3 Vector-control strategies

3.1 Introduction

The main factors to be considered in controlling vector-borne diseases in refugee settlements are as follows:

- choice of settlement site
- camp construction and organisation
- shelter
- community awareness and health education
- sanitation
- water-supply systems
- personal protection
- the use of insecticides.

These factors will now be considered in more detail.

3.2 Site choice

The decision as to where a refugee settlement should be placed is often made for political as well as practical reasons. If a choice of site is possible then careful consideration of possible sites in relation to disease vectors may be the single most effective way of controlling malaria, sleeping sickness, onchocerciasis, kalaazar and tick-borne fevers. Guidelines for reducing vector-borne disease transmission by site choice and camp organisation are as follows:

1. Avoid areas of known vector foci (for example, breeding sites of malaria mosquitoes in marshy, swampy areas in Africa or the forest edge in Thailand; or of blackflies in turbulent rivers in sub-Saharan Africa).

2. Minimise likely vector-human contact (for example, by the provision of an adequate water supply away from the vector foci, and using screening material on doors and windows).
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3 Minimise conditions which lead to increased vector populations (for example, by reducing potential breeding grounds such as poorly-maintained water supply systems, swampy ground, etc.).

4 Minimise conditions which lead to increased disease transmission (for example, overcrowding).

In some situations land may be available for refugees precisely because it has been abandoned by the local population on account of the prevalence of local disease vectors.

In South-East Asia it may be possible to reduce malaria transmission by *Anopheles dirus* by removing any forest growth within 2km of the camp. This land could be kept free of forest regrowth by using it for planting crops, or for such things as football fields.

An illustration of the effectiveness of site choice as an effective control measure: After 1980 many Khmers were denied refugee status in Thailand and were settled in camps on the Kampuchean side of the border, within the forested habitat of the jungle malaria vector *Anopheles dirus*. Camps were frequently evacuated as a result of fighting and relocated nearby; a process which had a major effect on malaria transmission in some camps. For example, the evacuation of Sok Sann camp to a new site within 6km of the previous camp resulted in dramatic reductions in malaria transmission and, according to Meek (1989) ‘...emphasises the potential for avoidance of malaria by appropriate siting of refugee camps when a choice of sites is available.’

3.3 Camp organisation

Since personal hygiene and community involvement in vector control are likely to be crucial factors in the control of vector-borne diseases, the factors which produce and encourage active refugee involvement in their own health care are also likely to have a major impact on the reduction of breeding sites for vector species (e.g. the construction and use of fly proof latrines or the removal of mosquito larvae breeding grounds).

In a comparison of refugee settlements run by the army, and those run with assistance from Oxfam and CIIR, in Nicaragua, Cuny (1977) found that, while there were no major health problems in the latter settlements (in which refugees were fully involved in camp planning and
organisation) the army run camps were "...plagued with skin infections, various waterborne diseases and several outbreaks of minor contagious disease".

The overall lay-out of a camp, the ease with which individual dwellings can be mapped, and the access routes throughout the camp, will all have an influence on the efficacy with which a control programme can be carried out.

### 3.4 Shelter

The availability of sufficient and effective shelter is of very high priority in setting up camps for refugees and displaced persons. Shelter is needed to protect people from the extremes of heat, cold, rain, and wind. Shelter in a refugee camp may vary from temporary flimsy structures which provide shade and little else, to traditional dwellings, houses, and tents. The materials used to construct shelters may be cotton fabric, mud, brick, concrete, wood, grass, palm fronds, or plastic. The type of shelter, where it is located, and the material of which it is built may affect vector-borne disease transmission in a number of ways:

1. Lack of sufficient shelter may result in crowding and the increased transmission of communicable diseases, such as typhus, which is transmitted by body lice.
2. Flimsy, open-walled structures may provide little protection from the entry of biting insects. Some vector species will not enter a solidly-built house.
3. Open-walled structures may not provide sufficient surface area for the spraying of a residual insecticide.
4. Cracks in masonry, and roofs of thatch may provide breeding and living habitats for certain disease vectors, such as reduviid bugs or bedbugs.
5. The siting of houses downwind and away from vector breeding sites may reduce the ease with which the vector can find its host.
6. The use of screens and curtains impregnated with insecticide will reduce the number of insects, especially mosquitoes, entering a dwelling.
7. A ceiling in a room can significantly reduce the number of mosquitoes by blocking their entrance from the eaves. The provision of material for ceilings can be considered as an important public health measure in some circumstances.

Insecticides vary in effectiveness depending on their formulation and the surface on to which they are sprayed. DDT and malathion, in wettable powder...
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(WP) formulations, have been widely used for malaria control by spraying as a residual deposit on to mud walls, thatch, and wood. Insecticides formulated to spray on fabrics are suitable for tent spraying.

Improving the quality of housing, either by providing corrugated roofs instead of thatch or by plastering walls, will reduce certain insect vectors and provide long-term control measures. Such improvements are expensive, and are often beyond the means of refugees themselves.

3.4.1 Termite damage to shelters

Termites can cause a considerable amount of damage to refugee camp buildings and dwellings where wood or plant material is used in construction. Repairs of termite damage can be expensive and time-consuming.

Termite-resistant timber

The most important method for termite control in buildings in the tropics is the use of termite-resistant timber. Such timber may be locally available and in many parts of the world is traditionally used in house building. A list of termite-resistant woods found in West Africa can be obtained from the Natural Resources Institute (see Appendix 1).

Preventing termite boring

To be effective, measures against termite boring must be initiated at the time of construction. Partial protection from termites can be achieved by treating the ends of the supporting posts that are placed in the ground, either by charring them, soaking them in sump oil, or painting them with creosote or copper-based wood preservatives. Another method is to bury wood ash in the post hole.

The most widespread method of termite control has involved the application of persistent residual organochlorine insecticides such as aldrin, dieldrin, and heptachlor. As a result of environmental considerations these chemicals are banned in many countries and are no longer so widely available; they are not recommended. Residual pyrethroids are effective termiticides when suitably formulated. All termiticides require very careful application, such as pre-treatment of timber and soil, and the possible hazards should be investigated. To treat a building after it has been constructed will not be very effective since the termites will be able to bore through those posts buried in the ground.
3.5 Community awareness and participation

The social cohesion, and political and structural organisation, of refugee and displaced communities vary according to the culture and recent political history of the community. Refugee communities may be rural peasants, nomads, or town and city dwellers, including the urban poor and the urban middle class. Those fleeing from civil war or political persecution may be highly politicised and socially structured, whereas rural farmers fleeing from famine-affected areas may have little social or political cohesion.

All vector control programmes require at least the passive if not the active participation of the refugees themselves. Wherever possible the refugee population should be the main source of labour in a vector-control programme and should be responsible for the development of and subsequent running of health promotion campaigns. Vector-control initiatives should, as with other health programmes, actively involve as many groups within the refugee community as possible, including teachers and schoolchildren, traditional leaders, religious groups, women’s groups, military authorities, and community health workers.

Many different mediums can be used to get the message across, including radio, loud-speaker, songs, theatre, puppets, and billboards. Health messages should include information on the disease, its relevance to the refugee population, the control measures to be used, and how they will help to prevent the spread of the disease. Every attempt should be made to explain the need for the control programme and then to organise it in such a way that social and cultural requirements are met. Remember: public support for a control programme is essential.

UNHCR have developed an approach called ‘people-oriented planning’ which provides a framework for involving refugees in decision making. This approach is based on UNHCR’s extensive experience, which shows that:

- Ignoring refugee resources (social as well as physical) undermines the ability of refugees to do things for themselves.
- It is usually more efficient in the short run, and always better for refugee capacity in the long run, to build on the patterns of work and distribution of resources that prevail in the refugee population.
- Work and programme patterns that are established in the first few days of an emergency are extremely difficult to change later on. For example, if women are not consulted by emergency staff at the programme’s inception, then it may be impossible for planners to get the information they need to set up gender-sensitive programmes.
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There are some circumstances in which health education is a particularly important aspect of a control campaign:

1 If the refugees are responsible for creating breeding sites. For example, the digging of shallow pits when collecting mud for house construction, in which water accumulates, can result in ideal mosquito breeding grounds. Discussions should be held with refugee authorities to decide on the most appropriate remedy. In some situations local legislation (either traditional law or local authority law) can be used against the creation of vector breeding sites.

2 If transmission of the disease is affected by cultural habits. For example, relapsing fever is most effectively transmitted when lice are crushed between the teeth or nails, enabling the spirochaetes to come into contact with the skin. Widespread public education on the dangers of such habits should be undertaken.

3 If the refugees themselves can effectively eliminate the breeding sites. Aedes mosquitoes, the vectors of dengue and dengue haemorrhagic fever, may be controlled by the covering of domestic water storage jars, and changing the water weekly. Again, widespread public mobilisation (possibly including legislation) is needed for effective results.

4 If the refugees effectively undermine insecticide campaigns. Residual insecticide spraying programmes for malaria control have faltered because householders have replastered or whitewashed newly-sprayed walls and covered up the insecticidal surface. Malathion, which is used for residual spraying, is often unpopular because of its smell. The mass control of body lice with insecticides requires that underclothing is thoroughly treated with insecticide. Women may be reluctant to be exposed to public delousing and the provision of private space may be important to the success of the programme.

5 If refugees can protect themselves from infection, for example, by using bednets or repellents.

3.6 Water supply

The availability of sufficient safe water for personal hygiene and domestic use is a very high priority in setting up a refugee camp. Water may be available to refugees either directly from rivers or swamps, via shallow or deep wells, or through a piped distribution system.
Collecting water may expose people to disease: When Chadian refugees were settled in the Poli Pehamba district of Cameroun it was feared that onchocerciasis, which was known to be endemic in the settlement area, could have a serious effect on a refugee population which had not previously been exposed to the disease. This fear prompted the call for assistance from an entomologist. He recommended that the refugee villages should be sited at a reasonable distance from the nearby river (where the vectors of onchocerciasis breed) and that water should be provided within the camp, in order to reduce the number of people visiting the riverside, where fly numbers were highest. (Walsh, 1981)

Refugees may store water in pots and jars for later use. The type of water supply system used and the condition it is kept in, may have a marked effect on the number of ‘container breeding’ mosquitoes. Control of mosquito breeding in overhead water tanks and cisterns can, in theory, be achieved using tight-fitting lids or small larvae-eating fish. Polystyrene beads (see later) have also been successfully used to control mosquito breeding in such situations.

The provision of piped water to community stand-pipes should reduce the need for household water storage pots, often the most important breeding site for Aedes aegypti. But if the use of water storage pots is the cultural norm then it may be difficult, without extensive discussion and education, to persuade people to change their habits. For this reason, most control programmes for A. aegypti rely on the use of insecticides; but there are only a few insecticides which may be safely used in drinking water.

3.6.1 Insecticides for treating drinking water

Insecticides approved by WHO for use in drinking water are:

- Temephos and pyrimiphos methyl: organophosphate insecticides of very low mammalian toxicity.
- Methoprene: a hormone that interferes with larval growth.
- Bacillus thuringiensis H-14: a bacterial insecticide.

No other insecticides should be used in drinking water.

Insecticides can all be formulated as slow-release briquettes, which gradually release the insecticide over a number of months. Alternatively they may be formulated with course sand granules, which also provide a slow-release system. The sand granules can be handled most easily if placed inside a fine nylon bag. Depending on the type of insecticide and the formulation these treatments should last between two and five months.
3.6.2 Water supply and mosquito control

Mosquito numbers can be controlled by careful water management. Measures include the following:

1. Remove mosquito breeding sites. Unblock gutters, empty water containers, including vases and animal dishes, on a weekly basis and scrub them out before refilling. Make sure that soakaways, septic tanks, and grease taps are tightly closed. Fill in any holes and cracks around their top. Drain or fill-in puddles where fresh water collects.

2. Prevent the excessive production of waste water. All piped water systems leak, and regular monitoring and repair of faulty pipes will reduce the production of stagnant pools. Water-saving taps can be used to reduce the wastage of water.

3. Find a use for waste water. Surplus water from stand pumps can be redirected into a vegetable garden. The amount of water required for washing is much greater than that required for drinking, and disposal of water after use may result in stagnant pools being created, or water being wasted in underground soak-away pits. Plants which are ‘water hungry’ such as eucalyptus, papaya, or banana, can be planted in the area of run-off, or by marshy ground, in order to absorb the surface water.

4. Screen or cover open water supply tanks to deny access to mosquitoes. Use rust-resistant material such as nylon, stainless steel or aluminium mesh.

5. Apply insecticides, that are safe for humans and animals, to drinking water. Slow-release briquettes of these insecticides are the most practical solution for use in water storage containers.

6. Larvivorous fish (i.e. fish that eat larvae) are used in some countries for controlling mosquito larvae in drinking water. This strategy is only feasible if there is already a programme in operation nearby.

3.7 Sanitation

Sanitation practices that are designed to reduce fly populations should take into consideration the fact that flies breed in all kinds of decaying organic matter (human and animal food waste, excreta, corpses, and rotting plant material). The choice of sanitation system will depend on a number of factors, such as the speed of provision, the number of people, and the resources available, the traditional defaecation practices, and the height of the water table.
The high rates of malnutrition and mortality related to diarrhoea in infants and younger children of Kurdish refugees (12 per cent of all children died within the first two months of the crisis) took place rapidly despite prompt relief efforts and a previously healthy population. This experience emphasises the need for early and aggressive public health management of sanitation, water sources, and diarrhoea control programmes to augment the traditional focus on food and medical relief during the emergency phase of a refugee crisis. (Yip and Sharp, 1993)

The type of sanitation system used may have a marked effect on fly numbers and also on the types of fly that will breed. Unless particular measures are taken to prevent fly breeding then the introduction of a sanitation system may actually increase fly numbers by providing permanent, damp, warm environments that are suitable habitats for flies to breed in.

There are several ways of preventing flies breeding in organic matter:
1 Incinerate rubbish, hospital dressings, and dried manure. In some situations animal manure may traditionally be used as a fuel source. If the dung is thinly spread and dried quickly, then fly numbers should not be excessive.
2 Prevent flies getting access to potential breeding sites. This may be achieved by burying garbage and faeces in a trench and covering it with a minimum of 25cm of compacted soil.
3 Localise the organic matter in such a way that flies breeding in it are unable to escape. For example, the ventilated pit latrine is designed to prevent flies escaping.
4 Treat organic matter with an insecticide. Filth flies are notoriously susceptible to developing insecticide resistance so this method should only be used if absolutely necessary and then only for a short time.

A well-organised, highly motivated, well-supervised defaecation system will ensure that defaecation is restricted to the proper sites and that latrines are kept clean and well-covered.

3.7.1 Types of defaecation system
Different defaecation systems will affect both the number and type of flies that occur.

Indiscriminate defaecation throughout the camp: some filth flies, including *Musca sorbens*, which is commonly found feeding on eye secretions, are adapted to breed in small piles of human faeces. Over 42,000 larvae have been found in 1kg of human faeces. Covering faeces with a thin layer of soil may
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actually *increase* the fly population, because the breeding habitat will remain moist. Flies are attracted to faeces by smell and, if necessary, will burrow down into loose earth to lay their eggs. **Defaecation fields:** these should be chosen to be at least 500m up wind from any habitation or feeding centre and at least 30m from the water supply. Defaecation fields will produce as large a number of flies as would indiscriminate defaecation but, if fields are sited up wind, the numbers of flies flying into the camp will be reduced. Washing facilities should be available nearby. Defaecation fields will localise excreta, making it easier to clear up. A large workforce will have to be employed to clear the fields and dispose of the excreta in prepared pits; it should then be covered with 25cm of compacted soil. The workers will require protective clothing.

Wind location may change frequently or seasonally. In Africa the wind usually changes direction at the beginning and end of the rains, and therefore defaecation fields should either be changed in accordance with wind changes or the site should be chosen to be up wind during the period of maximum fly numbers. Ask local inhabitants when flies are most common. **Dry latrines:** trench latrines, and any other ordinary latrine where faeces are piled together, provide an ideal breeding site for filth flies such as blue-bottles and green-bottles and less so the important *Musca* spp.

Trench latrines should be filled daily with compacted soil to a depth of at least 25cm to prevent flies breeding.

**Fly proofing of latrines**

**Tightly-fitting lids:** fly breeding can be reduced by making sure that well-fitting lids are used to cover the latrine hole. Wooden or sheet metal lids are likely to warp and therefore become ineffective. Sacking soaked in motor oil and used to cover the latrine hole will provide some protection from fly breeding.

**Pour flush latrines:** the water seal prevents the escape of smells from the latrine and also prevents the entry or departure of any insects. Such latrines are only appropriate where people use water, and nothing else, for anal cleansing. As for the ventilated improved pit latrine, this type of latrine must be perfectly sealed to be effective.

**Ventilated improved pit (VIP) latrine:** the VIP latrine is characterised by the presence of a ventilation pipe which draws odours away from the pit thus reducing unpleasant smells. If the latrine is fitted with a roof and is fairly dark inside, then flies breeding in the pit will try and leave the pit via the vent pipe and can be trapped in it by a wire mesh at the top. Flies will try to enter the latrine via the vent pipe — where the smell is strongest — but will be
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Fig. 2 Air currents and the movement of flies from a Blair VIP latrine

- Fly screen tightly fixed to vent above roof level
- Vent pipe facing equator if wind speed low
- Vent pipe minimum diameter 150mm
- Mortar seal
- Water and air-tight seal
- Only source of light in pit
- Pit lining if soil is weak
- Flies attracted to light from vent pipe
- Dark interior no windows or other vents
- Vent pipe should extend at least ¾m above roof and surrounding buildings and trees
- If there is a door which can be closed, there should be one ventilation opening above it with a cross-sectional area three times the vent pipe size
- Door access facing prevailing wind
- Superstructure minimum 150mm above ground level
- Minimum 3m deep 1m diameter
- Slab
- Foot rests
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preventee from doing so by the wire mesh. The main disadvantage of the VIP latrine is the cost of the vent pipe, which may be 90 per cent of the total cost of the latrine. In the Thai-Cambodian border camps VIP latrines were made using large bamboo pipes, painted black inside.

Latrines must be carefully constructed and well-maintained if they are to be effective at controlling flies. The main factors for ensuring the effectiveness of a VIP latrine are:

• the vent pipe must be of the correct size (150-200 mm) and work efficiently
• the pipe must be fitted with a corrosion resistant screen (e.g. stainless steel or aluminium)
• semi-darkness is essential within the covering structure
• the latrine hole should not be covered
• the latrine should be kept clean
• there must be no cracks in the masonry.

While in theory VIP latrines are simple to build and should provide effective fly control, in fact, they are often poorly constructed, badly sealed, and do not live up to their reputation.

VIP and pour flush latrines, if carefully constructed, will also provide effective control of the urban nuisance mosquito, *Culex quinquefasciatus*, the vector of bancroftian filariasis (elephantiasis). Malaria vectors will only breed in unpolluted water and will therefore not be found breeding in latrines.

Reducing mosquito breeding in wet latrines

Insecticides should *never* be used inside the latrine pit because they will kill beneficial organisms and thus prevent the natural breakdown of organic matter.

In a new refugee camp, mosquito control should be automatically included in every latrine during construction when:

• the water table is reached during latrine construction
• seasonal rains are very heavy and likely to cause water to lie in latrines
• large quantities of sullage water will be poured down the latrine.

In an established camp all latrines should be inspected and only the ‘wet’ ones ear-marked for treatment. There are three main methods to prevent the breeding of mosquitoes:

**Use of dry material:** the weekly addition of dry material to a latrine (for example, sawdust, ash, lime, or powdered earth) may absorb sufficient liquid to prevent mosquito breeding.

**Oil:** old engine oil can be poured into the pit latrine (one cup per standard family latrine). This makes the water surface of a wet pit latrine an unsuitable place for mosquito larvae to breed in as they are unable to breathe. This can be
an expensive use of oil, may not be effective on heavily polluted water, and
must be repeated weekly to be effective. Oil should not be poured into latrines
if there is the possibility that it may contaminate water supplies. Waste from
latrines where engine oil has been used should be carefully disposed of and
should not be composted for agricultural use. (A series of technical notes on
the construction of pit latrines and their vent pipes is produced by the
Intermediate Technology Group.)

**Polystyrene beads:** polystyrene beads (just like those found in bean bags)
have been used in vector control programmes in east Africa to prevent
mosquitoes from breeding in wet latrines. The beads can be purchased in their
unexpanded form, in which they are easier to transport. When they are heated
to 100°C in water over a fire they swell to 15–20 times their original size (this
process does not use CFCs). Steam treatment results in even greater expansion.
The expanded beads are then poured into the latrine. They form a surface cover
over the liquid which allows faeces to fall through but makes it impossible for
mosquitoes in the water to emerge. If the water dries out, then the beads settle
but they are rapidly refloated should the latrine fill with water again. These
beads can also be used in water storage tanks.

Although, in theory, a layer of polystyrene beads should last indefinitely, they
may be lost from the latrine during flooding or pit clearance. The risk of the
beads being lost, and the possible environmental consequences, should be
considered before implementing the use of beads as part of a control programme.

*The use of expanded polystyrene beads for mosquito control in wet
latrines:* A 2cm layer of 2mm beads is sufficient to eliminate mosquito
breeding. Thus, 20 litres of expanded beads are needed per square meter
of water surface, or 30 litres for a typical pit latrine. This weighs about
1.25kg if expanded in boiling water and costs about $2.50. Expansion in
boiling water uses about 0.05m³ of firewood to produce 240 litres of
expanded beads. This takes two to three hours from lighting the fire.
Using this system it is estimated that 1.5 tonnes of polystyrene beads will
be sufficient to treat 2000 latrines. (From Curtis, et al., 1991)

### 3.7.2 Screening

Screening of buildings is an important way of preventing disease transmission
by flies and mosquitoes. Rust-proof (stainless steel or aluminium) mesh should
be used in hospitals, feeding centres, and especially kitchens. If mesh is not
available then ‘fly doors’ (made of strips of plastic or fibre) will help to reduce
fly numbers.
3.7.3 Garbage collection

Garbage containers must be available throughout the camp and especially in the market area. Garbage should be collected daily if possible, but at least every three days, to reduce fly breeding. Collected garbage should then be burnt or buried in a deep pit or landfill site and covered with a minimum of 25cm of compacted soil. The more compact the garbage the fewer flies it will produce. If garbage is not disposed of, this will encourage rat populations to build up.

Garbage containers should be metal, and perforated at the base and supported off the ground to allow rain water to drain. 200 litre oil drums that are sawn in half are ideal for this task. If no containers are available, plastic sacks may be used as a temporary measure.

3.8 Environmental sanitation

3.8.1 Water

Water engineers employed to organise the water supply in a refugee settlement should also have a responsibility for reducing mosquito breeding sites through ‘environmental sanitation’. This includes the drainage of swampy areas, land levelling, the removal or planting of vegetation in or near swampy areas, and the building of dykes. Such control methods can be very effective and long-term solutions. Much of the small-scale, physical work can be carried out by the refugees themselves. A number of texts on vector control that are suitable for engineers are listed in the references at the end of the book.

3.8.2 Vegetation

Removal of vegetation within and around the borders of the camp may be useful for the control of ‘mite islands’, if these can be identified, and provided the vegetation is not mostly of crops. The destruction of a band of woodland around a settlement in a tsetse-infested area may reduce the threat of human and animal trypanosomiasis since tsetse-flies are reluctant to fly over open spaces. This control method has been used extensively in Africa and is known to be reasonably effective. In Africa there is a widespread belief that malaria vectors commonly breed in the leaf axils of maize plants: this is not the case.
3.9 Personal protection

There are a number of ways in which individuals can protect themselves from vector-borne diseases. They include:

- personal hygiene and behaviour
- suitable clothing
- use of bednets
- use of repellents.

These will now be looked at in more detail.

3.9.1 Personal hygiene, behaviour, and clothing

Regular washing of body and clothes, the use of soap, protecting food and cooking utensils from flies, and careful use of latrines will reduce considerably an individual’s exposure to fly-borne pathogens and lice, as well as reducing the chances of secondary infection of insect bites. Individuals can reduce their own exposure to mosquito, blackfly, sandfly, tsetse, and tick bites by wearing long clothing (such as trousers and long sleeved shirt or long dress) or clothing impregnated with insect repellents (see section 3.9.4). Personal cleanliness can be enhanced by the provision of soap, or soap-making facilities, to the refugee population.

3.9.2 Bednets

Bednets (mosquito nets) are used widely throughout the world (especially in the Far East) depending on mosquito nuisance, tradition, availability, and affordability. Other motives for using bednets are: privacy, and protection from cold, rats, gheckos, cockroaches, or spirits. In very hot climates bednets may be uncomfortable to sleep under because they reduce ventilation.

Bednets and malaria

Bednets are widely used because they reduce the nuisance of mosquito bites. Since many malaria vectors bite people at night, when they are sleeping, bednets can also reduce people’s exposure to malaria. A recent study in The Gambia showed that malaria prevalence levels were inversely related to mosquito vector density. The researchers concluded that this was because people in areas where there were a lot of mosquitoes protected themselves with bednets. However, in areas where malaria transmission is more intense, ordinary bednets may not reduce mosquito biting enough to affect malaria transmission.
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The effectiveness of the use of bednets for malaria control, as with any other control method, will be dependent on public support and co-operation. If the refugees are not familiar with the use of bednets then a carefully organised experimental trial should be initiated first, to assess their acceptability and effectiveness.

Provision of bednets

The questions to ask when considering bednets for vector control are:

- Are mosquitoes considered a major biting nuisance?
- Are the disease-carrying vectors normally biting people while they sleep?
- Are bednets widely used by the local population? If not why not?
- Are bednets normally widely used by the refugee population? If not why not?

Poor quality nets deteriorate quickly and do not stop mosquitoes biting. NGOs may play an important role in the provision of effective bednets (either free or at cost price) in a refugee situation, as well as encouraging their use by the host population. Providing suitable netting material to local tailors (or refugee tailors) will provide employment as well as a supply of bednets; but local tailors may not be able to produce large numbers of nets quickly in an emergency.

Bednets can be bought locally, in which case they are likely to be of a type familiar to people, but care should be taken to buy nets of a good quality otherwise their effectiveness will deteriorate rapidly. Cotton nets are usually the most comfortable but they are liable to rot in humid conditions and are more expensive than nylon, polyester or polythene nets. Polyethylene nets are the strongest type and, with proper care, should last up to five years. Nets made from 40-denier polyester are widely used in Asia but are very flimsy and are not recommended for refugee situations. The greater effectiveness of the more expensive, higher-denier nets (75-100) with borders is well worth the extra cost. Bednets may be a fire hazard and people should be warned not to smoke in bed when nets are used.

Cot, single, and family bednets can be bought as well as large communal nets. The size of net chosen should be in accordance with sleeping habits and space available. Many imported nets come from Thailand or the Philippines, where they are widely used. A family-size net should cost less than $5.00 (including shipping costs). Bednets may vary considerably in quality and style between manufacturers, so be sure to investigate your sources thoroughly before placing an order. A list of major manufacturers is given in Appendix 2.
Bednets are unlikely to provide complete protection from malaria for the following reasons:
• mosquitoes bite people before they go to bed, when they get up in the night, or when they rise in the morning
• mosquitoes can get inside nets that are not properly tucked in or are torn
• mosquitoes bite parts of the body which lean against the net
• hungry mosquitoes unable to feed from one person may feed instead on their unprotected neighbour.

Insecticide-treated bednets
This idea is not new. Egyptian fishermen in the fifth century BC were known to keep off mosquitoes while they slept by covering themselves with their oily nets (the fish oil presumably acting as a repellent). A surge in popularity of bednets treated with insecticide (usually pyrethroid) is currently under way. Widespread trials throughout the world (in particular China, Vietnam, Solomon Islands, Papua New Guinea, Burkina Faso, Tanzania, Kenya, and The Gambia) have shown it to be a useful technique that is practical in community-based projects and is effective against both nuisance biting and malaria transmission. Insecticide-treated bednets have been shown to reduce child mortality substantially in The Gambia, but their effectiveness in areas of higher malaria transmission is not yet clear.

Insecticides used for net impregnation
Photostable pyrethroids are chosen because of their low toxicity, rapid insecticidal effect, and long residual efficacy. Permethrin-treated bed nets have been endorsed by the WHO Expert Committee for Malaria and are least likely to cause any problems of skin irritation during dipping. Deltamethrin, lambdacyhalothrin, and other more recently developed pyrethroids are effective at lower concentrations but may cause temporary skin and nasal irritation.

Choice of insecticide should depend on availability, safety, persistence under environmental conditions, and cost. Good quality formulations which are specifically for bednets should be used. Agricultural permethrin should not be used as it will have been prepared using different solvents, which may reduce the safety and acceptability of the treatment. Individual treatment sachets for nets (which expatriates can use to treat their net before travel) can be obtained from the Schools of Tropical Medicine in London and Liverpool. Pre-impregnated bednets can now be purchased in a number of camping shops. They will be of particular benefit in an emergency situation but the means to re-impregnate them must still be organised in the field.
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Washing bednets

Washing the treated bednet will reduce the amount of insecticide on it (sometimes to nil) so it is recommended that bednets should be laundered before re-impregnation with insecticide, every six months. This problem needs to be clearly understood by the refugee community. Wash-proof formulations of insecticide may be on the market soon.

Bednets and other vectors and pests

Sandflies: mosquito nets are not usually fine enough to prevent the entry of sandflies, which are extremely small insects. Where sandflies are a major biting nuisance, ‘sandfly nets’ may be found which are made of opaque sheeting. The effectiveness of these nets can also be improved by treating them with a residual pyrethroid insecticide. A mosquito net that has been treated with insecticide will kill or at least repel sandflies trying to enter it.

Bed bugs and head and body lice: immediately after insecticide impregnation the bednet should be left to dry on the sleeping mat or bed of the owner. The residual effect of any pyrethroid that is left on the bed should eliminate bedbugs for up to two months and also reduce the prevalence of head and body lice.

Protocol for insecticide-impregnated bednet programme

Materials required:
- pyrethroid E.C,
- plastic bucket(s)
- protective gloves
- inert measuring cup
- insecticide syphon

To calculate the strength of the permethrin emulsion needed:

1 Calculate absorption of netting:

The amount of water absorbed by a net will depend on the type of cloth. For an average nylon family size net this may be 500ml whereas, for a cotton net, this may be 1.5-2 litres. It is therefore important to calculate the average amount of water used to soak an individual net if you want to dip nets en masse, or to work out the amount of water absorbed per net if they are dipped one at a time.

Let is assume the average amount of water absorbed is 500ml

2 Calculate amount of pyrethroid a.i. needed per net to give recommended dose cover/m
Vector-control strategies

The surface area of the net is:

\[(w \times h \times 2) + (l \times h \times 2) + (w \times l \times 1) + \text{(area of overlap if any)} = x\text{m} \]

\[w = \text{width}, \ h = \text{height}; \ l = \text{length}.\]

For an average single net this may be 10\text{m}^2

Treatment of 100 nets of 10\text{m}^2 area requires:
1 litre of permethrin 50 per cent E.C. in 249 litres water @ 0.5gms a.i./m
1 litre of deltamethrin 2.5 per cent in 249 litres water @ 0.025g a.i./m
400ml of lamdacyhalothrin 2.5 per cent in 249.6 litres water @ 0.001g a.i./m

After dipping, the nets should be gently squeezed to remove excess liquid and then laid out on a flat surface (preferably the mattress) to dry. If the nets are dried outdoors they must be spread out in the shade as sunlight will break down the insecticide. When dry, the net is ready for use. Nets should normally be impregnated immediately before the main malaria transmission season. If transmission occurs throughout the year then re-impregnation should usually be undertaken every six months.

Cost

Estimated cost is less than $0.50 per treatment. Treatment will be required 6-12 monthly depending on the pyrethroid chosen and control circumstances.

A preparation to treat a single net is available from some manufacturers and may be particularly suitable for NGO staff to use before leaving to work in a refugee camp.

3.9.3 Insecticide-impregnated curtains

The use of insecticide-treated curtains for malaria and leishmaniasis control has been tried experimentally in a number of situations. Curtains are particularly suitable for use where people do not normally use bednets and are unlikely to adapt them to their current way of living. Unlike impregnated bednet programmes, there is as yet little information as to the efficacy of the use of impregnated curtains as a control measure. Before embarking on an impregnated-curtain programme a carefully controlled experimental trial would be required.
Disease prevention through vector control

3.9.4 Repellents

Insecticide-treated bednets and repellents are essential to safe-guarding the health of aid workers exposed to certain disease vectors.

Traditional repellents
Throughout the world people use a variety of different substances to reduce the annoyance of insect biting. They use methods such as burning dung, citrus peel, or other material in the evening when mosquitoes are biting, or rubbing oils (such as turmeric or mustard oil), ash, or plant juices on the skin. Common traditional treatments for headlouse include rubbing neem or coconut oil on to the scalp. Such well-known practices should be encouraged, for example, by the provision of a simple oil-extraction press. Some traditional repellents are known to be very effective, although there are many which have not been evaluated scientifically. It should be noted that not all natural products are completely harmless and, where possible, further information on possible side-effects should be obtained.

Mosquito coils
These remain smouldering for four to six hours but may be too expensive for many refugees. The quality of mosquito coils varies considerably, and there are many on the market that are not effective at all. Pyrethroid-based coils are more effective than those using natural pyrethrins alone.

Commercial repellents
Deet (Diethyltoluamide) is the best known commercial insect-repellent and is widely used in commercial products. It will repel mosquitoes, sandflies, blackflies, chiggers, ticks, deer flies, and fleas. The concentrated Deet should be diluted to 25 per cent in a suitable solvent (e.g ethanol, isopropanol, petroleum jelly, or solvent-based cream) and smeared on to the exposed skin surface. It should act as an effective repellent for six hours. Applied to the skin it offers hours of protection but when absorbed onto clothing it usually provides protection for several days. It is relatively cheap if bought in large quantities ($9.00/kg). Other effective commercial repellents are Dimethyl phthalate and Dibutyl phthalate.

Permethrin repellent bar
This soaplike bar (which costs about $0.30/bar direct from the manufacturers) is an effective repellent if used correctly. The user should rub the bar on their
exposed skin in the evening and not wash it off until the morning or until ready
to go under a bednet to sleep. One bar may last up to a month if carefully used.

Choice of repellent

Trials by Lindsay (1989) in The Gambia on the use of different repellents
against blood-seeking mosquitoes showed that soap with deet (with or
without permethrin), burning santango (traditional Gambian repellent), or
a mosquito coil all provided reasonable degrees of protection. The choice
between these treatments is primarily a question of convenience and cost.

3.10 Insecticide control programme

There are three basic methods of using insecticides for control of insect vectors
and pests. The choice of which technique to use depends on the target insect,
the life stage to be controlled, and the various technical advantages or
disadvantages of each technique.

3.10.1 Residual spraying

Residual spraying of a suitable insecticide is the recommended technique for
malaria control where the vector is known to rest indoors. Table 14 gives
details of spraying programmes which might be appropriate. Residual spray
programmes are relatively simple to organise but must be well-supervised. The
roles and responsibilities of a spray team are given in Table 15. Spray teams
should spray all the dwellings, and sometimes the animal sheds as well, once
or twice a year (see Table 2, p.26 for operational indicators used in malaria
control). (Using a residual insecticide on bednets is not included here as it has
already been covered earlier on.)
**Disease prevention through vector control**

**Table 14 Residual spraying of insecticide**

<table>
<thead>
<tr>
<th>Residual spray</th>
<th>Target insects</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>this consists of applying a suitable insecticide to a surface upon which the vector/pest is known to rest long enough to pick up a lethal dose</td>
<td>indoor resting mosquito vectors and indoor feeding sandflies</td>
<td>indoors – the standard recommended technique for indoor resting mosquito vectors</td>
</tr>
<tr>
<td></td>
<td>Triatomine (cone-nosed) bugs</td>
<td>indoors – the standard recommended technique for triatomine bugs</td>
</tr>
<tr>
<td>indoor treatments are usually done with a hand-held compression sprayer while outdoor treatments are usually done with power-operated sprayers</td>
<td>household pests (bedbugs, cockroaches, fleas, ticks)</td>
<td>indoors</td>
</tr>
<tr>
<td></td>
<td>flies</td>
<td>not recommended for fly control as likely to increase development of resistance</td>
</tr>
<tr>
<td></td>
<td>tsetse-flies and sandflies body lice, bed bugs, fleas</td>
<td>outdoors – needs to be applied to vector resting sites (trees, termite hills) applied as a dust</td>
</tr>
</tbody>
</table>

**Table 15 Members of residual spray team for malaria control**

<table>
<thead>
<tr>
<th>Personnel in residual spray team for malaria control</th>
<th>No. per team</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisor</td>
<td>1</td>
<td>supervise the field team, undertake simple health education</td>
</tr>
<tr>
<td>Spraypersons</td>
<td>4</td>
<td>spray the insecticide</td>
</tr>
<tr>
<td>Mixer</td>
<td>1</td>
<td>collect water, mix the insecticide prior to adding it to the spray tank (not needed where pre-packed sachets of insecticide used)</td>
</tr>
<tr>
<td>Insecticide distributor</td>
<td></td>
<td>collect, weigh and package insecticide</td>
</tr>
</tbody>
</table>
3.10.2 Larviciding

Larviciding programmes can be technically simple to do, and can be easily organised provided there is sufficient supervision.

Larvicides may be applied by hand-carried, vehicle-mounted or aerial equipment. Applications may need to be repeated at intervals of 7-14 days depending on circumstances and the type of larvicide used. Table 16 gives details of appropriate methodology. Fuel oil can be used as an effective larvicide, but will be expensive as relatively large amounts of oil are required (150-200 litres/ha) when compared with larvicidal oils (20-50 litres/ha).

Table 16 Larviciding

<table>
<thead>
<tr>
<th>Larviciding</th>
<th>Target</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>should only be applied when and where breeding has been shown to occur; the operator/supervisor must be able to recognise the target insect</td>
<td>'container breeder' mosquitoes (e.g. Aedes)</td>
<td>the recommended method for mosquitoes breeding in artificial containers which cannot be controlled in another manner (see section 3.6 for mosquito control in drinking water)</td>
</tr>
<tr>
<td>should only be adopted where vector breeding cannot be limited by environmental or sanitation measures (such as draining, filling, destroying or covering breeding sites)</td>
<td>other mosquitoes</td>
<td>an important control technique where the extent of mosquito breeding is within the economic control capabilities of the control programme</td>
</tr>
<tr>
<td></td>
<td>blackflies</td>
<td>the only vector-control technique against vector blackfly species but must usually be done over a large area otherwise the breeding site will soon be reinvaded by migrant blackflies</td>
</tr>
</tbody>
</table>
3.10.3 *Space spraying*

Thermal fogging with 2-5 per cent malathion or a synthetic pyrethroid will give effective control of adult mosquitoes if the fog can penetrate to where they are resting. Pyrethroid insecticides have the advantage of tending to irritate insects and encouraging them to fly. Thermal fogs are usually applied by ground equipment such as the hand-held or shoulder-carried pulse-jet machine or a two-stroke engine-exhaust fog generator. Vehicle-mounted fogging machines are also available.

Aerial space spraying is usually done with the ULV (ultra low volume) method using the same insecticides (but as different formulations; see section ) as used in fogging programmes. Ground spraying with ULV can be achieved by modifying the normal fogging machines by restricting the flow of insecticide and removing the heating section.

Space spraying must be restricted to an hour or two in the early morning or evening, when the temperature is lowest and thermal currents, which cause excessive dispersion of the insecticide, are at a minimum. If done at other times, the programme will be considerably less effective.