

**Vector Control Technical Expert Group
Report to MPAC September 2013****Methods for maintaining coverage with long-lasting insecticidal nets (LLINs)****Contents**

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Foreword

Global malaria control efforts have achieved remarkable success over the past decade with estimated malaria-related deaths decreasing by 25% globally and by 33% in sub-Saharan Africa between 2000 and 2010. Much of the success is related to the rapid scale-up of distribution of long-lasting insecticidal nets (LLINs)¹.

These achievements must not be taken for granted. If vector control is withdrawn from an area where malaria transmission was originally intense but was suppressed for a few years by effective interventions, transmission is likely to return to its previous intensity, and can do so rapidly. Thus, there is a serious risk of malaria resurgence in many parts of Africa if LLIN coverage is allowed to decline. In the past, such lapses in intervention coverage have caused major epidemics with substantial loss of life. The malaria control community therefore has a shared responsibility to maintain coverage, despite challenges of constrained resources. The aim of this document is to guide national malaria control programmes seeking to achieve and sustain universal coverage of LLINs.

Our goal remains universal coverage. Gaps in coverage should therefore be addressed by using a mix of approaches, including mass campaigns coupled with routine distribution as appropriate², especially to pregnant women and infants through antenatal and child health immunization clinics. It is important to note that use is expected to be high when populations have access to nets. The World Malaria Report 2012 compared the proportion of the population with access to an ITN and the proportion sleeping under an ITN in 17 countries in Africa, and found that the median proportion of the population using an ITN among the population with access to one was very high, at 91%.

The WHO *Position Statement on ITNs* recognises that net distribution campaigns are a cost-effective way to achieve rapid scaling-up of net coverage, but emphasises the need for “strategies to sustain high levels of LLIN coverage in parallel with strategies for achieving rapid scale-up.” In particular, it recommends that mass campaigns should be complemented by LLIN distribution to pregnant women through antenatal services, and to infants through immunization services, in order to ensure continuous and sustainable coverage. Further experience in the last five years has revealed that the physical lifespan of nets is highly variable, with a gradual loss beginning immediately after the campaign. For this reason, WHO recommends that routine distribution through antenatal and immunisation should be given equal priority to mass campaigns.

¹World Health Organization. World malaria report 2012. Geneva, 2012.

² In the context of LLINs, the term “continuous” is used to describe distribution systems that deliver nets continuously and without interruption over time, as opposed to “campaigns” which deliver a consignment of nets to a defined target population in a single time-limited operation. “Routine” LLIN systems deliver nets along with other routine health services (especially ante-natal care and child immunization, through established health system delivery channels.

The *Position Statement on ITNs* also recognises that other distribution channels may also play an important role: schools, workplace programs and community-based networks have all been used for distribution of nets bought with public health funds. In some settings (especially in Asia) commercial markets have also made a substantial contribution to net coverage, including LLINs.

Mass campaigns can achieve high and equitable coverage quickly and efficiently, but this coverage declines over time and significant coverage gaps can appear in between campaigns. By contrast, routine distribution through routine channels such as antenatal and immunization clinics can sustain coverage levels that are stable over time, but fall significantly short of universal coverage (Figure 1). Progress has been made in assessing various continuous distribution channels in a range of country contexts, particularly in antenatal and child health clinics. There is also some experience with schools, community based distribution and the commercial sector in certain settings.

Although there is still much we do not know, it is possible to draw some initial conclusions about the strengths and weaknesses of the various options for maintaining LLIN coverage. These recommendations are discussed below, with emphasis on the public health channels.

Summary recommendations

Complementary campaign and continuous distribution systems

- *Universal coverage* remains the goal: this is defined as full coverage with effective vector control of all people at risk of malaria³
- In order to maintain universal coverage, WHO recommends a combination of mass distributions, complemented by continuous or “routine” distributions through multiple channels, in particular antenatal and immunisation services.
- There should be a single national plan for both routine and campaign distribution strategies that all partners adhere to. This unified plan will include a comprehensive quantification and gap analysis for all public sector LLIN distribution channels
- As with immunization programs, which also employ a combination of campaign and routine delivery services, LLIN campaign and routine distribution systems should be planned and coordinated as a unified program, with shared resources, communications and LLIN stocks.

³WHO. *Insecticide-treated mosquito nets: a WHO position statement*. Geneva, World Health Organization, 2007. Accessible at: <http://www.who.int/malaria/publications/atoz/itnspopaperfinal/en/index.html>

- These continuous distribution channels should be functional before, during and after the mass distribution campaigns, there should be no gap in access to LLINs and the behaviour change communications should be coordinated for both the campaign and continuous distribution activities.

Distribution channels appropriate for country contexts

- Each national malaria control programme should develop an overall co-ordinated LLIN distribution strategy. This strategy should be based on an analysis of local opportunities and constraints, and should identify a combination of distribution channels that will achieve and sustain high coverage.
- Mass free distribution campaigns will remain an important component for maintaining universal LLIN coverage. Technical training materials to support planning, implementation and evaluation of distribution campaigns are available through WHO and the Alliance for Malaria Prevention.⁴
- Antenatal, immunisation and child health clinics should be considered as the highest priority LLIN continuous distribution channels in countries where contact rates are high, as they are in much of Africa south of the Sahara.
- One possible method of delivering access to LLINs through public sector channels is the use of vouchers, which allow the recipient to obtain an LLIN either free or at subsidized cost through participating retail outlets. These outlets are then responsible for supply and storage of the nets, rather than in the public sector.

Schools may also be explored as a channel for LLIN distribution in countries where this approach is feasible and equitable.

Supplemental distribution methods

Additional channels may also be considered. Each country context is unique, with its own opportunities. Other channels such as community-directed distribution, church and mosque-based networks, and agricultural and food-security support schemes should be explored. Additional channels to be considered in the national strategy might include:

- Occupation-related distribution channels. In some settings – particularly in Asia where transmission ecology is often localised and patchy -- the risk of malaria may be strongly associated with specific occupations, such as plantation and farm workers and their families, as well as miners, soldiers and forest workers. The

⁴ More information on Alliance for Malaria Prevention available at:
<http://www.allianceformalariaprevention.com/index.php>

opportunities for distribution through local channels, including private sector employers and farmers' organisations etc., may be explored where appropriate.

- While not the direct responsibility of control programmes, the private and commercial sector can be an important supplementary channel to the free LLIN distributed through the public sector channels. Private sector engagement can take many forms:
 - Retail sales of all kinds of net have public health benefits, and should be encouraged. However, an LLIN is twice as effective as an untreated net.
 - Retail sales of LLINs may be encouraged throughout the country. LLIN products should be regulated by the national registrar of pesticides, in order to ensure the quality of the insecticide following the specifications as described by WHOPES.
 - Workplace programs, whereby the employer provides free malaria preventive services to the employee families and surrounding communities can also be effective.
 - Existing commercial markets in untreated nets are also beneficial and should not be discouraged. In the case of nylon and polyester nets, it may be possible to convert these nets into LLINs during or just after manufacture, using novel techniques: either by applying a long-lasting insecticidal treatment to a batch of nets in bulk, or by using an insecticide-impregnated yarn made for this purpose. These technologies allow the additional cost of the insecticide to be paid by public funds, while the cost of the net and its distribution are paid for the net-buyers who would normally be buying untreated nets. Such net treatments can therefore be considered an additional channel for improving LLIN access.

Time and place for mass distribution campaigns and continuous distribution

- LLIN distribution campaigns are a cost-effective way to rapidly achieve high and equitable coverage, and in almost all settings repeated campaigns will be needed. As coverage gaps will start to appear almost immediately post-campaign through net deterioration, loss of nets and population growth, complementary continuous distribution channels should be in place.
- The interval between mass campaigns should normally be no more than three years unless there is reliable observational evidence that a longer interval is appropriate (for example because routine distribution through ANC and EPI channels is maintaining high coverage or nets are lasting longer).
- In the future, there should be a gradual shift in the methods used to distribute publicly-funded LLINs, away from campaigns and towards a system where

continuous distribution systems, are the primary means of sustaining coverage. Campaigns may still be necessary, but will be deployed as a supplementary measure, as and when coverage is seen to be inadequate.

- In order to manage this shift in methods, programmes will need to track coverage as it evolves over time, and they will also need to distinguish the relative contributions to overall coverage of various parallel delivery channels. Appropriate indicators and methods are noted below.
- There should also be consideration of improving the product and/or behaviour change interventions to improve net longevity and usage.
- The lifespan of LLINs varies widely between individual nets in a cohort, and between settings. This variability makes it difficult to plan the rate or frequency at which replacement nets need to be procured and delivered. In several settings in Africa, the median lifespan of a cohort of LLINs (the interval until 50% of the nets are worn out or lost) has been observed to be approximately three years. WHO has developed technical guidance for countries and partners on how to monitor the survival of LLINs in field studies in sentinel sites, and recommends that all medium and large-scale LLIN programmes should carry out such monitoring.
- LLIN durability in the field is a major factor in the costs of maintaining universal coverage. Current evidence suggests that some LLIN products can be significantly more durable than others, depending on the setting. Programs are encouraged to compare the durability of alternative products under local conditions, using the standard methods mentioned above; this information can then be used to inform procurement decisions. It is possible that with more durable products and a strengthened routine LLIN delivery, programmes can move away from campaigns.
- Periodic “top-up campaigns” (as opposed to universal coverage campaigns) are not recommended at present. These campaigns are where community workers visit each household and replace only nets that have been lost, leaving in place those that are still in good condition.
 - Experience so far suggests that “top-up” campaigns may encourage under-reporting of the number of nets actually present in households, and further work on methods to overcome this problem will be needed before top-up campaigns can be given a more general recommendation. Top-up systems may be more feasible and efficient in areas where community health workers are involved because of their long-term relationship with each resident household but more evidence is required.
 - If the population coverage of nets less than two years old is less than 40%, such “top up campaigns” are not expected to be cost-saving, and a full-coverage campaign should be deployed instead.
- Improved supply chain management, including quantification, durability monitoring and evidence-based resource allocation is key to maintaining

universal coverage. Programmes should ensure there are adequate human and financial resources for efficient programme management, as well as for the basic costs of LLIN procurement and distribution.

Monitoring and Evaluation

Currently, the four basic survey indicators of coverage, as developed by the RBM Monitoring and Evaluation Reference Group (MERG) and used by WHO for the World Malaria Report are:

- a) Percentage of households with at least one ITN/LLIN
- b) Percentage of population with access to an ITN/LLIN within the household
- c) Percentage of population reporting having slept last night under an ITN/LLIN
- d) Percentage of under-five children reporting having slept last night under an ITN/LLIN

In addition to these cross-sectional outcome indicators, the following process indicators are likely to be necessary in order to manage the operations recommended above:

- (i) Changes in coverage over time, as measured by repeated estimates of the percentage of population with access to an ITN/LLIN within the household (i.e. a longitudinal version of b) above).
 - This can be measured using sentinel sites. The possibility of a “Hawthorne effect” must be considered: if net-owners know that a net will be inspected by someone coming to the house, they are more likely to look after the net and less likely to throw it away. However, this potential bias may be excluded or at least minimised by using several sites, so that only a subset of households will be visited.
- (ii) Operational coverage by ANC and EPI services, i.e. the proportion of pregnant women given an LLIN by ANC services, as a percentage of the total number of women attending these services, and the equivalent for children attending for immunisation.
 - Clinic records are not satisfactory for this purpose. Standard national household surveys (e.g. DHS and MICS) already ask detailed information from mothers about attendance at such clinics and the services received; an additional question may be asked as to whether the mother was given an LLIN. In some settings, family health cards or books are used to record child health and maternal health contacts, these should also record LLIN delivery.
- (iii) Relative contributions of different delivery services. This is best measured in household surveys, by identifying the source of individual nets.
 - To do this accurately, nets (and bales of nets) should have a batch-identification label attached at the time of manufacture, and LLIN programmes should carefully record the numbers of the batches sent

to each district and used by each channel of distribution. This will have the additional benefit of allowing an alternative method of determining net durability.

1. Foreword

Long lasting insecticidal nets (LLIN) are one of the two 'core' interventions for malaria vector control, along with indoor-residual spraying (IRS). Since 2007, the

World Health Organisation (WHO) has promoted universal coverage with effective methods of vector control for everyone at risk of malaria (1, 2). This goal is one of the foundations of the current Global Malaria Action Plan (1, 3). To achieve and sustain this goal, WHO recommends a combination of mass free distribution campaigns (sometimes referred to as 'catch-up' campaigns) along with regular, continuous LLIN distribution channels (sometimes referred to as 'keep-up' strategies) (2, 4).

LLINs wear out gradually over time and need to be replaced. This document considers how universal coverage can be achieved and sustained operationally; it explains current WHO guidance, and provides an overview of methods that have been used in practice, highlighting what is known and not known about the relative advantages and disadvantages of alternative approaches.

The primary focus of this document is public sector distribution channels, as these use public resources and can be most easily influenced by national programme managers. This includes public-private partnerships for delivering subsidized LLINs to target populations through voucher schemes. The unsubsidised commercial mosquito net and LLIN market is important in some countries and should be encouraged to reach what populations it can, but methods for building this particular channel are not considered in detail here.

Ten years ago, there were many outstanding questions about strategies for scaling up ITN coverage. Many of these questions have now been answered, and there is now broad consensus about the methods that can and should be used. However, in many countries the capacity to implement these methods requires strengthening. It is even more complicated in places where programmes have to address the threat of insecticide resistance. Nonetheless, it is important to note that despite the spread of pyrethroid resistance, mosquito nets of one kind or another are likely to continue to be important for the control of malaria and other diseases for many decades to come. Hence we should look for, and welcome, long-term opportunities for integrating net-delivery systems into existing health systems.

2. Background: why is sustaining coverage difficult?

In the period from 2005 to 2010, scaling-up LLIN coverage was the primary focus of the global malaria community, and large-scale campaigns proved to be a highly cost-effective means of quickly attaining high coverage (5, 6, 7, 8). However, it is recognized that just relying on a series of repeated campaigns will not sustain high coverage.

If the nets distributed together in a campaign were all to wear out at the same rate, then they would need replacement at roughly the same time, and a series of repeated campaigns every three years would be an efficient way to maintain coverage. In reality, however, there is considerable variation in LLIN durability, based not only on the nets themselves but also their conditions of use. The result is that

LLIN durability varies not only among countries and among regions within countries, but also among individual households (8, 9, 10, 11, 12). Aside from wear and tear, nets are also lost from the community when members of the family move away for work or school. This process of loss of nets may be faster or slower, but the key point is that it is *gradual*: it begins more or less immediately after a campaign, and extends over several years (8, 9, 10, 11, 12).

If coverage is to be maintained by repeated campaigns alone, it is difficult to decide how frequently these successive campaigns should be carried out, so as to balance effectiveness and efficiency. For maximum efficiency, successive campaigns should be carried out at long intervals, when most of the old nets have worn out and disappeared – but this also means that a substantial fraction of the target community will be waiting many months with no effective protection. Conversely, for maximum protection, successive campaigns must be carried out at short intervals, when the coverage gap is still small – but this also means that many of the old nets will still be present and in good condition, which increases the cost per effective year of protection delivered, and would likely be wasteful of scarce vector control resources.

Conventional campaign methods are effective and efficient as a means of initial rapid scaling up of coverage, and can deliver enough LLINs to cover the entire target population altogether at one time. Moreover, in some situations, such as in countries emerging from long conflicts and where access to health services remains limited, repeated conventional campaigns alone may still be the only practical option.

However, repeated campaigns every three years have some important disadvantages as a means of sustaining coverage at high levels over time. This is because in the absence of any other delivery mechanism, repeated campaigns result in a declining level of coverage over time (see Figure 1).

Therefore, the ideal system of replacement would be one that can deliver a continuous flow of nets into the community, with this inflow exactly balancing the loss of nets from wear and tear and outmigration. Although we have not been able to manage this, it is noteworthy that the balancing would be achieved by demand-driven systems where communities know when they need additional or replacement nets.

3. WHO coverage targets for LLINs

Since 2007, the WHO-recommended overall goal has been “universal coverage with effective vector control for everyone at risk of malaria” (12). The two key indicators for this target are: (a) the percentage of people who have access to LLINs in the household (assuming that 1 LLIN covers two persons); and (b) the percentage of people reporting having slept under an LLIN the previous night. Operational success (as opposed to a target of 100% universal coverage) is defined as the observation in surveys of at least 80% coverage in terms of these indicators. The adoption of

universal coverage as a target has been a very effective policy, and has been followed by an unprecedented decline in the global burden of malaria (13).

At the same time, it must also be recognised that in reality, resources may sometimes be insufficient to provide LLINs for everyone in all endemic areas throughout a country. The WHO Global Malaria Programme is currently reviewing this question of priorities when there are not enough nets for all and will issue detailed guidance separately.

4. Comparing continuous distribution (“keep-up”) methods involving publicly-funded LLINs

No single distribution channel is sufficient on its own, and the priorities and mix of distribution channels depends on the specific country context, the target populations and degree of access to the various channels.

Antenatal and child health clinic distribution channels.

The supply of LLINs through routine antenatal and/or child health immunisation channels in many countries is the only sustained national-scale routine service for LLIN delivery. The key disadvantage of this method is that the coverage levels it can sustain are intermediate, and short of the universal coverage target. This is illustrated in Figure 1.

Moreover, with this method of distribution, coverage is focused on pregnant women and on young children i.e. the age-group that is most vulnerable in conditions of moderate and high malaria transmission (15, 16). Thus, in most settings, delivering nets in this way maximises the epidemiological benefit per net delivered (17). Finally, these routine delivery methods are reasonably straightforward to implement in practice, and approximately as efficient (in cost per net delivered) as campaign delivery (18).

Because of these advantages in terms of both effectiveness and costs, where access to antenatal and child health immunization clinics is high and where there is adequate supply-chain logistics, WHO recommends the strategy of supplying LLINs both to pregnant women in antenatal clinics, and also to infants in immunisation clinics (2) as an essential part of overall efforts to ensure universal access to effective vector control.

As a variant of this approach, Tanzania has implemented a voucher scheme whereby pregnant women attending antenatal clinics receive a voucher that can be redeemed at a local retail shop for an LLIN at a discounted price or for free.

Several useful publications on implementation on routine methods of LLIN distribution have been produced by the ‘Continuous Distribution’ work-stream of the RBM Vector Control Working Group. One of these is a guide to practical

implementation issues, including an overview of practical experience with the alternatives discussed here and useful comments on other distribution mechanisms including commercial net markets (9).

School distribution

In communities with partial net coverage, school-age children between 5 and 15 years are the age-group least likely to be sleeping under a net (13). Like clinics, schools provide a stable and well-established point of contact with resident families and often include a “registration” system that can simplify distribution. For these two reasons, there is growing interest in the distribution of LLINs through schools (9). Schools can either be used for occasional mass campaigns called “catch-up” distributions when it is seen that community coverage levels need to be boosted, or for continuous “keep-up” distributions enacted in yearly or two-yearly intervals, or for all children reaching a defined age or school year.

So far, there is relatively little experience with this approach, and it is not yet possible to give clear evidence-based recommendations as to where and when it should be considered, or on how to define its role *vis-a-vis* other distribution systems. There has been some experience in the Western Pacific of LLIN distribution through boarding schools, and there have been successful “child friendly” initiatives such as school feeding programmes. In some countries, however, access to schools is limited and inequitable. Thus, the suitability of a school-based distribution system depends upon the country context and access to the at-risk population.

Top-up systems

As already noted, there is between-household variation in the rate at which nets wear out. This suggests that it might be advantageous to try to deliver nets as needed, selectively replacing nets that have worn out but leaving in place nets that are still in good condition.

Top-up methods could be implemented on a continuous basis e.g. a “new-for-old” facility, but so far have been mostly considered as a form of campaign, modified to take account of existing nets. This means visiting each household, and handing out just the number of nets needed to replace lost and worn nets, thus maintaining universal coverage (9). This strategy has in most cases been found to be not cost-saving if pre-existing coverage is high.

In practice, because of the additional workload of counting and inspecting nets, the operational costs of running a top-up campaign is likely to be significantly greater, per-household and per-campaign, than the costs of running a universal coverage campaign where the number of nets given to each household depends only on its size.

Another disadvantage is that the process of net loss is continuous, so the coverage achieved by any campaign-based delivery method fluctuates over time. The

gaps in coverage that gradually expand between campaigns diminish the overall health benefits of this approach. Top-up methods are designed to reduce the commodity costs of running a campaign, but they are much less likely to reduce and could even increase the operational costs of each campaign, since the programme team still has to visit every household and count every net, whatever the number of nets given to the household on each occasion. Hence, the cost per net delivered is minimised with fewer campaigns at longer intervals, whereas frequent campaigns at short intervals would be needed to avoid gaps in coverage. This trade-off appears to be a significant constraint on the potential for cost-savings of top-up methods unless it is in a country with a strong community structure, i.e. Rwanda, Nigeria and South Sudan.

Furthermore, inspecting households and only providing new nets when the previous net is lost or worn out is a difficult and inaccurate process, depending upon the communication and understanding between the inspector and house owner. There might be a tendency for householders to under-report the number of nets-in-good-condition present in the house, and there is some evidence that this may have happened in Senegal and Nigeria. For these reasons, top-up campaigns are generally considered to be not cost-effective.

Defining risk groups

The target groups for LLIN coverage depends upon the malaria transmission ecology in that particular local context. In much of rural Africa, where the primary vectors are *Anopheles gambiae*, *An. arabiensis* and *An. funestus*, transmission may be occurring in and around the house, and so all members of those communities should be protected. In many parts of heavily urbanized areas, these vectors may be absent or be much more patchily distributed, and the population at risk far more localized. Likewise, in many contexts outside Africa, malaria transmission is very patchy or heterogeneous and more precise geographical targeting is recommended.

In the South-West Pacific there is “coastal malaria” associated with the presence of *An. farauti*. In much of South-East Asia, the primary malaria vectors are forest-associated species *An. dirus* and *An. minimus*. Here, the at-risk population may be whole families homesteading or working in distant farm plots, or adult men involved in forest-related occupations for limited periods of time. Similar “occupational exposure” is also common in many parts of the Amazon basin, as with gold miners for example. Occupational risk is also seen in Africa, where economic development zones may expose certain populations at increased risk, or when during certain times of the year, individuals or families may move to “fishing camps” and be more exposed to malaria vectors.

Again, national programmes need to assess their situation and adapt their mix of distribution channels to fit their particular context. In some cases, the public health target is universal coverage for entire populations over a wide geographic area where there is a mix of mass free LLIN distribution along with continuous distributions from other sources such as ANC clinics and schools. In other situations,

particularly outside rural Africa, there may be different strategies to reach specific at-risk populations such as forest visitors, homesteaders and migrant families colonising newly-cleared areas, agricultural, construction and mining workers.

Some of these occupation-related risk groups may be reached through their employers, who should be encouraged to provide malaria treatment and prevention services (including LLINs) to their workforce, the families of their workforce and the surrounding community. There is good evidence from a number of private sector initiatives in Africa that malaria control provides a positive return for investment in terms of reduced absenteeism and health care costs, and increased productivity of the enterprise.

5. Procurement issues

Routine distribution channels.

A clear link between the mass free distribution and the continuous routine distribution channels has advantages for procurement quantification and supply, including that quantification for campaign and continuous distribution can incorporate data from the ANC and immunization services when these are to be among the primary routine distribution channels. Second, logistics, including procurement, transport and warehousing can be integrated between the campaign and continuous distribution systems (17).

Top-up systems

Procurement quantification can be challenging, especially for top-up campaigns. The critical questions are how to estimate how many old nets are still present, and whether it is worthwhile to allow for these nets in procurement. The current recommendation is that when coverage with LLINs from routine and continuous distribution is >40% with LLINs that are less than 24 months old, it may be cost saving to account for existing nets during the universal coverage campaign.

The methods used to estimate how many nets are present rely on coverage data from previous surveys, combined with records of how many nets were distributed in the period leading up to the campaign, and adjusted by the expected lifespan of these nets. The “expected lifespan” can be difficult to estimate as the lifespan of nets varies over a wide range between locations and settings. WHO recommends that all LLIN programmes should collect their own data on LLIN durability in local conditions, using standardised methods (10). In the future, this information will allow programmes to estimate current coverage from distribution history with much more precision.

Currently, most programmes do not have precise data on the durability of LLINs in their communities, and must rely on standard estimates of net survival derived from other settings. Two calculation methods have been proposed. Based

on recommendations from the RBM Vector Control Working Group, the RBM Harmonisation Working Group developed a tabular method that assumes rates of net loss of 8% in the first year, 20% in the second year and 50% in the third year, and discounts all non-campaign nets older than 3 years (9, 26). This method is easy, is based on reasonable assumptions and can be a useful “working hypothesis” while more reliable local data is produced. Alternatively, precise estimates, which make more comprehensive use of existing local data, can be gained with the NetCalc model (11).

Allowing for existing nets involves reducing the number of nets to be procured in order to save money and prevent waste. However, it may not be cost-effective if this saving is outweighed by the cost of the additional work for inspection and implementation. It is relatively easy to get an initial estimate of how many nets are expected to be present, based on existing survey data, records of the number distributed in recent years and crude assumptions about how many of the latter are expected to be still in good condition. Sooner or later, however, decisions have to be made about how to assign the nets to households, and this means not only recording the size of every household, but also inspecting the condition of every net in every household. This requires a substantial amount of additional work.

In terms of accounting for existing LLINs when planning campaigns, currently, the best available estimates suggest that at below 40% coverage it is not worthwhile to consider existing LLINs. At above 40% coverage, the existing LLINs could be considered. This estimate must be regarded as provisional: it is based primarily on expert consensus, supported by modeling projections from a limited amount of practical experience (27). Nevertheless, for those situations where a clear threshold is useful, 40% is presently the best estimate.

Similarly, there is broad agreement that in estimating existing coverage, only nets less than two years old should be considered. This is because older nets cannot be expected to survive more than another year or two on average, even if they are currently in good condition.

For these reasons, and without excluding other options, the following procedure is suggested as a suitable approach (28) to quantification for a large-scale top-up distribution:

- i. A preliminary estimate should be made of the overall level of coverage expected to be present in the target population at the time when the campaign is to be carried out (which is likely to be at least six months in the future). This estimate should be based on data on the size and timing of previous LLIN distributions (including campaigns and routine channels) as well as conventional assumptions about average survival rates, and should only consider nets that will be less than two years old at the time of the campaign.
- ii. If this estimate indicates that population coverage by existing nets less than two years old is likely to be greater than 40%, then it may be worthwhile to

undertake more detailed investigations to obtain a more precise and careful estimate of coverage, which can then be used to determine the quantities to be procured.

- iii. If the preliminary estimate of expected coverage with nets less than two years old is less than 40%, then accounting for existing nets in procurement quantification is unlikely to save money in most large-scale projects.

This guidance is intended for the managers of LLIN campaigns operating at the very large (e.g. national) scale, and for the donors supporting such campaigns. In such programmes, there is usually no opportunity to collect accurate prior information on the number and condition of the nets present in every individual household in the target population.

In some situations, however, it may be possible to collect such information using existing infrastructure at minimal additional cost – for example, in local projects with permanent volunteers in each village. In these cases, there are much greater opportunities not only to monitor and provide for the net needs of each individual household, but also to do this in way that still encourages residents to look after their nets and minimises the incentive to provide inaccurate information.

In the majority of cases, therefore, a universal coverage campaign is implemented, followed by regular routine distributions (primarily with routine EPI and ANC services) to maintain coverage, and then followed by a “top up “ campaign three years later - and only consider accounting for existing nets if coverage is greater than 40%. Currently in the majority of countries, these top-up campaigns are rarely organized.

Product Choice in Procurement

WHO has been encouraging the development of more durable insecticide-treated nets since the advent of LLINs more than ten years ago.

The WHO Pesticide Evaluation Scheme (WHOPES) includes an assessment of LLIN durability, comparing each individual product with a set of minimum performance criteria. By recommending two products, WHOPES does not imply that they are identical, but rather that they both meet the performance criteria. It is therefore incorrect to assume that the WHOPES scheme is equivalent to drug pre-qualification (29).

There is currently only limited data on LLIN durability in domestic use. The evidence so far suggests that there can be substantial differences between the durability of different products, but these differences are not consistent: the relative durability of different products seems to vary from setting to setting. It seems that local LLIN programmes could obtain substantial efficiency gains by choosing LLIN products with better performance, but this would require reliable data on relative durability in local conditions. Hence, in order to develop the capacity to buy the net

product that represents the best value-for-money in the local context, all large-scale LLIN programmes are encouraged to monitor the relative durability of alternative products in local conditions, using standard methods developed for this purpose (10).

WHO recommends that data of this kind should be used to inform product choice decisions in procurement. In particular, in the *Guidelines for procuring public health pesticides* (29), it is recommended that the “value-for-money” of alternative products should be assessed in terms of overall operational cost:

The criteria for comparing the operational cost and ‘value for money’ of different products for the intended application(s) should be set at the onset. For LNs, the criteria for comparison can be ‘cost per median year of net life under local conditions of use’ (29).

If adopted by national malaria programmes and by the major institutional financiers of LLIN purchases, this policy recommendation is likely to bring about gradual but profound effects on the market in LLINs. Further discussion of its implications can be found in the WHO concept note “A system to improve Value for Money in LLIN procurement through market competition based on cost per year of effective coverage” (30).

Manufacturers have already shown some interest in developing more durable nets, and it is hoped that using value-for-money to guide procurement will enable these efforts to be rewarded, and thus provide the incentive necessary to promote further development. It seems likely that it is technically possible to develop LLINs that are much more durable and better value-for-money than those we have now. In the short-term, and since procurement decisions can be contentious, considerable care will be needed in the process of collecting data on LLIN durability (10), including quality-assurance processes with external independent supervision. WHO continues to work on further details of the decision-making process – for example, deciding exactly which durability datasets are (a) admissible and (b) relevant to the local setting.

6. Equity and indicators

LLINs are a public health good and one of the roles of the national programme is to ensure equitable access for all those at risk. As described in the document, over the past decade there has been much progress in developing standard indicators and surveillance tools for LLIN access, ownership and use by different populations, including different members of the household through different seasons.

Carefully-defined indicators for LLIN coverage are available, and these will also serve the effectiveness of any continuous “keep-up” LLIN distribution strategy.

While LLIN distribution campaigns, either targeted to young children or aimed at universal coverage, have been shown to achieve highly equitable coverage of all socioeconomic strata, equity may vary with continuous distribution channels. For example, when considering antenatal and immunization services as a prime channel for continuous distribution, reach and equity of access must be considered, as this varies between countries. In some countries, contact rates are high and access is reasonably equitable across socio-economic groups. In other countries, however, access is inequitable, with limited contact rates and low coverage in the poorest fraction of the population. Therefore, socio-economic equity in the standard LLIN coverage and use indicators needs to be monitored with additional care.

Our current methods for LLIN distribution program assessment are geared more towards mass free distribution campaigns rather than continuous distribution campaigns, such as those offered through antenatal and immunization clinics. Often there is a post-campaign survey shortly after the distribution to measure the success of the operation (26), whereas there are fewer program assessments and operational indicators for continuous distribution channels.

There is already an indicator on the proportion of targeted risk group receiving an ITN designed to cover pregnant women and children attending immunization (13). However, the indicator does not specify the source of such nets. It is therefore recommended that countries should measure and report upon “the proportion of women reporting having been given an LLIN through antenatal services, out of all women reporting having attended such services”, as well as “the proportion of infants whose carers report having been given an LLIN through immunisation services, out of all infants completing vaccination”.

7. Commercial markets

While commercial mosquito net and LLIN markets have health value in many situations, their cost brings up issues of equity, and the public sector has limited ability to influence personal consumer-product choices intended for public health impact. Nevertheless, commercial markets represent a resource that can be facilitated and encouraged to provide quality product to those segments of the population with access and means to procure. Another advantage of commercial nets is their diversity, adaptation to local tastes, and the fact that their distribution channels do not rely on public-sector support.

There is very wide variation between countries on the role of the commercial sector in background levels of net ownership and use. In some countries, such as Ethiopia, nets and net-use were very uncommon (<5%) until the recent mass-distributions of LLINs (31). Still, there is very little commercial availability of nets and ITNs in Ethiopia. In most parts of South East Asia, nets are owned and used by a majority of the population, even (and sometimes especially) in poor rural communities. For example, surveys of high-risk forest-fringe villages in Cambodia have consistently found more than 80% of the population reporting having slept

under a net the night before, with little variation (70%-90%) between the poorest and least poor households (32). High levels of traditional net use are also found in some parts of South Asia and Latin America, and also in some parts of Africa, notably in the Sahel (31, 33, 34, 35, 36, 37, 38, 39).

This availability of nets through private channels is valuable: it produces significant public health benefits without public funds. There is clear evidence from a wide range of settings that untreated nets protect against malaria, but only if they are in good condition. In Africa, there is now a moderately large body of evidence suggesting that the protection given by an untreated net in good condition tends to be approximately half that given by a treated net (40, 41, 42, 43, 44, 45).

Another advantage of selling nets through local commercial markets is that these nets are diverse and locally adapted, and they are produced in a variety of fabrics, sizes, colours and shapes that cater to a wide range of tastes and sleeping habits. For example, hammock nets are common in forest communities in Cambodia (while less so in Myanmar), while dark-coloured and finely-knitted nets, specially made for the Harmattan, are sold in northern Nigeria and Niger. Finally, the commercial net distribution system is another important asset: nets are traded along with domestic textiles of all kinds, and these are available even in remote rural areas. Net traders are typically well-adapted to seasonal fluctuations and responsive to local shifts in demand.

There are a number of options for engaging the commercial sector. On the demand side, efforts to promote awareness and demand for nets has been generally positive, and some countries (such as Tanzania) have seen a massive expansion in both consumer demand and the supply capacity of local net producers.

On the supply side, the lessons of experience are more controversial and less clear. Most of our experience has been with traditional “social marketing projects” selling their own branded nets at subsidised prices, using a range of distribution systems from clinics to shops. There is evidence that this approach is significantly less equitable than distribution of nets free-of-charge through campaigns or routine services (5, 6). With each of these strategies, the operational cost-per-net-delivered varies widely between projects, and there is overlap between strategies in the observed range of costs. According to one review, the mean cost-per-net-delivered, averaged across projects, was higher with subsidised sales and social marketing than with various forms of free distribution (6).

A second approach is the use of vouchers. Instead of an LLIN, the mother may be given a voucher enabling the holder to obtain an LLIN from a shop or specialised outlet, either free of charge or at a discount price. This variant has been used in practice in a few cases, including the Tanzania National Voucher Scheme. This has advantages in that it can be used to encourage private sector supply of LLINs. In some projects, a high proportion of vouchers are redeemed. However, in situations where the recipient must pay, a significant proportion of the price will be a barrier for poorer people and lead to inequitable coverage (23, 24).

A third approach to supply-side intervention is to convert untreated nets locally available into LLINs. Although it has received relatively little attention so far in Africa, long-lasting net treatments are a significant part of the national malaria control strategies in Myanmar and Cambodia. In both Myanmar and Cambodia, the coverage of re-treatments and of LLINs is still very low (Coosemans, personal communication). In Cambodia, the re-treatment is done at the wholesale level where untreated nets are “bundled” with retreatment kits. This approach appears to have much potential in settings where there is already significant coverage with locally-made untreated polyester nets (treatment of cotton nets is problematic and not recommended). In the last few years, new opportunities for doing this have been created by the advent of novel LLIN technologies. One of these is the mass application of a long-lasting insecticidal coating to ready-made nets, using a batch process which was developed for the WHOPES-approved DawaPlus 2.0 LLIN.⁵

A fourth approach takes advantage of the fact that in many places, most or all of the local nets are machine-knitted in local factories using standard methods and standard polyester yarn; this makes it possible to use a special yarn, which is extra-durable and insecticide-treated, as a substitute for the usual polyester. In principle, such methods could allow local factories, which already supply nets to hundreds of millions of people in malaria endemic countries, to make nets to WHOPES standards that are both more durable and have long-lasting insecticidal activity. Moreover, this could be an extremely cost-effective approach: it costs potentially a few cents per net for the insecticide, plus the small additional cost of using a more durable polymer, plus the cost of additional ventilation and chemical safety measures to protect factory staff.⁶

There is probably little point in trying to restrict or regulate commercial markets in untreated nets, because untreated nets have no more hidden qualities than other textiles, and the quality of the material and stitching can easily be assessed by prospective buyers before purchase. However, as with any other pesticide product, insecticide-treated nets sold at retail level will need to be registered with the appropriate national authority.

8. Implementation research

There remain many unanswered questions for developing the most cost-effective strategies to maintain universal coverage of LLINs adapted for the individual country context. These involve *tactical* questions, such as malaria risk stratification or

⁵ For more information on the DawaPlus 2.0 LLIN, visit: www.tananetting.com

⁶ A system whereby users pay for the net, while the government pays for the addition of the insecticide, may be especially appropriate in terms of economic theory. An untreated net is basically a private good, mainly benefiting the user to the exclusion of others. A treated net, by contrast, kills mosquitoes, and thus protects people nearby. According to conventional economic theory, this external benefit is critical for justifying the use of subsidy.

measuring LLIN durability, as well as *strategic* questions such as resource allocation among multiple distribution channels and mass campaigns.

Protocols and procedures for malaria risk stratification and LLIN durability are available. Answering the more strategic questions on resource allocation among multiple distribution channels and mass campaigns is more challenging.

The first set of questions for resource allocation is the measurement of efficiency and cost-effectiveness. For LLINs, the fundamental measure is cost-per-net-delivered for a defined segment of the population at risk, how coverage of this segment contributes to the public health impact, and how coverage should be measured. For example, in high transmission conditions, it might sometimes be useful to consider the additional health benefits of targeting children.

In comparing alternative top-up campaign methods (including community-based and demand driven systems), it is important to consider the costs as well as the savings from not replacing older nets in good condition. If the threshold for replacement is set so that only the oldest and most worn-out nets are replaced, the current campaign is likely to be cheaper, but a further campaign will be necessary. Finding the optimum balance between these two constraints cannot be done through modelling alone: it will require careful data collection from practical operations.

Beyond the basic cost-per-net-delivered is the long-term development and sustainability value of the distribution channel. It is important to take into account that some of these delivery systems are specialised and stand-alone, while others are integrated with, and likely strengthen, existing essential health or social services. Another important consideration is whether and how these systems can be adapted to take advantage of local opportunities. For example, some countries have a traditional high coverage of commercial untreated nets. How can programs take advantage of this to convert these into LLINs, either at the individual level, the wholesale distribution level, or during the manufacturing process itself?

Finally, there are specific questions about particular distribution channels. In the case of routine antenatal and immunisation systems, these include:

- does LLIN distribution through these channels help to boost coverage of antenatal and immunisation services?
- what overall levels of LLIN coverage can be sustained using these methods, alone and/or together with parallel complementary distribution systems?
- if LLINs are given only to households with children, do they move between households via extended family relationships?

In the case of top-up methods, the critical questions include:

- when is it cost-effective to make allowance for existing nets?
- what is the best way to estimate existing coverage?

- do the incentives created by top-up systems cause people to neglect their nets, and/or to hide them when project staff come to check nets and assess household needs? Can this problem be avoided, and what circumstantial factors make it worse or better?

It is important to note that planning and evaluation of all these methods for maintaining coverage is critically dependent on assumptions about net durability. There is an urgent need for numerous local small-scale evaluations of net durability, using prospective methods with a specific focus on how the resulting measures of durability are to be used in procurement to inform quantification and product choice.

9. Conclusions

Countries face unique and constantly evolving challenges to maintaining high LLIN coverage. Assuring equitable access to LLINs and their appropriate use by the populations that need them is not a challenge that can be solved with a single solution across all country contexts. Experience has shown that campaign distributions must be complemented by continuous distribution channels.

These distribution channels are often multiple, involving antenatal and child health clinics, some schools, agriculture and other public sector networks, as well as private employers and the commercial sector, both formal and informal. In addition to existing services targeted to pregnant women and infants through schools or employers, there are options to create stand-alone “top-up” systems to deliver replacement nets.

Where antenatal and immunisation service contact rates are moderately high and equitable and have a functioning supply chain, these can already serve as the primary channel for continuous LLIN distribution. In areas where transmission is naturally moderate or high, and where children and pregnant women are most at risk, it is recommended that countries should give as much priority to the distribution of nets through antenatal and immunisation systems as is given to campaigns. Countries may choose to announce a policy that “all pregnant women going to antenatal services and all children completing immunisation should be given a net”. In some countries, this will require strengthening local facilities and the capacity of local clinic staff.

With this strategy, LLIN coverage will decline much more slowly following a campaign. In order to monitor these channels, appropriate indicators of performance are needed to measure operational success in delivering LLINs to all women attending antenatal clinics and to all young infants completing their routine vaccinations. In evaluating these indicators and coverage outcomes, particular attention should be paid to indices of equity.

Antenatal and child health clinics alone will not be sufficient to maintain high levels of coverage indefinitely. Complementary strategies, such as school-based or

other social-service based distribution will become necessary and may in some cases replace the need for three year campaigns.

In countries where a large proportion of the targeted population at risk already sleeps under untreated commercial nets, it is possible that these nets might be given a long-lasting insecticide treatment in bulk and during or just after manufacture.

Stand-alone top-up methods in general are relatively untried, and their cost-effectiveness is not yet established; they may also create undesirable incentives for residents (e.g. to hide or destroy nets in good condition).

For the foreseeable future, periodic mass free LLIN distributions to the at-risk populations will continue to be necessary. In places where large-scale distribution of nets through routine health systems (e.g. antenatal and immunisation services) is absent, or achieves very low coverage, these campaigns should be recurrent with an interval of not more than three years. In places where there is large-scale distribution of nets through routine antenatal and/or immunisation services, there should be catch-up campaigns, i.e. timed as a response to operational coverage falling below the threshold (e.g. 80%).

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Figure 1: The advantages and disadvantages of campaign and continuous distribution systems. With a single campaign, coverage rises rapidly to high levels, but then declines, so with a series of recurrent campaigns, coverage fluctuates in a zig-zig pattern, with significant gaps in coverage between campaigns (Red line). With continuous distribution through antenatal (ANC) and immunisation (EPI) channels, coverage rises more slowly but then reaches a stable level (Blue line). If LLINs are delivered through both regular campaigns and ANC or EPI, then high levels of coverage can be sustained with only small gaps in coverage (Black line).

