GLOBAL MALARIA PROGRAMME

INSECTICIDE-TREATED MOSQUITO NETS:

a WHO Position Statement

World Health Organization

EXECUTIVE SUMMARY

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

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

The way in which full coverage should be achieved may vary with particular epidemiological and operational situations. Where young children and pregnant women are the most vulnerable groups, their protection is the immediate priority while progress is made towards 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 the *free or highly subsidized distribution of LLINs 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 accompanied by provision of *information on how to hang, use and maintain them properly*.

The GMP position does not exclude 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 important roles of other partners – now and in the future – in implementing this intervention.

Neither LLINs nor indoor residual spraying (IRS), the other main method of malaria vector control, may be sufficiently effective alone to achieve and maintain interruption of transmission in holo-endemic areas of Africa. Operational research is needed to determine the extent to which combining the two interventions would maximize the 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 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

life" situations, the protective efficacy of untreated nets is significantly compromised by their poor physical condition. Currently, most mosquito nets are made of polyester and rarely last longer than 2–3 years under field situations. However, new technologies and materials such as polyethylene have been developed to produce nets that are stronger and longer-lasting.

2. ITNs: epidemiological impact and cost

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

On the basis of five community-randomized trials, a Cochrane review concluded that, when full coverage is achieved, ITNs reduce all-cause child mortality by an average 18% (range 14–29%) in sub-Saharan Africa (*5*). The general implication of this is that 5.5 lives could be saved per year for every 1000 children under 5 years of age protected. It was also concluded that ITNs reduce clinical episodes of malaria caused by *Plasmodium falciparum* and *P. vivax* infections by 50% on average (range 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*), confirming 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.

Compared with a control situation in which there were no mosquito nets, use of ITNs in Africa increased mean birth weight by 55 g (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 (*7*). Placental parasitaemia was reduced by 23% in all gravidae (RR 0.77, CI 0.66–0.90). In Uganda, a combination of co-trimoxazole prophylaxis, antiretroviral therapy and ITNs substantially reduced the severity of malaria in adults with HIV (*8*).

2.2 Impact on diseases other than malaria

ITNs have been proved to be 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. They also provide protection against nuisance mosquitoes and kill head lice and bedbugs (*12*), which contributes greatly to the acceptance and use of ITNs by the population.

2.3 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 costs per death averted and per DALY averted with LLINs lasting 3 years were less than half the comparable costs incurred in using conventional ITNs. The study's findings also suggest that, in high-transmission areas where most of the malaria burden occurs in children under the age of 5 years, and assuming that this population group can be effectively targeted with LLINs, the use of LLINs is 4–5 times cheaper than IRS, which cannot be targeted to children only. The annual cost per LLIN averaged US$ 2.10 (range 1.48–2.64); this is equivalent to US$ 1.05 per person protected per year, compared with US$ 3.60 for IRS (calculated for the whole population)[1]. However, these calculations also assume that LLINs are properly used and are effective for 3 years.

The estimated cost[2] per child death averted varies according to the price and effective duration of LLINs used. It is US$ 212 for an LLIN purchased for US$ 4.50 that lasts for 3 years, US$ 145 for an

[1] Yukich J, Tediosi F, Lengeler C. *Comparative cost-effectiveness of ITNs or IRS in sub-Saharan Africa.* Basel, Swiss Tropical Institute, 2007 (newsletter July 2007).

[2] Based on 5.5 lives saved per 1000 children under 5 years sleeping under an LLIN and a distribution cost of US$ 2.50/LLIN.

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.

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

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

The social marketing techniques employed in some countries use 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.

3.3 Ensuring proper use

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

3.4 Sustaining high coverage

A number of countries have embarked on campaign-like strategies as a means of rapidly increasing LLIN coverage. However, the importance of strategies for delivering LLINs through routine health services in order to maintain those high levels of coverage has been underestimated. Because of the limited lifespan of the current generation of LLINs (3–5 years) it is critical to ensure the sustainability of mechanisms for their replacement.

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

The WHO Global Malaria Programme is calling on national malaria control programmes and their partners involved in insecticide-treated net interventions to:

- purchase only long-lasting insecticidal nets;
- distribute free or highly subsidized LLINs, either directly or through voucher/coupon schemes;
- achieve full LLIN coverage, 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 of LLINs; and
- implement strategies to *sustain* high levels of LLIN coverage in parallel with 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 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.

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 a high burden of malaria or at risk of outbreaks because of climatic conditions, or areas with limited access to health services. Where malaria is a problem in people with HIV/AIDS, the possibility of providing LLINs through services targeting these population groups should be explored.

4.4 Communication and advocacy

Provided that people use them properly and consistently, ITNs, including LLINs, are highly effective. However, although LLINs are designed to resist repeated washing, excessive or aggressive washing and the use of harsh detergents (such as some traditional soaps) rapidly reduces their useful life. Distribution of LLINs should therefore be systematically linked to the simultaneous provision of information and advice, reinforced by local and national media campaigns.

4.5 Sustainability

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

5. Research

5.1 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 on both the physical strength of the netting and the duration of efficacy of the insecticide treatment. There is now broad consensus among partners and pesticide companies on the need for stronger and longer-lasting nets, prompting a move away from polyester to more robust polymers. New polymers, new yarns and knitting patterns as well as improved treatment technologies are being developed to cope with the wide range of conditions under which LLINs are used in the field and to facilitate technology transfer for local production in endemic countries.

5.2 ITNs and pyrethroid resistance

There is convincing evidence from some parts of west Africa that one particular 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 and malaria vector species, on the entomological impact of resistance under programme conditions (effectiveness), and on how resistance affects the other mode of action of ITNs – control of malaria transmission.

5.3 Use of non-pyrethroid insecticides on mosquito nets

Current developments are moving towards treatment of LLINs with a combination of a pyrethroid and non-pyrethroid insecticides, as either a mixture or a mosaic treatment, with the dual objective of enhancing efficacy of treated nets against vectors and pest mosquito species and of preventing or

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.

6. Conclusion

The effectiveness of ITN interventions in reducing the burden of malaria has been amply demonstrated in a variety of epidemiological settings. Now, the advent of LLINs 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 these new technologies for all populations at risk of malaria.

Integrating the distribution of free or highly subsidized LLIN into existing health services, especially immunization and antenatal care services, complemented by distribution through child health days/weeks and immunization campaigns, should help in the rapid achievement – and sustaining – of full LLIN coverage. To increase current ITN coverage, the untreated or conventionally treated nets currently in use should be treated using long-lasting treatment kits, once such kits are available. Effective communication and monitoring and evaluation strategies must be in place, alongside systems for delivery, 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 to and use of LLINs; its focus is on making use of all existing opportunities within countries.

This Position Statement is therefore intended as general guidance and should not prompt a move away from strategies that have proved effective in specific contexts. Moreover, since the ITN/LLIN landscape is rapidly evolving, this guidance will be reviewed as and when new evidence becomes available.

A field manual (*The use of long-lasting insecticidal nets for malaria prevention*) to be published shortly by WHO as a trial edition will provide more detailed practical guidance for national implementers managing LLIN interventions.

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