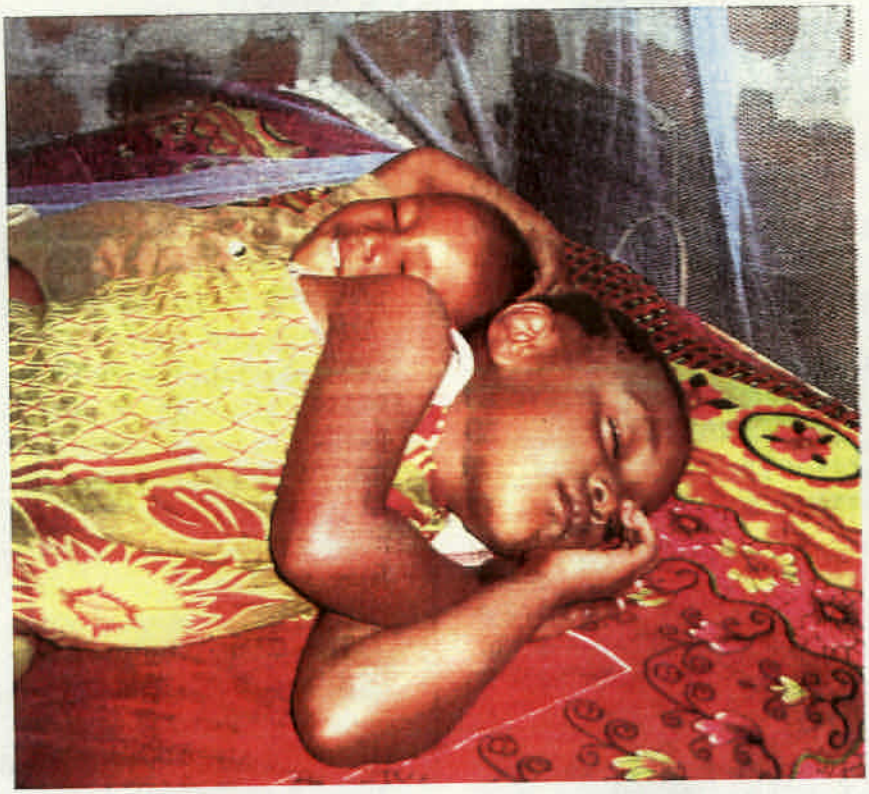
GLOBAL MALARIA PROGRAMME



INSECTICIDE-TREATED MOSQUITO NETS:

a WHO Position Statement

World Health Organization

INTRODUCTION

The WHO Global Malaria Programme (WHO/GMP) recommends the following three primary interventions for effective malaria control, which must be scaled up if countries are to move towards achieving the United Nations Millennium Development Goals* by 2015:

- **diagnosis of malaria cases and treatment with effective medicines;**
- **distribution of insecticide-treated nets (ITNs), more specifically long-lasting insecticidal nets (LLINs), to achieve full coverage of populations at risk of malaria; and**
- **indoor residual spraying (IRS) to reduce and eliminate malaria transmission.**

This Position Statement reviews the evidence and experiences to date on ITNs, describes the current WHO/GMP position on ITNs, including LLINs, for prevention and control of malaria, and outlines additional research needs.

ITNs and LLINs

An ***insecticide-treated net*** is a mosquito net that repels, disables and/or kills mosquitoes coming into contact with insecticide on the netting material. There are two categories of ITNs: conventionally treated nets and long-lasting insecticidal nets:

- A *conventionally treated net* is a mosquito net that has been treated by dipping in a WHO-recommended insecticide. To ensure its continued insecticidal effect, the net should be re-treated after three washes, or at least once a year.
- A ***long-lasting insecticidal net*** is a factory-treated mosquito net made with netting material that has insecticide incorporated within or bound around the fibres. The net must retain its effective biological activity without re-treatment for at least 20 WHO standard washes under laboratory conditions and three years of recommended use under field conditions.

1. ITNs: modes of action

All mosquito nets act as a physical barrier, preventing access by vector mosquitoes and thus providing personal protection against malaria to the individual(s) using the nets. Pyrethroid insecticides, which are used to treat nets, have an excito-repellent effect that adds a chemical barrier to the physical one, further reducing human–vector contact and increasing the protective efficacy of the mosquito nets. Most commonly, the insecticide kills the malaria vectors that come into contact with the ITN. By reducing the vector population in this way, ITNs, when used by a majority of the target population, provide protection for all people in the community, including those who do not themselves sleep under nets (*1*, *2*). A recent study has shown that relatively modest coverage (around 60%) of all adults and children can achieve equitable community-wide benefits (*3*). ITNs thus work in this case as a vector control intervention for reducing malaria transmission.

ITNs have been shown to avert around 50% of malaria cases, making protective efficacy significantly higher than that of untreated nets which, under ideal conditions (such as those found in research settings), usually provide about half the protection of nets treated with an effective insecticide (*4*). In "real

* http://www.un.org/millenniumgoals

LLIN purchased for US$ 5.50 that lasts for 5 years, and US$ 104 for an LLIN purchased for US$ 5.50 that would last for 7 years. Thus, the longer the useful life of the LLIN, the cheaper it is to use – even if the initial purchase price is higher.

3. Review of experiences in delivery strategies

Since 2002, a number of countries have begun scaling-up the free or highly subsidized provision of ITNs, including LLINs, and several of them have shown a substantial increase in coverage as a result. In many countries, however, coverage still falls far short of the targets contained in a 2005 World Health Assembly resolution (*13*), which urged Member States to establish policies and operational plans to ensure that at least 80% of those at risk of, or suffering from, malaria should benefit from major preventive and curative interventions by 2010.

3.1 Target groups for ITN distribution

Recently, models for delivery of ITNs have focused on different target groups depending on the local epidemiological situation:

- in perennial transmission areas: targeted distribution to vulnerable groups, i.e. pregnant women and children under 5 years of age;
- in areas with unstable malaria and limited populations at high risk: delivery to the total population within a defined geographical area.

3.2 Delivery strategies

ITNs have been delivered to households through the public sector, through the private sector, and through a mix of public and private sectors.

Delivery of LLINs through antenatal care services and immunization programmes allows advantage to be taken of existing health services to reach both pregnant women and children under the age of 1 year. Delivery of LLINs to pregnant women through antenatal care is practised or planned in many countries and can be done in two ways:

- giving a free or subsidized LLIN (i.e. direct product), or
- giving a voucher or coupon that can be exchanged for an LLIN at a distribution point such as a commercial outlet.

Separating the delivery of the subsidy and the LLINs through distribution of vouchers/coupons to the target population makes it possible to stimulate local trade by building and maintaining a countrywide network of outlets. Thus commercial demand and the commercial market are strengthened while the burden on the public health system of the logistics and distribution of ITNs, including LLINs, and of the associated management functions, is reduced. However, the use of vouchers/coupons requires there to be private sector retail outlets, which are often absent in rural areas, and additional management and monitoring systems, to maximize penetration.

Delivery of LLINs to children together with immunizations may be done through routine immunization or as part of campaigns such as measles or poliomyelitis. LLINs can be delivered at health facilities or by mobile teams as part of monthly outreach services. There is already good experience of combining immunization and LLIN distribution in a number of countries. LLINs are also delivered through child health days/weeks, which target children under 5 years of age with a package of interventions including LLINs, vitamin A supplementation and deworming.

In emergency situations in areas with unstable malaria, campaign-like delivery as part of relief efforts can help to achieve rapid coverage of the entire population.

Where alternative approaches have been successfully developed and implemented in specific contexts, these should be maintained. Emphasizing the role of public health services in LLIN implementation does not exclude the involvement of partners such as nongovernmental organizations and the private sector, which have played and will continue to play an important complementary role in implementing LLIN interventions.

4.1 Long-lasting treament technologies

As few programmes have so far been able to ensure regular retreatment of nets and achieve high levels of treatment coverage, the use of long-lasting treatment technologies is recommended. In most settings, these technologies make the achievement and maintenance of high coverage far easier and less costly.

Three LLINs are currently recommended by WHO; additional nets are under evaluation and promising new technologies are emerging. Also in development are long-lasting treatment kits, designed to transform untreated nets into LLINs (as per the WHO definition) by simple dipping. Once such kits are available, their use as an interim strategy to treat millions of untreated nets currently in use would have significant operational implications for rapidly increasing treatment coverage rates. The final goal, however, remains one of replacing all untreated and conventionally-treated nets with LLINs.

4.2 Free or highly subsidized distribution

In general, rapid scale-up in the coverage of target populations can be achieved most efficiently through the distribution of free or highly subsidized LLINs. Cost should not be a barrier to making LLINs available to all people at risk, especially young children and pregnant women. The role of vouchers/coupons as an LLIN delivery mechanism is the subject of much debate and should be considered in the light of local experience. Commercial markets are valuable sources of nets. Where strong commercial markets exist or are developing, they should be encouraged: they can provide important benefits, ensuring longer-term access and enhancing management of logistics and education efforts.

4.3 Full coverage

Since high coverage rates are needed to realize the full potential of LLINs, GMP recommends full coverage of all people at risk in areas targeted for malaria prevention through ITNs, including LLINs.

In endemic areas with intense malaria transmission (stable malaria), all infants at their first immunization and all pregnant women as early as possible in pregnancy should receive one LLIN through immunization and antenatal care visits. The consistent delivery of LLINs through these channels would, under ideal conditions, make it possible to achieve full population coverage. The provision of one LLIN per infant and one per pregnant woman would result in nine LLINs distributed per 100 people per year, based on an estimated five pregnancies and four infants annually per 100 people in the total population. If the LLINs have a useful life of 5 years and each LLIN is used by two people, 90% of the population would be covered after 5 years.

In reality, however, there will be losses of LLINs due to tearing, excessive washing and diversion (resale of nets, use of nets for other than the intended purpose); moreover, antenatal care and immunization coverage is below 100%, and most LLINs currently last less than 5 years. In most countries, achieving high LLIN coverage rapidly will therefore necessitate the provision of additional LLINs through immunization campaigns, for example measles or polio campaigns. Mass distribution campaigns have the potential both to rapidly scale up coverage and to raise awareness of the benefits of using LLINs. This is an effective approach to creating consumer demand and a "net culture" in which the use of LLINs becomes a norm. If campaigns that include LLIN delivery take place every 4 years, this strategy – in combination with delivery through antenatal and immunization services – will provide full population coverage within 4–5 years, provided that LLINs are effective for 5 years. With LLINs lasting 3 years, coverage rates would be 39–75%, and these methods would have to be complemented by additional distribution mechanisms.

slowing down the development of resistance. New contact insecticide(s) may become available in the near future to supplement pyrethroids for treatment of mosquito nets.

5.4 Long-lasting treated materials

Long-lasting treatment technologies can be used to produce materials other than mosquito nets. Long-lasting treated hammocks, for example, are being evaluated for the prevention of forest malaria, and plastic sheeting with incorporated insecticide has been developed with potential for malaria prevention in complex emergencies. Other potential applications such as treated curtains, blankets and clothing are under consideration.

5.5 Social and behavioural aspects

The cultural factors that determine ownership, retention and use of ITNs, including LLINs, must be taken into consideration to ensure that communication and advocacy activities contribute to effective use of these nets. In this context, research into local perceptions of mosquitoes, malaria, ITNs/LLINs and washing practices is needed to inform the choice of media, messages and advocacy strategies. The ultimate aim should include a measurable increase in ITN/LLIN awareness and reported changes in ITN/LLIN retention and use.

5.6 Combining LLINs and IRS in high transmission areas

In most settings where IRS has been or is being deployed, ITNs/LLINs are already in use. Neither LLINs nor IRS alone will be sufficiently effective to achieve and maintain interruption of transmission in holo-endemic areas of Africa or in hyperendemic areas in other regions.

More evidence is needed on the efficacy of combining IRS and LLINs (epidemiological impact, resistance management), on the feasibility of this combination, and on targeting, social acceptability, compliance and costs. Gathering such evidence will require large-scale operational trials in areas with different epidemiological and insecticide resistance profiles.

5.7 Impact on other vector-borne diseases

More rigorous studies are needed to demonstrate or confirm the impact of LLINs on the incidence of other vector-borne diseases.

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Overall Evaluations of Carcinogenicity to Humans

Group 3: Not classifiable as to carcinogenicity to humans

As evaluated in *IARC Monographs* Volumes 1-99

This list contains all agents evaluated as Group 3 carcinogens to date.
Where appropriate, chemical abstract numbers are given [in square brackets]. For details of the evaluation, the relevant Monograph should be consulted (volume number given in round brackets, followed by year of publication of latest evaluation). Use a free-text search to find a particular compound.

Group 3: *Not classifiable as to its carcinogenicity to humans* (515)

Agents and groups of agents

Acenaphthene [83-32-9] (Vol. 92; in preparation)

Acepyrene (3,4-dihydrocyclopenta[*cd*]pyrene) [25732-74-5] (Vol. 92; in preparation)

Aciclovir [59277-89-3] (Vol. 76; 2000)

Acridine orange [494-38-2] (Vol. 16, Suppl. 7; 1987)

Acriflavinium chloride [8018-07-3] (Vol. 13, Suppl. 7; 1987)

Acrolein [107-02-8] (Vol. 63; 1995)

Acrylic acid [79-10-7] (Vol. 19, Suppl. 7, Vol. 71; 1999)

Acrylic fibres (Vol. 19, Suppl. 7; 1987)

Acrylonitrile-butadiene-styrene copolymers (Vol. 19, Suppl. 7; 1987)

Actinomycin D [50-76-0] (Vol. 10, Suppl. 7; 1987)

Agaritine [2757-90-6] (Vol. 31, Suppl. 7; 1987)

Aldicarb [116-06-3] (Vol. 53; 1991)

Aldrin [309-00-2] (Vol. 5, Suppl. 7; 1987)

Allyl chloride [107-05-1] (Vol. 36, Suppl. 7, Vol. 71; 1999)

Allyl isothiocyanate [57-06-7] (Vol. 73; 1999)

Allyl isovalerate [2835-39-4] (Vol. 36, Suppl. 7, Vol. 71; 1999)

Amaranth [915-67-3] (Vol. 8, Suppl. 7; 1987)

5-Aminoacenaphthene [4657-93-6] (Vol. 16, Suppl. 7; 1987)

2-Aminoanthraquinone [117-79-3] (Vol. 27, Suppl. 7; 1987)

para-Aminobenzoic acid [150-13-0] (Vol. 16, Suppl. 7; 1987)

1-Amino-2-methylanthraquinone [82-28-0] (Vol. 27, Suppl. 7; 1987)

2-Amino-4-nitrophenol [99-57-0] (Vol. 57; 1993)

Permethrin [52645-53-1] (Vol. 53; 1991)

Perylene [198-55-0] (Vol. 32, Suppl. 7, Vol. 92; in preparation)

Petasitenine [60102-37-6] (Vol. 31, Suppl. 7; 1987)

Phenanthrene [85-01-8] (Vol. 32, Suppl. 7, Vol. 92; in preparation)

Phenelzine sulfate [156-51-4] (Vol. 24, Suppl. 7; 1987)

Phenicarbazide [103-03-7] (Vol. 12, Suppl. 7; 1987)

Phenol [108-95-2] (Vol. 47, Vol. 71; 1999)

Phenylbutazone [50-33-9] (Vol. 13, Suppl. 7; 1987)

meta-Phenylenediamine [108-45-2] (Vol. 16, Suppl. 7; 1987)

para-Phenylenediamine [106-50-3] (Vol. 16, Suppl. 7; 1987)

N-Phenyl-2-naphthylamine [135-88-6] (Vol. 16, Suppl. 7;1987)

ortho-Phenylphenol [90-43-7] (Vol. 73; 1999)

Picene [213-46-7] (Vol. 92; in preparation)

Picloram [1918-02-1] (Vol. 53; 1991)

Piperonyl butoxide [51-03-6] (Vol. 30, Suppl. 7; 1987)

Polyacrylic acid [9003-01-4] (Vol. 19, Suppl. 7; 1987)

Polychlorinated dibenzo-*para*-dioxins (other than 2,3,7,8-tetrachlorodibenzo-*para*-dioxin) (Vol. 69; 1997)

Polychlorinated dibenzofurans (Vol. 69; 1997)

Polychloroprene [9010-98-4] (Vol. 19, Suppl. 7; 1987)

Polyethylene [9002-88-4] (Vol. 19, Suppl. 7; 1987)

Polymethylene polyphenyl isocyanate [9016-87-9] (Vol. 19, Suppl.7; 1987)

Polymethyl methacrylate [9011-14-7] (Vol. 19, Suppl. 7; 1987)

Polypropylene [9003-07-0] (Vol. 19, Suppl. 7; 1987)

Polystyrene [9003-53-6] (Vol. 19, Suppl. 7; 1987)

Polytetrafluoroethylene [9002-84-0] (Vol. 19, Suppl. 7; 1987)

Polyurethane foams [9009-54-5] (Vol. 19, Suppl. 7; 1987)

Polyvinyl acetate [9003-20-7] (Vol. 19, Suppl. 7; 1987)

Polyvinyl alcohol [9002-89-5] (Vol. 19, Suppl. 7; 1987)

Polyvinyl chloride [9002-86-2] (Vol. 19, Suppl. 7; 1987)

Polyvinyl pyrrolidone [9003-39-8] (Vol. 19, Suppl. 7, Vol. 71; 1999)

Updated December 2007

WHO recommended insecticide products treatment of mosquito nets for malaria vector control

1. Conventional treatment:

INSECTICIDE	*FORMULATION*[1]	*DOSAGE*[2]
Alpha-cypermethrin	SC 10%	20-40
Cyfluthrin	EW 5%	50
Deltamethrin	SC 1%; WT 25%; and WT 25% + binder[3]	15-25
Etofenprox	EW 10%	200
Lambda-cyhalothrin	CS 2.5%	10-15
Permethrin	EC 10%	200-500

2. Long-lasting treatment:

Product name	*Product type*	*Status of WHO recommendation*
ICON® MAXX	Lambda-cyhalothrin 10% CS + binder Target dose of 50 mg/m^2	Interim

[1] EC = emulsifiable concentrate; EW = emulsion, oil in water; CS = capsule suspension; SC= suspension concentrate; WT = water dispersible tablet.
[2] Milligrams of active ingredient per square metre of netting.
[3] K-O TAB 1-2-3®

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/.

Updated December 2007

WHO recommended long-lasting insecticidal mosquito nets

Product name	*Product type*	*Status of WHO recommendation*
Duranet®	Alpha-cypermethrin incorporated into polyethylene	Interim
Netprotect®	Deltamethrin incorporated into polyethylene	Interim
Olyset®	Permethrin incorporated into polyethylene	Full
PermaNet 2.0®	Deltamethrin coated on polyester	Interim
Interceptor®	Alpha-cypermethrin coated on polyester	Interim

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