based interventions.

### 2.2 ESTABLISHMENT/STRENGTHENING OF DENGUE DISEASE SURVEILLANCE

The availability of accurate data (patient’s addresses, start of epidemics, vector density, composition, trend, resistance level etc) is the fundamental factor to prioritize the areas, type of vector control operations and also the time of intervention(s). For this purpose, presence of functional dengue surveillance at all level is the primary requirement.

**Operational Guidelines for Strengthening of Dengue Disease Surveillance**

• Appointment of a designated *Disease Surveillance Officer* at provincial level for regularly monitoring of situation by collecting and analysis of relevant data.

• At district level there should also be a nominated “*Focal Person*” preferably entomologist for better coordination with provincial and federal offices.

• Introduction of *Sentinel Site Surveillance* system to capture required informations which are not being captured by the routine system of reporting.

• There should be at least 30 sentinel sites across the country (2 in each low, moderate and highly endemic district in each provinces (5 provinces including FATA/FANA and AJK).

• District malaria control in District Headquarter Hospital (DHQ) should be chosen as sentinel sites.

• Introduction of dengue-specific DEWS in collaboration of EIC-NIH, and WHO.

• Development and implementation of dengue-specific *Reporting and Recording* tools for vectors control at all levels.

### 2.3 PARTNERSHIP BETWEEN LOCAL GOVERNMENT, LINE DEPARTMENTS AND COMMUNITIES

A strong and effective partnership between district government, line departments particularly malaria control authorities and communities is a most important element in a successful dengue prevention and control program around the globe. This
partnership ensures solid commitment of all stakeholders and understanding of importance of issue and their active involvement and support in implementation of vector control measures at local level.

**Operational Guidelines for Developing Partnership with Line Departments**

- All provincial health departments should strengthen their coordination with Epidemiological Investigation Cell (EIC)-National Institute of Health (NIH) and DEWS-WHO for better disease surveillance and timely response to curtain outbreak with appropriate contingency plans for vector control, case management, community awareness and logistics.

- There should be *multi-sectoral* (national/provincial/district) dengue committees to foster and support inter-programmatic, inter-agency, inter-sectoral and inter-country collaboration to ensure the sustainability of intervention(s).

- Promotion of *school-based community awareness* programs targeting children and parents for improved water storage practices and use of larvicides to control vector breeding at home level.

- Students from schools, colleges, and universities should be trained as volunteers to train others at community level.

- LHW and lady volunteers from community should be trained to convey the messages to house wives for better acceptance of intervention(s), early reorganization of disease symptoms for prompt treatment seeking behavior, and also timely referral of complicated cases.

**2.4 HEALTH PROMOTION CAMPAIGN**

*Aedes aegypti* and *A. albopictus* are major vectors of dengue in Pakistan which have close association with human dwellings due to their breeding preference towards clean water domestic habitats and the most attracted indoor breeding sites particularly of *A. aegypti* in Pakistan are Underground Water Tanks, Earthen Pots and Drums placed under shaded place inside of house. Keeping in view significant association of both dengue vector species with human dwellings, a systematic and intensive health promotion campaign focusing communities is extremely important for dengue vector(s) control programs at home level. After such
campaigns, the homeowners can help greatly by eliminating breeding sources of dengue mosquitoes on their own household.

**Operational Guidelines for Effective and Sustainable Health Promotion Campaign**

The overall objective of health promotion campaign should be the community awareness for better acceptance of intervention(s) particularly *Personal Protective Measures* and *Environmental Management* (EM) for elimination of breeding sites. For an effective and sustainable health promotion campaign following targets or actions should be kept in top priorities;

- Change the behavior of people for improved hygiene practices that include proper coverage of water holding containers, periodically change of water (at interval of a week) and straining of water stored in small (<20 L) containers with fine wire screening or cloth material, especially during normal and non-epidemic times.
- Promotion of *Personal Protection Measures* (use of LLINs, repellants, coils, mates, and treatment of cloths etc).
- Promotion of use of larvicides in drinking water containers, focusing *Insect Growth Regulators* (IGRs).
- Recognition of symptoms of disease for prompt treatment seeking behavior. Home residents should also be trained using mass media and community volunteers.
- Cleanliness of the surroundings.
- Draining out of stagnant water.
- Treatment of undesired stagnant water with used mobil oil and chemicals (larvicides) where necessary for other nuisance mosquitoes.
- “On-Spot” awareness raising campaign at public places play a vital role in achieving tangible successes in control of this rapidly spreading viral disease. School based campaign should also be kept in priority list.
- Mass distribution of leaflets, brochures, pamphlets particularly at public places. In this regards the larval profile and locally made photographs of the different breeding sites should be used to develop health education messages to ensure the community understanding and involvement (Figure 1).
• Other recommended events for awareness raising should be;
  ➢ Special walks
  ➢ Events with celebrities
  ➢ Matches (foot ball, cricket )
  ➢ Health melas
  ➢ Kids competition

• Involving local leaders, Imams, teachers, and LHWs is the best approach for the success of such campaigns.

2.5 PERSONAL PROTECTION MEASURES (PPMs)

The use of Personal Protection Measures (PPMs) particularly during dengue outbreak is one of the best recommended strategies for mosquito (both nuisance and vector) control. PPMs which include the use of repellants, bednets, coils, lotions and protective cloths give rapid relief and are also equally important for all age groups and for population living in dense vegetation areas.

If routine IRS operation could not be done and there is a threat of dengue outbreak, the priority should be given to Personal Protection Measures than IRS.

PPMs can be used by an individual or small group of people to protect themselves from biting mosquitoes and subsequent disease transmission. These measures are also very important for internally displaced population (IDPs) and for Armed Forces particularly when they deployed in forest areas. However, the efficiency of PPMs depends on their acceptance and proper usage by affected population. Similarly these methods have no significant impact of reduction of diseases incidence. Following are the main recommended methods of Personal Protection Measures against dengue vectors;

2.5.1 Use of Repellents

Repellents are among the most commonly used methods to prevent bite of blood sucking pests including dengue mosquitoes. They are applied directly on skin or to cloths and they evaporate much quickly than insecticides. Insecticides last longer and act by killing or knocking down vector when
come in contact, where as repellents prevent human-vector contact only. Duration of protection by repellents applied to the skin varies from 15 minutes to 8 hours depending on the type used, body and environmental temperature, amount of perspiration and rubbing of the skin, and abundance of mosquitoes. Repellants are available in varying concentrations, ranging from 7.5-95% and lower concentration products are generally adequate for most outdoor activities. However, the use of repellents must be according to precautions and directions mentioned on product label.

Some individuals may experience skin irritation or allergic reactions after exposure to any of the repellent products and in rare cases repellents may cause illness after their absorption through skin. This is particularly true in case of repeated applications of products containing DEET. Symptoms reported particularly involving small children are headache, crying, irritability, confusion, mood changes, and nausea. Accidental (children) or deliberate (adults) ingestion of repellants result in symptoms such as low blood pressure, seizures, and unconsciousness. Technically there are following three types of repellents as under;

2.5.1a. Chemical-Based Repellants

The repellents containing N, N-Diethyl-m-toluamide (DEET) and PICARIDIN/ICARIDINE (odorless and more advance form of repellants) etc are highly recommended against dengue vectors. However Permethrin, Benzyl benzoate, dimethyl phthalate, dimethyl carbamate, ethyl hexanediol, citronella, eucalyptus, and other "natural" ingredients can also be recommended.

Operational Guidelines for Use of Repellents

- Repellents should be applied particularly to exposed body parts (foot, arms, face etc).
- Repellents should not be sprayed directly to the face; spray the repellent onto hands and then apply to face. Sensitive areas like eyes, nostrils and lips should be avoided.
- Do not apply repellent to skin that is under clothing.
- Never use repellents on cuts, wounds, abrasions, or on sunburnt or irritated skin.
• Also avoid application of repellants near food.

• Always keep repellents out of the reach of children and they should not be allowed to use repellents without adult supervision.

• Children <5 and pregnant women (PW) must use repellents at time of sleeping, particularly when sleeping outside. During outbreak or emergencies including displaced population, the repellents must also be used by children and PW even when they are not sleeping.

• Repellents should not be used for children <2 years because they are more prone to putting their fingers in their mouths. However in case of extreme need, it should not be applied to their hands and/or faces, preferably to their clothing.

• For children repellents particularly DEET with lower concentrations (<15%) should be preferred.

• Clothing can also be treated with P/ICARIDINE or DEET, etc. to repel dengue vectors.

• The repellents (DEET) containing concentration 15-35% can be used by adults spending long periods of time outdoors (about 5 to 8 hours). However, practically effect will last for up to 4-5 hours.

• The repellent which gives at least 8 hrs should be preferred (PICARIDIN/ICARIDINE), particularly during outbreak of VBDs including dengue.

• Though frequent re-application is unnecessary for effectiveness, however only in case of hot and sweating days and also during outbreak, application of repellents of short duration (2-4 hrs) can be repeated.

• To avoid indiscriminate or overuse, repellents must be used according to label directions as severe allergies can develop.

• Prolong use of repellants for more than 2 months should be consulted with doctor.

• Permethrin-based products should not be applied directly to skin rather applied to outer clothing only.

• Do not reuse empty containers. Do not incinerate aerosol cans.

• Mosquito coil is usually effective when used in indoor or places with limited ventilation like scrubby areas with dense vegetation.
• One coil is sufficient for a room of space about 35m$^3$. Several coils should be used at different points for a larger space.

**Use of coils and mates should be avoided in closed rooms.**

• While using indoors, make sure to maintain good ventilation (with open windows) as the smoke may cause irritation to the eyes and respiratory tract.

• Great care should be taken in using coils in sensitive areas where children, pregnant women, the elderly or the sick live.

• Mosquito coil should be installed at a stable and heat resistant place, and kept out of reach of children.

• If coils are used outdoors, make sure to be downwind of the coils for protection.

• Continuous and prolog use of mates particularly coils should also be avoided and products must use according to the label instructions.

2.5.1b. **Natural products**

• Repellents that contain "natural" ingredients like citronella, geraniol, eucalyptus spp, cedar, clove oils, can also be used to avoid the vectors' bite. However, their benefits are weak and short-lived, not more than 10-40 minutes. Citronella products provide about 30-40 minutes of protection.

• Also these products should not be used during indoors activities, their greatest benefit may be when used in screened-in porches/houses or other areas where air movement is limited.

• Plants that can repel mosquitoes are strong-smelling herbs, such as mint, lavender and basil (Niazboo), or hot spices, such as cinnamon, thyme or cayenne pepper. However, these plants have not been found effective in repelling mosquitoes, particularly during peak breeding season.

• The scented geranium plant, *Pellargonium* spp. more commonly known as the Citrosa "Mosquito Fighter" plant, has not proven to be effective in repelling mosquitoes, particularly during peak breeding months.
- In case of outdoor sleeping or during emergencies or outbreak, burn (smoke) the leaves of neem, Eucalyptus spp. close to sleeping place (downward wind direction) at least 1 hr before the sleeping time and stopped just before sleeping for avoiding health hazards.

**The use of such natural products particularly during dengue outbreaks should be avoided.**

2.5.1c Mechanical Devices

- Electrical and ultrasonic repeller devices have no significant effect on mosquito including dengue vectors behaviour for reduction or elimination of biting activity, therefore not recommended, particularly during emergencies outbreaks of VBDs including dengue.

- Traps using ultraviolet light as an attractant are not effective in reducing the biting mosquito population. However, traps using CO$_2$, Octenol, and other chemicals to attract mosquitoes are little bit effectively.

2.5.2 Use of Long Lasting Insecticidal bed nets (LLINs)

Currently the use of LLINs has become front line defense in many VBD control programs, particularly for children<5 and pregnant woman (PW) and also for those people living outdoor during peak vector breeding season. However during outbreak, emergency or among displaced population the use of LLLINs become ONLY choices for the control of vectors of public health importance including dengue vectors. Due to their unique technology, LLINs also provide significant protection against bedbugs, human lice, fleas, sand flies (vector of leishmaniasis), spiders and cockroaches in addition to mosquitoes (vectors of dengue, malaria, Japanese encephalitis, lymphatic filariasis, yellow fever, West Nile Virus etc).

**For dengue control, the use of LLINs should be mainly for the isolation of dengue patients to prevent the further spreading of disease.**

Operational guidelines for use of LLINs

The efficacy of LLIN depends upon the way how to use it and at community level, following are the major instruction for greater benefit of LLINs for dengue control;
• ONLY WHOPES-Recommended LLINs will be used and promoted in country. List of WHOPES-Recommended LLINs are available at http://www.who.int/whopes/recommendations/wgm/en/). List attached as Table 2.

• All confirm dengue cases should be provided LLIN to prevent the further spread of disease.

• Dengue patient must sleep under LLINs till its recovery.

• Before sleeping put/tuck the hanging edges under bed sheet/mattress.

• LLINs should be washed after at least 3-4 months. However avoid its washing during peak transmission months, outbreak particularly polyethylene-made LLINs.

• After opening of packet, LLIN should be spread under shade for 1 hrs before use particularly polyester-made LLINs.

• If there is any hole in bed net it must be replaced when with new one. However, if new one is not available it must be repaired immediately.

• Never use torn or broken bednet for dengue patient.

• For best use of LLINs Directorate of Malaria Control has already developed “Guidelines for use of LLINs at community level” which can be download from www.malariaR7.com.pk

2.5.3 Cloth Treatment

Aedes mosquitoes can also bite through cloths particularly when they are skin tight.

**Treatment of cloths with quick-acting insecticides of pyrethroids group such as “Permethrin” can be the best choice to prevent the Aedes mosquito bites.**

Though these compounds don’t repel the mosquitoes but allow them to make contact with fabric and irritate or kill them before they manage to bite. Some of the other pyrethroids like “cyfluthrin” can also be effective however this product degrade quickly in sunlight. Similarly, if the clothing is treated with non-repellent pyrethroids, mosquitoes including dengue vectors can bite on uncovered skin, necessitating the application of repellent to skin. Synthetic insecticides should generally be preferred to volatile repellents for clothing treatment because;

• They are most feasible and effective during dengue out break and peak breeding season of other mosquitoes.
• Act quickly and repel or kill Aedes mosquitoes quickly.

• Cloth treatment is also best choice for dengue patients when they are not using LLINs.

• Permethrin is the best insecticides to treat cloths because of is safe, economical, low odor, safe for fabrics and effective against all public pests including dengue vectors, when label instructions are followed.

• Long sleeve shirt (Kameez) and Doupatta/Chaddar of female (PW) can be treated with this insecticide at the recommended dose of 1.25mg/m² during outbreak of dengue.

• They are long lasting and effective up to 10-12 washes in cold water. However, washing of treated cloths in hot water and during peak transmission period should be avoided.

• Preferably retreat the clothing with Permethrin after every 5 washings.

• To avoid any irritation on skin, it should be applied at right dose mentioned above.

Since these synthetic pyrethroids are non-volatile in nature, therefore there is risk of attack of mosquitoes to bare part of body. Therefore during dengue outbreaks or peak transmission period the use of volatile repellents should be preferred. They remain effective on cloths up to a week. Treated cloths also provide protection against biting midges, fleas, sand flies, and body lice etc.

2.5.3.1 How to treat clothing

The clothing can be treated with Permethrin by spraying the insecticides from a pressurized can or by soaking in an aqueous emulsion. The recommended dose for long sleeve shirt is 1.25mg/m².

2.5.4 Protective cloths

During dengue outbreaks or peak breeding of dengue vector mosquitoes the protective cloths can offer one of the best protections against their bite particularly when cloths are thick and loose. These cloths should especially be used at night and in the early morning hours when mosquitoes are most active.
Operational Guidelines for Efficient Use of Protective Cloths

Following important measures should be adopted during dengue transmission period particularly outbreaks;

- Wear long sleeves while sleeping particularly during day time.
- Wear the sock and also cover other exposed body parts.
- Use full trousers.
- Loose fittings.
- Light color clothing should be preferred.

These cares are particularly recommended for dengue patients (both confirm and suspected) and even for children <5 years of age and pregnant women against malaria.

2.5.5 Screening of Houses.

- Vector-proof screens on doors and windows should be promoted to prevent the entry of dengue vector(s).
- Screen of mesh size 150-170/ inch² or 25-30/cm² should be used to prevent entry of dengue vectors.
- In case of tent, net with same mesh size should be hanged at entrance.
- In case of any damage to screen, it should be repaired quickly well before dengue transmission period.

2.6 USE OF CHEMICALS

Use of chemicals for public health vectors control is one of the key elements for any successful VBD control program worldwide and Indoor Residual Spraying (IRS) has always been given top priority particularly during past few decades.

Despite the importance of use of chemicals for VBD control, the indoor residual application of insecticides has very little impact for long-term control of DF/DHF. Therefore, the use of insecticides should be discouraged as a long term strategy against DF/DHF.
However, experiments on control of *Ae. aegypti* in several countries has shown that thorough indoor treatment at an interval of 1-2 weeks with portable fog generator produced significant control of *Ae. aegypti* and subsequent disease transmission.

Pakistan, since the commencement of global malaria eradication program solely dependent on the use of chemicals for vector control, with indoor residual house spraying as the main intervention. However due to withdrawal of external support and less supports from Government side particularly since late 1980’s vector control activities are being carried out on very limited scale and without effective guidelines and long term policies. Currently the lack of trained entomologists, quality assurance, and effective monitoring and evaluation mechanism for vector control interventions are the major challenges for the control of VBDs including dengue which requires serious and systematic efforts to keep the VBDs under control. In general, chemical control can be divided into two major operations i.e. larviciding and adulticiding.

**2.6.1 Larval Control (Larviciding)**

Best method to control vector mosquito densities and disease transmission is to find and eliminate or alter their breeding places and this intervention should be the backbone of any good dengue vector control program. However, the mosquito breeding sites that are undesirable or impossible to alter or eliminate should be treated with an appropriate larvicide. Generally the larvicides should be applied after;

- Careful breeding sites assessment survey
- Specifically after the evaluation of resistance level against in-use larvicide(s)
- At site where proper *target life-stage* of mosquito larvae are present.

Overall the degree of success of larviciding depends on physio-chemical and biotic characteristics of habitat which include amount of pollution (inorganic) and the type and amount of vegetative cover present. For most efficient larviciding program, treatments must be repeated at fairly short cycles which may vary from 7-10 days (3-4 cycles per month). Normally larvicides should be carrier out for at least 2 months for both nuisance and vector mosquitoes.

Since both dengue vectors species *A. aegypti* and *A. albopictus* have significant association with clean domestic water domestic habitats like underground water tanks,
earthen pots, drums and buckets placed under shaded place inside of house, therefore larviciding program for their control should be different as that of malaria vectors. Normally larviciding for malaria vector control should be focused only to those water bodies which are close to human population (within 1km radius). For malaria vector(s) larval control, Directorate of Malaria Control (DoMC) has already circulated national guidelines in 2008 and 2009 which can be download from www.malar iar7.com.pk. National and international entomological data revealed that proper covering of these domestic water holding containers impart a direct impact on the reduction of densities of both species. However the use of larvicides in these habitats (particularly in underground water tanks) should also be a top most priority for better management of dengue vectors. For best dengue mosquito control keeping in view long-lasting efficacy following are recommended larvicides;

- Pyriproxyfen (Sumilarv 0.5G), Methoperene, Diflubenzuron (IGR). Most economical.
- Bacillus Thuringienensis (B.t.i), B. israelensis (B.s).
- Temephos/Abat. However, its use is strictly subjected to available information of resistance level of local A. aegypti species.

Details of these products will be discussed in section 8.2. For proper use, all label directions for mixing, application rates, and precautions should be carefully read and followed particularly when use for drinking water. List of WHOPES-Recommended larvicides has been given at table 4.

2.6.2 ADULT DENGUE MOSQUITO CONTROL (Adulticiding)

The adulticiding through indoor residual application is less efficient and has very limited impact for long-term control of DF/DHF. Adult dengue vector(s) control only be used for supplemental or emergency purposes as a part of Integrated Vector Management (IVM). Adult dengue vector control comprise of following two components ;

2.6.2.1 Space spraying/Treatment

A space spray–technically called fogging (sometimes also called aerosol) – is a liquid insecticide (diluted or pure) dispersed into the air in the form of hundreds of millions of tiny droplets of >50 μm in diameter with very little or no residual effect. Space treatment is only effective when
insecticide droplets form clouds which remain airborne and have direct contact with target vector(s) species. The major aim of space spraying is to achieve a rapid decline of vector(s) populations through knock-down effect and mortality and subsequently interrupt the transmission cycle of VBDs including dengue.

**Since space spraying may not be ideal for all vectors or situations and may not be an economical method of control, therefore this intervention is not recommended for routine vector control operations.**

To be cost-effective, space spraying should be considered as epidemic contingency measure particularly during dengue outbreak or complex emergencies (IDPs). For efficacy and sustainability, following information about target vector(s) species must be gathered;

- Behaviour and biology: peak activity time of target vector(s)
- Insecticides and formulations: most suitable for space spraying
- Targeted vector(s) resistance level against insecticides
- Application technology: which equipment is needed and how to use it
- Monitoring and evaluation of intervention(s): evaluate the efficacy of the programme
- Definition and characterization of human population: density, type of dwellings/buildings, road layout, vegetation and accessibility

These basic informations will assist in determining the most appropriate space spray application method(s), choice of insecticides, equipment and application timing, areas to be treated. Space treatments are applied mainly as Thermal fogs or Cold fogs.

**2.6.2.1.1 Thermal Fogging**

The insecticide used in thermal fogs is diluted (LV or HV) in a carrier liquid, which is usually oil-based. Thermal fog generators break up the insecticide by means of hot gases or superheated steam decreasing the viscosity of the oil carrier, and vaporizing it. When it leaves the nozzle the vapour hits outer colder air and condenses to form a dense white cloud of fog or smoke. The size of most of droplets is smaller than 20 μm in size and remain airborne. This droplet size is affected by the interaction between the formulation, the flow rate and the temperature at the nozzle (usually >500 °C). The hot emission gas is obtained from engine exhaust, friction plate/engine exhaust or from a pulse jet engine. Thermal fogging has many advantages which include; visible fog
whose dispersal and penetration can be easily observed and monitored; Community satisfaction as people can see something being done to solve problem; low concentration of active ingredient in spray mixture which minimize operator exposure.

2.6.2.1a Indoor Fogging

For endophilic vector mosquito control, particularly for dengue vectors, the space spraying during emergencies situation or outbreak should also be an important component of vector control operation. However, it should be concentrated inside houses with the help of hand portable fog machines. Reports from many countries revealed that indoor fog applications at an interval of 7-10 days with handy fog machines complimented with vehical-mounted applicators have produced significant control of Ae. aegypti. However, currently with the increased use of ultra-low volume (ULV) cold aerosol application techniques, thermal fogs have become less desirable.

Operational Guidelines for Indoor Thermal Fogging

- All electricity must be switched off at main/master switch before start of operation.
- All heating and cooking equipments including pilot light (and allow them for a cool down) also be turn off before operation.
- To reduce the risk of fire, water-diluted products should be used.
- All foodstuff and water containers must be properly protected.
- During dengue outbreak fogging should be done (preferable at dawn) on alternate days during 1st week of outbreak and later on every 3rd - 4th day for whole month. During 2nd month the operation should be conducted on weekly basis.
- For indoor fogging, a team of 2 persons should target 75-100 houses per day
- The person operating machine should move backwards and away from fog to minimize the exposure.
- Other persons should assist in moving furniture, exposing hidden sites and guide the spray man through tight spaces.
• For small single-storey house, the spray can be delivered from front door or through open window without having entry to every room, provided that adequate dispersal of insecticides have achieved.

• For large single-storey building, fogging should be carried out from room to room beginning at back of building and moving towards the front.

• For multi-storey buildings, operations should be started from top floor to ground and from back of the building to front.

• Before fogging, windows and doors (tents also) should be closed and keep them closed for at least 15-30 minutes to ensure the maximum efficacy.

• Residents and pets should move out.

• Before entry of home, ventilation of home/building must be ensured.

• Size of an average household/building (in m$^2$) first should be estimated and volume of diluted spray required should be prepared according to manufacturers’ label recommendations. The “Flow Rate” of machine (ml/minute) should be checked so that average time required to treat the home/building should be calculated and fog machine operator should be informed and trained.

• A fog must be “dry” before going in to house/building. To check it place the machine on ground and check the area immediately in front of nozzle is not wet. To reduce the production of large wetting droplets, obtain the correct balance between flow rate and combustion temperature, usually by reducing the flow rate.

2.6.2.1.1b Outdoor Fogging

For outdoor fogging operation, maps of area must be prepared to facilitate advance planning of spray routes. If suitable maps of the area are not available these must be prepared. The total area in hectares (1 h=10,000 m$^2$) should be calculated and then the options for spray routes must be established. The route distances and vehicle or walking speeds should be calculated so that the correct dosage can be applied.
Operational Guidelines for Outdoor Space Treatment

- One day before operation, there should be an announcement about the purpose and schedule of operation and how community can cooperate and also community should be advised to keep open doors and windows during outdoor fogging operation.

- To alleviate public concerns, information should also be provided about the safety of the treatments and may include some specific advice(s).

- Outdoor space spraying must be conducted at the time of peak activity of adult dengue vector(s), preferably at dawn and dusk.

- It should be implemented in a compact community and should be within 500-1000 meter radius of affected areas.

- First prepare plan with respect to layout of streets and wind directions.

- Fogging should be done perpendicular to the wind direction (figure). While using vehicle mounted fog machine, speed of vehicle must be maintain at 5-8 km/hr.

- The downwind side of spray area should be treated first, working systematically from downwind to upwind as shown in figure.

- To avoid driving into spray cloud, dead-end road must be sprayed only on way out.

- During outbreak of dengue, fogging should be done (preferable at dawn) on alternate days during first week of outbreak and later on 3rd day for next 2-3 weeks.

- Finally there should be 4 cycles/month during the epidemic/emergency situation and operation should be continued for at least 2 months.

- For vehicle-mounted equipment, in areas where the roads are narrow and houses are close to roadside, the spray should be directed from “Backwards” from vehicle.
• In areas with wide roads and building far from the roadside, the spray should be directed at an “Angle (downwind)” to the road rather directly behind the vehicle.

• The nozzle of vehicle-mounted thermal fogger should be directed horizontally.

• Spray must be turned off when vehicle is stationary.

• Outdoor fogging operation should not be carried out when:
  - Wind speed is >10 km/h.
  - Day time heat is >28°C.
  - Wind speed is less than 3 km/h.
  - Relative humidity is >85% (during/immediately after rains).

• Operators must be well trained in the safe use and maintenance of the equipment as well as in the safe handling and application of insecticides.

• All personnel involved in space treatments must be provided with protective equipment including overalls and respiratory and ear protection equipment.

• All equipments must be calibrated according to manufacturer’s instructions well before use.

• Strictly follow the dose criteria of manufacturer mentioned on label.

2.6.2.1.2 Cold Fogging OR Ultra-Low Volume (ULV)

*Ultra-Low-Volume (ULV)* spraying is the application of formulated product without any further dilution against flying adult vector(s) including dengue vectors. If the insecticide is diluted the application will be considered low volume (LV) or high volume (HV) as in case of indoor residual treatments (IRS) and thermal fogging. Insecticide concentration varies depending on the amount of active ingredient in formulation, ranging from 2% in case of some pyrethroids to 95% with the organophosphates (OP). Since these applications do not target the eggs larvae or pupae, therefore sequential applications are necessary to control adults emerging from immature stages.

ULV application method is very cost-effective and is rapidly getting popularity among mosquito control organizations throughout the world particularly during emergencies.
and outbreaks. ULV generators produce a very tiny droplet of high concentrate insecticide by mechanical breaking up either by passing it through high-pressure nozzles or by passing a slow stream of the mixture through a high-velocity vortex of air which results in a greater area coverage with less dosage. Like the thermal fog generator, the cold aerosol machine should be used at time when adult dengue mosquito is most active i.e. dawn and dusk.

ULV or cold aerosol method has certain advantages over thermal fogging. Less insecticide is applied, resulting in less pollution problems. Smaller holding tanks and consequently smaller vehicles are needed. No traffic hazard when compared to near-zero visibility created by thermal foggers. However, ULV ground applications are somewhat less effective than thermal fogs in areas with heavy vegetation.

**Operational Guidelines for ULV or Cold Fogging**

- ULV applications should be avoided in thickly vegetated areas.
- The nozzle of vehicle-mounted “cold fogger” should be directed upwards when there is barrier that impedes airflow. (Horizontal in case of thermal fogger).
- Dose criteria of manufacturers, proper mixing instructions, application rates, and precautions, all label directions should be read carefully and followed strictly.
- Other operational precautions are the same as mentioned in section of thermal fogging.

**N.B:** *Blood cholinesterase of operators must be monitored on regular basis, if organophosphates compounds are used during space spraying.*

List of WPOES—Recommended insecticides for space spraying has been given at table 5.

### 2.6.2.1.3 Aerial Application

Aerial spraying can be used to treat large areas quickly and can be carried out when field conditions prevent wheeled vehicle access. It mainly used in agricultural lands, however, for the control VBDs its use is very limited and only to those areas where vector(s) are exophillic and breeding and resting sites cover huge areas. During aerial application, careful consideration must be given to local metrological factors that include high
wind speed and direction, temperature inversion, relative humidity that may limit treatment application. Whilst trees, waterways, environmental considerations and overhead power lines further prevent some fields from being treated. Vortices created by the aircraft passage will also greatly influence spray distribution efficiency. Environmental contamination can be significant if spraying deposition on target sites is not accurate. Ideally aerial treatments should be often late in evening to take the advantage of any inversion and to allow droplet to fall from a higher release height to where the disease vector(s) are flying.

**Operational Guidelines for Aerial Application**

To be environmentally and technically effective, aerial application for the control of public health pests should only be done when;

- Vector(s) are exophillic, breeding and resting sites are huge in size and away from human settlements
- Time of peak activity (exposed) is dawn and dusk
- Surface wind speed is 1-2.5 m/s. or <10 km/h. When the wind speed is <3m/s, boom height of 2-3 m above the surface will ensure good lateral movement of the spray
- Crosswind, flying speed and application rate are constant for both flight directions.
- At low relative humidity 70% (+5).
- Availability of smooth or uniformly leveled area (at least 1 km).
- Ground temperature is <30°C. (Higher temperature prevents the spray cloud settling within the treated area).

**In Pakistan, aerial application for control of dengue and other vectors of public health importance is ABSOLUTELY NOT A FEASIBLE OPTION because;**

- Major public health vectors particularly dengue vector(s) are exclusively endophilic.
- Breeding/resting sites are small, within human settlement (in/around house).
- Unavailability of smooth area etc.
- Breeding of vector mosquitoes in domestic drinking water sources.
2.6.2.2 Indoor Residual Spraying (IRS)

Indoor Residual Spraying (IRS) is an application of dilute solution of insecticides having residual efficacy on the walls of houses or dwellings to kill mosquitoes and other vectors of public health importance. IRS is designed to interrupt disease transmission by killing adult female mosquitoes when they enter houses and rest on the walls after feeding and before they can transmit the infection to another person. To ensure their long lasting efficacy, walls must be made from porous materials such as mud or wood but not plaster as in urban dwellings.

IRS is a commonly-used malaria vector control method that is particularly effective in preventing malaria epidemics. For dengue vectors control IRS as routine activity is generally not highly recommended intervention particularly during outbreak. However, it can only be limited to dengue confirm household and its nearby surrounding houses.

Overall for long-term prevention and control of DF/DHF IRS is generally not recommended. However it must be use as part of IVM strategy.

Operational Guidelines for IRS

For dengue vector control, following points for IRS should be considered;

- ONLY WHOPES-tested insecticides of recommended manufacturer(s) will be used and promoted for spraying. List insecticides and Reports of the WHOPES Working Group Meetings (available at http://www.who.int/whopes/recommendations/wgm/en/) which should be consulted for guidance on use and recommendations. List of WHOPES-Recommended insecticides attached as table 3.

- During outbreak, IRS should mainly focus on schools, hospitals and offices and other public meeting places

- Special mobile squads (Rapid Response Teams: Entomologists, Malaria Superintendent, M. Supervisors, CDC Officer etc) should be raised to carry out
vector density surveys in district by involving district government staff and logistics.

- In case of confirm case of dengue, 6-8 surrounding houses should also be sprayed thoroughly with residual insecticides.

- Verandas, porches and all sleeping rooms, stores, bath rooms should be sprayed thoroughly. Ceilings of rooms must also be sprayed along with walls.

- Doors and windows from inner side and undersides/behinds of furniture boxes should also be sprayed.

- Treatment of curtains with insecticides particularly from backside will also be useful to control dengue vectors.

- After spraying, room should be closed for at least half an hour.

- Keep the children and animals away from room during this period.

- Never leave any food item inside room during spraying and always transfer food item insides at least after 1 hour of spray.

- Never clean (broom) the wall after spray.

- A black cloth sheet (CHADDAR) in corners of in treated rooms can be hang and spray it thoroughly which will also give vectors mortality resting inside during day time.

- There is no need of spraying in open air/sunlight, on water or on debris/garbage.

- The insecticides with longer residual efficacy should be preferred.

- The recommended dose criteria of manufacturer should be strictly followed.

### 2.6.2.3 Selection of Insecticides

Selection of insecticides for vector control operation including dengue vectors is most crucial for success of intervention(s). When choosing an insecticide product, consideration must be given to the following points;

- Resistance level of local vector(s) species against insecticides. Selected insecticides should not be used where site-specific insecticide resistance has been reported.

- Relative toxicity to man and domestic animals.
- Cost effectiveness.
- Availability in quantities needed.
- Chemical stability.
- Easy handling.
- Corrosiveness and
- Offensive odor, staining etc.

**Standard:** As per national policy ONLY WHOPES-tested insecticides of recommended manufacturer(s) will be used and promoted for spraying.

World Health Organization Pesticides Evaluation Scheme (WHOPES) recommends a number of insecticides for individual residual spraying: DDT wettable powder (WP); malathion WP; fenitrothion WP; pirimiphos-methyl WP and emulsifiable concentrate (EC); bendiocarb WP; propoxur WP; alpha-cypermethrin WP & suspension concentrate (SC); cyfluthrin WP; deltamethrin WP; etofenprox WP; lambda-cyhalothrin capsule suspension (CS) and WP. List of insecticides, formulations and dose criteria recommended by WHOPES can be found on [http://www.who.int/whopes/recommendations](http://www.who.int/whopes/recommendations).

### 2.7 ENVIRONMENTAL MANAGEMENT (EM)

Environmental Management (EM) for vector control refers to any modification in environment which deprives the vector population of its requirements for survival, thus reducing *man-vector contact* and subsequent transmission risks. If such measures result in long-lasting or permanent changes in environment, they are called as *environmental modification*. When such measures have a temporary effect and need to be repeated, they are known as *environmental manipulation*.

Though on large scale particularly during rainy season, EM is not effective and feasible option, however very effective at home level. Therefore, home level EM should be top most priority and in this regards following are important strategic directions for control of public health vectors breeding;

- Remove the stagnant water by;
  - Fill the ditches with soils.
  - Drain out water in nearby water course/channel.
- Application of used mobil oil to cover unusable water bodies.
- Cover the water storage containers properly.
- Elimination of hiding resting places by;
  - Sealing of cracks and crevices.
  - Removal of unnecessary grasses and weeds particularly in around houses.

Since both vectors of dengue, particularly *A. aegypti* breeds inside house in clean water habitats, therefore the acceptance and adopting of EM strategy by house owners can greatly helps to prevent their breeding. Following are some of the EM activities which are extremely useful for dengue vector(s) control;

### 2.7.1 Solid Waste Management

Dengue mosquitoes do not need big water bodies to lay their eggs and complete their life cycle. Very small water collections such as in abandoned cans, jars old tyres, pieces of plastic bags, and plastic boxes, buckets, drums, and bottles that retain clean water can provide breeding grounds to dengue mosquitoes.

**Operational guidelines for Solid Waste Management**

- All above mentioned solid wastes should be disposed off quick and safely.
- Old tyres should be kept under shed to prevent the accumulation of rainwater and subsequent breeding of mosquitoes.
- Such dumping places for types must be regularly monitored.
- Local authorities/municipalities should play leading role in this regards through Health Promotion Campaign and also strict legislation.
- *Clean-up* and other public hygiene campaigns should be organized on regular basis in all community settings, particularly before transmission period and also during outbreak.
- Participation by municipal sanitation bodies and Public Health Engineering departments should be encouraged also to assume a leading role in the implementation of these clean-up campaigns.

### 2.7.2 Source Reduction and Habitat Alteration
Many mosquito-related health problems can be permanently solved by elimination or alteration of mosquitoes breeding grounds. Such practices not only deprive larvae of nutrients but also to provide an environment unfavorable for their survival. No special expertise particularly on a small scale is needed and communities can carry out such work at their own level.

**Operational Guidelines for Source Reduction and Habitat Alteration**

- Outdoor faucets and pipes etc should be repaired
- Desert room coolers, refrigerators tray etc should be emptied when not in use.
- Change the water in bird baths and fountains at least once a week.
- Before refilling of money plant vassals/bottles, these must be washed vigorously and water should be poured at dry place to destroy larvae, pupae and eggs particularly.
- All underground water tanks, drums, buckets, earthen pots etc must be covered properly, particularly after taking water out or refilling.
- Use of mosquitofish should be encouraged in these underground water tanks.
- No hole should be made in lid or covering of underground water tank as shown in picture (Figure).
- Regular removal of floating debris from household ornamental ponds, fountains, bird baths etc.
- Remove debris from drain particularly from those covered by metallic frame to ensure continuous flow of water (Figure).
- Remove emergent grasses and vegetation from/along the margins of lakes and ponds.
- Also ditch and clean stagnant streams watercourse, water channels to ensure a continuous flow of water.
- Fill in low areas in yards to discourage puddles.
- The use of Expended Polystyrene Beads (EPSB) in habitats having permanent underground water collections like wells, underground tanks, chocked manholes and septic tanks, temporary rainwater pools, cisterns, overhead tanks, and unused wells should be encouraged for control of dengue vectors on long term basis (Figure).
- The EPSB can be applied to confined and stagnant permanent/semi-permanent water bodies that can not be drained off, or difficult to use larvicides.

- However, the use of EPSB should be avoided to water surfaces which are subjected to wind currents (as slight breeze can drift them away exposing the water surface for mosquito oviposition). And also not interfered much by humans or animals.

- District Surveillance Officer (entomologist) must visit regularly the sites of constructions to control the breeding sites created during construction.

- Local authorities must make sure the regular water supply to discourage prolongs water storage for domestic use.

### 2.8 INTEGRATED VECTOR MANAGEMENT (IVM)

Vector control has proven highly effective in preventing disease transmission around the globe. However, for complete prevention of disease, vector control intervention(s) should be supplemented by drug-based intervention(s). Similarly implementation of single vector control intervention will not give its desired results and ideally one or two even more interventions should be used simultaneously and also through involvement of different line departments. This approach called Integrated Vector Management (IVM) which is now being endorsed as the recommended strategy to exploit the preventive power of vector control in cost-effective, sustained and ecologically sensitive ways. IVM in a broader sense can be defined as “evidence-based decision-making procedures aimed at planning, implementing, monitoring, and evaluating targeted, cost-effective, and sustainable combinations of vector control interventions.

**IVM is based on principal that effective sustainable vector control is not the sole responsibility of the health sector but requires the collaboration of various public and private agencies, line departments and community participation.**

Implementation of IVM requires institutional arrangements (preferably at Central/National level), regulatory frameworks, decision making criteria, and procedures that can be applied at the lowest administrative level.

Cost effectiveness of vector control measures is the “Central Point” of IVM. WHO is promoting the use of IVM for control of VBDs, supporting encouraging member countries to implement IVM in following strategic areas;

- Introducing IVM into national health policy.
• Conducting a needs assessment to identify vector control gaps in term of human and logistics.

• Conducting a national consensus workshop to promote partnership with other line departments, agencies for smooth implementation of IVM.

• Integration with other disease vector control programs for maximization of cost-effectiveness and synergy. For example the use of identical vector control methods to control malaria and leishmaniasis in rural areas, or malaria and dengue in urban areas.

• Developing technical country-specific guidelines for implementing IVM.

• Increasing capacity to conduct operational research.

Pakistan being a subtropical country, has a rich fauna of public health vectors which include mosquitoes, sandflies, houseflies, ticks, fleas, cockroaches, bed bugs and major VDBs are malaria, dengue, and leishmaniasis which are showing continuous rising trend in country. However, only Malaria Control Program (MCP) has an organized vector control component and there is no other specific institute/department in Pakistan for the control of vectors of leishmaniasis, dengue, and also bedbugs, ticks, human mites, fleas, houseflies etc. Currently vector control operations (mainly IRS) are being carried out on limited scale individually by different departments (mainly by Municipal Corporations) without any coordination, planning, effective guidelines and long term policies. The National Institute of Health (NIH)-Islamabad, which is a premier institute of the country, has an Epidemic Investigation Cell which deals with all types of epidemics due to infectious diseases including VBDs. A separate entomology unit also functioning in this institute. Likewise Pakistan Medical Research Council, various universities and NGOs conduct research studies on various disease vectors in the country. There is however, a strong need for collaboration and coordination for implementation of IVM strategy which is currently lacking in Pakistan. Similarly keeping view of rising trend of dengue/DHF in Pakistan particularly since 2005, there is an urgent need (i) to establish a separate “Dengue Control Cell” within the Ministry of Health as a part of overall health system strengthening, focusing the implementation of IVM strategy in Pakistan.
Guiding Principles for Development and Implementation of IVM for Dengue Vector Control in Pakistan

- Being economically feasible, cost-effective, sustainable, environmentally sound and socially acceptable, IVM is must be an essential element of dengue vectors control at all level in country.

- Active involvement of other sectors than health sector (agriculture, irrigation, livestock, education, defence, municipalities etc) with defined roles and responsibilities for IVM initiative.

- There must be strong advocacy initiatives to ensure political commitment for IVM to develop appropriate policies and legislation, enhance community participation and mobilization of human and financial resources.

- A strong partnership should be established to mobilize public and private sectors, together with civil society, NGOs and donors, to optimize allocation of resources and effective implementation of IVM for dengue vectors control.

- National as well as provincial IVM strategies and plans of actions based on regular vector control needs assessment for dengue should be developed as soon as possible, identifying needs, gaps (programmatic and financial) and opportunities for dengue vector control.

- There must be a nominated qualified and competent national as well as provincial Focal Person for dengue vector control with comprehensive understanding of principles of IVM.

- There must be allocation of a specific budget for IVM to ensure the deployment of appropriate technical and human resources at all levels.

- Operational research should be one of top priority to provide relevant information for formulation of evidence-based interventions, including rationale use of insecticides.

2.9 BIOLOGICAL CONTROL

2.9.1 Use of mosquitofish

Use of mosquitofish is a cost-effective and environment-friendly biological method of mosquito control. These fish are small with size range of 0.5-
3.0 inches, can eat up to 200 mosquito larvae in a day when used properly or correctly. Currently many mosquito control programs are using this intervention as one of the main defense-line against mosquito breeding without harming the ecology of area or the fauna of indigenous fish and amphibians. Worldwide Gambusia (Gambusia affinis) and Guppy (Poecilia reticulate) are being used extensively in many mosquito control program after careful and intensive mosquito breeding sites assessment surveys. However, globally, there is always a big debate over the efficacy of mosquitofish and it is strongly recommended not to release mosquitofish in wider habitats like ponds, lakes etc.

Mosquitofish are effective and successful when used in small clean water habitats like household water tanks, small public ponds, ornamental ponds, animal water troughs, bird bath fountains, big money plants vassals, unused and broken swimming pools which are free from excessive organic and non-organic materials.

Large ponds always have excessive organic materials that include leaves, grasses, dropped branches and flowers etc. Such habitats also have green plant algae which maintain the oxygen balance in pond and also serve as a good source of food for fish. However their heavy accumulations consume more O₂ through excessive and rapid decomposition adversely affecting the efficacy of mosquitofish to consume mosquitoes’ young ones. Among non-organic characteristics, Biochemical Oxygen Demand (BOD), Electro-conductivity (EC), Total Dissolve Salts (TDS), and ammonia (NH₃) level etc also results in poor performance of mosquitofish and also in adverse conditions a rapid death of mosquitofish.

In Pakistan surface water bodies like open ponds have extremely higher concentration of organic and non-organic pollutants and these physio-chemical and biotic characteristics favor the breeding Culex quinquefasciatus, Cx. pipiens and also Anopheles subpictus while these characteristics of habitats also completely prevent the breeding of both dengue vector species A. aegypti and A. albopictus. On the other hand, open and large habitats having clean water like rice field, commercial fish ponds, and irrigation channels support the breeding of Cx. tritaeniorhynchus, Cx. bitaeniorhynchus, Cx. pseudovishnui, Cx. vishnui, A. culicifacies, A. stephensi, A. pulcherrimus, A. nigerrimus, and A. barbirostris etc in Pakistan but again no breeding of both dengue vectors particularly A. aegypti.

Similarly, these organically pollutant habitats also have many mosquito-larvae eating insects like giant water bugs, water beetles, diving beetle, dragonfly larvae, water scorpions, water boatman, and backswimmers, and tadpole etc in Pakistan. Their
natural presence particularly of water beetle, diving beetle and dragonflies in such habitats show considerably more effective control on mosquito breeding than introduced *Gambusia*. When mosquitofish will be released in such habitats they will eat other insect youngones instead of mosquito larvae. Therefore mosquitofish will not drastically reduce mosquito breeding in large water bodies rather these fish has a detrimental affect on other mosquito-eating insect and overall on ecology of local area. Many studies in world proved that mosquitofish are only effective when used in small ponds where other aquatic fauna is limited and mosquitofish have no choice other than mosquito youngones. During 2005-2010, comprehensive field investigations on vector mosquitoes in Pakistan did not report any notable breeding of *A. aegypti* in open habitats like such ponds. However, a limited breeding of *A. albopictus* was reported from some open habitats having fresh and clean water.

*Tilapia* fish has a wide range of feeding preference on both animal and plants (omnivorous) and if the habitats has heavy accumulation of vegetations and other insects’ larvae, it will ultimately reduce the predatory potential Tilapia fish on mosquito larvae. Other two kinds of mosquitofish available in our eco-system are Gambusia and Guppy which are mainly carnivorous (eat animals). However it is well documented that their food preference, particularly of *Gambusia* depends on the availability of food items rather than choice which also compromised their efficacy in big organically polluted water habitats.

**Operational Guidelines for Use Mosquitofish for Dengue Vector Control**

- Mosquitofish must be released after very careful and intensive mosquito breeding sits assessment surveys.
- Physio-chemical BOD, EC, pH, TDS, and NH$_3$ concentration and biological parameters must be thoroughly studied before the release of mosquitofish.
- Mosquitofish should only be use in small clean water habitats like household water tanks (most attracted breeding place of *A. aegypti* in Pakistan) small public ponds, ornamental ponds, animal water troughs, bird bath fountains, big money plants vassals, unused and broken swimming pools which are free from excessive organic materials.
- Since underground cemented water tanks are most attracted breeding site for *A. aegypti*, therefore introduction of mosquitofish (1-2 pairs) should be high priority intervention in such habitats.
• Mosquitofish should not be released in wider habitats like open big ponds, lakes etc. having heavy accumulation of organic pollutants.

• *Gambusia* and *Guppy* (carnivorous) should be preferred on *Tilapia* fish (omnivorous).

A. Habitats where mosquitofish should NOT be released

| Large organically polluted habitats |

B. Actual habitats for release of mosquitofish

| Small habitats with clean water |


### 2.9.2 Bacillus Thuringiensis (*Bti*) B. israelensis, B. sphaericus

*Bacillus thuringiensis var israelensis* (or *B.t.i.*) and *Bacillus sphaericus* (B.s.) are live bacterial spores that produce a toxin when it comes in contact with mosquitoes’ larval gut, infect and kill them. *B. sphaericus* is a relatively new bacteria larvicidal product that is very effective against *Culex* mosquitoes for up to 20-25 days. *B.t.i.* provides control over a wider range of mosquito genera and habitat types. A product that combines both *B.t.i.* and *B. shaericus* produce an additive toxic effect for controls of multiple mosquito genera in the same breeding habitat.

These bacteria are highly selective, killing only mosquitoes and their close relatives like gnats and black flies and do not harm other kinds of insects, fish, birds, worms or any mammals. However, *B.t.i.* must be ingested by the larvae in sufficient concentration to cause death by disruption of the function of the larval midgut. When sufficient quantity of *Bti* is eaten by the mosquito larvae, they damage the gut cells and quickly paralyze them, then kill the larvae quickly and efficiently. A moderate to heavy dose can reduce 50% mosquito population in 15 minutes and the rest within 1 hour. It is very important to note that *B.t.i.* is no longer effective after the larvae turn into pupae, because they stop eating.

### 2.9.3 Synthetic Insect Growth Regulators
Insects Growth Regulators (IGRs) are hormones that prevent the larvae from eventually molting to adults mosquitoes. Pyriproxyfen and Methoprene are the most commonly used synthetically produced IGRs which provide 90-100% control of emergence of adult mosquitoes without any negative environmental impact.

**Operational Guidelines for Use of Biological Products**

- Apply B.t.i and B.s after careful assessment of life stage of mosquitoes in a habitat i.e. only applies during first 3 instars of larval stage.
- Don’t apply B.t.i at **pupal stage** because they stop eating.
- Disperse these products by hand or drop through aerial application when large area need to be treated.
- B.t.i. is one of the least toxic materials available for larviciding and is usually effective for ground application.
- A product that combines both B.t.i. and *B. shaericus* should be preferred for better controls against multiple mosquito genera breeding dame same habitat. However, it is more costly and not cost-effective intervention for dengue vector control.
- Due to its stability, Pyriproxyfen (available brand Sumilarv 0.5%G) is most preferred IGR in our local environmental condition.
- Due to long lasting efficacy and safety, Pyriproxyfen (Sumilarv 0.5%G) can also be used in drinking water particularly at home level (WHO/PCS/01.6).

## 2.10 CAPACITY BUILDING

Currently vector control personals at all levels have very limited capacity for indoor residual spraying, larviciding particular for the implementation of IVM strategy according to WHO standard. It has also been noticed that most of staff involve in vector control never received any training for vector control throughout their career. Mostly insecticides are being applied through hired labor on daily wages and also without any specific criteria of selection of target areas for application. Currently there is no mechanism of monitoring and evaluation of intervention due to budgetary, staff and other logistics constrains. The recent outbreaks of DF/DHF worsen the situation just because of lack of entomologists and lack of basic training for mosquito control. This issue requires
immediate and systematic steps giving top most priority to enhance the vector control capabilities of currently working personals in malaria control programs, municipalities etc with a view to implement the preventive measures effectively on large scale for reduction of VBDs incidence in Pakistan.

**Operational Guidelines to Enhance Capacity of Vector Control Personals**

- There must be sufficient allocation of budget in provincial and district annual plan for capacity building of field staff.

- Regular field demonstrations for IRS, larviciding, bednet use, DEWS as a part of capacity building initiatives should be included in provincial/district implementation plans.

- Provincial health department in general and districts particularly must designate “Permanat and Regular” teams after comprehensive and intensive trainings for vector control interventions.

- Provincial health departments must develop a competent team of Master Trainers for vector control which have full understanding of IVM strategy. For sustainability of the initiative and also to trickle down the impacts of these capacity building programs, these Master Trainers should conduct training at district level from their provincial resources.

- Newly recruited malaria staff must get at least one month training before deployment at field. In this regards, National Institute of Malaria Research and Training (NIMRT)-Lahore, Institute of Public Health (IPH)-Lahore, Health Services Academy (HAS) must play their pro-active role.

- All “In-Service” staff must get one Refresher Course for vector control intervention in each year at NIMRT/IPH/HSA.

- Technical Assistance (Resource person(s) from Federal Directorate of Malaria Control must be sought out in this regards.

- The members of Technical Working Groups (TWGs) should also be included as resource person(s) for these capacity building initiatives.

- There must a “Consultative Workshop on Vector Control Guidelines” for upgradation at national level (Directorate of Malaria Control) through participatory approach with provinces and other stakeholders on every second year.
• Establishment of *Entomological Reference Laboratories* at provincial headquarters to act as central point for capacity building of districts-level vector control staff. Federal Directorate of Malaria Control has already circulated concept paper and allocated resources for development of these entomological reference laboratories. After devolution, these funds have been transferred to provinces which must be used for this purposes.

2.11 OPERATIONAL RESEARCH/RESEARCH & DEVELOPMENT

Problem-solving operational research with direct relevance to dengue control must be an integral component of vector control strategy at all level. To implement cost effective and sustainable interventions for vector(s) control in the country, it is essential that such interventions should first be tested on pilot scale under field conditions and then based on the scientific data generated should be scale up or promote on large scale. Operational research must cover the technical, operational and managerial aspects and implies to review ongoing research and its relevance to short, medium and long term dengue control needs. Currently, priority areas for operational research on dengue should be:

- Exploration of mosquito fauna of country and role of different mosquitoes in dengue transmission.
- Monitoring of insecticides resistance in dengue vector(s).
- Characteristics of the virus, vector(s) densities and bionomics between highly and low affected areas, frequency of host–vector contact and disease epidemiology.
- Association of dengue sero-types with different vector species.
- Stratification of epidemiology of dengue in Pakistan.
- Impact of different intervention on dengue diseases transmission.
- KAP surveys for the impact analysis and acceptance of interventions by community.

The research studies should be conducted through award of contracts to prime research institutions/organizations (PMRC, IPH, HSA, NIH, NARC, Universities), researchers, public health post graduate students, Ph.D students in the country through transparent mechanism. International collaboration for facilitation and conduction of operational research should also be sought out.
## Technical Comments/Expert Opinions

### 2.12 Closure of Swimming Pools

During 2011 there was a big outbreak in the country, particularly in Lahore, Punjab, reporting 22,000 confirmed cases of dengue and DHF and 375 deaths. Provincial health department, Punjab, took all possible steps on “War-Footing” to contain this outbreak and there was a huge anti-vector campaign. As a result of this comprehensive campaign, the outbreak of DF/DHF was controlled within a short period of time. However, one of the key steps during 2011 taken by all provincial governments was the ban on all swimming pools in the country. *The overall objective of these steps was to control the breeding of dengue vectors A. aegypti and A. albopictus and subsequently the disease transmission.* As a part of this document, here is some “evidence-based” expert opinion to re-consider this intervention against dengue vectors;

1. **There are always heavy tides on surface of water in swimming pools due to wind and human activities etc.** Since female mosquitoes always prefer to lay eggs in still and calm water habitats, therefore any slight disturbance on water surface prevents the egg laying of *Aedes* mosquitoes. Similarly mosquito larvae always keep their breathing tube (siphon) outside the surface of water as shown in figure and if there is any slight movement on water surface, the larvae and pupae dive down. However, these young ones cannot survive under water for more than a few minutes. Therefore they come to surface as soon as possible to restore breathing. So when there is regular disturbance on water surface like in swimming pools, the young ones of mosquitoes cannot survive in such disturbed water habitats.

2. **The adult female mosquitoes will lay eggs in water habitats where there are some emergent vegetation and grasses along the margin of pool and also floating organic matter in pools.** These materials always provide the sitting place to females to lay eggs on water surface without coming in contact directly with water surface and also provide food and shelter to larvae and pupae of mosquitoes. Therefore the presence of vegetation is also another primary requirement for breeding of mosquitoes in open habitats. These pools are also made of *concrete tiles* and walls of swimming pools are perpendicular rather slanting there is no possibility of emergent vegetation and grasses along the margin of pool and more important any...
decaying organic matter (food of larvae) at bottom which further makes it extremely difficult for mosquitoes to breeding in it.

- These swimming pools which are luxury facilities and only available in high standard hotels and very rich families in country and there is always a system of daily cleaning. Due to regular cleaning and use, heavy tides on water surface, absence of floating materials, structure and construction of swimming pools make almost impossible the breeding of *Aedes* mosquitoes in them.

- On top of all these facts (in agreement to international data) both dengue vector species, *A. aegypti* particularly and generally *A. albopictus* have statistically significant associated with small man-made artificial breeding habitats placed in shaded areas of human dwellings and not in large open sites like swimming pools.

Some international studies reported the breeding of dengue vector mosquitoes in swimming pools, but in only those S/Pools which were not in use for a long time resulting in heavy accumulation of decaying organic matters.

<table>
<thead>
<tr>
<th>DISUSED S/Pool where dengue vector CAN breed</th>
<th>S/Pool where dengue vector CANN’T breed</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Disused Pool" /></td>
<td><img src="image2.png" alt="Normal Pool" /></td>
</tr>
<tr>
<td><img src="image3.png" alt="Disused Pool" /></td>
<td><img src="image4.png" alt="Normal Pool" /></td>
</tr>
</tbody>
</table>

2.12.2. Closure of Service Station

Similarly our 5 years entomological findings on dengue vectors (supported by international data) also not in favor of closure of care Services Stations due to following reason(s);

- **Mixture of detergents and petroleum products:** Level of detergents and other pollutants are also major deterrents for the breeding preference of *A. aegypti* and *A. albopictus* in a particular habitat. As it is already stated that naturally the egg-laying female mosquitoes will prefer the habitats with suitable physio-chemical characteristics to ensure the survival of their next generation. However, the water coming out from cars service station always has a high level of mixture of detergents and also other petroleum products due to which there are negligible chances of breeding of *A. aegypti* and *A. albopictus* in such water habitats.
Overall results confirmed that closure of service stations will not show any contribution in controlling of dengue vectors mosquito breeding and subsequently disease transmission in country.

3.0 References


8. Disease surveillance and outbreak prevention and control of dengue outbreak. [Internet]: World Health Organization; 2009 [updated March; cited 2009 April 22];


10. National guidelines for control of dengue vector in Pakistan 2008; Directorate of Malaria Control.


13. List of WHOPES-Recommended LLINs [Internet]: World Health Organization; 2009 [updated March; cited 2009 April 22];

http://www.who.int/whopes/recommendations/wgm/en/


15. WHO. Dengue and dengue haemorrhagic fever. Fact sheet 117. [Internet]: World Health Organization; 2009 [updated March; cited 2009 April 22];

http://www.who.int/mediacentre/factsheets/fs117/en/


19.

20.


28. Priest. F.G. A REVIEW Biological control of mosquitoes and other biting flies by *Bacillus sphaericus* and *Bacillus thuringiensis*. *J. App Bact.* 1992, 72, 357-369


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**Table 2: List WHOPES-Recommended LLINs (September 2011)**
### Table 3: List of WHOPES-Recommended Insecticides (September 2011)

<table>
<thead>
<tr>
<th>Insecticide compounds and formulations (1)</th>
<th>Class group (2)</th>
<th>Dosage (g a.i./m²)</th>
<th>Mode of action</th>
<th>Duration of effective action (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDT WP</td>
<td>OC</td>
<td>1.2</td>
<td>Contact</td>
<td>&gt;6</td>
</tr>
<tr>
<td>Malathion WP</td>
<td>OP</td>
<td>2</td>
<td>Contact</td>
<td>2-3</td>
</tr>
<tr>
<td>Fenitrothion WP</td>
<td>OP</td>
<td>2</td>
<td>Contact &amp; airborne</td>
<td>3-6</td>
</tr>
<tr>
<td>Pirimiphos-methyl WP &amp; EC</td>
<td>OP</td>
<td>1.2</td>
<td>Contact &amp; airborne</td>
<td>2-3</td>
</tr>
<tr>
<td>Bendiocarb WP</td>
<td>C</td>
<td>0.1-0.4</td>
<td>Contact &amp; airborne</td>
<td>2-6</td>
</tr>
<tr>
<td>Propoxur WP</td>
<td>C</td>
<td>1-2</td>
<td>Contact &amp; airborne</td>
<td>3-6</td>
</tr>
<tr>
<td>Alpha-cypermethrin WP &amp; SC</td>
<td>PY</td>
<td>0.02-0.03</td>
<td>Contact</td>
<td>4-6</td>
</tr>
<tr>
<td>Bifenthrin WP</td>
<td>PY</td>
<td>0.025-0.05</td>
<td>Contact</td>
<td>3-6</td>
</tr>
<tr>
<td>Cyfluthrin WP</td>
<td>PY</td>
<td>0.02-0.05</td>
<td>Contact</td>
<td>3-6</td>
</tr>
<tr>
<td>Deltamethrin WP, WG</td>
<td>PY</td>
<td>0.02-0.025</td>
<td>Contact</td>
<td>3-6</td>
</tr>
<tr>
<td>Etofenprox WP</td>
<td>PY</td>
<td>0.1-0.3</td>
<td>Contact</td>
<td>3-6</td>
</tr>
<tr>
<td>Lambda-cyhalothrin WP, CS</td>
<td>PY</td>
<td>0.02-0.03</td>
<td>Contact</td>
<td>3-6</td>
</tr>
</tbody>
</table>

(1) CS: capsule suspension; EC = emulsifiable concentrate; SC = suspension concentrate; WG = water dispersible granule; WP = wettable powder.

(2) OC= Organochlorines; OP = Organophosphates; C= Carbamates; PY= Pyrethroids.

Note: WHO recommendations on the use of pesticides in public health are valid ONLY if linked to WHO specifications for their quality control. WHO specifications for public health pesticides are available on the WHO homepage on the Internet at http://www.who.int/whopes/quality/en/.

### Table 4: List of WHOPES-Recommended Larvicides (September 2011)

<table>
<thead>
<tr>
<th>Product name</th>
<th>Product type</th>
<th>Status of WHO recommendation</th>
<th>Status of publication of WHO specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dawa Plus 2.0</td>
<td>Deltamethrin coated on polyester</td>
<td>Interim</td>
<td>Published</td>
</tr>
<tr>
<td>Durane</td>
<td>Alpha-cypermethrin incorporated into polyethylene</td>
<td>Interim</td>
<td>Published</td>
</tr>
<tr>
<td>Intecopor</td>
<td>Alpha-cypermethrin coated on polyester</td>
<td>Interim</td>
<td>Published</td>
</tr>
<tr>
<td>LifeNet</td>
<td>Deltamethrin incorporated into polypropylene</td>
<td>Interim</td>
<td>-</td>
</tr>
<tr>
<td>MAGNet</td>
<td>Alpha-cypermethrin incorporated into polyethylene</td>
<td>Interim</td>
<td>Published</td>
</tr>
<tr>
<td>Netprotect</td>
<td>Deltamethrin incorporated into polyethylene</td>
<td>Interim</td>
<td>Published</td>
</tr>
<tr>
<td>Olyset</td>
<td>Permethrin incorporated into polyethylene</td>
<td>Interim</td>
<td>Published</td>
</tr>
<tr>
<td>PermaNet 2.0</td>
<td>Deltamethrin coated on polyester</td>
<td>Interim</td>
<td>Published</td>
</tr>
<tr>
<td>PermaNet 2.5</td>
<td>Deltamethrin coated on polyester with strengthened border</td>
<td>Interim</td>
<td>Published</td>
</tr>
<tr>
<td>PermaNet 3.0</td>
<td>Combination of deltamethrin coated on polyester with strengthened border (side panels) and deltamethrin and PBO incorporated into polyethylene (roof)</td>
<td>Interim</td>
<td>Published</td>
</tr>
<tr>
<td>Royal Sentry</td>
<td>Alpha-cypermethrin incorporated into polyethylene</td>
<td>Interim</td>
<td>Published</td>
</tr>
<tr>
<td>Yorkoo LN</td>
<td>Deltamethrin coated on polyester</td>
<td>Full</td>
<td>Published</td>
</tr>
</tbody>
</table>

Notes:
1. Reports of the WHOPES Working Group Meetings should be consulted for detailed guidance on use and recommendations. These reports are available on the WHO homepage on the Internet at [http://www.who.int/whopes/recommendations/wom/en/](http://www.who.int/whopes/recommendations/wom/en/); and
2. WHO recommendations on the use of pesticides in public health are valid ONLY if linked to WHO specifications for their quality control. WHO specifications for public health pesticides are available on the WHO homepage on the Internet at [http://www.who.int/whopes/quality/en/](http://www.who.int/whopes/quality/en/).
Table 5: List of WHOPES-Recommended space spraying insecticides (November 2011)

<table>
<thead>
<tr>
<th>Compound and formulation</th>
<th>Indoor (g A/1000 m²)</th>
<th>Outdoor (g A/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cold</td>
<td>Thermal</td>
</tr>
<tr>
<td></td>
<td>fog</td>
<td>fog</td>
</tr>
<tr>
<td>Deltamethrin UL</td>
<td>0.5</td>
<td>0.05</td>
</tr>
<tr>
<td>Deltamethrin EW</td>
<td>-</td>
<td>0.05</td>
</tr>
<tr>
<td>Lambda-cyhalothrin EC</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Malathion UL</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Permethrin (25% sc/7% trans; 10.35% wet) + 5% bioallethrin (0.14% wet) + piperonyl butoxide (0.85% wet) EW</td>
<td>0.55 permethrin</td>
<td>0.73 permethrin</td>
</tr>
<tr>
<td>d,l-trans-cyphenothrin</td>
<td>0.1-0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Notes:
1. Reports of the WHOPES Working Group Meetings (available at http://www.who.int/whopes/recommendations/wgm/en/) and the WHOPES publication Pesticides and their application for control of vectors and pests of public health importance (available at http://whqlibdoc.who.int/hq/2005/WHO_CDS_NTD_WHOPES_GDPP_2005_1_eng.pdf) should be consulted for guidance on use and recommendations;
2. WHO recommendations on the use of pesticides in public health are valid ONLY if linked to WHO specifications for their quality control (available at http://www.who.int/whopes/quality/newspection/en/).
Author gratefully acknowledges the facilitation provided by all provincial malaria control program managers during technical discussion. Technical support from Dr. Jaleel Kamran and Dr. Mumtaz Ali Khan of Epidemic Investigation Cell (EIC)-NIH, Dr. Altaf Bosan and Dr. Faisal Mansoor (Ex-Directors of DoMC) also highly appreciated and acknowledged. No doubt without their contribution, the completion of this document was not possible. DoMC also highly appreciate the sincere efforts and contribution of Dr. Quttbudin Kaker (National Technical Officer), WHO-Pakistan made during dengue field investigations which resulted in the production of this document. Last but not least, the authors especially would like to thanks Mr. Ghulam Murtza and Muhammad Shafiq of DoMC for their great dedication to facilitate this mission.
No Fear but Care

Protection from Mosquitoes
Prevention from Dengue and Malaria