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RESEARCH ARTICLE

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ASSOCIATION ASSESSMENT OF OWNERSHIP OF LLIN AND MALARIA PREVENTION IN FRAGILE HEALTH ZONE OF KARISIMBI OF GOMA IN NORTH KIVU, DRC

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ABSTRACT

Introduction: Malaria is and remains a serious health concern in Africa. In DRC, where malaria is endemic and a major public health problem. The important control measure put in place was the use of long-lasting insecticidal nets (LLINs). This study consists of identifying the level of appropriation and determining the relationship between the appropriation of LLINs and malaria morbidity in households with children under 5 years of age in the fragile Karisimbi health zone in Goma in Nord Kivu/ RDC. **Methodology:** A cross-sectional community survey study involving 418 households was conducted in 19 health areas in the Karisimbi Health Zone. A structured questionnaire was used to collect data on LLIN ownership and as well as demographic characteristics, economic status and socio-cultural conditions in the households. **Results:** Findings showed that 53.4% of the households own LLINs while 46.7% do not. Findings showed that in the 53.7% of households owning LLINs, 27.8% of households own at least one LLIN and 37.7% of households own two LLINs each, and in 26.5% of households there are three LLINs and 8.1% of households own four or more LLINs. Regarding the source of nets owned, 78.9% of households got their nets from free net distribution, 16.1% of households got their nets from antenatal clinics, and 4.5% of households got their nets from Shop/Market. 0.5% of households got their nets from other sources. The following reasons were given for not owning an LLIN: 43.6% of households said that they were not at home during the mass distribution campaign, 19.5% of households had not received any information about the distribution campaign, 19.0% of households had not received a pre-campaign visit from a mobiliser, 14.9% had not received a post-campaign visit from a mobiliser, and 3.1% of households felt that this was because of the high cost of the LLIN. **Conclusion:** LLIN ownership is weak and cannot guarantee the correct use of LLINs for effective malaria prevention in the health zone, as intended. Reminder campaigns for LLIN distribution and evaluation research are essential for effective malaria prevention and control.

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INTRODUCTION

Malaria remains one of the major causes of morbidity and mortality in the World. About 50% of the world's population lives in malaria-endemic areas (Dayanand *et al.*, 2017). It is not only a major threat to public health but also a heavy economic burden despite all the control strategies put in place by Sustainable Development Goals (UN SDGs, Target 3, 2015), the Alma-Ata Declaration (1978), the Abuja Declaration (2000), and the Roll Back Malaria (RBM) (1998) UN organizations such as WHO (2021), USAID (2017), the President's Malaria Initiative (2018), the World Bank (2022) and other stakeholders such as the Global Health Fund who have focused heavily on reducing malaria morbidity and mortality across the globe

(WHO, 2017; WHO, 2020; Fokam *et al.*, 2017; Ntonifor and Veyufambom, 2016). However malaria remains one of the major causes of morbidity and mortality in the World. About 50% of the world's population lives in malaria-endemic areas (Dayanand *et al.*, 2017). World Malaria Report estimated 229 million cases of malaria in 2019, up from 228 million cases in 2018 and 409,000 deaths in 2019 and Children under 5 years of age are the most vulnerable group affected by malaria in 2019 accounting for 67% (274,000) of all malaria deaths worldwide (WHO, 2021). About 94% of malaria deaths globally were in African countries. Nigeria (23%), the Democratic Republic of the Congo (11%), the United Republic of Tanzania (5%), Mozambique (4%), Niger (4%) and Burkina Faso (4%) accounted for about 51% of all malaria deaths globally in 2019 (WHO, 2020). Despite ongoing efforts and the resilience of endemic

countries, the number of malaria cases continued to increase between 2020 and 2021, but at a slower rate than between 2019 and 2020. No significant progress has yet been made towards getting back on track and achieving the key objectives of the SDGs (Sustainable Development Goals) (WHO, 2022). In DRC, malaria remains a major public health problem (WHO, 2018) and the leading cause of morbidity and mortality (Losimba *et al.*, 2018). 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). In 1998, the DRC set up a National Malaria Control Program (NMCP). The primary objective of this program was to reduce malaria mortality by 50% and malaria morbidity by 25% by 2015. The NMCP actions focused not only on the distribution of insecticide-treated nets (LLINs), promotion of indoor residual spraying, promotion and implementation of intermittent preventive treatment during pregnancy, but also on the promotion of rapid diagnostic tests, and implementation of community and maternal case management using artemisinin-based combinations (NMCP/RDC, 2017; NMCP/DRC, 2016).

Despite such advances, malaria accounted for 38% of overall morbidity and 36% of mortality in 2018 (WHO, 2017; WHO, 2018; NMCP/DRC, 2016) in the country. In 2018, the country recorded 15 million malaria cases and approximately 27,458 malaria deaths. A majority of malaria cases and rapid progression to death occur in young children (WHO, 2018). In addition, despite the existence of this program, malaria is creating new problems and challenges in the prevention and management of simple, severe, and complicated episodes. This situation is made more difficult by the emergence, spread and complexity of chemoresistance to basic antimalarial drugs and the vectors to insecticides (Roll Back Malaria, 2002). Therefore, the involvement of local populations in prevention activities and domestic control of malaria becomes a major issue in ensuring the viability of prevention programs and malaria control (WHO, 1997) but also the program required to be Multisectoral Program. The high morbidity and mortality rates can be explained by several factors related to environmental conditions, uncontrolled construction, lack of knowledge of prevention methods, low participation in control activities, lack of personal protection against mosquitoes, and the increasing resistance of Plasmodium to the usual antimalarial drugs (NMCP/DRC, 2012). Several African studies have found that adequate ownership of an LLIN for two people and use of LLINs within a household have shown their limits. The Democratic Republic of Congo (DRC) has implemented strategies, ensuring universal access to the most effective malaria control interventions to reduce the socio-economic burden of this disease. Several strategic plans have been put in place, the latest of which was developed for the period 2016-2020 with the main objective of reducing malaria-related morbidity and mortality by 40% compared to 2015 levels (NMCP/DRC 2022-2023).

The Democratic Republic of Congo (DRC) has implemented strategies, ensuring universal access to the most effective malaria control interventions to reduce the socio-economic burden of this disease. Several strategic plans have been put in place, the latest of which was developed for the period 2016-2020 with the main objective of reducing malaria-related morbidity and mortality by 40% compared to 2015 levels (NMCP/DRC 2022-2023). At the household level, there is a high level of ownership and use that is still difficult to achieve and sustain (Raghavendra *et al.* 2017). In the DRC there was a decrease in ownership of at least one mosquito net between the 2013-2014 DHS (70%) and the 2017-2018 MICS (63%). This could be explained by the delay in mass distribution campaigns following the change of Global Fund implementing partners at the end of 2017. This led to the postponement of around four mass distribution campaigns (around 7.9 million ITNs) which were finally distributed just after the 2017-2018 MICS survey data collection. But despite this drop, the percentage of households in which everyone had access to a net (i.e. possession of at least one LLIN for every two people in the

household) had proved to be as low (PMI/DRC, 2022). The Karisimbi Health Zone was not spared this situation and the distribution was not accompanied by a major behavior change campaign. The health zone is fragile, as it is characterized by an intense movement of internally displaced people from all over the province as a result of armed conflicts. Several African studies have found that adequate ownership of an LLIN for two people and use of LLINs within a household have shown their limits.

The Democratic Republic of Congo (DRC) has implemented strategies, ensuring universal access to the most effective malaria control interventions to reduce the socio-economic burden of this disease. Several strategic plans have been put in place, the latest of which was developed for the period 2016-2020 with the main objective of reducing malaria-related morbidity and mortality by 40% compared to 2015 levels (NMCP/DRC 2022-2023). To monitor the appropriation of LLINs, certain indicators should be taken into account, in particular the possession of at least one LLIN per household and malaria morbidity at household level. This information is useful for determining the frequency of health education in order to improve malaria prevention in the region, which is plagued by recurrent conflicts. This is all the more important as many inhabitants have been exposed to malaria vectors as internally displaced persons. The aim was to assess the association between LLIN ownership and malaria morbidity in the Karisimbi health zone of Goma in North Kivu.

METHODS

Study Setting and Participants: 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 meters 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 km². From a health and demographic point of view, Goma is a dense city with more than 1,250 inhabitants per Km², 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: Data were collected using a pretested structured questionnaire prepared in English and then translated into Swahili the local language. It included variables related to Net possession demographic characteristics, economic status, socio-cultural conditions and malaria morbidity, and so forth. Pretest was carried out on 5% of the households. Necessary modifications were made thereafter. Community health workers administered the questionnaire through house visits and information was primarily collected from the mothers or the heads of household.

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.

Statistical Analysis

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 relationship between LLIN ownership and malaria morbidity. Binary logistic regression was performed to obtain the odds of LLIN ownership to determine the strength of the association where p-values less than 0.05 at a 95% confidence interval were considered statistically significant.

Operational Definitions

A *household* was defined as a wife with her direct dependents, and a compound was divided into several households depending on the number of wives, where the husband was assigned to the first wife’s household (Kimbi *et al.*, 2014; Wanzira *et al.*, 2018).

Household ownership of LLINs was defined as the proportion of households with at least one LLIN, where the numerator comprises the number of households surveyed with at least one LLIN and the denominator is the total number of households surveyed (Polec *et al.*, 2015; CDC, 2013; Cho *et al.*, 2018).

Long-Lasting Insecticidal Nets (LLINs): According to WHO (2008), WHO (2007); WHO (2005) and Kimbi *et 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”.

Ethical Clearance: Ethical clearance was obtained from 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
- 8) NIS: National Institute of Statistics

RESULTS

Ownership of LLIN in the household

In relation to household ownership of the LLIN, the results of the table 1 showed that 53.4% of the households own LLINs while 46.7% do not. The results showed that in the 53.7% of households owning LLINs, 27.8% of households own at least one LLIN and 37.7% of households own two LLINs each, and in 26.5% of households there are three LLINs and 8.1% of households own four or more LLINs. Regarding the source of nets owned, 78.9% of households got their nets from free net distribution, 16.1% of households got their nets from antenatal clinics, and 4.5% of households got their nets from Shop/Market. 0.5% of households got their nets from other sources.

The following reasons were given for not owning an LLIN: 43.6% of households said that they were not at home during the mass distribution campaign, 19.5% of households had not received any information about the distribution campaign, 19.0% of households had not received a pre-campaign visit from a mobiliser, 14.9% had not received a post-campaign visit from a mobiliser, and 3.1% of households felt that this was because of the high cost of the LLIN. The graph below is an illustration of the above table.

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

Variable	N= 418	Proportion (%)
Ownership of LLIN		
No	195	46.7
Yes	223	53.4
If Yes LLIN owned		
Number of LLINs Owned per household		
One	62	27.8
Two	84	37.7
Three	59	26.5
≥ Four	18	8.1
Source of Net received		
From mass Net Distribution Campaign		
Antenatal Clinic	36	16.1
From Shop/Market	10	4.5
From Relative/Others	1	0.5
If No LLIN owned		
N =195 Proportion(%)		
Reasons for not owning the Net		
as not aware of the distribution campaign	38	19.5
Not home during distribution campaign	85	43.6
No received pre-campaign visit	37	19.0
No received post-campaign visit	29	14.9
High cost of the Net	6	3.1

Source: Field data

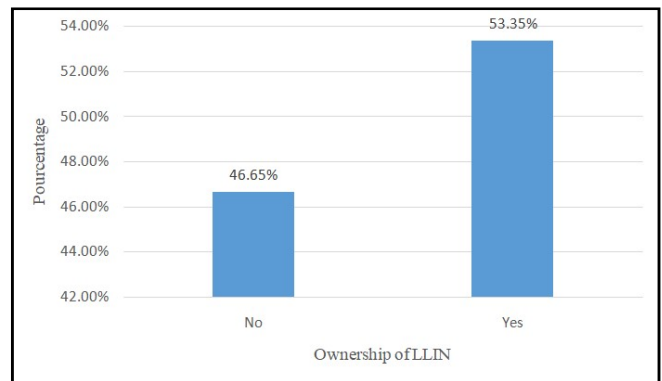


Figure 1. Evolution of Ownership of LLIN

DISCUSSION

Demographic characteristics associated with ownership of LLIN in the household: The results of the table 2 showed that the majority of mothers of children under 5 years of age in the surveyed households are between 25-49 years of age, i.e. 64.1%, of whom 35.7% have the LLIN and 28.5% do not. While 28.0% of mothers are aged between 20-24 years, of which 13.9% have the LLIN and 14.1% do not. On the other hand, 4.3% of the mothers are aged between 15-19 years, of whom 2.4% have the LLIN and 1.9% do not, and finally 3.6% of the mothers interviewed are aged ≥ 49 years, of whom 1.4% have the LLIN and 2.2% do not. With regard to the parity of mothers, the results show that 26.1% of mothers have a parity of 2, which is considered the highest proportion. The results also show that just over half, 51.9% of heads of household, are aged between 35-45 years, of whom 26.5% have the LLIN and 25.4% do not, the highest proportion. With regard to the age of children under 5 in the households surveyed, it can be seen that 34.7% of children under 5 are aged between 24-35 months, of whom 20.3% have an LLIN and 14.4% do not. Looking at the results, we can see that just over half, or 50.7%, of children under 5 years of age are female, of whom 27.8% have the LLIN and 23.0% do not. On the other hand, 49.3% of children under 5 years of age are male, of whom 25.6% have an LLIN and 23.7% do not. However, the results show that 47.6% of the households surveyed have two children under the age of 5, which is the highest proportion, and of these 26.1% have an LLIN and 21.5%

do not. The table 2 of results also shows that there are no demographic variables that explain LLIN ownership in the association between demographic characteristics and LLIN ownership in households as the probabilities are all above 5%.

ownership in households. The association between variables such as the main source of household income, the mother's occupation, the occupation of the head of household and the possession of an LLIN in the household did not give a significant relationship between the

Table 2. Presentation of results by Demographic characteristics associated with LLIN ownership in the household

Variable	Number of respondents(418)	Ownership of LLINs		Crude Odds Ratio (cOR)		P-Value
		NO=46.7%	YES=53.3%	cOR	95% CI	
Age of mother (in Years)						
15-19	18(4.3)	8(1.9)	10(2.4)	1.0		
20-24	117(28.0)	59(14.1)	58(13.9)	0.7	(0.22- 2.15)	0.53
25-49	268(64.1)	119(28.5)	149(35.7)	0.9	(0.29- 3.35)	0.99
≥ 49	15(3.6)	9(2.2)	6(1.4)	0.6	(0.09- 3.42)	0.53
Parity of the Mother						
1	55(13.2)	28(6.7)	26(6.5)	1.0		
2	109(26.1)	55(13.2)	54(12.9)	1.0	(0.47- 2.13)	0.99
3	98(23.4)	48(11.5)	50(12.0)	1.2	(0.54-2.57)	0.67
4	70(16.8)	26(6.2)	44(10.5)	1.8	(0.75- 4.24)	0.19
≥5	86(20.6)	38(9.1)	48(11.5)	1.5	(0.62-3.48)	0.37
Age of the Household Head (in Years)						
18-25	20(4.8)	11(2.6)	9(2.2)	1.0		
25-35	111(26.6)	44(10.5)	67(16.0)	1.9	(0.64- 5.71)	0.24
35-45	217(51.9)	106(25.4)	111(26.5)	0.9	(0.28- 3.03)	0.90
45-60	61(14.6)	29(6.9)	32(7.7)	1.1	(0.28-3.88)	0.93
> 60	9(2.2)	5(1.2)	4(1.0)	1.2	(0.15- 9.69)	0.85
Age of children < 5 years (in Months)						
12-23	109(26.0)	54(12.9)	55(13.2)	1.0		
24-35	145(34.7)	60(14.4)	85(20.3)	1.5	(0.86-2.59)	0.15
36-47	73(17.5)	38(9.1)	35(8.4)	1.03	(0.53-1.96)	0.94
48-59	40(9.6)	22(5.3)	18(4.3)	0.8	(0.39-1.86)	0.69
6-11	51(12.2)	68(5.0)	65(7.2)	1.6	(0.79-3.34)	0.18
Sex of children < 5 years						
Male	206(49.3)	99(23.7)	106(25.6)	1.0		
Female	212(50.7)	96(23.0)	116(27.8)	1.2	(0.77- 1.71)	0.972
Number of under 5 in the household						
One-1	178(42.6)	88(21.1)	90(21.5)	1.0		
Two-2	199(47.6)	90(21.5)	109(26.1)	1.1	(0.69-1.71)	0.708
≥ Three-3	41(9.8)	17(4.1)	24(5.7)	1.2	(0.59- 2.80)	0.516

p>0.05. Source: Field data

Table 3. Distribution of the results by Economics conditions associated with Ownership of LLIN

Variables	Number of respondents (418)	Ownership of LLIN		Crude Odds Ratio (cOR)		P-Value
		NO=46.7%	YES=53.3%	cOR	95% CI	
Main source of income in the household						
Daily casual jobs	201(48.1)	90(21.5)	111(26.6)	1.0		
No source of revenue	43(10.3)	22(5.3)	21(5.0)	0.8	(0.40-1.65)	0.58
Income generating activities	132(31.6)	68(16.3)	64(15.3)	0.8	(0.51- 1.33)	0.43
Salaried Job	42(10.1)	15(3.6)	27(6.5)	1.3	(0.58- 2.78)	0.54
Mother's occupation						
Not employed	72(17.2)	33(7.9)	39(9.3)			
Employed	93(22.3)	37(8.9)	56(13.4)	0.8	(0.37- 1.89)	0.68
Self-employed	148(35.4)	67(16.0)	81(19.4)	0.9	(0.53- 1.70)	0.89
Other sources of revenue	105(25.1)	58(13.9)	47(11.2)	0.9	(0.41- 1.95)	0.79
Household Head's Occupation						
Not employed	57(13.6)	31(7.4)	26(6.2)			
Employed	155(37.1)	62(14.8)	93(22.3)	1.6	(0.79- 3.61)	0.17
Self-employed	136(32.5)	58(13.9)	78(18.7)	1.5	(0.80-2.99)	0.19
Other sources of revenue	70(16.8)	44(10.5)	26(6.2)	0.7	(0.27- 1.87)	0.51

p>0.05. Source: Field data

Economic conditions associated with ownership of LLIN in the household: Looking at the results of the table 3 presenting the economic conditions of households and LLIN ownership, it emerges that 31.6% of households have income-generating activities as their main source of income, 48.1% of households have daily work as their source of income, 10.3% of households have no source of income, while 10.1% of households have a paid job. As regards the mother's occupation, 35.4% are self-employed, 22.3% are employed and 25% have other sources of income, 17.2% are not employed. The table also shows that 37.1% of heads of household are employed, 32.1% are self-employed and 16.8% have other sources of income and 13.6% of heads of household are not employed. The table 3 of findings also shows that there are no economic variables that explain LLIN ownership in the association between economic conditions and LLIN

variables because all the probabilities respectably are 0.58, 0.43, 0.54, 0.68, 0.89, 0.79, 0.17, 0.19 and 0.51 were greater than p-value= 5%. Socio-cultural status and Ownership of LLIN in the household. Findings of table 4 showed that the majority of heads of households, i.e. 90.2%, are monogamous, but 4.1% are polygamous and 5.7% are divorced. With regard to the education of heads of households, 47.6% have secondary education, 26.8% have other education, 19.9% have primary education, and 5.7% have no basic education. With regard to the religion of the head of household, 44.3% practice the Protestant religion, constituting the highest proportion. Of the mothers surveyed, 91.6% were married and 44.3% practiced the protestant religion, the highest proportion. On the other hand, 15.1% of mothers attend revivalist churches. More than half (54.3%) of the mothers surveyed have a secondary education, 31.1% have a primary education and

26.8% of the mothers of children under 5 years of age have another level of education. In terms of migration status at the household level, 21.5% of households was internally displaced while 78.5% of households are not displaced. Household size is such that 51.7% have a size of between 4-6 persons and 30.6% of households have a size of ≥ 7 persons against 17.7% of households with a size of between 1-3 persons. Findings showed that households that did not experience displacement (Migration) were 1.8 (cOR) times more likely to own the LLIN for 95% CI= (1.01- 3.17) than Internal Displaced Persons households. The results show that 78.5% are not internally displaced, of which 34.5% did not own an LLIN and 44.0% did for p-value= 0.043*. On the other hand, 21.5% were internally displaced households of which 12.2% did not own an LLIN and 9.3% did not own an LLIN.

Outcome: Malaria morbidity in the household: Observing the Table 5 of results and Figure below we can see 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.

Proportions of children < 5 years old had malaria in the last 3 months in the household: The results in Table 6 showed that 76.3% of households had only one child under five with malaria, while 23.7% of households had two children under five with malaria.

Ownership of LLINs and Malaria morbidity in the Household: Looking at the table 7, 46.6% of households do not own an LLIN, including 20.3 % of households that did not have children under the age of 5 who had malaria in the three months preceding the survey,

Table 4. Distribution of results by socio-cultural status associated with Ownership of LLIN in the household

Variable	Number of respondents (418)	Ownership of LLIN		Crude Odds Ratio (cOR)		P-Value
		NO=46.7%	YES=53.3%	cOR	95% CI	
Marital status of household Head						
Widowed/Divorced	24(5.7)	13(3.1)	11(2.6)	1.0		
Married Monogamy	377(90.2)	173(41.4)	204(48.8)	0.2	(0.02- 1.20)	0.08
Married Polygamy	17(4.1)	9(2.2)	8(1.9)	0.4	(0.05- 2.46)	0.30
Educational level of household Head						
None	24(5.7)	14(3.4)	26(6.5)	1.0		
Primary	83(19.9)	35(8.4)	48(11.5)	1.9	(0.54- 6.45)	0.32
Secondary	199(47.6)	102(24.4)	97(23.2)	0.9	(0.24-3.23)	0.85
Others	112(26.8)	44(10.5)	68(16.3)	1.1	(0.28- 4.34)	0.89
Religion of household Head						
No religion	12(2.9)	5(1.2)	7(1.7)	1.0		
Christianity	115(27.5)	45(10.7)	70(16.8)	0.8	(0.15-4.25)	0.81
Protestant	185(44.3)	81(19.4)	104(24.9)	0.7	(0.13-3.39)	0.64
Islam	41(9.8)	23(5.5)	18(4.3)	0.7	(0.05- 7.77)	0.74
Revival Church	63(15.1)	39(9.3)	24(5.7)	0.5	(0.10-2.72)	0.45
Others	2(0.5)	2(0.5)	0(0.0)	-	-	-
Marital status of the mother						
Single	12(2.9)	8(1.9)	4(1.0)	1.0		
Married	383(91.6)	173(41.4)	210(50.2)	7.1	(.79- 63.0)	0.08
Divorced/Separated	21(5.0)	13(3.1)	8(1.9)	1.1	(.19-6.17)	0.91
Widowed	2(0.5)	1(0.2)	1(0.2)	2.1	(.06-75.1)	0.67
Educational level of the mother						
None	30(7.2)	16(3.8)	14(3.4)	1.0		
Primary	130(31.1)	68 (16.3)	62(14.8)	0.6	(.195- 1.87)	0.38
Secondary	227(54.3)	104(24.9)	123(29.4)	1.2	(.350- 3.83)	0.81
Others	31(7.4)	7(1.7)	24(5.7)	2.8	(.608-12.4)	0.19
Religion of the mother						
No religion	5(1.2)	2(0.5)	3(0.7)	1.0		
Christianity	123(29.4)	49(11.7)	74(17.7)	0.5	(0.03- 8.37)	0.65
Protestant	185(44.3)	79(18.9)	106(25.4)	0.6	(0.04-9.72)	0.74
Islam	36(8.6)	21(5.02)	15(3.6)	0.3	(0.01- 8.80)	0.49
Revival Church	69(16.5)	49(10.5)	25(6.0)	0.3	(0.02-4.18)	0.37
Migration status of the household						
Internal Displaced						
Yes	90(21.5)	51(12.2)	39(9.3)	1.0		
No	328(78.5)	144(34.5)	184(44.0)	1.8	(1.01- 3.17)	0.043*
Household size						
1-3 persons	74(17.7)	40(9.6)	34(8.1)	1.0		
4-6 persons	216(51.7)	96(23.0)	120(28.7)	1.7	(0.94- 3.06)	0.082
≥ 7 persons	128(30.6)	59(14.1)	69(16.5)	1.5	(0.80- 2.89)	0.193

p<0.05. Source: Field data

Table 5. 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 6. Distribution of results by Number of Children <5 had fever in the last three months in the households

Variable	Number of respondents (114)	Proportion (%)
Number of children		
One child	87	76.3
Two children	27	23.7

Source: Field data

Table 7. Ownership of LLIN associated of Malaria Morbidity

Variable	Number of respondents (418)	Have a child or children <5 years who have had malaria in the last 3 months?		Crude Odds Ratio (cOR)		P-Value
		NO= 204(48.8%)	YES= 214(51.2)%	cOR	95% CI	
Ownership of LLIN						
Yes	223(53.4)	119(28.5)	104(24.9)	1.0		
No	195(46.6)	85(20.3)	110(26.3)	1.4	(1.006-2.179)	0.046*

$P=0.046^* < p < 0.05^*$. Source : Field data

compared to 26.3 % of households that had children under the age of 5 who had malaria in the three months preceding the survey. According to these results in Table 7, the presence of a relationship between LLIN ownership and malaria morbidity emerges. The chi2 probability associated with these two variables is less than 5% i.e. p-value = 0.046*. There is a significant difference between household possessions of LLINs as comparing to those households without LLINs. The logistic cross-tabulation shows that those who do not own LLINs are 1.4 times more likely to have children under 5 suffering from malaria in the last 3 months.

DISCUSSION

Household ownership of LLINs in prevention of malaria in children under 5 years of age old in the Karisimbi Health Zone in North Kivu: Findings showed that just slightly above a half of the households surveyed, owned LLINs. These findings corroborate those of studies carried out by Wekere *et al.*, (2020) and by (Enato and Sadoh, 2022) in Nigeria, which found almost same LLINs ownership levels. Although universal coverage (100% ownership) has emerged as the new goal in the fight against malaria following the Abuja declaration, there are still questions that require answering despite the many interventions to achieve it (Menendez *et al.*, 2015) and Roman *et al.*, (2015). However, these results contrasted with those of a study by Ng'ang'a *et al.* (2021) in the Lake Victoria basin of Kenya, where the national target of 100% net ownership was almost achieved. Other studies carried out in sub-Saharan Africa including results from Ghana, Kenya and Uganda, Ethiopia and Mozambique, where household ownership of LLINs ranged from just about three quarters to 90% (Wanzira *et al.*, 2014; Konlan *et al.*, 2019; Tassew *et al.*, 2017, Hambisa *et al.* 2018 and Moon *et al.*, 2016). Elsewhere, similar of high ownership have been shown in Nigeria (WHO, 2022) that comes close to achieving the WHO's universal coverage targets of at least 80% for possession of LLINs in at-risk populations (WHO, 2014; Koenker *et al.* 2018), particularly among pregnant women and children under 5 years of age. The free and regular distribution of LLINs to pregnant women at antenatal and pre-school clinics may be one of the main reasons for the high rate of LLIN ownership in these countries (Nyavor *et al.*, 2017). This assumes that insufficient distribution has a negative impact on household ownership.

Furthermore, results also revealed that just about a quarter of households had at least one LLIN and a third of households had two LLINs each, and only half of households had at least one insecticide-treated net or insecticide-treated nets for two people. This figure is below the standard level of WHO recommendations for universal LLIN coverage (MEASURE Evaluation, 2013). The low ownership of at least one LLIN per household in this study contrasts results of other studies where well over three quarters of households reported elsewhere in Africa and outside Africa (Xu *et al.*, 2014, Habimana *et al.*, 2020 and Alowode *et al.*, 2019) and was even much higher reported in Madagascar (Finlay *et al.*, 2017), Uganda (Nuwamanya *et al.*, 2018), and North East Myanmar (Liu *et al.*, 2015). However, there was a similarity with results of the MICS-Palu surveys in the DRC, which showed that 55% of households in North Kivu had at least one LLIN, and 19% had at least one LLIN for two members of the household in the province of North Kivu (NIS/DRC, 2020). This shortfall may be due to insufficient numbers of nets obtained at ANCs, stock-outs and operational challenges in the net distribution system, as some studies have identified operational barriers to net distribution (Theiss-Nyland *et al.*, 2017; Webster *et al.*, 2013).

Among households with nets over three quarters obtained their nets from free net distribution, about one in every 6 households obtained their nets from antenatal clinics, with only one in every twenty households obtaining their nets from shops/markets. These results are similar to the findings of a study carried out in Kenya in 2021. This study indicated that 76.0% of LLINs were acquired during free mass distribution campaigns conducted by the Ministry of Health and 12.9% were acquired in public health facilities and given to pregnant women and mothers of children under 5 years of age who were visiting public health facilities. On the other hand, eighty percent (80%) of the LLINs had been acquired less than 6 months ago and 25% less than 3 months ago at the time of the survey. With regard to the condition of the LLINs, 74.9% were in good condition with no holes, 17.2% were in average condition and 7.8% were in poor condition with many holes.

The condition of the LLINs was a function of the number of nets per household ($\chi^2 = 44.584$; $p = 0.007$) and their perceived effectiveness ($\chi^2 = 21.358$; $P = 0.045$) (Ng'ang'a *et al.*, 2021). The following reasons were given for not owning a MIDA: 43.6% of households said they were not at home during the mass distribution campaign, 19.5% of households did not receive information about the distribution campaign, 19.0% of households did not receive a pre-campaign visit from a mobiliser, 14.9% did not receive a post-campaign visit from a mobiliser, and 3.1% of households thought it was because of the high cost of the MIDA. These results are almost similar to the results of a study conducted by Babalola *et al.* (2019) in Nigeria where 40.2% of respondents did not know where to obtain the LLIN, 34.8% preferred to use other preventive measures against malaria, 25.8% of respondents said they did not have money to buy an LLIN, 17.4% said that they had not received a voucher from the mobiliser to collect free LLINs during the mass distribution campaign, 8.3% of respondents said that they had not received an LLIN because of a stock-out of LLINs during the mass distribution campaign, and 6.0% said that they had lost the voucher during the free LLIN mass distribution campaign.

However, these figures contrast with the results of a study carried out in Sierra Leone by Gerstl *et al.* (2010), where 91.9% of households reported that they had not taken part in the mass distribution organized by Médecins Sans Frontières in 2010. Results of this study confirm long established evidence on LLINs ownership by households in contexts similar to DRC one, where the major source is free net distribution by governments and or partners. Economic capacity for households to buy or acquire nets from sources that would require incurring out of pocket expenses whether direct for nets and or indirect for transport and other related expenses, is weak. The case of where many households are constantly migrating due to insecurity as is with DRC makes this capacity even worse. The results of this study further confirm that in a context that depends majorly on free distribution, that it is still possible for a number of households to miss out due to many other factors including poor mobilization and lack of leading evidence on targets of households and or number of households to covered during the distribution. This imply the need for evidence-based system of distribution if the planned targets have to be met.

The association of demographic characteristics with household possession of LLINs: Findings showed that there were no demographic variables that explained LLIN ownership in the association between demographic characteristics and LLIN ownership in households as all probability thresholds were greater than 5%.

These demographic factors not associated with LLIN ownership were: Age of the mother, Parity of the mother, Age of the head, Age of the child, Sex of child, Number of children in household. Another similarity relates to the results of a study conducted in Rwanda by Habimana *et al.* where the association between possession of LLINs and age categories was not statistically significant $p\text{-value} = p = 0.863\% > 5\%$ (Habimana *et al.* 2020). However, on the age of the head of household, the results of the present study contrast with other studies. For instance, in a classic study by Babalola *et al.* (2020) in Nigeria, results showed that younger women (aged < 30 years) were less likely to own LLINs compared to older women (OR 0.6, CI 0.4-0.6, $p = 0.01$). Some studies have suggested reasons explain this scenario, that older women have greater maturity and experience, and greater access to social resources such as knowledge (Rakotondrabe, 2001). Elsewhere, results of a study conducted by Fru *et al.* (2021) in Cameroon indicated that heads of households aged ≤ 20 years were 8.4 times more likely to own a net for $p\text{-value} = 0.01$; (95% C.I. 1.7-41.1) compared to heads of households aged between 21-40 years and 41-60 years and female-headed households had more nets than male-headed households. Logistic regression showed that female-headed households were 0.5 times more likely to own a net than male-headed households with $p\text{-value} = 0.04 < 5\%$; (95% CI. 0.2-1.0). From the foregoing, little evidence supports results of this study on lack of association on demographic characteristics of mothers and household heads. This may imply effect of migratory pattern of households in DRC has eroded even existing capacities with some demographic characteristics to own LLINs. Hence, emphasis and focus on strengthening free distribution as an important strategy towards realization of global and national targets on LLINs ownership among DRC households and households under context.

The association of economic conditions with household possession of LLINs: Findings showed that less than half of the total (48.1%) of the households surveyed in this study derived their livelihoods mainly from occasional daily employment, which is essentially a subsistence activity. In general, the majority of people were engaged in an economic activity that enabled them to earn a living, but not enough to meet daily household needs, including the affordability of LLINs. Respondents who identified themselves as employees represented 10.1%, similar to the results of the study carried out by Bashinyore (2010) in Uganda, where employees represented 10.2%. With regard to the mother's occupation, this study showed that 35.4% were self-employed, 22.3% were employed, 25% had other sources of income and 17.2% were not employed. Women's degree of economic autonomy can have a major impact on their ability to make decisions and take action in the area of health practices (Adjmagbo *et al.*, 1999). According to Zougrana (1993): "Women's work has a positive impact on their access to modern health services, since it gives them a degree of financial autonomy and a high level of decision-making power in the household". With regard to the occupation of the head of household, the results show that 37.1% of heads of household are employed, 32.1% are self-employed and 16.8% have other sources of income, while 13.6% of heads of household are unemployed. Employment remains the foundation on which households survive and meet their daily needs. It also defines the income threshold available to the household and, consequently, its ability to meet the household's needs. However, results of this present study also shows that there are no economic variables that explain LLIN ownership in the association between economic conditions and LLIN ownership in households. The association between variables such as the main source of household income, the mother's occupation, the occupation of the head of household and the possession of an LLIN in the household did not give a significant relationship between the variables because all the probabilities respectively were greater than $p\text{-value} = 5\%$.

This contrasts with the results of a study by Biadgilign *et al.* (2012) in Ethiopia where the occupational status of the head of household was one of the factors influencing LLIN ownership. Similar results have been documented in other studies, notably in Ethiopia where government employees and independent traders were less likely to own a net (Haileselassie and Ali, 2008). Furthermore, the results of the present study contrast with those of studies conducted by Quive *et*

al. (2015) and Sena *et al.* (2013) which found that net ownership was found to be positively associated with household economic status. Previous studies have reviewed potential factors in LLIN ownership in selected sub-Saharan African countries such as Ethiopia, Zimbabwe and Rwanda (Tassew, 2017; Tapera, 2019; Katera, 2015). Similar to observation under demographic characteristics, little evidence supports results of this study on lack of association between economic characteristics of household. Therefore, this further indicate effect of migratory pattern of households in DRC has eroded observed existing capacities with some economic characteristics to own LLINs. Further strengthening the position of emphasis and focus on strengthening free distribution strategies towards realization of global and national targets on LLINs ownership among DRC households and households under context.

The association of socio-cultural characteristics with household possession of LLINs: Findings showed that there were no socio-cultural variables which explained the association between LLIN ownership and the socio-cultural conditions of the household, except for the internal migration status of the household. Results showed that households which had not been displaced (Migration) were 1.8 times more likely to own LLINs for 95% CI= (1.01- 3.17) than households of displaced people. However, these results contrast with those of a study conducted by Ejembi *et al.* (2018) among Internal Displaced Persons in a camp in Nigeria, whose respondents were 2.6 times more likely to own the LLIN for 95% CI= (1.01- 3.17). The association between variables such as the marital status of the head of household and the mother, the level of education of the head of household and the mother, the religion of the head of household and the mother, and the size of the household did not give a significant relationship between the variables and possession of the LLIN because all the probabilities were greater than $p\text{-value} = 5\%$. In contrast, a study carried out in Tanzania by Oresanya and colleagues showed that a one-unit increase in family size more than doubled the chances of owning an LLIN, and that for households with at least one child under the age of five, the chances of owning a net were around 60% and sometimes higher than for those with no children under the age of five (Oresanya *et al.* 2008). In a study by Matovu and colleagues, the education of the woman and the head of household, the occupation of the head of household, the marital status of the head of household and the mother, and the size of the household were found to be associated with the appropriation of LLINs (Matovu *et al.*, 2009 and Wiseman *et al.*, 2007). Indeed, the degree of women's economic autonomy could have a major impact on their ability to make decisions and take action in the field of health practices (Adjmagbo *et al.*, 1999). Results of this study showing a relationship between displaced households and LLIN ownership irrespective of their socio-cultural characteristics, goes further to only affirm the serious effect of displacement and fragility of context such as the DRC on household capacity to own LLINs.

Ownership of LLINs and Malaria morbidity in the Household: Findings showed that 46.6% of households do not own an LLIN, including 20.3 % of households that did not have children under the age of 5 who had malaria in the three months preceding the survey, compared to 26.3 % of households that had children under the age of 5 who had malaria in the three months preceding the survey. The presence of a relationship between LLIN ownership and malaria morbidity emerges. The chi2 probability associated with these two variables is less than 5% i.e. $p\text{-value} = 0.046^*$. There is a significant difference between household possessions of LLINs as comparing to those households without LLINs. The logistic cross-tabulation shows that those who do not own LLINs are 1.4 times more likely to have children under 5 suffering from malaria in the last 3 months. In contrast, there is no doubt that progress has been made in the prevention and control of malaria. Feachem *et al.* (2019) claim that more than half of the world's countries are malaria-free. However, the cases are still overwhelming compared to the efforts made so far. Furthermore, Snow *et al.* (2017) revealed inconsistent and meagre rates of malaria decline across the belts of high malaria transmission areas in Africa from 1990 to 2015. In contrast, Africa accounts for approximately 93% of global malaria cases and nearly 85% of global malaria deaths (WHO, 2019), despite the continued deployment of LLINs.

CONCLUSION

There remains a need to improve ownership of LLIN, this is a key factor of correct use of LLIN in the household for malaria prevention as requested by the national policy against malaria. The proportion of households with at least one LLIN was low in the Goma Health Zone in North Kivu in the DRC. Malaria represents a potentially high economic burden, mainly for internally displaced people and for the national economy as a whole. Increasing universal coverage could therefore help to reduce poverty. The Ministry of Health through the National Malaria Control Programme and other stakeholders need to identify mechanisms to ensure easy and uninterrupted access to and regular use of LLINs for all in order to reduce malaria morbidity in the Karisimbi Health Zone.

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