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RESEARCH ARTICLE

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## ASSOCIATION OF IMPORTANCE OF KNOWLEDGE AND GOOD PRACTICES IN THE PROPER USE OF LLIN IN RELATION TO MALARIA MORBIDITY IN HOUSEHOLDS WITH CHILDREN UNDER 5 IN THE KARISIMBI HEALTH ZONE OF GOMA IN NORTH KIVU/DRC

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### ABSTRACT

**Introduction:** Malaria in children under the age of five is a major public health problem in the DRC. Long-lasting insecticidal nets (LLINs) have been advocated as an effective tool against malaria transmission. However, the success of this intervention depends largely on knowledge of correct use and practices regarding malaria and its prevention. Few studies have been carried out on knowledge of the correct use of LLINs and practices regarding the correct use of LLINs in relation to malaria morbidity in children under 5 years of age. **Methods:** A cross-sectional community survey was conducted among 223 households of U5 selected in 19 health areas of the Karisimbi Health Zone using a multi-stage sampling technique. A pre-tested interviewer-administered questionnaire was used to collect information on the importance of LLINs and good practice in the correct use of LLINs in households with children under the age of 5. The correct use of LLINs was defined as the proportion of U5 who slept under the net the night before the survey. Data were analyzed using descriptive statistics, chi-square test and logistic regression at  $p < 0.05$ . **Results:** The association between variables showed that no variable on importance of knowledge and good practices in proper use of LLIN significantly explains malaria morbidity of children under five years in the household because the associated probability is greater than 5%. In addition, logistic cross-tabulation showed that household who did not use properly LLINs were 1.9 times more likely to have children under 5 suffering from malaria in the last 3 months. Findings showed that no variable linked to good practices in the proper use of LLINs significantly explained the number of cases of children under 5 who had contracted malaria during the last 3 months, given that all the probabilities were greater than 5% ( $p > 5\%$ ). **Conclusion:** The level of knowledge of respondents about the importance of correct use of LLINs and the practices of correct use of LLINs among households with children under the age of five was low. However, it is far from the target of 80%. Efforts should be made to further improve the level of knowledge on the correct use and practices of LLIN through intensified promotion of health education.

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## INTRODUCTION

In DRC, malaria remains a major public health problem (WHO, 2018) and the leading cause of morbidity and mortality (Roll Back Malaria, 2014), particularly among children under 5 years of age despite the distribution of LLINs (Ajegena and Oti, 2020). The country accounts for 11% of the global malaria burden. Malaria is endemic in the country and the risk exists throughout the year in almost the entire country: 97 % of DRC is endemic and the remaining 3 % in the mountainous areas in the East are considered at risk of epidemic of malaria (WHO, 2006). LLINs are a key intervention in malaria prevention in the country as is the case in many African countries (NMCP/DRC, 2017).

Several studies have shown that LLINs have significant impact in reducing malaria morbidity and mortality in endemic areas (Lengler, 2004; Russell et al 2010). When over 60% of the community is covered, LLINs could have a community effect by providing protection to both users and non-users of treated nets (RBM, 2011). Over the years, distribution of long-lasting insecticidal nets has increased in sub-Saharan Africa (WHO, 2021) unfortunately the rate of ownership and use of insecticide-treated nets has not increased proportionately. LLIN uptake and use varies by population at risk and country in sub-Saharan Africa (WHO, 2019), including in the DRC where uptake lags behind ownership. The proper use of LLINs is considered an effective and cost-effective method for malaria prevention. It refers to households that have an LLIN and one or more members of which slept under a net, as confirmed by enumerator

observation during the morning prior to this survey (FMOH, 2013, 2007). LLINs can only be effective if people have them and use them regularly and properly. It is therefore essential that they have the right knowledge and practices for malaria control interventions. It is essential to determine the level of association between the importance of knowledge about LLINs and practices relating to their correct use (Koenkeret al., 2018). Studies have shown that in sub-Saharan Africa, between 2015 and 2020, the rate of increase in LLIN ownership and use did not change at all as household ownership ranged from 63% to 68%, while LLIN use ranged from 46% to 52% for at risk populations in children under five years of age (WHO, 2020). In a country like Nigeria, in 2020, household LLIN ownership was 60.6%, while LLIN ownership among at-risk populations was 47.5%, with a lower usage rate of 43.2% (USAID, 2021). These rates in sub-Saharan Africa fall far short of the WHO targets for universal coverage (at least 80% for LLIN ownership and use in the at-risk population) (Koenkeret al. 2018; WHO, 2014). According to the findings of a study by Afoakwah and colleagues in Ghana, the use of insecticide-treated mosquito nets among children increases their survival rate. The study found that the mortality rate of children under five who slept under treated nets was 18.8% lower than that of children who did not sleep under treated nets. Although the provision of health services was found to reduce under-five mortality and childbirth in older women was found to be detrimental to child survival (Afoakwah et al., 2015).

LLINs are unique from other prevention mechanisms in that their protective efficacy requires proper and regular use and adherence to their use by the entire family, all the year and all night and accessibility in the household. A study carried out in Cameroun indicated that despite good knowledge of malaria and prevention measures, few people apply good practices. More sensitization needs to be done to improve adherence to good practices concerning malaria prevention (Talipouo et al. 2019). A knowledge assessment study on the correct use of mosquito nets for malaria prevention in parts of Cameroon by Ntonifor and colleagues focused on the different characteristics of correct net use. The responses related to this assessment varied according to the knowledge of the respondents shown that 50.2% of the respondents said that they take down their LLINs before going to bed, their MIDAs before going to bed, 30.4% adjusted them properly on the bed before sleeping, 11.4% put them permanently on their bed, and (8.1%) of them used nets that did not have holes and were able to install them properly on their bed within the correct hours. In addition, 71.9% of the total population had nets in good condition, while 37.0% did not answer the question. These results were significant at  $P \leq 0.049$  (Ntonifor et al., 2016). A study conducted by Moukenet and colleagues in 2022 on Knowledge and practices surrounding malaria and LLIN use among Arabs in Chad reported that good malaria prevention practices are assessed by the possession and use of LLINs at night. In this study, respondents were considered to have good prevention practices if they reported owning and sleeping under an LLIN the night before the survey. In contrast, poor LLIN ownership was defined as not sleeping under an LLIN (Moukenet et al., 2022). A study carried out in Cameroun by Talipouo et al. indicated that despite good knowledge of malaria and prevention measures, few people apply good practices. More sensitization needs to be done to improve adherence to good practices concerning malaria prevention (Talipouo et al. 2019).

According to the findings of a study by Afoakwah and colleagues in Ghana, the proper use of insecticide-treated mosquito nets among children increases their survival rate. The study found that the mortality rate of children under five who slept under treated nets was 18.8% lower than that of children who did not sleep under treated nets. Although the provision of health services was found to reduce under-five mortality and childbirth in older women was found to be detrimental to child survival (Afoakwah et al., 2015). The 2017-2018 MICS-Paluin DRC survey found that 39 percent of children under five slept under an LLIN the night before the survey. This percentage is higher in urban areas 42 % than in rural areas 38 % and decreases from 59 percent among children aged 0-11 months to 31 percent among children aged 48-59 months at North Kivu Province. Results from the 2017-2018 North Kivu MICS-Palu survey indicate that 55 percent of households own at least one LLIN, and 19 percent own at

least one LLINs for every two household members in North Kivu Province (INS/DRC, 2020). The literature indicates that household ownership of nets is a key determinant of net proper use. If the household does not own a net, it cannot use one. In sub-Saharan Africa, considerable efforts have been made to increase the number of households with LLINs. In addition, malaria control programs have made an impressive distribution effort, with significant government and donor support in recent years. Many countries have increased household coverage to the point where the average household coverage with at least one LLIN has increased from 5% to 31% in recent decades (WHO 2009). Household ownership of nets is a key determinant of LLIN use. LLINs are renowned for their dual action. They act as a physical and chemical barrier, preventing mosquito bites and killing or repelling mosquitoes that come into contact with them. Their effectiveness may depend on their physical integrity, as well as on the proportion of people using them properly, especially among those who own them (Hemingway et al., 1995; Coetzee et al., 2000). The purpose of this paper is to assess the association of the importance of knowledge and practices in the proper use of LLINs in relation to malaria morbidity in the Karisimbi Health Zone of Goma in North Kivu/DRC.

## METHODOLOGY

**Study Setting and Design:** A cross-sectional community survey was carried out in the Karisimbi health zone, comprising 19 health areas. This zone was purposely chosen because it is one of the main malaria-prone areas in North Kivu, mainly in the city of Goma in the DRC. The town of Goma is located at an altitude of 1,530 metres and is built on ancient volcanic lava flows on the northern shore of Lake Kivu and to the south of the Nyiragongo volcano, between 1° 41' 36" South and 29° 13' 31" East, covering an area of 75.72 km<sup>2</sup>. From a health and demographic point of view, Goma is a dense city with more than 1,250 inhabitants per Km<sup>2</sup>, with three entire health zones, namely Goma, Nyirangongo and Karisimbi. The source population comprised all households with children under the age of five. Households were selected on the basis of stratified sampling proportional to the size of each health area. The sample size was calculated using the formula for a single population proportion, assuming a 95% Confidence Interval (CI) and a 5% margin of error, and the prevalence of LLIN ownership was assumed to be 50%. The final sample size was therefore 418 households. Health extension workers distributed long-lasting insecticidal nets (LLINs) to community households as part of a free mass distribution campaign in 2022. The study was conducted from March to April 2023.

**Questionnaire and Data Collection:** The study was a community-based descriptive cross-sectional survey to assess the association of the importance of knowledge and practices on the correct use of LLINs in relation to malaria prevention among children under 5 years of age in the Karisimbi health zone. A pre-tested questionnaire to assess basic knowledge in households on the importance of knowledge and practices of correct use of LLINs was used for data collection. After preparing the questionnaire, 10 community health workers carried out internal revisions to assess the clarity of the questions and their interpretability. A pilot study was then carried out on a group of 30 households to test the validity, internal consistency and reliability of the questionnaire. The questionnaire was administered only once to the respondents, and the number of correct answers given to the various questions was recorded to measure test-retest reliability. Before the survey began, community health workers were trained in the use of the questionnaire and in methods of approaching respondents and obtaining their consent. Relatives (head of household, spouse or and eldest representative of the household) who consented to the study were interviewed. The interviews were conducted in Swahili, which is the local language known by almost everyone. Only households where consent forms were accepted were included in the study.

### Operational Definitions

- Households were considered LLIN owners if they had at least one ITN at the time of the interview. Children that were

reported to have slept under an LLIN in the night prior to the survey interview were considered as owners.

- Proper use refers to households that have an LLIN and one or more members of which slept under a net, as confirmed by enumerator observation during the morning prior to this survey (FMOH, 2013, 2007).
- Morbidity is the state of being symptomatic or unhealthy for a disease or condition. It is usually represented or estimated using prevalence or incidence. Prevalence describes the proportion of the population with a given symptom or quality.
- Long-Lasting Insecticidal Nets (LLINs): According to WHO (2008), WHO (2007); WHO (2005) and Kimbiet *al.* (2014), a long-lasting insecticidal net (LLIN) is “a factory-treated mosquito net made with netting material that has specific insecticide such as permethrin, deltamethrin, alphacypermethrin incorporated within or bound around the fibers. The net must retain its effective biological activity without retreatment for at least 20 WHO standard washes under laboratory conditions and three years of recommended use under field conditions”.
- Knowledge: To have knowledge means to know or be aware of things. Knowledge is understanding gained through learning or experience.

### Data analysis

The data was cleaned to detect inconsistencies in data entry and responses. The responses collected in the Kobo Collect software were extracted into an Excel sheet and exported to STATA software version 16.0 for analysis after cleaning. For descriptive purposes, Microsoft Excel was used to draw up graphs to make it easier to understand the results. Categorical variables were summarized in percentages and cross-tabulated, and chi-square analysis was performed to determine the association between importance of Knowledge and practices in the proper use of LLIN in relation to Malaria morbidity and malaria morbidity. To identify association of the importance of Knowledge and practices in the proper use of LLIN in relation to Malaria morbidity in the household a logistic regression analysis was operated and the odds ratios (OR) as well as their 95% confidence intervals (95% CI) was computed using STATA software. Statistical significance was set at  $p < 0.05$ .

**Ethical Clearance.** Ethical clearance was obtained from Great Lakes University of Kisumu (GLUK), The research has been conducted in accordance with GLUK's research ethics policy. Verbal consent was obtained from individual respondents.

### Abbreviations

- 1) 95 % CI: 95 % confidence interval
- 2) OR: Odds Ratio
- 3) p: Significance value
- 4) DRC: Democratic Republic of Congo
- 5) LLIN: Long-Lasting Insecticidal Nets
- 6) NMCP: National Malaria Control Program
- 7) MICS: Multiple indicators cluster survey

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- 7) MICS: Multiple indicators cluster survey
- 8) NIS: National Institute of Statistics

## RESULTS

### Ownership of LLIN in the household

In relation to household ownership of the LLIN, findings of the table 1 showed that 53.4% of the households own LLINs while 46.6% do not.

**Table 1. Distribution of respondents by Ownership of LLIN in the household**

Variable	Number of respondents (418)	Proportion (%)
Ownership of LLIN		
No	195	46.7
Yes	223	53.4

Source: Field data

### Findings according Use of LLIN in the households

Findings of the table 2 showed that 52.1% of households that own mosquito nets do not use them compared to 47.9% of households that do. For households that do use mosquito nets, 97.5% of these households use mosquito nets on the bed and 2.5% of households use mosquito nets on the floor of a mattress.

**Table 2. Distribution of respondents by Use of LLIN in the Household**

Variables	N=(223)	Percentage (%)
Use of LLIN in the household		
No	116	52.1
Yes	107	47.9
If Yes	N=(107)	Percentage (%)
LLIN used on bed or mattress on floor		
On bed	104	97.5
On mattress on floor	3	2.5
Age of LLIN		
less than 3 months	16	15.0
3-6 months ago	19	17.5
6-12 months ago	21	20.0
1- years ago	47	44.0
3-5 years ago	4	3.5
Net condition in the Household		
Good (No holes)	61	57.0
Average	37	35.0
Bad (Dirty, Big holes)	9	8.0
Preferred Net Shape by Household		
Rectangular	91	85.5
Conical	12	11.5
Any shape	3	3.0
Preferred Color		
White	91	85.0
Blue	10	9.5
Green	2	1.5
Any color	4	4.0
Net Hanged observed		
None	19	18.0
One	56	52.5
Two	32	29.5
Child < 5 years slept under LLIN the previous night		
No	13	12.5
Yes	94	87.5
If Yes Number of Child < 5 years slept under LLIN the previous night		
One child	66	61.7
Two children	34	32.0
Three Children	7	6.3
If No use	N=(116)	Percentage (%)
Reasons of non-using of LLIN		
Difficult in hanging the Net	28	23.9
Little space in the house and poor sleeping conditions and positions	36	31.2
Don't know the benefits of LLIN	52	45.0

Source: Field data

Regarding the age of the net, 44.0% of households say their nets are one year old, 20.0% of households say their nets are 6-12 months old, 17.5% of households say their nets are 3-6 months old, 15% of households say their nets are less than 3 months old and 3.5% of households say their nets are 3-5 years old. Regarding the condition of the nets in households, more than half of the households (57.0%) say that their nets are in good condition. In contrast, 35.0% said that their nets were in average condition, i.e. not in good condition and not in bad condition. As for the preferred shape of the net, 85.5% of households prefer a rectangular shape of net, 11.5% of households prefer a conical shape, 3.0% any shape. Regarding the color of the net, 85.0% of households prefer white, 9.5% blue, 4.0% of households prefer any color and 1.5% of households prefer green. In relation to the observation of the hanging net, more than half or 52.5% of households have two LLINs hanging on the bed. This is the highest proportion. In terms of children having slept under an LLIN the night before the survey, 87.5% of households reported having children under 5 sleeping under the net last night compared to 12.5% of households whose children under 5 did not sleep under the net the night before the survey. The table below shows that in the proportions of households whose children slept under an LLIN the previous night, more than half, or 61.7% of households had one child under 5 years old sleeping under an LLIN the previous night, 32.0% of households had two children sleeping under an LLIN and 6.3% of households had more than three children under 5 years old sleeping in an LLIN. In addition, the table results revealed the reasons given by respondents who do not use the LLIN. The results show that in the 218 households that do not use the LLIN, 45.0% of the households are still unaware of the benefits of an LLIN when it is used regularly and correctly, 31.2% talk about the lack of space or poor conditions in the house and sleeping positions, 23.9% of the households experience the difficulty of hanging the net.

#### Knowledge on importance and good practices in proper use of LLINs in the households

Respondents were asked about their knowledge of the importance and good practice of using LLINs in the household. Out of a total of 223 respondents the results in table 3 showed that over half (132) 59.1% agreed that sleeping under a mosquito net every night is necessary to prevent malaria, compared to (91) 40.9% of respondents who disagreed. The results showed that (136)61.0% agreed with the use of LLINs to fight malaria, compared to (87)39.0% of respondents who disagreed.

Findings then showed that (142)63.7% of respondents agreed that LLIN protects against mosquitoes and malaria infection compared to (81)36.3% of respondents who disagreed. The results also show that (137)61.4% agreed that LLIN protects against other insect bites compared to (81)38.6% who disagreed. With regard to knowledge of LLIN use practices, the results revealed that (102)45.7% of respondents agreed that the net should be pulled down before sleeping compared to 54.3% who disagreed. Similarly, (114)51.1% agreed that a mosquito net should be placed on the bed at night, compared with (109)48.9% who disagreed. Findings showed that (103)46.2% agreed that the net should be permanently on the bed compared to (120)53.8% who disagreed. Finally, the findings showed that (108)48.4% agreed that the LLIN should not have any holes in it and should be properly hung on the bed in a good room, compared to (115)51.6% who disagreed.

#### Knowledge on importance of LLINs proper associated with use of LLINs in the households

FMOH, (2013) and (2007) explain: "Proper use of an LLIN refers to households that own an insecticide-treated net and where one or more members have slept under a net and this has been confirmed by observation by an interviewer during the morning prior to a survey". The results in the table 4 revealed that 59.1% of households agree that sleeping under an LLIN every night prevents malaria, 61.0% agree that LLINs are used to kill malaria-carrying mosquitoes, 63.7% agree that LLINs protect against mosquito bites and malaria, and 61.4% agree that LLINs protect against the bites of other insects. In view of these results, more than half of the households surveyed have knowledge about the use of LLINs. The results in table 4 reveal that 59.1% of respondents agreed that sleeping in a mosquito net prevents malaria of which 36.1% use LLINs and 23.0% do not use LLINs. Table 4 further shows that 61.0% agreed that LLINs are used to kill malaria mosquitoes of which 38.1% use LLINs and 22.9% do not use LLINs. With regard to the fact that LLINs are intended to protect against mosquito bites and malaria infection, 63.7% of respondents agreed, of whom 38.6% use LLINs and 24.6% do not. With regard to protection against the bites of other insects, 61.4% agreed that LLINs protect against the bites of other insects. Of these, 37.7% use LLINs and 23.8% do not. The association between variables showed that no variable of knowledge on the importance of LLINs significantly explained the proper use of LLINs because the associated probability is greater than 5%.

**Table 3. Distribution of respondents by Knowledge on importance and good practices in proper use of LLINs within the household**

Variable	Number of respondents (223)	Number of respondents (223)	
		Agree N=116(52.0%)	Disagree N=107(48.0%)
1 Knowledge on importance of LLINs			
1.1 Sleeping under mosquitoes Net every night prevents malaria	132(59.1)	91(40.9)	
1.2 LLIN used to kill malaria mosquitoes	136(61.0)	87(39.0)	
1.3 LLINs protect against mosquito bites and malaria infection	142(63.7)	81(36.3)	
1.4 LLINs protect against the bites of other insects	137(61.4)	86(38.6)	
2 Knowledge on good practice in use of LLINs			
2.1 Pulling Net down over bed before sleeping	102(45.7)	121(54.3)	
2.2 Net well fitted on bed in the evening	114(51.1)	109(48.9)	
2.3 Net put permanently over bed	103(46.2)	120(53.8)	
2.4 Net free from holes and fitted correctly over bed within the right room	108(48.4)	115(51.6)	

Source: Field data

**Table 4. Knowledge on importance of LLINs associated with proper use of LLINs in the household**

Variable	Number of respondents (223)	Proper use of LLINs		Crude Odds Ratio (cOR)		P-Value
		NO n=116(52.0%)	YES n= 107(48.0%)	cOR	95% CI	
Sleeping under mosquitoes Net every night prevents malaria						
Agree	132(59.1)	51(38.6)	81(61.4)	1.0		
Disagree	91(40.9)	65(71.4)	26(28.6)	0.8	(0.436- 1.725)	0.686
LLIN used to kill malaria mosquitoes						
Agree	136(61.0)	51(37.5)	85(62.5)	1.0		
Disagree	87(39.0)	65(74.7)	22(25.3)	0.5	(0.261- 1.051)	0.069
LLINs protect against mosquito bites and malaria infection						
Agree	142(63.7)	55(39.4)	86(60.6)	1.0		
Disagree	81(36.3)	61(75.3)	20(24.7)	0.5	(0.254- 1.024)	0.058
LLINs protect against the bites of other insects						
Agree	137(61.4)	53(38.7)	84(61.3)	1.0		
Disagree	86(38.6)	64(74.4)	22(25.6)	0.6	(0.300-1.085)	0.087

### Relationship between Knowledge on good Practice and proper use of LLINs in the household

Good practices on the proper use of the LLINs are considered to be Pulling the net down from the bed before sleeping, Adjusting the net properly on the bed at night, Putting the net permanently on the bed, Do not put holes in the net and adjust it properly on the bed in the right room (Ntonifor, 2016). The table 5 of results showed that 54.3% disagreed that the LLIN should be pulled down over the bed before sleeping but of which only 23% use the LLIN properly and 77% do not. While 51.1% of the households agreed that the LLIN should be placed on the bed at night of which 71% use the LLIN properly while 29% do not. In addition, the results reveal that 48.9% do not agree that LLINs should be placed on the bed at night, but of which 24% of respondents use LLINs compared to 76% who do not use LLINs. Findings of the table 4 indicate that 46.2% of households agree that the LLIN should be placed on the bed at all times, of which 74% use the LLIN and 26% do not. In addition, 48.4% agree that the LLIN should not have any holes in it and should be placed properly on the bed in an appropriate room, of which 70% use the LLIN properly and 30% do not. Findings of this association showed the presence of a significant relationship between knowledge good practice and proper use of the LLIN. The probabilities are all lower than 5%. Good knowledge of the fact that the LLINs should be pulled down over the bed before sleeping significantly explains the proper use of the LLINs, as the Chi2 probability is less than 5%, i.e. p-value= 0.000\*. The fact that the LLINs is properly placed on the bed, permanently positioned above the bed, and has no holes in it significantly explains its proper use, as the probability is less than 5%, i.e. p-value = 0.000\*.

children under 5 who had suffered from malaria during the last three months preceding the survey, compared to 20.7% of households surveyed who had children who had suffered from malaria during the three months preceding the survey. According to the results of the same table, 52% of households do not use an LLIN, including 21.5% of households that did not have children under the age of 5 who had malaria in the three months preceding the survey, compared to 30.5% of households that had children under the age of 5 who had malaria in the three months preceding the survey. There was a significant relationship between the proper use of LLINs and Malaria Morbidity as the probability associated with chi-square was less than 5% or p-value = 0.001\*. The number of frequent malaria cases was explained by the fact that the proper use of LLINs was not regular in the households. The logistic cross-tabulation showed that household who did not use properly LLINs were 1.9 times more likely to have children under 5 suffering from malaria in the last 3 months.

### Knowledge on proper use LLINs in the households associated with Malaria Morbidity

Findings of the table 7 revealed that over than half (59.1%) of households agreed that sleeping under an LLIN every night prevents malaria, of which 30.4% have had a child or children <5 years who have had malaria in the last 3 months, 63.7% agreed that LLINs protect against mosquito bites and malaria of which 32.3% have had a child or children <5 years who have had malaria in the last 3 months. The result of the logistic regression showed that no variable on knowledge of LLIN use significantly explains the Malaria Morbidity variable, as all probabilities are greater than 5%, i.e. 0.314 and 0.291 respectively.

**Table 5. Distribution of results by Relationship between Knowledge on good practice and proper use of LLIN in Household**

Variable	Number of respondents (223)	Proper use of LLINs		Chi2
		NO n=116(52.0%)	YES n= 107(48.0%)	P-Value
Pulling Net down over bed before sleeping				0.000*
Agree	102(45.7)	23(23)	79(77)	
Disagree	121(54.3)	93(77)	28(23)	
Net well fitted on bed in the evening				0.000*
Agree	114(51.1)	33(29)	81(71)	
Disagree	109(48.9)	83(76)	26(24)	
Net put permanently over bed				
Agree	103(46.2)	27(26)	76(74)	0.000*
Disagree	120(53.8)	89(74)	31(26)	
Net free from holes and fitted correctly over bed within the right room				0.000*
Agree	108(48.4)	32(30)	75(70)	
Disagree	115(51.6)	61(72)	32(28)	

p>0.05. Source: Field data

**Table 6. Distribution of results by Malaria morbidity in the household**

Variable	Number of respondents(223)	Proportion (%)
Have a child or children <5 years who have had fever in the last 3 months?		
No	109	48.9
Yes	114	51.1

Source : Field data

**Table 7. Distribution of results by Proper Use of LLINs associated with Malaria Morbidity**

Variable	Number of respondents(223)	Have a child or children <5 years who have had malaria in the last 3 months?		Crude Odds Ratio (cOR)		P-Value
		NO=109(48.9%)	YES=114(51.1%)	cOR	95% CI	
Proper Use of LLIN						
Yes	107(48.0)	61(27.4)	46(20.6)	1.0		
No	116(52.0)	48(21.5)	68(30.5)	1.9	(1.278- 2.781)	0.001*

P=0.001\*<0.05\*. Source: Field data

### Outcome: Malaria morbidity in the household

Observing the Table 6 of findings and it is observed that just over half of respondents, or 51.2% of households, have had children <5 years old who have suffered from fever in the last 3 months.

### Proper use of LLINs associated with Malaria morbidity in the Household

Looking at the results of table 4.13, it emerges that 48.0% of households surveyed use the LLIN, of which 27.4% did not have

### Knowledge on good practice in proper Use of LLIN in the household associated with Malaria Morbidity

Good practice was measured on the basis of the respondent's previous health behavior, decisions and actions regarding malaria prevention and control, using a total of five questions. Each question contained one point for a positive or correct lifestyle, 0.5 for a neutral lifestyle and 0 points for negative or incorrect lifestyle practices. The total score of responses was five points and classified into three categories

**Table 8. Distribution of respondents by Knowledge on proper Use of LLINS in the households associated with Malaria Morbidity**

Variable	Number of respondents(223)	Have a child or children <5 years who have had malaria in the last 3 months?		Crude Odds Ratio (cOR)		P-Value
		NO=109(48.9%)	YES=114(51.1%)	Cor	95% CI	
Sleeping under mosquitoes Net every night prevents malaria						
Agree	132(59.1)	64(28.7)	68(30.4)	1.0		
Disagree	91(40.8)	45(20.2)	46(20.6)	0.7	(0.394-1.347)	0.314
LLINs protect against mosquito bites and malaria infection						
Agree	142(63.7)	70(31.4)	72(32.3)	1.0		
Disagree	81(36.3)	38(17.0)	43(19.3)	1.4	(0.748-2.627)	0.291

$p > 0.05$ . Source: Field data

**Table 9. Distribution of results by Knowledge on good practice in proper Use of LLIN associated with Malaria Morbidity**

Variable	Number of respondents(223)	Have a child or children <5 years who have had malaria in the last 3 months?		Crude Odds Ratio (cOR)		P-Value
		NO=109(48.9%)	YES=114(51.1%)	cOR	95% CI	
Pulling Net down over bed before sleeping						
Agree	102(45.7)	54(24.2)	48(21.5)	1.0		
Disagree	121(54.3)	55(24.7)	66(29.6)	0.8	(0.444-1.668)	0.658
Net well fitted on bed in the evening						
Agree	114(51.1)	61(27.4)	53(23.8)	1.0		
Disagree	109(48.9)	47(21.1)	62(27.8)	1.4	(0.662-2.857)	0.392
Net put permanently over bed						
Agree	103(46.2)	55(24.7)	48(34.1)	1.0		
Disagree	120(53.8)	54(24.2)	66(29.6)	1.1	(0.591- 2.164)	0.708
Net free from holes and fitted correctly over bed within the right room						
Agree	108(48.4)	58(26.0)	50(22.4)	1.0		
Disagree	115(51.6)	51(22.9)	64(28.7)	1.2	(0.583-2.342)	0.659

$p > 0.05$ . Source: Field data

according to Bloom's threshold (60%-80%), based on other studies (Wanyama *et al.* (2015); Yimer *et al.* (2014)): Good: practice score of four points or more (80%-100%); Fair (Moderate): practice score of between 3 and 3.9 points (60%-79%); Poor: practice score of less than three points (less than 60%) (Wubishet *et al.*, 2021). Looking at the table 8 of findings referring to knowledge on good practice the proper use of the LLIN in the households it appears that 54.3% of the households disagree that the LLIN should be pulled down over the bed before sleeping, 51.1% of the households said that the LLIN should be placed on the bed at night, 53.8% of the households disagreed that the LLIN should be permanently placed on top of the bed, 51.6% of the households disagreed that the LLIN should be placed on top of the bed in a good room without holes.

These results suggest that the proper use of the LLIN in households is still a matter of concern. Findings showed that 54.3% disagreed that the LLIN should be pulled down over the bed before sleeping but of which only 29.6% have had a child or children <5 years who have had malaria in the last 3 months and 24.7% have not had. 51.1% of the households agreed that the LLIN should be placed on the bed at night of which 23.8% have had a child or children <5 years who have had malaria in the last 3 months and 27.4% have not had. Findings revealed that 48.9% do not agree that LLINs should be placed on the bed at night, but of which 27.8% have had a child or children <5 years who have had malaria in the last 3 months and 21.1% have not had. Findings indicated that 46.2% of households agreed that the LLIN should be placed on the bed at all times, of which 34.1% have had a child or children <5 years who have had malaria in the last 3 months and 24.7% have not had. 48.4% agree that the LLIN should not have any holes in it and should be placed properly on the bed in an appropriate room, of which 22.4% have had a child or children <5 years who have had malaria in the last 3 months and 26.0% have not had. However, the regression results showed that no variable linked to good practices in the proper use of LLINs significantly explained the number of cases of children under 5 who had contracted malaria during the last 3 months, given that all the probabilities were greater than 5% ( $p > 5\%$ ).

## DISCUSSION

### *Knowledge on importance and good practices in proper use of LLINs in the households*

Prevention practices are generally good and are mainly influenced by the level of knowledge (Mavoungou *et al.* 2022). Out of a total of 223 respondents the results showed that over half (132) 59.1% agreed that sleeping under a mosquito net every night is necessary to prevent malaria, compared to (91)40.9% of respondents who disagreed. Results which are less than the results of 77.8 % of Ntonifor (2016) and also less than the 80% target set by the WHO (2014). This result was also lower than that observed in Cameroon (Sielinou *et al.*, 2020), Rwanda (Habimana *et al.*, (2020) and Gambodia (Yasuoka, *et al.* 2018) where 99.2% to 100% of respondents were aware that sleeping under an LLIN helps to avoid mosquito bites but also that the use of LLINs helps to reduce the burden of malaria. Findings showed that (136)61.0% agreed with the use of LLINs to fight malaria, compared to (87)39.0% of respondents who disagreed. These results are inferior to the results of a study by Tesfaye *et al.*, which showed that almost 70% of respondents had a good knowledge of the use of insecticide-treated nets in malaria prevention, with more than three quarters understanding that they could kill mosquitoes (Tefaye *et al.*, 2012). Perhaps the various training courses and health education provided by community health workers in health facilities and within the community could be the reason for the high level of knowledge of the people interviewed (Habimana *et al.* 2016). Findings then showed that (142)63.7% of respondents agreed that LLIN protects against mosquitoes and malaria infection compared to (81)36.3% of respondents who disagreed. The results also show that (137)61.4% agreed that LLIN protects against other insect bites compared to (81)38.6% who disagreed. These findings contrast with the national target of 100% set in Abudja in 2000 and are still below than 80% correct use recommended by the WHO (2011). In addition (137) 61.4% agreed that LLINs protect against other insect bites. These results were lower compared to the results of the study by Israel *et al.*(2018) where (99.8%) of the respondents stated that LLINs protect against other insect bites. However, these results were similar to the

results of the study by Teklemariam *et al.* (2015) in Ethiopia where more than half of the respondents had knowledge about the correct use of LLINs in their households. Knowledge of malaria prevention strategies is a key aspect of acceptance and use of LLINs by community members (Adebayo *et al.*, 2015). Although half of the households have knowledge on the correct use of LLINs, there are still a significant number of households that did not know the role that an LLIN can play once properly hung and stored. Therefore, the Health Zone office must strive to provide ongoing health education through health extension workers so that people know the importance of regular and correct use of LLINs. This is why this ongoing education could be followed by the implementation of an intervention program supported by large-scale distribution of LLINs in communities in order to improve their accessibility and availability. This will have a positive impact on the long-term appropriation and correct use of impregnated mosquito nets in households. The low level of knowledge about the importance and good practices of LLIN use in households is contrasted with previous studies conducted among households in Nigeria and other parts of Africa where respondents all gave correct meanings about LLIN use practices (Israel *et al.*, 2018; Babalola *et al.*, 2019; Malusha *et al.*, 2009; Edelu *et al.* 2010; Idovu *et al.* 2011).

The disagreement observed in this study could be the result of the low level of knowledge about LLINs in households. It remains to be believed that health education in health centers does not insist on or emphasize the shortcomings identified with regard to not sleeping under a mosquito net on a regular basis. To date, this can be seen as a factor in the misuse or non-use of LLINs in households. Household knowledge of LLINs and their benefits would improve LLIN use, yet protecting children under five from malaria is often the reason for using nets. (Cilundika *et al.*, 2016). A study by Kebede *et al.* (2023) showed that the majority of participants in the study (83.9%) stated that using an LLIN was an advantage because it enabled them to avoid contracting malaria. On the other hand, 89.3% of study participants said that using LLINs had no benefit in terms of sleep quality. LLINs offer a number of advantages: not only do they protect against mosquito bites, but they also kill aggressive mosquitoes. These effects are particularly beneficial for women and children under the age of five, the main victims of malaria worldwide. When used regularly, it reduces the morbidity and mortality caused by malaria. It helps save the lives of infants and fetuses and reduces the medical costs of treating malaria. Therefore, community health workers need to work in households and help teach people about aspects such as hanging and correct use of the insecticide-treated net. On the contrary, the findings of this study showed inconsistency with some studies indicating the non-protection of LLINs in malaria prevention. Two case-control studies conducted in Machinga District, Malawi in 2013 (Mathanga *et al.* 2015) and Haiti in 2012 (Steinhardt *et al.* 2017), as well as a cluster randomized trial conducted in Rakhine State, Myanmar in 2013 (Smithuis *et al.* 2013) all found that LLINs did not significantly protect against malaria.

Since these regions have a high endemicity for malaria, people may develop a higher protective immunity due to long exposure to malaria parasites. A study such as that by Gama *et al.* revealed that LLINs are vector control devices, which function as physical and chemical barriers and prevent not only contact with malaria-vector mosquitoes, but also contact with other blood-sucking insects present on the site (Gama *et al.*, 2012) sparing households from the inconvenience of bites and the transmission of other pathogens. Another important aspect of LLINs is raised by a study conducted by Gunasekara *et al.*, (2014): "LLINs are protective tools not only for the people who use them, but also for people who do not use nets and who are in the vicinity of the places where they have been hung. The reason is as follows: mosquitoes die on contact with the insecticides present in the fibers, resulting in a reduction in local vector density". Findings of this study suggested that health promotion activities are essential for the proper use of nets to protect households with children under 5 years of age. Educational activities are necessary to raise awareness in these households and should be carried out on an ongoing basis, not just at the time of net installation. According to Sousa *et al.*, (2019), the population must be as involved as possible.

### Knowledge on importance of LLINs associated with proper use of LLINs in the households

On one hand, findings showed a strong positive association between knowledge of good practices in the use of LLIN and actual correct use, in all the four LLIN proper utilization practices tested including: Pulling Net down over bed before sleeping; Well-fitting of nets; net put permanently on bed and Net free from holes. While on the other hand, there was no association between knowledge on importance of LLINs and actual adoption and use of good practices in the use of LLINs. The disparity in measure of association between knowledge of importance and proper practices, is against the finding which show that knowledge about importance of LLINs was higher among households than knowledge of proper practices in the use of LLINs. For instance, more than half of the proportion of households had good knowledge on importance of LLINs with proportional variations ranging between 59.1 – 63.7% across all the four variables tested (Sleeping under mosquitoes Net every night prevents malaria, LLIN used to kill malaria mosquitoes, LLINs protect against mosquito bites and malaria infection and LLINs protect against the bites of other insects). For the knowledge on proper practices in the use of LLINs, with exception of only one practice (Net well fitted on bed in the evening) that had 51.1%, majority households had poor knowledge across the proper practices tested (including, Pulling Net down over bed before sleeping, Net put permanently over bed and Net free from holes and fitted correctly over bed within the right room) all of which had between 45.7 – 48.4% on good knowledge for the practices. The findings in this study, agrees with some findings elsewhere, where for instance, although not being specific as to the nature of knowledge, Israel *et al.*, (2018) showed that households who had a good knowledge of the LLIN (aOR=1.8; 95% CI 1.4-2.5) were more likely to use the LLIN properly.

Low proportion of households with knowledge on proper practices in use of LLINs have also been shown by Ntonfor study (2016), where 50.2% pulled down their LLINs before they went to bed, 30.4 % of respondents fitted them well to the bed before sleeping, 8.1% of them used Nets which were free from holes and could correctly fit the Nets over their bed within right hour and 11.4 % put them permanently over their beds. However, finding of this study contradicts some earlier findings elsewhere. For instance, ownership has been shown to be a good indicator of correct use by households (Sangare *et al.* 2012). Results of this study therefore, clarified one major ambiguity in the earlier findings by other studies. This study confirms that indeed knowledge of LLINs is important and with more important being the knowledge on proper practices in the use of LLINs. This implies that knowledge on practices for proper use of LLINs should become the central message in the awareness besides importance of the LLINs. This confirmed the importance of the findings by other studies, that have examined the effectiveness of LLINs in preventing malaria, where barrier has been found to be poor adherence to correct use of LLINs (Onyemaechi *et al.*, 2017; Uzoamaka *et al.* 2016), with correct use of LLINs being largely influenced by people's knowledge. And this means that LLIN use behavior depends on people's knowledge of the consequences of non-proper use as was also shown by Diema *et al.*, (2017). Therefore, Government efforts through policies together with and all stakeholders involved in the fight against malaria need to develop behaviour change interventions and campaigns to encourage and improve the correct use of LLINs, if the ultimate goal of LLINs will be achieved. Comparatively, the level of knowledge both for importance and proper use practices to the national target of 100% as decided in Abuja in 2000 and 80% of the recommendations set by the WHO (2004), implies that in DRC, the focused awareness is of greater concern and therefore urgency towards realizing importance of regular correct use of LLINs as has been demonstrated by Adebayo *et al.*, (2015). Policy and intervention investments in this regard are worthwhile as several reports have confirmed that correct use of LLINs increases when individuals receive information about nets (Hill *et al.*, 2006, and Adongo *et al.*, 2005). A study carried out in a malaria-endemic region of Iran showed that proper use of insecticide-treated nets rose from 58.3% to 92.5% after an educational intervention (Soleimani *et al.*, 2012).

### Knowledge on good practice in proper Use of LLIN associated with Malaria Morbidity in the household

Findings showed, over half of the households surveyed had children under the age of 5 who had suffered from malaria in the last 3 months. In a similar vein, the findings of a study by Wuresahet *et al.* (2022) in Ghana, on a history of malaria prior to the study where 177 (59.6%) claimed to have had malaria during this period. Findings showed a statistically significant relationship between LLIN ownership and malaria morbidity in households  $p$ -value = 0.046. Households without LLINs were 1.4 times more likely to have had children under the age of 5 suffering from malaria in the previous 3 months. Findings in this study confirmed the position posit by numerous studies carried out in sub-Saharan Africa, notably by Akello *et al.* (2022); Adaji and Gabriel (2019); Strachan *et al.* (2016); Odeyemi *et al.*, 2022; Fru *et al.* (2021); Nawamanya *et al.* (2018) and WHO (2016), which have demonstrated that insecticide-treated nets are highly effective in reducing malaria morbidity and mortality when used correctly and regularly. However, elsewhere, other studies have noted contrasting findings, for instance a study by Wuresah *et al.* (2023); Fruet *et al.* (2021), Saleh *et al.* (2018) showed that possession of LLINs had no significant impact on malaria morbidity. This situation calls for reminder campaigns, distribution of insecticide-treated mosquito nets and evaluation research to ensure effective malaria prevention for vulnerable groups. Therefore, findings of this study clarified to confirm that ownership of LLINs is important for malaria morbidity control. Further analysis showed that there was even a further significant relationship between correct use of LLINs and malaria morbidity ( $p$ -value = 0.001). In comparison with households practicing proper practices in the use of LLINs, the logistic cross-tabulation showed that households owning but did not use LLINs correctly are 1.9 times more likely to have children under 5 suffering from malaria in the last 3 months as compared to the 1.4 times likelihood of non-ownership of LLINs versus households with LLINs ownership. This finding of the study confirms results of other studies that showed positive relationship of LLINs ownership and proper use in the prevention of malaria. For instance, a study by Kamau *et al.* (2022) in Kenya reported adjusted odds ratio of correct use of LLINs against fevers associated with malaria infection as 0.63 (95% CI 0.58-0.68;  $p < 0.001$ ).

Study by Nlinwe *et al.* (2022) showed that sleeping under an LLIN the previous night was also significantly associated with a reduced risk of malaria in the participants. The same study showed that attributable risk was 41% of malaria incidence and the likelihood ratios of 0.48 and 0.18 for LLIN ownership and sleeping under a net the previous night, respectively, and on a relative risk basis, nets with holes were 0.28 times more likely to contract malaria than participants who did not observe holes in their nets (Nlinwe *et al.* 2022). A study carried out by Bongajum *et al.* (2023) showed that regular use of LLINs was significantly associated ( $p = 0.007$ ) with low household malaria morbidity. The same study showed that not sleeping under a mosquito net was more associated with malaria and that tucking mosquito nets into the bed seemed to protect against malaria as morbidity was significantly higher in those who did not tuck the nets in (20.8%) than in those who tucked the nets in every night (6.5%) and some nights (9.9%). Therefore, affirmations of this study regarding LLINs ownership and proper use, further imply that the Mass distribution of long-lasting insecticidal nets remains a cost-effective means of achieving widespread coverage, despite the challenge of maintaining high coverage and use of long-lasting insecticidal nets, especially in areas where there is internal population displacement. Therefore, on ownership and proper use of LLINs, this study indicated that the program should be reinforced to ensure required frequency in distribution campaign and focus on education on proper use for LLINs if the mass campaign and distribution of nets in health facilities, would be effective in malaria control.

## CONCLUSION

The study revealed that the level of knowledge about the importance of the correct use of LLINs and LLIN practices among respondents was low. It is still far from the 80% target. Daily use is low as only

more than half of the children sleep under the net every day. Factors that could influence the correct use of LLINs and good practices could be the level of education and the level of knowledge of respondents about good practices for the correct use of LLINs in households. There remains a need to improve knowledge on importance of good practice in proper use of LLIN, this is a key factor of reducing malaria morbidity among children under five years in the Karisimbi Health Zone. Efforts must continue to be ensured that information on the importance of the correct use of ITNs is properly channeled. The study highlights the need to implement new awareness-raising models, such as community educators, discussion groups or social media (Facebook, WhatsApp, YouTube and others) to reach a larger number of people in order to promote good practice in the proper use of LLINs in households.

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