



Ownership, Usage, and Maintenance LLINs Behavior in Six Endemic Malaria Areas Post Distribution in Indonesia 2019–2020

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Abstract. Malaria remains a public health concern in Indonesia, especially in the east. The intervention of the Long Lasting Insecticides Nets (LLINs) distribution program is one of the strategies used to reduce malaria cases in Indonesia. Therefore, treating LLINs according to the guidelines is critical to maintaining the effectiveness of the mosquito net. This research aimed to determine the ownership, usage and maintained LLINs behaviour after they were distributed in 2019–2020. This study was an observational study with a cross-sectional design. In six malaria-endemic districts, structured questionnaires were administered to 2,658 households in randomly selected villages that received bed nets in 2019–2020. Of the 2658 households, 2421 are known to have LLINs. The data collected included mosquito net ownership, utilization, socio-demographic characteristics such as gender, age, education, occupation, household size, and LLINs care behaviour. The collected data were analyzed descriptively. The study found that 91% of households had at least one LLIN, and 84.7% slept under LLINs the previous night. In addition, 82.6% of households followed the washing instructions for the bed net, and most households (64.8%) followed the care instructions for mosquito nets. However, 34.4% of households were still drying the mosquito nets in direct sunlight. The overall maintenance behaviour for LLINs, beginning with the first time they received the bed net and including how to wash and dry it, was inconsistent with the correct usage instructions (88.4%). Better community education and promotion by health workers on the appropriate use and upkeep of LLINs are essential to ensure the effectiveness of LLINs-based malaria interventions.

Keywords: LLINs · malaria · ownership · usage · maintained

1 Introduction

Malaria is a vector-borne disease transmitted by female *Anopheles* mosquitoes that feed on the blood of sick humans and transmit the disease to healthy humans through their bites. According to the World malaria report, there were an estimated 241 million cases

and 627000 malaria deaths worldwide in 2020 [1]. Indonesia is one of the malaria-endemic countries in South-East Asia, with 226364 cases in 2020 [2]. Most malaria cases have been found in eastern Indonesia because of the favourable conditions for breeding malaria vectors in the region's natural habitats.

The malaria control strategy is carried out in two activities: treating humans infected and controlling the *Anopheles* as a malaria vector. Management control of malaria vectors that have been recommended by the WHO are Long-Lasting Insecticidal Nets (LLINs) and Indoor Residual Spraying (IRS) [3]. LLINs are bed nets treated with insecticides and their efficacy against mosquito vectors for 20 standards washed under laboratory conditions and three years of recommended use under field conditions [4]. LLIN is one of the strategies to reduce the risk factors of malaria transmission. Bed nets must be available as a resource (supply), accessible to households (ownership and universal access), utilized regularly (use) and properly maintained (care and repair) to achieve their optimal effectiveness [5].

In Indonesia, LLIN is carried out in stages; more than 27 million LLINs have been distributed since 2004 to reduce malaria within high and moderate endemic areas such as Sumatera, Kalimantan, and Sulawesi Islands [6]. LLINs are distributed free of charge to people living in high malaria-endemic areas (API >5 per 1000), with a target of at least 80% of the population in the area getting the protection of insecticide-treated nets. In addition, each family receives a mosquito net based on the number of sleeping groups. In moderately endemic areas (API 1–5 per 1000), LLINs are distributed to populations in focus areas through the Mass Distribution nets focus campaign and to high-risk groups of pregnant women and infants. In contrast, low-endemic areas and netting eliminations are distributed in situations such as outbreaks [7].

The Long-Lasting Insecticide-Treated Nets (LLINs) mass campaign has been massively carried out in malaria-endemic areas. However, malaria prevalence is still high, especially in eastern Indonesia. If installed and laundered properly, mosquito nets made from LLINs can effectively kill mosquitoes [8, 9]. According to the effectiveness standards for proper LLINs mosquito net care, the nets should not be soaked, brushed, or dipped repeatedly until the dirt is removed, and not be dried in direct sunlight [7]. It is essential to understand the community's behaviour regarding treating insecticide-treated mosquito nets (LLINs), which can affect the effectiveness of LLINs against malaria vector mosquitoes. World Health Organization (WHO) recommends assessing and evaluating the use of LLINs to improve their use in communities facing a high burden of malaria. Studies report that the maintenance of LLINs among the community is still limited in Indonesia. Therefore, this study examines the ownership, use, and treatment patterns of LLINs in malaria-endemic areas after distribution in 2019–2020 to assist Indonesian health programs with mosquito net campaigns to reduce malaria cases.

2 Materials and Methods

This was a cross-sectional study using a structured questionnaire of a selected household. The survey was undertaken from August to December 2021. The research was conducted in six districts: Sorong (West Papua Province), Batubara (North Sumatra), West Sumba (East Nusa Tenggara), and Tambrau (West Papua), Mappi, and Boven Digoel (Papua

Province). Based on 2019 case data, the district was determined by considering the proportion of regional endemicity strata for malaria cases [7]. Next, villages in the selected districts were identified based on whether the village received distributed LLIN mosquito nets in 2019–2020. The number of villages in the six selected districts was determined randomly and proportionally. The sample size was determined using the proportion estimation formula [10], with an absolute precision of 15%, a confidence level of 90%, and a design effect of 2, 69.9% of pregnant women slept under mosquito nets the night before. By estimating the proportion of pregnant women among childbearing women in the population, which was 2%, a minimum sample size of 2600 houses was required for research. Rapid surveys were conducted in each selected village of 30 households. By calculating the proportion of villages in each district, the total number of villages surveyed in the six districts was 96.

A structured questionnaire was used to interview selected households about socio-demographic characteristics (age, education level, occupation, and household size), LLIN ownership, use, and treatment. The collected data were analyzed descriptively.

3 Results

3.1 Socio-Demographic Characteristics

There were 2658 households and 11478 participants interviewed; 2421 (91%) of the 2658 households owned at least one LLIN as part of the program distribution, and 84.7% slept under LLINs the night before. We investigate households with LLINs in the 2019–2020 distribution ($n = 2421$). According to household characteristics, the majority were between the ages of 25 and 65, with many respondents having no education (34.7%). Most household heads (60.6%) were farmers, and the number of household members ranged from 1 to 5. (72.1%) (Table 1).

3.2 Knowledge of the Advantages and Treatment of LLINs

Table 2 shows participants' knowledge of LLINs' benefits and treatment patterns. Although most respondents (78,5%) know that nocturnal mosquito bites transmit malaria, some are unaware of how malaria is transmitted (21,5%). However, most are conscious (88,3%) that bed nets protect against mosquito bites. Unfortunately, most respondents (33.6%) did not follow the correct washing instructions for their mosquito nets, as the nets were still washed and brushed, which could compromise the insecticide content. Similarly, 32,3% of those who knew how to dry LLINs did not adhere to the correct procedures.

Table 1. Head of household socio-demographic characteristics

Variable	N (2421)	%
Age (years old)		
<25	88	3.6
25–65	2169	89.6
>65	164	6.8
Education level		
None	839	34.7
Primary School	633	26.1
Secondary School	372	15.4
Senior High School	525	21.7
University	52	2.1
Occupation		
Unemployed	281	19.2
Farmer	1466	60.6
Employed/Self-employed	369	15.2
Others	305	12.6
Household size (person)		
1–5	1745	72.1
≥5	676	27.9

3.3 Maintenance LLINs

Based on maintenance LLINs patterns. Most had followed the instructions for use when receiving the LLINs for the first time. The bed net was aerated first after being removed from the packaging for 24 h (66.1%). In addition, 82.6% of households followed the washing instructions for the bed net (maximum of 20 washes), but 2.3% of households washed the mosquito net more than 20 times (Table 3). Most households did not follow the instructions for appropriate maintenance when washing their bed net. The nets were soaked in detergent and then washed/brushed, which could damage the netting and reduce its efficacy. However, in contrast to drying the bed nets, most households (64.8%) followed the care instructions for mosquito nets. Although 34.4% of households were still drying the mosquito nets in direct sunlight.

Based on an overall analysis that included when the mosquito net was first obtained, washing frequency, washing and drying method. It was discovered that as many as 88.4% had not followed the treatment instructions, and only 11.6% adhered to the guidelines (Table 3).

Table 2. Distribution of participants' knowledge of LLINs' benefit and treatments

	Variable	N (2421)	%
1	How do people get malaria?		
	– Through nocturnal mosquito bites	1900	78.5
	– Not known	521	21.5
2	Bed nets to prevent malaria mosquito bites		
	– No	283	11.7
	– Yes	2138	88.3
3	How to wash bed net		
	– Not known	84	3.5
	– Bed nets are soaked in water. Treated with detergent, rubbed/brushed, and rinsed until all traces of dirt are removed	813	33.6
	– Bed net is soaked in water without detergent and scrubbed until all dirt is eliminated	597	24.7
	– Bed net is soaked and rinsed in water until all dirt has been cleared	286	11.8
	– Laundered or washed in a washing machine	2	1.0
	– The bed net is dipped in a detergent solution until all dirt is eliminated, without soaking or brushing. And then thoroughly rinsed	639	26.4*
4	How to dry out bed net		
	– Not known	68	2.8
	Bed nets are dried in sunlight	783	32.3
	The bed net is dried in an area that is shielded from direct sunlight	1570	64.8*

*Maintenance LLINs according to the guidelines

Table 3. Maintenance llins

	Variable	n	%
1.	The first time receiving an LLIN		
	– Not Known	49	2.0
	– Immediately after removing it from its packaging. The LLINs are installed	411	17.0
	– After removing the LLINs from its packaging. it is exposed to air for 24 h.	1601	66.1*
	– After removing the LLINs from its packaging. it is aired for more than 24 h	360	14.9
2.	Washing frequency		
	– LLINs have never been washed	367	15.2
	– >20 times	55	2.3
	– 1–20 times	1999	82.6*

(continued)

Table 3. (continued)

	Variable	n	%
3.	How to wash LLINs		
	– Not known	22	1.1
	– Bed net is soaked in water. Treated with detergent. Rubbed/brushed. And rinsed until all traces of dirt are removed	723	35.2
	– Bed net is soaked in water without detergent and scrubbed until all dirt is eliminated	549	26.7
	– Bed net is soaked and rinsed in water until all dirt has been cleared	235	11.4
	– Laundered or washed in a washing machine	1	0.0
	– Bed net is dipped in a detergent solution until all dirt is eliminated. Without soaking or brushing. And then thoroughly rinsed	524	25.5
4.	How to dry out bed net		
	– Not known	16	0.8
	– Bed nets are dried in sunlight	707	34.4
	– The bed net is dried in an area that is shielded from direct sunlight	1331	64.8*
5	Guidelines-compliant LLINs maintenance behaviour		
	– Not	2140	88.4
	– Yes	281	11.6

*Maintenance LLINs according to the guidelines

4 Discussion

The results of this study in 6 endemic malaria areas found that ownership and use of LLINs were relatively high; 91% and 84.7%, respectively. Our study was consistent with another quantitative household survey conducted in the Lake Victoria basin of Western Kenya in 2017, which reported a high proportion of net use (98.1%) among 96.9% of households owning at least one net [11]. However, a study in western Kenya found that despite high ITN ownership of 71%, compliance on usage was slightly low at 56.3% [12]. In another study in the western coastal plain of Yemen. 90.6% owned at least one LLIN, but only 19.0% slept under LLINs the night before the survey [13]. The high ownership and use of LLINs in Indonesia show that the government is serious about controlling malaria cases. In Indonesia, LLINs were introduced through a subnational campaign to eastern Indonesia and parts of Sumatera in 2005, to all of Sumatera in 2007, to Kalimantan and Sulawesi in 2009, and subsequently, nearly every two years in highly endemic districts and villages. The continuous distribution of LLINs was integrated with routine immunization and antenatal care services (malaria screening during pregnancy) [14]. Then, after the mass bed net campaign, the health program

conducted monitoring and evaluation to assess the success of program implementation and community participation in supporting the program through bed nets [7].

The study in six endemic regions revealed that the overall maintenance behaviour of LLINs, beginning with the first time they received the bed net and including how to wash and dry the net, was inconsistent with the correct usage instructions. This is probably due to a lack of knowledge regarding treating LLINs per the recommendations. The study found that only 35.2% of households knew how to wash a bed net. LLINs are soaked in water, treated with detergent, rubbed/brushed, and rinsed until all traces of dirt are removed. Furthermore, only 32.3% of households know that bed nets are dried in sunlight. The study in Muara Enim found that 95.52% of respondents used LLINs daily, but 78.26% did not know how to wash insecticide-treated bed nets properly, and the majority of respondents dry bed nets in direct sunlight [15]. Another study in Kotabaru, South Kalimantan, showed the practice of washing bed nets excessively and drying them in direct sunlight [16].

Bed-net maintenance practices are crucial for preserving mosquito net threads' insecticide content. However, WHO has recommended that LLINs be washed 20 times and have a shelf life of 3 years. This depends on how the community treats the mosquito nets. Different washing methods and drying regimens can affect the efficacy of LLINs. It has been demonstrated that direct sunlight can damage and reduce the effectiveness of insecticide-treated bed nets [17]. The study conducted in Kenya found that LLINs used in the community did not meet the 3-years WHO efficacy criteria. It was caused by inappropriate exposure to sunlight. The average loss through washing has reduced the efficacy [18]. Education to the public on how to use and maintain mosquito nets following guidelines is essential because it can affect the effectiveness of LLINs interventions in preventing malaria transmission. The approach by health workers and community leaders trained in educating the community is one strategy that can be done to increase public knowledge about proper mosquito net care.

The limitation of this study was the utilization status of LLINs obtained verbally from the respondents the night before the survey, which may not reflect accurate. Future research is needed to analyze the durability and Bio-efficacy of LLINs used by the community.

5 Conclusions

Based on the study results, it was found that most people already know the importance of using LLINs to prevent malaria transmission. However, LLINs maintenance has not been carried out according to the instructions. Thus, it is necessary to carry out socialization and education through approaches by health workers and local community leaders to increase public knowledge about how to treat LLINs properly.

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