GLOBAL MALARIA PROGRAMME

INSECTICIDE TREATED MOSQUITO NETS: a position statement
EXECUTIVE SUMMARY

This WHO Global Malaria Programme (WHO/GMP) Position Statement describes a shift in guidance on malaria prevention through the use of insecticide treated mosquito nets (ITNs).

The WHO/GMP calls upon National Malaria Control Programmes and their partners involved in insecticide-treated net interventions to **purchase only long-lasting insecticidal nets (LLINs)**. LLINs are designed to maintain their biological efficacy against vector mosquitoes for at least three years in the field under recommended conditions of use, obviating the need for regular insecticide treatment.

LLINs should be deployed as a vector control intervention in order for their full potential to be realized. WHO/GMP, therefore, recommends **full coverage of all people at risk of malaria** in areas targeted for malaria prevention with LLINs.

The way full coverage should be achieved may be different depending on the epidemiological and operational situation. Where young children and pregnant women are the most vulnerable, their protection is the immediate priority while progressively achieving full coverage. In areas of low transmission, where all age-groups are vulnerable, national programmes should establish priorities on the basis of the geographical distribution of the malaria burden.

In most high-burden countries, ITN coverage is still below agreed targets. The best opportunity for rapidly scaling-up malaria prevention is **free or highly subsidized LLIN distribution through existing public health services** (both routine and campaigns). LLINs should be considered a public good for populations living in malaria endemic areas. Distribution of LLINs should be systematically associated with **provision of information on how to hang, use and maintain them properly**.

The GMP Position is not exclusive of other approaches that have been successfully developed and implemented in specific contexts. Focusing on the role of national health services in LLIN implementation does not exclude the role of other partners that have played and will continue to play an important role in implementing this intervention.

Neither LLINs nor indoor residual spraying (IRS), the other main method for malaria vector control, may alone be effective enough to achieve and maintain interruption of transmission in holo-endemic areas of Africa. Operational research is needed to determine to which extent combining both interventions would maximize public health impact of malaria vector control and offer opportunities for management of insecticide resistance.
INTRODUCTION

The WHO Global Malaria Programme (WHO/GMP) recommends the following three primary interventions that must be scaled up in countries for effective malaria control, towards achieving the United Nations Millennium Development Goals by 2015 (http://www.un.org/millenniumgoals):

- 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 paper reviews the evidence and experiences to date on ITNs and describes the current WHO/GMP position on ITNs, including LLINs, for prevention and control of malaria, as well as needs for additional research.

1. Insecticide-treated nets (ITNs) and long-lasting insecticidal nets (LLINs)

An insecticide-treated net is a mosquito net which repels, disables and/or kills mosquitoes when they come 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 which has been treated by dipping the net in a WHO-recommended insecticide. To ensure continued insecticidal effect, nets 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.

2. ITNs: modes of action

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

ITNs have been shown to avert around 50% of malaria cases. Their protective efficacy is thus significantly higher than that of untreated nets, which under ideal conditions (such as those found in research
ITNs (impregnated nets) settings), usually provide about half the protection of nets treated with an effective insecticide (4). In "real life" situations, the protective efficacy of untreated nets is significantly compromised due to the poor condition of the nets. Most mosquito nets are currently made of polyester netting that often does not last long under field situations (between 2 and 3 years). New technologies and netting materials are being developed to produce nets that will be stronger and longer-lasting.

3. ITNs: epidemiological impact and cost

3.1 Impact of ITNs on overall childhood mortality and malaria-related morbidity

A Cochrane review concluded, on the basis of five community-randomized trials, that when full coverage is achieved ITNs reduce all-cause child mortality by 18% on average (with a range of 14%-29%) in sub-Saharan Africa (5). This implies that, in general, 5.5 lives could be saved per year for every 1,000 children under five years of age protected. The review also concluded that ITNs reduce clinical episodes of malaria caused by *Plasmodium falciparum* and *Plasmodium vivax* infections by 50% on average (with a range of 39%-62%), as well as reducing the prevalence of high-density parasitaemia.

Protection against forest malaria has recently been demonstrated in the Amazon Region and in Cambodia (6), which confirms that provision of personal protection against malaria is an important mode of action of ITNs. Forest malaria is a complex phenomenon characterized by frequent population movements and lack of permanent structures, which makes vector control interventions difficult.

In Africa, compared with a control situation in which there were no mosquito nets, ITNs increased mean birth weight by 55 grams (95% confidence interval [CI] 21–88), reduced low birth weight by 23% (relative risk [RR] 0.77, 95% CI 0.61–0.98), and reduced miscarriages/stillbirths by 33% (RR 0.67, CI 0.47–0.97) in the first few pregnancies. Placental parasitaemia was reduced by 23% in all gravidae (RR 0.77, CI 0.66–0.90) (7).

A combination of co-trimoxazole prophylaxis, antiretroviral therapy, and ITNs substantially reduced the severity of malaria in adults with HIV (8).

3.2 Impact on diseases other than malaria

ITNs have been proven effective against a range of other vectors involved in the transmission of diseases such as leishmaniasis (9), Japanese encephalitis (10), lymphatic filariasis (11) and Chagas’ disease. ITNs also provide protection against nuisance mosquitoes and kill head lice and bedbugs (12), which contributes greatly to population acceptance and use of ITNs.

3.3 Cost-effectiveness of ITN distribution

Use of ITNs is one of the most cost-effective interventions against malaria. In a recent analysis of the cost of five ITN and two IRS programmes in Africa, LLINs were found to be significantly cheaper to use than conventionally treated nets. The cost per death averted and the cost per DALY averted with LLINs lasting three years were less than half the comparable costs using conventional ITNs. The findings of the study also suggest that, in high-transmission areas where most of the malaria burden occurs in children under five years, and assuming it is possible to effectively target LLINs to this population group, the use of LLINs is 4 to 5 times cheaper than IRS which cannot be targeted to children only. Average annual cost per LLIN was US$ 2.10 (1.48-2.64), equivalent to US$ 1.05 per person protected per year, compared with US$ 3.60 per person protected per year for IRS (calculated for the whole population) (Yukich, Lengeler et al., submitted). However, these calculations are based on the assumptions that LLINs are properly used and are effective for three years.
The estimated cost per child death averted varies according to the price and effective duration of LLINs used. This cost is US$ 212 for a LLIN purchased for US$ 4.50 that lasts for three years, US$ 145 for a US$ 5.50 LLIN that lasts for five years, and US$ 104 for a US$ 5.50 LLIN that lasts for seven years. LLINs, with longer useful life, are cheaper to use, even if they are more expensive to buy.

4. Review of experiences in delivery strategies

Since 2002, a number of countries have begun scaling-up free or highly subsidized provision of ITNs, including LLINs. As a result, there has been a substantial increase in coverage in several of these countries. However, in many countries, 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.

4.1 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 five years of age;
- in areas with unstable malaria and limited populations at high risk: delivery to the total population within a defined geographic area.

4.2 Delivery strategies

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

Delivery of ITNs through antenatal care services and immunization programmes represents an opportunity to take advantage of existing health services to reach both pregnant women and children under the age of one year. Delivery of LLINs to pregnant women through antenatal care is currently taking place or planned in many countries and can be done in two ways: (i) giving a free or subsidized LLIN (i.e. direct product) or (ii) giving a voucher/coupon which can be exchanged for a 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 offers the possibility of stimulating and supporting local trade building and maintenance of a network of outlets country-wide. Strengthening commercial demand and the commercial market is therefore possible alongside alleviating the burden on the public health system of the logistics and distribution of ITNs, including LLINs, as well as the associated management functions. However, vouchers/coupons require the presence of private sector retail outlets, often absent in rural areas, and additional management and monitoring systems, to maximize penetration.

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

* Based on 5.5 lives averted per 1000 children under five years sleeping under a LLIN, and distribution cost of US$ 2.50 per LLIN.
In emergency situations in areas with unstable malaria, campaign-like delivery can help to achieve rapid coverage of the entire population.

In a number of countries, more nets have been delivered through the commercial market than by other mechanisms, and in Sahelian countries with a strong tradition for using nets, there is even evidence that commercial availability can produce equitable distribution (14). However, the majority of these nets are not treated, and there is no evidence that high coverage of insecticide treatment can be obtained through commercial channels. By contrast, Eastern and Southern African countries have limited commercial sector penetration beyond urban and periurban areas.

To finance the provision of ITNs, public sector delivery in the past has applied cost-sharing strategies, requiring a small payment ("top-up") to purchase a subsidized net at the health facility or at a commercial outlet upon presentation of a voucher/coupon. The level of subsidy for both LLINs or for vouchers/coupons has ranged from 40% to 100%. In most settings, cost sharing schemes have varied in their effectiveness at achieving high coverage, and have been generally more effective in urban than in rural areas resulting in socio-economic disparities in coverage.

Social marketing techniques are used in some countries with a range of distribution approaches, including public health facilities and a combination of community-based and private sector distribution, the latter mainly in urban centres.

4.3 Ensuring proper use

Experience has shown that possession and appropriate use of ITNs do not automatically go hand-in-hand. In the past, not enough attention was paid to designing and implementing locally-appropriate communication strategies, alongside ITN distribution, to inform communities of the importance of ITNs and how to hang, use and maintain them properly. As a result, many people who received the ITNs did not sleep under them, re-sold them, reduced their efficacy through inappropriate washing practices, or failed to replace them when damaged or torn.

4.4 Sustaining high coverage

A number of countries have embarked on campaign-like strategies to rapidly increase coverage with LLINs. However, the importance of strategies for delivery of LLINs through routine health services to maintain those high levels of coverage has been underestimated. Based on the lifespan of the current generation of LLINs, which is expected to be from three to five years, there is a need to ensure sustainability of mechanisms and approaches for LLIN distribution.

5. WHO position on the use of LLINs for malaria prevention

The WHO Global Malaria Programme is calling upon National Malaria Control Programmes and their partners involved in insecticide-treated net interventions to:

- purchase only long-lasting insecticidal nets (LLINs);
- distribute free or highly subsidized LLINs either directly or through vouchers/coupons;
- achieve full coverage of LLINs, including in high-transmission areas, by distributing LLINs through existing public health services;
- develop and implement locally-appropriate communication and advocacy strategies to promote effective use; and
- implement strategies to sustain high levels of coverage with LLINs complementary to strategies for achieving rapid scale up.
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 non-governmental organizations and the private sector, which have played and will continue to play an important complementary role in implementing LLIN interventions.

5.1 Long-lasting technologies

As few programmes have been able so far to ensure regular retreatment of nets and to achieve high levels of treatment coverage, the use of long-lasting 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 new promising technologies are being developed. Long-lasting treatment kits are an emerging technology designed to transform non-treated nets into LLINs as per the WHO definition by simple dipping. Once available, the use of such kits as an interim strategy to treat millions of non-treated nets currently in use would have tremendous operational implications in rapidly increasing treatment coverage rates. The final goal is to replace all non-treated and conventionally-treated nets with LLINs.

5.2 Free or highly subsidised distribution

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

5.3 Full coverage

Since high coverage rates are needed to realize the full potential of LLINs, GMP recommends full coverage of all people at risk of malaria 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 five years and each LLIN is used by two people, then after five years 90% of the population would be covered.

However, in reality there will be losses of LLINs due to tear, excessive washing and diversion, and the coverage of antenatal care and immunization services is below 100%. In addition, currently most LLINs do not last for five years. In order to achieve high LLIN coverage quickly, it will therefore be necessary in most countries to provide additional LLINs through immunization campaigns, for example, measles or polio campaigns. Mass distribution campaigns have the potential to rapidly scale up coverage as well as to raise awareness of the benefits of using LLINs. This is an effective approach towards the creation of consumer demand and a net culture so that the use of LLINs becomes a norm. If such campaigns including LLIN delivery take place every four years, then this strategy in combination with delivery through antenatal and immunization services will provide full population coverage in four to
five years, provided that LLINs are effective for five years. With LLINs lasting three years, coverage rates would be between 39% and 75%, and these methods would have to be complemented by additional distribution mechanisms.

In endemic areas with low malaria transmission (unstable malaria), LLINs should be delivered to all people and should initially focus on priority target areas, for example those with high burden of malaria or at risk of outbreaks due to climatic conditions or areas with limited access to health services. Where malaria is a problem in people with HIV/AIDS, the possibility for providing LLINs through services targeting these population groups should be explored.

5.4 Communication and advocacy

ITNs, including LLINs, are effective provided that people use them properly and consistently. In addition, although LLINs are designed to resist multiple washes, excessive or aggressive washing or the use of harsh detergents, such as some kinds of traditional soaps, rapidly reduces the useful life of LLINs. Therefore, distribution of LLINs should be associated systematically with provision of information through direct advice during distribution, as well as advocacy through local and national media campaigns.

5.5 Sustainability

LLIN distribution through campaigns offers opportunities to rapidly increase LLIN coverage in targeted communities (“catch-up”). However these distributions are most effective when implemented complementary to continuous LLIN distribution through routine antenatal or immunization services to maintain coverage (“keep-up”). Long-term sustainability requires the provision of an “enabling environment” and a vigorous campaign of public and privately funded demand creation and communication campaigns for behavioural impact. Countries which have already achieved high coverage rates should assess their achievements, especially regarding coverage, access in remote areas and equity and prepare targeted strategies to fill the gaps.

5.6 Combining LLINs and IRS in high transmission areas

ITNs/LLINs are already used in most settings where IRS has been or is being deployed. Neither LLINs nor IRS alone may be effective enough to achieve and maintain interruption of transmission in holo-endemic areas of Africa and hyperendemic areas in other Regions. Operational research is needed to determine to which extent combining both interventions would maximize public health impact of malaria vector control and offer opportunities for management of insecticide resistance.

6. Research

6.1 Improvement of long-lasting treatment technologies and technology transfer

Development of long-lasting treatment technologies is relatively recent and rapidly evolving. Improvement of technologies focuses both on the physical strength of the netting and on duration of efficacy of the insecticide treatment. There is now a wide consensus among partners and pesticide companies on the need for nets that are stronger and longer-lasting, thereby moving away from polyester to more robust polymers. New polymers, new yarns and knitting patterns as well as improved treatment technologies are being developed to cover the wide range of conditions under which LLINs are used in the field and to facilitate technology transfer for local production in endemic countries.
6.2 ITNs and pyrethroid resistance

There is convincing evidence from some parts of West Africa that a certain type of pyrethroid resistance does not significantly reduce the level of personal protection provided by ITNs (15-17). However, more information is needed on other resistance mechanisms as well as entomological impact of resistance under programme conditions (effectiveness), and on how resistance affects the other mode of action of ITNs, which is to control malaria transmission.

6.3 Use of non-pyrethroid insecticides on mosquito nets

There are current developments towards treatment of LLINs with a combination of a pyrethroid and non-pyrethroid insecticides, as a mixture or a mosaic treatment, with the dual objective of enhancing efficacy of treated nets against vectors and pest mosquito species as well as preventing or slowing down the development of resistance. New contact insecticide(s) may be available in the near future to fully supplement pyrethroids for treatment of mosquito nets.

6.4 Long-lasting treated materials

Long-lasting treatment technologies can be used to treat materials other than mosquito nets. Long-lasting treated hammocks are under evaluation for prevention of forest malaria. Plastic sheeting with incorporated insecticide have been developed for malaria prevention in complex emergencies. Other potential applications such as treated curtains, blankets or clothing are under consideration.

6.5 Social and behavioural aspects

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

6.6 Combining IRS and ITNs

More evidence is needed on combining IRS and LLINs with regards to efficacy (epidemiological impact, resistance management), feasibility of combining and targeting, social acceptability, compliance and costs. Such evidence should be gained through large-scale operational trials carried out in areas with different epidemiological and insecticide resistance profiles.

6.7 Impact on other vector-borne diseases

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

7. Conclusion

The effectiveness and potential of ITN interventions to reduce the burden of malaria has been amply demonstrated in a variety of epidemiological settings. Now, the advent of long-lasting insecticidal nets and treatment technologies has opened up prospects for improving ITN interventions by addressing the issue of treatment and re-treatment. It is critical to seize this opportunity and rapidly expand access to this new technology for all populations at risk of malaria.
Integration of free or highly subsidized LLIN distribution into existing health services, especially immunization and antenatal care services, complemented by distribution through child health days/weeks and immunization campaigns, should help to rapidly achieve and sustain full coverage of LLINs. To increase current ITN coverage, the crop of existing non-treated or conventionally treated nets currently in use should be treated using long-lasting treatment kits when such kits are available. Effective communication and monitoring and evaluation strategies must be in place alongside systems for delivery of the commodities so that the impact of the intervention can be enhanced and assessed.

Importantly, the WHO Global Malaria Programme emphasizes a pragmatic approach to scaling up access and use of LLINs, and is focusing on utilization of all existing opportunities within countries. Therefore, this Position Statement is intended as general guidance, but should not result in moving away from strategies that have been proven effective in specific contexts. Furthermore, the ITN/LLIN landscape is constantly changing and this guidance will be reviewed as and when new evidence becomes available.

A LLIN manual will soon provide more detailed practical guidance for national implementers managing LLIN interventions.
References


