Monitoring the durability of long-lasting insecticidal nets in field conditions in Nepal


ABSTRACT

Understanding and improving the durability of long-lasting insecticidal nets (LLINs) in the field is critical for the success of malaria prevention using mosquito nets, as well as contributing to procurement decisions based on the number of years of protection, rather than the current practice of unit cost. Using the recently published guidelines from the World Health Organization (WHO) some progress has been made in the monitoring and assessment of performance of nets in the field. This paper describes the protocol of an ongoing retrospective study of the attrition rate, physical integrity and bioefficacy of three polyester LLIN products that were distributed during 2010 to 2013 in Nepal. It is hoped that robust and auditable data on net survival (physical integrity and bioefficacy) of these three brands in different environments will assist the Nepal National Malaria Control Programme in planning future LLIN-replacement strategies, including behaviour-change communication about LLIN care and maintenance. The advantages and disadvantages of prospective and retrospective cross-sectional approaches are discussed, including appropriate strategies to validate the timing for mass distribution of nets. Similar studies should be done in other countries to (i) track LLIN durability to support management of resupply, and (ii) inform procurement decisions at the global level. New, more predictive, textile laboratory testing is also urgently needed.

Key words: Bioefficacy, long-lasting insecticidal nets, malaria, malaria control, malaria transmission, physical integrity

BACKGROUND AND RATIONALE

The National Malaria Control Programme in Nepal is using indoor residual spraying (IRS) and long-lasting insecticidal nets (LLINs) to reduce the transmission of malaria, with the long-term goal of malaria elimination, in line with World Health Organization (WHO) recommendations, and the regional malaria-control strategy. Distribution and promotion of the use of LLINs is an integral component of the National Malaria Control Programme. Since 2005, 3.3 million LLINs have been distributed with support from the Global Fund. The national LLIN distribution policy 2005 recommended one LLIN per household in endemic districts in stratum 1; this was later changed in 2009 to one LLIN for two persons. By the end of 2013, the estimated LLIN coverage was 100% of target population in high- and moderate-risk areas. The procurement and distribution of LLINs in Nepal was mainly managed by Population Services International (PSI-Nepal), and all other activities of malaria prevention and control activities are implemented by the Epidemiology and Disease Control Division (EDCD). Since 2007, WHO has promoted universal coverage with effective methods of vector control for everyone at risk of malaria. Recently, WHO has also recommended free distribution of nets through mass campaigns, complemented by continuous distributions through antenatal-care facilities and child immunizations, in order to achieve and sustain the goal for universal coverage. For procurement purposes, this requires an overall ratio of one LLIN for every 1.8 people in the target population; this is based on an allocation of one LLIN per two persons, adjusted for the effect of odd-numbered households. LLINs were developed in the 1990s and first approved by the WHO Pesticide Evaluation Scheme in 2003.
LLIN technology is based on the slow release of pyrethroid insecticides, rendering them wash resistant and extending insecticide residual effectiveness to at least 3 years without the need for retreatment.1,9

As the largest funder for malaria programmes, Global Fund financing helped provide over 310 million LLINs for malaria control between 2002 and 2012,10 resulting in a rapid increase in bednet ownership and utilization (in addition to largely used conventional nets) in the target population.11 However, a critical question, which has direct implication for the success of malaria control, remains: “How long does an LLIN last in serviceable condition, under field conditions?” Current budgeting for LLINs is based on an assumption that LLINs have an average useful life of at least 3 years.1,9 However, there is a significant paucity of information on LLIN survival time, the variation in performance between LLINs of different textiles, and the general environment in which the net is being used (climate, housing, sleeping place and washing patterns). For these reasons, a recent publication by WHO provided guidance on how to estimate the longevity of nets using durability data from the field.12

Villagers in Nepal generally wash clothes and LLINs with detergent powder and soap and dry them in sunlight for 4–5 hours. In 2008, bioassays tests conducted in Dhanusha, Kanchanpur, Kavre and Makwanpur districts, with LLINs washed up to three times, showed 100% mosquito mortality.5 In 2009, bioassay tests carried out in Banke, Dang, Dhanusha, Kanchanpur, Morang and Nawalparasi districts, on LLINs washed not more than twice, also showed 100% mosquito mortality. After the fourth washing, there was a sharp decline in mortality to 42% in Kanchanpur district.5 The report concluded that “LLIN distributed in 2010 had many public comments like: it was weak, not durable and not effective like previous LLIN”. In reality, there is considerable variation in LLIN durability in relation to their conditions of use, for example, local washing and drying techniques and storage. These factors may partly explain the observed variations.13

Field data on LLIN survival are not currently available to inform the National Malaria Control Programme on the timing and nature of future LLIN replacement strategies, including changing people’s behaviour with respect to care and repair of nets, that is, avoiding holes and repairing them early to prevent deterioration. Acknowledging this gap, the Ministry of Health and Population requested WHO to give guidance on this question, and to assist in the planning and implementation of a retrospective study of LLINs that were distributed during 2010 to 2013.

This paper summarizes the protocol of this study and the progress to date. As far as the authors are aware, this is the second study of this type in the WHO South-East Asia Region. Similar studies in other countries where the use of LLINs is one of the key strategies for malaria prevention and control are also advocated.

### STUDY PROTOCOL: OBJECTIVES AND METHODS

The objectives of this ongoing study are: (i) to assess the physical integrity and bioefficacy of three polyester LLIN products; (ii) to determine the attrition rate of LLINs and factors that have contributed to attrition in four eco-zones since 2010; and (iii) to compare the use of LLINs distributed since 2010.

The study was conducted in 11 districts representative of the four ecological zones, that is, (i) Terai plain rice (2 districts); (ii) Terai foothill (3 districts); (iii) Inner Terai forest fringe (3 districts); and (iv) hills and river valleys (3 districts). Information on physical integrity (holes), bioefficacy and attrition in local conditions was collected using a standardized questionnaire, and analysed to allow the programmes to gather scientific evidence related to the study objectives.

Using the method of Kilian for estimating the necessary sample size,14 a sample of 40 LLINs per village development committee (VDC) was considered sufficient. This was based on the assumption of one measurement for each of the nets per time point, an alpha error of 0.05, power of 80%, and standard deviation of 8.0.

A total of 440 households were randomly selected from VDCs of the above districts, with a range of 30–50 households per district. VDCs were selected on the basis of LLIN distribution dates, having >50 households, and being representative of the major ethnic tribes. Household rosters showing dates of LLIN distributions, and GPS points available from PSI were used to validate the identity of household locations including interviews with household heads by district/health facility staff. Households were randomly selected from this list prior to the follow-up surveys; if the household was absent, or if the house was no longer in the VDC, the next house on the list was selected.

After getting informed consent, the interview was conducted and one randomly selected LLIN was collected and replaced with a new LLIN. Each LLIN sampled was hung up from the four corner points and examined. The size of holes, divided into the categories <0.5 cm, 0.5–2 cm, 2–10 cm, and >10 cm diameter; their position on the LLIN; and the number of holes in each category were recorded. Hole categories are designed to be easily and accurately measured under field conditions and were weighted as 1, 23, 196 and 578, respectively. The number of holes in each category was multiplied by the category weight and expressed as a proportionate hole index (PHI).13

From each of the LLINs collected, four pieces 25 × 25 cm in size were cut from four sides of the net as per WHO guidelines,13 using sharp scissors. For chemical assays, 10% of randomly selected LLINs were selected; four subsamples per LLIN were assembled as one sample, rolled up and placed in a new, clean aluminium foil, labelled and stored at room temperature for chemical analysis at Walloon Agricultural Research Centre,
WHO Collaborating Centre for Quality Control of Pesticides, Gembloux, Belgium. Another two sets of four subsamples were similarly rolled up in clean aluminium foils and tested using standard WHO cone bioassay methods, at the Vector Borne Disease Research and Training Centre Hetauda and Kasetsart University, Thailand.

STUDY IMPLEMENTATION: UPDATE

The study was approved by the National Health Research Council, Kathmandu, Nepal. Villagers are informed about the aims and objectives of the study through house-to-house visits. Information on various aspects of the study was read in the local language and written consent was obtained from each household before the start of the interview.

An orientation workshop was conducted to finalize the survey protocol with EDCD, Kantipur College of Medical Sciences research team, and enumerators. A precoded, structured questionnaire was adapted from the WHO guidelines,\textsuperscript{13} pretested and adjusted for any issues arising from the piloting in Kavre and Sindhupalchowk districts. Data collection commenced in December 2013. The information collected through survey questionnaires and reports of cone bioassay and chemical analysis\textsuperscript{11} will be entered in a Microsoft Access database and analysed using SPSS statistical software.

The field survey in 11 districts representing four different ecological zones were completed; 440 LLINs (4 triplicate pieces from 440 nets) were collected by the end of January 2014. The LLIN pieces are undergoing bioassay at the Vector Borne Disease Research and Training Centre, Hetauda and Kasetsart University, Thailand, and the chemical content of 10\% of the samples representing different locations, brands and years of distribution are being tested at the WHO collaborating centre in Belgium. The results from the analysis are expected to be available soon, and will provide the National Malaria Control Programme with scientific evidence for policy review.

DISCUSSION AND RECOMMENDATIONS

In this study protocol, the following possible limitations were considered: (i) the survival of LLINs cannot be estimated in most settings; (ii) LLINs available may be a biased sample, as worn-out LLINs may no longer be present; (iii) a significant and unknown portion of the local population has moved into or out of the study area; (iv) the number of opportunities for follow-up are limited; (v) labels on LLINs fade or are lost over time, making identification difficult; and (vi) recall by users of what happened more than 12 months previously may be unreliable. However, prospective studies obviate some of the disadvantages listed above, compared with retrospective, cross-sectional studies.\textsuperscript{13} Protocol development for comparing different products is required to test the “true” performance of some brands, which may reach 4 years or more in some environments.\textsuperscript{14} This may include the one or more products that are already in large-scale use in that setting, together with some selected alternatives (e.g. some of those that bid for the last tender but were not selected).

In view of the huge investments on LLINs for malaria control, amounting to USD 500 million every year,\textsuperscript{11, 15} and the fact that, with the exception of IRS, there is no other malaria vector-control tool that could be easily scaled up to help accelerate progress in malaria control towards elimination, a similar study should be carried out in other countries, to track LLIN durability. This would support management of resupply, and inform, at global level, procurement decisions, in conjunction with urgently needed new, more predictive textile laboratory testing. It should be noted that there is an urgent need for the development and validation of novel vector-control strategies, since LLINs and IRS are not sufficient to combat outdoor and early-biting transmission of malaria, which is a major concern in South-East Asia.

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