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Bed nets that kill mosquitos

The treatment of mosquito nets with an insecticide helps to reduce the numbers of mosquitos and the frequency with which people are bitten.

In recent years there has been a disquieting increase in the number of malaria cases in many countries, arising from growing resistance to insecticides among the mosquito vectors, increasing drug resistance among the malaria parasites, and inadequate national resources for mounting malaria control programs with vertical administration. In 1983 a group of experts recommended that a more active field research program should be started in order to arrive at the most appropriate vector control methods for communities and/or primary health care programs, that protective bed nets should be used, and that the efficacy of bed nets impregnated with pyrethroid insecticides should be investigated (*1*).

Mosquito nets or bed nets are employed worldwide to protect people from insect attack. Even if torn, they may prevent biting by mosquitos (*2*), and they can therefore complement malaria vector control programs by helping to reduce transmission of the disease. When a net is in use, its lower edge should be tucked under the bedding in order to achieve complete protection.

In some societies the nets confer status, in others privacy, but their chief value, of course, is that they give protection against malaria. Anyone can use them without special assistance. They are made by hand or machine in a variety of mesh sizes, textures, weights and colors, but those produced and sold commercially are commonly made of a fine mesh of cotton or synthetic fibers, e.g., nylon or polyester. They are usually rectangular or conical, and can be purchased in several sizes.

Where mosquitos feed mostly indoors, the application of a persistent, safe, rapidly-acting contact insecticide to bed nets would have several advantages. The useful life of the net, even if it were torn, would be extended. When holes and tears developed, the insecticide would hinder mosquitos from finding the openings and gaining access to the person inside. By killing mosquitos that contacted the net, the insecticide would reduce the attack rate. The treated net would also be a toxic resting site during the day when not in use. *Anopheles gambiae* is reportedly attracted to mosquito nets because they provide shade and a suitable surface for resting (*3*); another report indicates that unoccupied nets can be productive sites for the collection of *A. farauti* (*4*).

An insecticide selected for the treatment of nets can complement another being used in a malaria program if they belong to different chemical groups, and the risk of resistance developing in the mosquito population will thereby be diminished.

Permethrin is a synthetic insecticide acting by contact or ingestion. It is nonrepellent, quick-acting, nearly odorless and nonstaining,

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and is resistant to degradation when exposed to rain, heat, sunlight, wear, laundering, rinsings and immersion in water. It has been subjected to extensive testing to determine its toxicity resulting from ingestion, chronic topical application, and inhalation. A review of mammalian toxicity studies (*5*) indicates that it does not pose a threat to human health at the low rates suggested for the treatment of mosquito nets.

Permethrin is available as a wettable powder and as an emulsifiable concentrate, the latter being preferred for mosquito net treatments because it provides better adhesion to the net fibers and does not leave a powdery residue. The cost of treating a net at 0.2–0.8 g of technical permethrin per m^2 is a fraction of the cost of the net itself. A treated net may remain toxic to mosquitos for 3–6 months. If large numbers of nets are to be treated in a container at one time, it is necessary to adjust the liquid volume. Several trial runs with plain water may be necessary so as to arrive at the right amount. If too much emulsion remains after the treatment is completed, the permethrin will have been applied at less than the recommended rate.

The current cost of permethrin for small numbers of nets is less than US$ 1.25 for an application rate of 0.5 g per m^2. Bulk purchases would reduce the cost of treatment per net. Costs could be further reduced if governments helped to set up small industries employing local people to produce and distribute treated mosquito nets.

In addition to their other activities in the fight against malaria, health workers might stress the following points in favor of mosquito nets:

— they reduce the exposure of children to insect-borne disease;
— they are easy to use;
— other pests than mosquitos are also killed, i.e., cockroaches, fleas, lice, biting flies, ants, houseflies, mites and bedbugs;
— they allow one to sleep in comfort;
— there is prestige in owning a mosquito net.

Health workers should also:

— encourage the impregnation with permethrin of nets already in use, and make the necessary materials available;
— make new nets available to people who do not have them, and distribute them while the idea is fresh and the need exists;
— encourage the proper use of nets and maintain communication with the people concerned so as to counter any tendency to incorrect usage;
— determine what effect the long-term use of treated mosquito nets has on vector-borne disease in the district covered.

In the Western Pacific Region, national vector control workshops have been used to demonstrate the technique to public health officers, malaria supervisors, entomologists, sanitarians, community health workers, and other categories of staff.

A study on the effects of treated mosquito nets was conducted in Gonoa village, Papua New Guinea. There was less malaria among children aged 0–4 years in Gonoa than in an untreated village. The villagers readily used nets even though many had not done so before, compliance exceeding 90%. Unfortunately, there were too few nets per family, and some people slept with their arms and legs outside the nets because of crowded conditions. It was estimated that people using nets received only 5% of the number of bites recorded on people equipped with aspirator tubes for the removal of mosquitos landing on the body. The nets probably provided more protection to young children than adults, since children went to bed earlier.

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There were also reports that head lice disappeared from many people using nets, and that annoyance from bedbugs decreased.

A factor accounting for the apparently negligible mortality in the vector population at Gonoa concerned the type of material used to

Procedure for treating a mosquito net*

1. Calculate the area of net to be treated (length × width = area in m^2).

2. Calculate the amount of technical permethrin needed. A dosage of 0.5 g/m^2 is considered to give satisfactory results irrespective of the material used.

3. Use the following formula to calculate the amount of permethrin emulsifiable concentrate needed.

$$\frac{\text{Amount of technical permethrin needed (step 2)} \times 100}{\text{\% permethrin in product used}} = \text{g of product needed}$$

4. Determine the amount of water necessary to saturate but not run off the net. Cotton absorbs water but nylon does not. Permethrin sticks well to both fibers. As a rule, cotton nets require approximately 30 ml of water per m^2, while nylon nets need 15 ml per m^2. The same solution can be used to treat 1–5 nets.

5. Mix the permethrin emulsifiable concentrate (from step 3) with the water (from step 4). Put the net in a plastic bag with the permethrin emulsion. Close the bag and knead (press) it carefully so that the liquid reaches all parts of the net. After treatment, remove the net and lay it on the bag to dry. The bag can be used to store the dry net. Do not hang the net up to dry, because if this is done some of the emulsion will be lost due to dripping.

* Further details of the technology are given in document WHO/VBC/85.915, available from the Division of Vector Biology and Control, World Health Organization, 1211 Geneva 27, Switzerland.

construct the nets. They appeared to be made from solid pieces of cloth with no openings for air circulation. Nylon nets, on the other hand, have a wider mesh and may be more attractive to mosquitos trying to reach a human host inside. Detectable vector mortality can probably be achieved by using large-mesh nets.

The use of nets is also being tried in areas of high malaria prevalence where measures other than DDT indoor residual spraying are desired. A recent report from West Africa (*6*) on tests against *Anopheles gambiae* and *A. funestus* concluded that treated mosquito nets, even if they were damaged, could become an effective method of malaria prevention.

Field evaluation of treated mosquito nets has been conducted in China, Malaysia, and Papua New Guinea, where the main vectors are *A. dirus, A. balabacensis* and *A. farauti.* Projects are being planned against *A. minimus* in Laos and Viet Nam. Preliminary findings show that the method can appreciably reduce the numbers of mosquito bites inflicted on people. Since the treatment is simple, quick, nontoxic and cheap, individuals in the community will ultimately be able to participate in this type of vector control program using the primary health care approach. □

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