Ownership, Coverage, Utilisation and Maintenance of Long-lasting insecticidal nets in Three Health Districts in Cameroon: A Cross-Sectional Study

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ABSTRACT

The Bamenda, Santa and Tiko Health Districts are in the highest malaria transmission strata of Cameroon. The purpose of this study was to explore the indicators of ownership and utilisation as well as maintenance of long-lasting insecticidal nets (LLINs) in three health districts in Cameroon. A cross-sectional household survey involving 1,251 households was conducted in the Bamenda, Santa and Tiko Health Districts in Cameroon. A structured questionnaire was used to collect data on LLINs ownership, utilisation, and maintenance as well as demographic characteristics. The average number of LLINs per household was higher in the Bamenda Health District (BHD) compared to the Tiko Health District (THD) (2.5±1.4 vs 2.4±1.6) as well as the household ownership of at least one LLIN (93.3% vs. 88.9%). The proportion of the *de facto* population with universal utilisation was higher in BHD compared to THD (13.1% vs 0.2%). In multinomial regression analysis, households in the Santa Health District (SHD) (OR = 0.4, 95% = C.I; 0.2 – 0.8, p = 6.10x10^{-3}), were less likely to own at least one LLIN, while those in the BHD (OR = 1.3, 95% = C.I; 0.8 – 2.1, p = 0.33) were more likely to maintain LLINs compared to those in THD. Ownership of LLINs was low in SHD and THD in comparison to the goal of one LLIN for every two household members. Overall, LLINs coverage and accessibility was still low after the free Mass Distribution Campaigns, making it difficult for all household members to effectively use LLINs.

Keywords: Ownership of LLINs, Utilisation of LLINs, Maintenance of LLINs, Cameroon.

Introduction

Malaria is a preventable and curable disease transmitted by female Anopheles mosquitoes [1, 2] and it is a serious global public health problem with an estimated 216 million cases in 91 countries in 2016 [1, 3] and 2,000 cases in the United States each year [4]. Africa is the most a□ected region, with 90% of all estimated malaria cases and 91% of deaths in 2016 and 15 African countries contributing 80% of all cases [3, 5].

Cameroon, bordered by the Gulf of Guinea and Nigeria to the west; Chad and the Central African Republic to the east; and Equatorial Guinea, Gabon, and the Democratic Republic of Congo to the south, through the Ministry of Health (MOH), completed her third national universal long-lasting insecticidal net (LLIN) campaign in 2019. With support from the Global Fund, the MOH has made provision of free LLINs to pregnant women at antenatal care (ANC) clinics since 2008 [6, 7]. In 2011, the Cameroon MOH undertook a nationwide free LLINs distribution campaign from health facilities to all households, with the objective to provide a LLIN with a lifespan of

five years, to all household beds or a LLIN for every two individuals per household, to a maximum of three LLINs per household [8, 9]. Malaria is endemic in Cameroon, with an estimated mortality rate of 11.6%, surpassing that of the African region of 10.4% as well as neighbouring countries [6]. It is the first major cause of morbidity and mortality among the most vulnerable groups [7, 10, 11]: children under five years and pregnant women, accounting, respectively, for 18% and 5% of the total population estimated at 19 million [12].

The main contemporary malaria control interventions are insecticide-treated bed nets and indoor residual spraying [2, 5, 7, 13, 14]. Alliance for Malaria Prevention has been instrumental in keeping long-lasting insecticide net (LLIN) campaigns on track: between 2014 and 2016 about 582 million LLINs were delivered globally and in 2017 there was the successful delivery of over 68 million nets to targeted recipients in Sub-Saharan Africa (SSA) and beyond [3]. Over 80% of all households have at least one mosquito net, up from 57% in 2011, still only about 60% of these households have enough nets to cover everyone at night [15]. The proportion of people in SSA sleeping under LLIN rose from less than 2% to over 50% between 2000-2015, preventing an estimated 450 million malaria cases [16].

Most studies in Cameroon and elsewhere have focused on various aspects of net ownership and utilisation. Effective LLIN use in the prevention of malaria in Mezam Division of the North West Region as well as the Tiko Health District in the South West Region [17, 18], *Plasmodium falciparum* infection in Rural and Semi-Urban Communities in the South West Region [8], predictive factors of ownership and utilisation in the Bamenda Health District (BHD) [19] and socio-demographic factors influencing the ownership and utilisation among malaria vulnerable groups in the Buea Health District and the Bamendankwe Health Area [20, 21]. However, there is paucity information on the indicators of LLIN ownership, utilisation, as well as maintenance. This study examines the indicators of net ownership and utilisation as well as maintenance, in three health districts in Cameroon.

Materials and Methods

Study design and setting: This cross-sectional survey conducted in the THD from June to July 2017 and in the BHD and SHD from March to May 2018 utilised a stratified multistage cluster sampling design. The study sampling frame included all health areas (HAs) in the study area, except those that were inaccessible for security reasons. Each Health Area (HA): urban, rural, or semi-urban localities were subdivided into quarters (primary sampling units or clusters in our

study). On average, each HA had about five quarters. Sampled HAs in the THD had about 2,089 (35.58%) of the sampled population.

First stage: we randomly selected four HAs in the THD by probability proportionate to size (PPS) and conveniently sampled one each from the BHD and SHD.

Second stage: within each selected HA, we randomly selected at least three quarters and at most eight quarters by PPS (**Figure 1**).

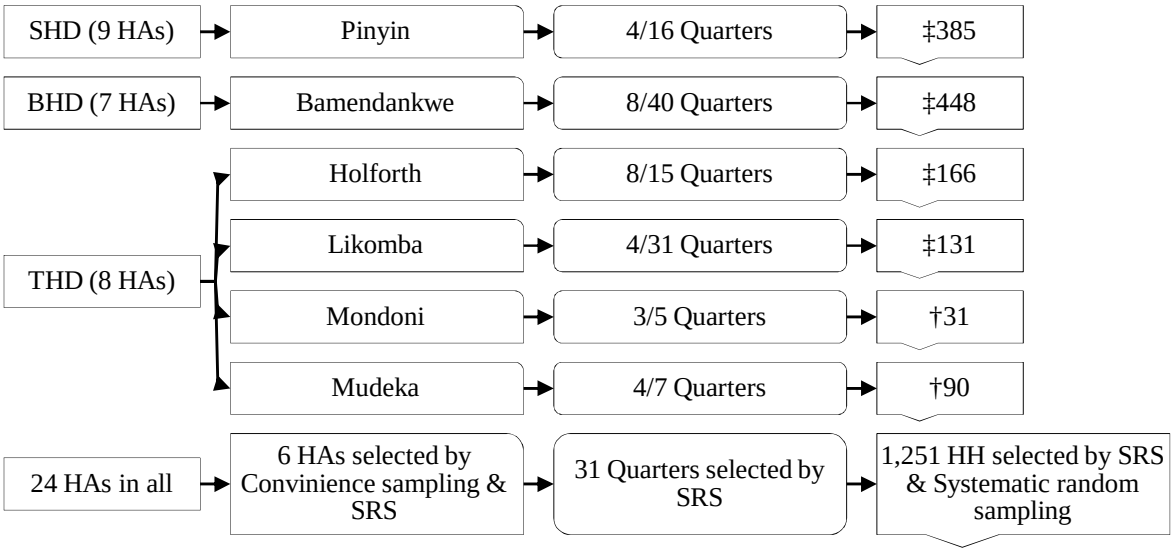

Figure 1: Multistage sampling (HA; Health Area, SRS; Simple Random Sampling)
‡Households (HH) sampled by systematic random sampling, †HHs sampled by SRS

Third stage: within each selected quarter, the survey team mapped and enumerated all households and selected households in each cluster by systematic random sampling (that is, a random start and interval to cover the entire quarter). The estimated number of households in each quarter was obtained from the quarter head to determine the sampling interval to select the households.

The study area consisted of the BHD with an estimated 350,000 residents and the Santa Health District (SHD), 35 Km from the BHD with 73,406 residents in the North West Region and the Tiko Health District (THD), 351 Km from the BHD with an estimated 134,649 residents in the South West Region of Cameroon [22]. Generally, malaria in Cameroon is caused mainly by *Plasmodium falciparum*, with *Anopheles gambiae* as the major vector [7, 12, 23]. The BHD (semi-urban community) and the SHD (rural community) are in the high western plateau altitude, where malaria transmission is permanent, occurring all year long, sometimes lessened by altitude although never totally absent [12, 24]. It is one of the most densely populated regions of Cameroon [7, 12]. The THD (urban and rural communities) is in the coastal strata, zone of dense hydrophile forest and mangrove swamp with the highest transmission of malaria in the country

[7, 12]. Like the Buea health district, the THD has a constant variation in the trends of malaria prevalence all round the year [25, 26].

Sample size determination: A minimum sample size of 384 for each health district, which was calculated with the CDC- Epi-Info version 7.2.2.6 (Centre for Disease Control, Georgia USA) StatCalc with the following characteristics, an average population of 307,620 in 2009 with an annual increase rate of 2% (6152.4) to 369,144 in 2018 [27], estimated proportion of households owning LLINs of 50%, accepted error margin of 5%, design effect of 1.0 and three clusters.

Recruitment procedures and measures: Interviewers explained the purpose of the study and obtained signed/verbal informed consent from the head of the household or spouse. In cases where the household head was absent, any elderly person who has lived in the house for at least the last 12 months replaced her/him. The questionnaire for this study is as described in another study [18].

Outcome variables

1. **LLINs ownership indicators**: *Ownership of LLINs*, *Coverage*, and *Access to LLINs within the household* were defined as described in other studies [10, 28].
2. **LLIN utilisation indicators**: *Household universal utilisation of LLINs* was defined as described in earlier studies [10, 28, 29]. *LLINs utilisation by the vulnerable population in the household* was defined as the proportion of children under five (or pregnant women) that slept under a LLIN the previous night [10]. *Regularly sleeping under bed nets*: household heads who reported habitually using nets daily [30]. *Slept under LLINs the previous night (SULPN)*: proportion of household heads who slept under a LLIN the previous night, as described in earlier studies [18, 21].
3. **Maintenance of LLINs**: proportion of households in which the household heads admitted respecting the recommended washing frequency of LLINs.
4. **Independent variables (IV)** considered for association with LLINs ownership, utilisation, and maintenance were age, gender, marital status, education, occupation, health district, house type, and household composition.

Statistical analysis: We entered data into MS-Excel (Microsoft Inc. 2016) and analysed with IBM-SPSS Statistics 25.0 for windows (IBM-SPSS Corp., Chicago USA). The Chi square (χ^2) test was used to compare household characteristics with LLINs, ownership/utilisation indicators and multivariate logistic regression to identify significant correlates of the main outcomes. Statistical significance was set at $p \leq 0.05$.

Results

Characteristics of the study participants: A total of 1,251 household heads was sampled with 5,870 *de facto* residents across six health areas in three health districts. Of the total household residents counted, 1,267 (21.6%) were children 0 – 5 years old and 93 (1.6%) were expectant mothers. The general characteristics of the study participants are shown in **Table 1**. The overall mean (±SD) family size was 4.7±2.1 members: 4.6±2.1 in BHD and 5.0±2.5 in THD. Majority of the houses, 1,060 (84.7%) were made of mud/cement, while households with 1 – 3 bedrooms; the mean (±SD) number of bedrooms 2.0±1.1 were about 1,141 (91.2%).

LLINs ownership, coverage and accessibility: One thousand one hundred and fifty-seven (92.5%) of the 1,251 households sampled had at least one LLIN, while 836 (66.8%) had at least a bednet for every two persons in the household (**Table 2**). The overall LLIN-to-person ratio was 0.50, that is, one net for every two persons (**Table 1**), constituting a coverage of 3,913 (66.7%) of the *de facto* population. The mean number of LLINs/LLINs density in the households was 2.4±1.4.

Overall household accessibility to bednets was 865 (69.1%). Household accessibility (**Table 3**) to bednets was associated with gender, marital status, occupation of the household head, and health districts, where household residents in housed headed by females, unmarried, those with domestic chores and those in the BHD and SHD significantly ($p < 0.05$) had more access to LLINs than the other groups. In univariate analysis, these characteristics also showed significant associations with accessibility. Four thousand and fifty-eight (69.1%) of the *de facto* population, from 865 (69.1%) of the 1,251 households sampled, had access to LLINs.

In univariate and multivariate analyses, LLINs ownership, coverage and accessibility were associated ($p < 0.05$) with health districts (**Table 3**), where households in the SHD significantly ($p = 6.1\text{x}10^{-3}$) owned fewer nets, while those in the BHD significantly ($p = 9.31\text{x}10^{-14}$) had more coverage than the other districts. Ownership, coverage and accessibility were associated with marital status both in univariate and multivariate analysis. Coverage was also associated with the gender of the household head and household size (**Table 3**), where households headed by females ($p = 2.21\text{x}10^{-3}$) and those of household size of 1 – 4 members ($p = 2.9\text{x}10^{-3}$) significantly influenced coverage than the others. Secondary educational and occupational status significantly influenced household ownership of nets ($p < 0.05$). Household heads in the agricultural sector (OR = 2.1, 95% C.I = 1.1 – 3.9, $p = 1.75\text{x}10^{-2}$) as well as those in domestic affairs (OR = 2.6,

95% C.I = 1.1 –5.7, $p = 2.18x10^{-2}$), were more likely to have LLINs coverage when compared with their counterparts (**Table 3**).

Use of LLINs: Of the 1,251 households sampled, 520 (41.6%) and 256 (20.5%) were those in which all children 0 – 5 years and those in which all who slept home last night used bednets, respectively representing 859 (14.6%) and 942 (16.0%) of the 5,870 *de facto* population that slept home last night (**Table 2**).

Marital status (OR = 2.2, 95% C.I = 1.5 – 3.2, $p = 6.09x10^{-5}$), vs (OR = 1.4, 95% C.I = 1.0 – 2.1, $p = 4.40x10^{-2}$), household size (OR = 1.3, 95% C.I = 0.6 – 2.7, $p = 0.45$) vs (OR = 1.2, 95% C.I = 0.7 – 2.2) and the installation of LLINs on all beds in the household were the predictors of the utilisation of LLINs by all children 0 – 5 years old and the entire household (**Table 4**).

Of the 1,251 household heads sampled, 484 (38.7%) regularly used bednets on all nights of the week, while 350 (28.0%) had their household heads using bednets last night (**Table 2**).

The other uses, "out of norms", of LLINs are summarised in **Table 5**. Three hundred and fifty-nine [359 (28.7%); 95% C.I = 26.3 – 31.3] of the household heads sampled, admitted that LLINs were put into other diverse uses. These uses ranged from being used as goal post nets by children; 2.8% (95% C.I = 2.0 – 3.9), to yard fences; 22.7% (95% C.I = 20.5 – 25.1). Except for harvesting and drying of melon seeds (egussi), the other "out of norm" uses of LLINs were significantly ($p < 0.05$) associated to the health districts.

Care and maintenance of LLINs: Out of the 1,251 household heads sampled, 1,089 (87.1%) said LLINs can be washed, while 627 (50.1%) affirmed the recommended LLINs washing frequency of 2 – 4 times a year (**Table 6**).

The question of washing bednets or not, was associated to the gender of the household head, where households with females heads significantly ($p = 2.22x10^{-2}$) washed them compared to those headed by males.

The WHO recommended washing frequency was associated with the health district, where households with heads in the BHD ($p = 3.14x10^{-7}$) abided more significantly to the recommended washing frequency than those in the other health districts.

DISCUSSION

This study examined the indicators of LLIN ownership, utilisation, and maintenance in the Bamenda, Santa and Tiko Health Districts. Overall, 92.5% and 20.5% of the households

interviewed owned at least one LLIN per household and utilisation by the entire household last night, respectively.

Indicators of household LLINs ownership: Currently, targets in national strategic plans for all three LLINs coverage indicators are usually set for all people at risk of malaria [1, 5], to ≥ 80%. Household ownership of at least one LLIN per household in this study is higher than rates reported elsewhere in and out of Cameroon [8, 17, 19, 20, 30-44]. It was however, lower than the proportions reported within the THD, Uganda, Ethiopia, and Myanmar [18, 45-47] and in line with the 93.3 – 98% reported in the Bamendankwe Health area, Madagascar and India [21, 33, 48]. The high proportion of owning at least a LLIN per household in this study could be attributed to the free LLINs MDCs [8, 12, 49].

The universal household coverage of 66.8%, although within the WHO range of 39 – 75 % [50], was lower than rates reported elsewhere in Cameroon and Myanmar [21, 46], in line with the 68.9% reported in Southwest Ethiopia [42] and higher compared to rates in Madagascar, Uganda and a host of eight other African countries [33, 35, 51].

Access to LLINs in the household of 69.1% in this study was lower compared to results reported elsewhere [21, 33, 42, 45], higher than the 21% reported in Batwa [43], within 57.3 – 78.8% in eight African countries [35] and 32.3 – 81.3% reported in a multi-country study [52]. The low household universal coverage and accessibility in this study could be attributed to the significant differences amongst the health districts and differences in family size vs gender of household head.

Household utilisation of LLINs: Household universal LLINs utilisation of 20.5% (16.0% of the *de facto* population) was very low compared to previous studies elsewhere in and out of Cameroon [19, 20, 30, 33, 37, 45, 46, 48, 51, 53, 54]. This was however high compared to the 6.9 – 15.3% reported in Myanmar [32]. The very low household LLINs utilisation could be attributed to the significant differences amongst the health districts as well as household composition and the installation of LLINs on all beds in the household. It could also be due to inadequate education on LLINs utilisation, socio-political tensions, and differences in the different study designs.

Bednet utilisation by all children 0 – 5 years and expectant mothers in the household of 14.6% and 63.4%, respectively, is low compared to 63% vs 60% reported in BHD [19], 52% vs 58% in the national territory and elsewhere in the world [31, 33, 34, 37, 46, 51, 53, 55]. The low LLIN utilisation by all children 0 – 5 years old could be attributed to significant differences in the

health districts, age and gender of household heads, educational status of the household head as well as the presence or absence of bushes or water pools around dwellings.

Use of LLINs by the household head last night of 28.0% was low compared to 58.3% reported in Rural and Semi-Urban communities in the South West Region of Cameroon [8] and 47.2 – 63.8% elsewhere [30, 42]. Meanwhile, the regular use of LLINs of 38.7% was low compared to 48% reported in China [30]. The low use of LLINs last night by household heads and regular use of LLINs could significantly be attributed to differences in the health districts and age of the household heads.

LLIN misuse of 2.3 – 22.7% was also similar to the 18.2% reported in Mezam Division [17] and 21% in Kenya and Ethiopia [56, 57]. The use of LLINs for other purposes, other than the prevention of mosquito bites could be attributed to: inadequate education on utilisation, normal social behaviour, lack of good playgrounds, as 2.8% of the households admitted that children used bednets as football goal post nets.

Care and maintenance of LLINs: Out of the 1,251 household heads sampled, 1,089 (87.1%) said LLINs can be washed, while 627 (50.1%) affirmed the recommended LLIN washing frequency of 2 – 4 times a year. The recommended LLIN wash frequency reported in this study was similar to the 52.0% reported in Kenya [56] and lower than the 68 – 87.3% reported worldwide [58-60]. The optimal LLIN washing frequency could be attributed to the age and occupation of the household head as well as the health district.

RECOMMENDATION

The populations of the three health districts should be properly educated by community health workers and stakeholders on the regular utilisation of LLINs and by all household occupants.

CONCLUSIONS

Our findings highlighted low rates of household universal coverage, accessibility, and utilisation indicators as well as maintenance amidst high ownership of at least one LLIN per household and the free MDC. Quelling the on-going socio-political crisis and scaling up efforts can lead to increased coverage which may systematically contribute to household universal utilisation and thus reduce malaria morbidity. Our finding that health districts are strongly associated with LLINs ownership, utilisation and maintenance suggests that MDCs should be complemented by education and behaviour change communication, emphasizing that malaria is transmitted by mosquito bites and it can be prevented by sleeping under LLINs.

STRENGTHS AND LIMITATIONS OF THE STUDY

Strengths: The data used in this study was collected by trained surveyors. The health district offices were consulted for the mapping of the HAs, quarters and census list of households used in the last MDC and Expanded Programme on Immunisation campaigns. The quality of data collected was assured through the multistage sampling strategy to minimize bias and pretesting of questionnaires.

Limitations: This was a cross-sectional study, representing the snapshot of the population within the study period and does not show cause and effect since the predictor and outcome variables were measured simultaneously. Data was collected through self-reporting and thus there is a possibility of recall bias where the respondent provides socially acceptable answers. In this study, however, respondents were required to only recall whether they and occupants of their households slept under a LLIN the previous night, as well as the source and number of LLINs in the household. Ownership, utilisation, and maintenance of LLINs in the three health districts in 2017 and 2018 could not be attributed solely to the 2015 - 2016 MDC, as other sources of LLINs: ANC for pregnant women and gift from a relation, and our study design could not capture the contribution of each intervention.

What is already known on this topic

- The proportion, as well as factors associated with LLINs ownership and utilisation have been investigated in some health districts in Cameroon and Africa.
- The ownership of LLINs, leads to increased utilization in some health districts in Cameroon and Africa.

What this study adds

- Information on the care and maintenance of LLINs.
- Information on ownership, care, and maintenance of LLINs shall enhance and improve on the prevention of malaria in the health districts concerned.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Conceptualization and Methodology: FNC, PNF, and PNF. Field data collection: FNC, PNF, BMC, SFM, YEN, and PKJ. Data curation/ Statistical analysis: FNC, PNF, and PKJ. Original

draft preparation: FNC, PNF, SFM, BMC, PKJ, and PNF. Review and editing of draft: FNC, PNF, PKJ, PNF, and ASE. Administration and supervision: CNF, ANT, PNF, and ASE. All authors read and approved the final manuscript. FNC, PNF, and PKJ contributed equally to this work.

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Data Availability

The dataset used for analysis in this study, is provided within the study, and is provided here as (**S1 file: Dataset**). A preprint with DOI: https://doi.org/10.1101/465005. of this study is also available at www.biorxiv.org.

ABBREVIATIONS

95% C.I: 95% Confidence Interval

BHD: Bamenda Health District

HA: Health area

LLINs: Long-lasting insecticidal nets

OR: Odds Ratio

p: Significance value

SD: Standard Deviation

SHD: Santa Health District

THD: Tiko Health District

χ^2: Chi square

Ethical Approval

Ethical clearance was obtained from the IRB-FHS of the University of Buea.

Supplementary Materials

S1 file: Dataset. (*Supplementary Materials*)

Tables

Table 1: General characteristics of the study population.

Table 2: LLINs ownership and utilisation indicators in association with health districts.

Table 3: Multinomial logistic regression of socio-demographic characteristics in association with LLINs ownership indicators.

Table 4: Multinomial logistic regression of socio-demographic characteristics in association with LLINs use by all children 0 – 5 and the entire household.

Table 5: LLINs Misappropriation: by health districts.

Table 6: Logistic regression of socio-demographic characteristics in association with LLINs maintenance.

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Table 1
General characteristics of the study population

Characteristic	Health district			
Age groups (in years)	Bamenda (*n* = 448)	Santa (*n* = 385)	Tiko (*n* = 418)	Total (%)
≤ 20	9	6	15	30 (2.4)
21 – 40	298	227	295	820 (65.5)
41 – 60	141	152	104	404 (32.1)
Mean age (±SD)	36.2±9.9	38.0±11.0	34.3±11.2	36.1±10.8
Gender				
Females	282	288	281	851 (68.0)
Males	166	97	137	400 (32.0)
Marital status				
Unmarried	179	232	154	565 (36.8)
Married	269	153	264	686 (54.8)
Education				
Primary	145	138	204	486 (38.8)
Secondary	157	143	170	470 (37.6)
Tertiary	146	105	44	295 (23.6)
Occupation				
Unemployed	0	140	59	199 (15.9)
Agricultural	163	0	28	191 (15.3)
Household/domestic	0	0	55	55 (4.4)
Unskilled	126	188	127	441 (35.3)
State/Parastatal	33	57	126	216 (17.3)
Professional	126	0	23	149 (11.9)
House type				
Caraboat/Temporal	16	44	131	191 (15.3)
Mud/Cement Block	432	341	287	1060 (84.7)
Number of bedrooms				
1 – 3	410	353	378	1,141 (91.2)
4 – 7	38	32	40	110 (8.8)
Mean number of bedrooms (±SD)	2.0±1.0	1.9±1.1	1.9±1.2	2.0±1.1
Environmental factor				
No	85	21	29	135 (10.8)
Yes	363	364	389	1,116 (89.2)
Household Composition				
Mean number of children < 5 (±SD)	1.0±1.0	1.2±1.1	0.9±0.9	1.0±1.0
Mean household size (±SD)	4.6±2.2	4.5±1.7	5.0±2.5	4.7±2.1
Net Ownership				
Number of nets in HHs	1,126	847	985	2,958
Mean number of nets in households (±SD)	2.5±1.4	2.2±1.2	2.4±1.6	2.4±1.4
Mean number of reserved nets (±SD)	0.5±0.9	1.3±1.1	0.5±0.9	0.7±1.0
Number of HHs surveyed				
Children 0 - 5 surveyed	448	465	354	1,267
Children 6 - 17 surveyed	728	544	704	1,976
Persons ≥ 18	835	680	1,019	2,534
Expectant women surveyed	46	35	12	93
Population surveyed	2,057	1,724	2,089	5,870
Bednet : Person ratio	0.5	0.5	0.5	0.5

SD; Standard Deviation, HH(s); Household(s)

Table 2

LLINs ownership and utilisation indicators in association with health districts

	Households						***De facto* population in households**			
LLINs indicator	*n* (%)	BHD	SHD	THD	χ^2	***p*-value**	*n* (%)	BHD	SHD	THD
Ownership										
At least One	1,157 (92.5)	418	367	372	12.23	$\mathbf{2.22x10^{-3}}$	5,577 (95.0)	2,000	1,680	1,897
Coverage	836 (66.8)	387	214	235	120.46	$\mathbf{6.97x10^{-27}}$	3,913 (66.7)	1,893	937	1,083
Accessibility	865 (69.1)	374	214	277	77.97	$\mathbf{6.97x10^{-27}}$	4,058 (69.1)	1,825	937	1,296
Utilisation										
Children 0 – 5 years	558 (44.6)	251	138	169	74.69	$\mathbf{5.68x10^{-13}}$	859 (14.6)	427	188	244
Entire household	879 (70.3)	380	193	306	268.21	$\mathbf{3.22x10^{-44}}$	942 (16.0)	767	10	165

Boldface numbers indicate significant *p* values, BHD; Bamenda Health District, SHD; Santa Health District, THD; Tiko Health District, χ^2; Chi square

Table 3

Multinomial logistic regression of socio-demographic characteristics in association with LLINs ownership indicators

Dependent variable →	**Ownership (*n* = 1,157)**			**Coverage (*n* = 836)**			**Accessibility (*n* = 865)**		
Independent variable ↓	***n* (%)**	***p*-value**	**OR (95% C.I.)**	***n* (%)**	***p*-value**	**OR (95% C.I.)**	***n* (%)**	***p*-value**	**OR (95% C.I.)**
Gender	*n* = 1,157			*n* = 836			*n* = 865		
Female	786 (67.9)	-	-	582 (69.6)	**$2.21x10^{-3}$**	0.6 (0.5 – 0.9)	607 (70.2)	**$1.22x10^{-4}$**	0.6 (0.4 – 0.8)
Male	371 (32.1)	-	-	254 (30.4)	Ref	1.0	258 (29.8)	Ref	1.0
Marital status									
Unmarried	512 (44.3)	0.24	1.3 (0.8 – 2.2)†	360 (43.1)	**$1.32x10^{-2}$**	1.4 (1.1 – 1.9)†	365 (42.2)	**$5.83x10^{-3}$**	1.5 (1.1 – 2.0)†
Married	645 (55.7)	Ref	1.0	476 (56.9)	Ref	1.0	500 (57.8)	Ref	1.0
Education									
Primary	454 (32.9)	0.49	1.3 (0.6 – 2.6)†	316 (37.8)	0.39	1.2 (0.8 – 1.7)†	337 (39.0)	0.59	1.1 (0.8 – 1.6)†
Secondary	421 (36.4)	**$1.88x10^{-2}$**	2.2 (1.1 – 4.4)†	303 (36.2)	0.10	1.3 (0.9 - 1.9)†	312 (36.1)	0.11	1.3 (0.9 - 1.9)†
Tertiary	282 (24.4)	Ref	1.0	217 (26.0)	Ref	1.0	216 (25.0)	Ref	1.0
Occupation									
Unemployed	182 (15.7)	**$1.54x10^{-2}$**	5.5 (1.4 – 21.8)†	124 (14.8)	0.67	0.9 (0.4 – 1.7)	130 (15.0)	0.60	0.8 (0.4 – 1.6)
Agricultural	174 (15.0)	**$8.06x10^{-3}$**	5.6 (1.6 – 20.2)†	148 (17.7)	**$1.75x10^{-2}$**	2.1 (1.1 – 3.9)†	150 (17.3)	0.08	1.7 (0.9 – 3.0)†
Household/domestic	50 (4.3)	**$1.86x10^{-2}$**	6.8 (1.4 – 33.9)†	26 (3.1)	**$2.18x10^{-2}$**	2.6 (1.1 – 5.7)†	33 (3.8)	**$2.63x10^{-3}$**	2.5 (1.1 – 5.5)†
Unskilled	408 (35.3)	**$1.94x10^{-2}$**	4.5 (1.3 – 15.7)†	289 (34.6)	0.46	1.3 (0.7 – 2.3)†	295 (34.1)	0.42	1.3 (0.7 – 2.2)†
State/ Parastatal	197 (17.0)	**$2.82x10^{-2}$**	4.4 (1.2 – 16.7)†	121 (14.5)	0.13	1.6 (0.9 – 3.0) †	132 (15.3)	0.13	1.6 (0.9 – 2.9)†
Professional	146 (12.6)	Ref	1.0	128 (15.3)	Ref	1.0	125 (14.5)	Ref	1.0
Health District									
Bamenda	418 (36.1)	0.40	0.8 (0.4 – 1.4)	387 (46.3)	**$9.31x10^{-14}$**	0.2 (0.1 – 0.3)	374 (43.2)	**$7.70x10^{-6}$**	0.4 (0.2 – 0.6)
Santa	367 (31.7)	**$6.10x10^{-3}$**	0.4 (0.2 – 0.8)	214 (25.6)	0.11	1.3 (0.9 - 1.9)†	214 (24.7)	**$3.59x10^{-4}$**	1.9 (1.3 – 2.7)†
Tiko	372 (32.2)	Ref	1.0	235 (28.1)	Ref	1.0	277 (32.0)	Ref	1.0
House type									
Caraboat/Temporal	180 (15.6)	-	-	118 (14.1)	0.12	0.8 (0.5 – 1.1)	132 (15.3)	0.11	0.7 (0.5 – 1.1)
Mud/Cement Block	977 (84.4)	-	-	718 (85.9)	Ref	1.0	733 (84.7)	Ref	1.0
House size									
1 - 3 bedrooms	1,055 (91.2)	-	-	758 (90.7)	0.12	1.4 (0.9 – 2.3)	786 (90.9)	0.38	1.2 (0.8 - 1.9)
4 - 7 bedrooms	102 (8.8)	-	-	78 (9.3)	Ref	1.0	79 (9.1)	Ref	1.0
House composition									
0 Children 0 - 5 SHLN	417 (36.0)	0.08	4.1 (0.8 – 19.8)†	329 (39.4)	0.25	1.4 (0.8 – 2.5)†	339 (39.2)	0.75	1.1 (0.6 – 2.0)†
1 - 2 Children 0 - 5 SHLN	639 (55.2)	0.75	1.3 (0.3 – 6.1)†	439 (52.5)	0.45	1.2 (0.7 – 2.1) †	456 (52.7)	0.79	1.1 (0.6 - 1.8)†
3 - 4 Children 0 - 5 SHLN	101 (8.7)	Ref	1.0	68 (8.1)	Ref	1.0	70 (8.1)	Ref	1.0
Family size 1 – 4	551 (47.6)	0.28	1.8 (0.6 – 5.2)†	433 (51.8)	**$2.96x10^{-3}$**	0.5 (0.8 - 0.8)	429 (49.6)	0.15	0.7 (0.4 – 1.1)
Family size 5 – 7	478 (41.3)	0.80	0.9 (0.3 – 2.6)	322 (38.5)	0.10	0.7 (0.4 – 1.1)	347 (40.1)	0.15	0.7 (0.4 – 1.1)
Family size ≥ 8	128 (11.1)	Ref	1.0	81 (9.7)	Ref	1.0	89 (10.3)	Ref	1.0

Boldface numbers indicate significant *p* values, SHLN; Slept home last night, O.R; Odds ratio, 95% C.I.; 95% Confidence interval, †; more likely group(s), Ref; Reference

Table 4
Multinomial logistic regression of socio-demographic characteristics in association with LLINs use by all children 0 – 5 and the entire household

Dependent variable →	**Children < 5 years old (*n* = 520)**			**Entire household (*n* = 256)**		
Independent variable ↓	***n* (%)**	***p*-value**	**OR (95% C.I.)**	***n* (%)**	***p*-value**	**OR (95% C.I.)**
Age groups (in years)	*n* = 520			*n* = 256		
≤ 20	16 (3.1)	-	-	6 (2.3)	0.23	0.5 (0.2 – 1.5)
21 – 40	330 (63.5)	-	-	187 (73.0)	**$1.32x10^{-3}$**	0.5 (0.4 – 0.8)
41 – 60	174 (33.5)	Ref	1.0	63 (24.6)	Ref	1.0
Gender						
Female	357 (68.7)	0.31	1.2 (0.8 – 1.9)†	166 (64.8)	0.55	1.1 (0.8 – 1.6)†
Male	163 (31.7)	Ref	1.0	90 (35.2)	Ref	1.0
Marital status						
Unmarried	176 (33.8)	**$6.09x10^{-5}$**	2.2 (1.5 – 3.2)†	98 (38.3)	**$4.40x10^{-2}$**	1.4 (1.0 – 2.1)†
Married	344 (66.2)	Ref	1.0	158 (61.7)	Ref	1.0
Education						
Primary	218 (41.9)	**$9.41x10^{-3}$**	0.5 (0.3 – 0.9)	94 (36.7)	0.40	0.8 (0.5 – 1.3)
Secondary	194 (37.3)	0.12	0.7 (0.4 – 1.1)	95 (37.1)	0.77	0.9 (0.6 – 1.5)
Tertiary	108 (20.8)	Ref	1.0	67 (26.2)	Ref	1.0
Occupation						
Unemployed	59 (11.3)	-	-	14 (5.5)	0.30	0.6 (0.3 – 1.5)
Agricultural	115 (22.1)	-	-	66 (25.8)	0.14	1.5 (0.9 – 2.4)†
Household/domestic	31 (6.0)	-	-	8 (3.1)	0.66	1.2 (0.5 – 3.3)†
Unskilled	151 (29.0)	-	-	77 (30.1)	0.35	1.3 (0.8 – 2.1)†
State/Parastatal	77 (14.8)	-	-	26 (10.2)	0.09	1.8 (0.9 – 3.4)†
Professional	87 (16.7)	Ref	1.0	65 (25.4)	Ref	1.0
Health District						
Bamenda	250 (48.1)	-	-	193 (75.4)	**$6.10x10^{-14}$**	0.2 (0.1 – 0.2)
Santa	103 (19.8)	-	-	4 (1.6)	**$2.53x10^{-6}$**	13.4 (4.5 – 39.3)†
Tiko	167 (32.1)	Ref	1.0	59 (23.0)	Ref	1.0
House type						
Caraboat/Temporal	72 (13.8)	0.70	0.9 (0.5 – 1.6)	23 (9.0)	0.39	1.3 (0.7 – 2.2)†
Mud/Cement Block	448 (86.2)	Ref	1.0	233 (91.0)	Ref	1.0
House size						
1 - 3 bedrooms	470 (90.4)	0.45	1.3 (0.6 – 2.7)†	233 (91.0)	0.47	1.2 (0.7 - 2.2)†
4 - 7 bedrooms	50 (9.6)	Ref	1.0	23 (9.0)	Ref	1.0
House composition						
0 Children 0 - 5 SHLN	0 (0.0)	-	-	128 (50.0)	**$8.52x10^{-7}$**	0.1 (0.0 – 0.2)
1 - 2 Children 0 - 5 SHLN	457 (87.9)	-	-	123 (48.0)	**$3.28x10^{-4}$**	0.2 (0.1 – 0.4)
3 - 4 Children 0 - 5 SHLN	63 (12.1)	Ref	1.0	5 (2.0)	Ref	1.0
Family size 1 – 4	113 (21.7)	**$4.55x10^{-6}$**	3.9 (2.2 – 7.0)†	175 (68.4)	-	-
Family size 5 – 7	315 (60.6)	0.30	0.7 (0.4 – 1.3)	70 (27.3)	-	-
Family size ≥ 8	92 (17.7)	Ref	1.0	11 (4.3)	Ref	1.0
Own at least one LLIN						
No	2 (0.4)	0.19	3.5 (0.5 – 23.0)†	1 (0.4)	-	-
Yes	518 (99.6)	Ref	1.0	255 (99.6)	Ref	1.0
Install nets on all beds						
No	124 (23.8)	**$4.08x10^{-3}$**	1.9 (1.2 – 2.9)†	58 (22.7)	**$4.57x10^{-10}$**	3.4 (2.3 – 5.0)†
Yes	396 (76.2)	Ref	1.0	198 (77.3)	Ref	1.0
Environmental factor						
No	64 (12.3)	**$3.87x10^{-3}$**	0.4 (0.2 – 0.7)	46 (18.0)	0.39	0.8 (0.5 – 1.3)
Yes	456 (87.7)	Ref	1.0	210 (82.0)	Ref	1.0

Boldface numbers indicate significant *p* values, SHLN; Slept home last night, O.R; Odds ratio, 95% C.I.; 95% Confidence interval, †; more likely group(s), Ref; Reference

Table 5
LLINs Misappropriation: by health districts

Variable	Bamenda	Santa	Tiko	Total (%)	95% C.I.	χ^2	*p* value
Aware of LLINs misuse	172	6	181	359 (28.7)	26.3 - 31.3	202.731	**< 0.001**
Missuses							
Fishing	32	11	15	58 (4.6)	3.6 – 6.0	10.160	**0.006**
Football net	35	0	0	35 (2.8)	2.0 - 3.9	64.540	**< 0.001**
Harvesting/Drying egussi	46	40	26	112 (9.0)	7.5 - 10.7	5.755	0.056
Bathing shelter	23	29	5	57 (4.6)	3.5 - 5.9	19.038	**< 0.001**
Chicken shed/ poultry	58	6	6	70 (5.6)	4.5 - 7.0	71.401	**< 0.001**
Mesh on windows	83	27	74	184 (14.7)	12.9 - 16.8	26.370	**< 0.001**
Wall material	0	125	3	128 (10.2)	8.7 - 12.0	299.504	**< 0.001**
Yard fences/Garden	153	79	52	284 (22.7)	20.5 - 25.1	59.598	**< 0.001**

Boldface numbers indicate significant *p* values, χ^2; Chi square

Table 6

Logistic regression of socio-demographic characteristics in association with LLINs maintenance

Dependent variable →	**Can wash LLINs (*n* = 1,089)**			**Recommended wash frequency (n = 627)**		
Independent variable ↓	***n* (%)**	***p*-value**	**OR (95% C.I.)**	***n* (%)**	***p*-value**	**OR (95% C.I.)**
Age groups (in years)	*n* = 1,089			*n* = 627		
≤ 20	24 (2.2)	0.20	1.9 (0.7 – 5.0)†	10 (1.6)	0.25	1.6 (0.7 – 3.7)†
21 – 40	709 (65.1)	0.16	1.3 (0.9 - 1.9) †	424 (67.6)	0.25	0.9 (0.7 - 1.1)
41 – 60	356 (32.7)	Ref	1.0	193 (30.8)	Ref	1.0
Gender						
Female	775 (69.3)	**2.22×10^{-2}**	0.7 (0.5 – 0.9)	431 (68.7)	0.08	0.8 (0.6 - 1.0)
Male	334 (30.7)	Ref	1.0	196 (31.3)	Ref	1.0
Marital status						
Unmarried	485 (44.5)	0.63	1.1 (0.8 - 1.6)†	263 (41.9)	0.16	1.2 (0.9 - 1.5)†
Married	604 (55.5)	Ref	1.0	364 (58.1)	Ref	1.0
Education						
Primary	422 (38.8)	0.91	1.0 (0.6 – 1.5)	233 (37.2)	0.95	1.0 (0.7 - 1.4)
Secondary	416 (38.2)	0.20	0.7 (0.5 - 1.2)	235 (37.5)	0.77	1.0 (0.8 - 1.3)
Tertiary	251 (23.0)	Ref	1.0	159 (25.4)	Ref	1.0
Occupation						
Unemployed	167 (15.3)	0.23	1.6 (0.7 – 3.3)†	72 (11.5)	0.19	1.4 (0.8 – 2.5)†
Agricultural	163 (15.0)	0.92	1.0 (0.5 - 1.8)	133 (21.2)	0.48	0.8 (0.5 – 1.4)
Household/domestic	54 (5.0)	0.07	0.1 (0.0 – 1.2)	19 (3.0)	0.06	2.0 (1.0 – 4.2)†
Unskilled	389 (35.7)	0.94	1.0 (0.5 – 1.8)	202 (32.2)	0.19	1.3 (0.9 – 2.1)†
State/Parastatal	190 (17.4)	0.80	0.9 (0.5 – 1.8)	104 (16.6)	0.79	1.1 (0.7 - 1.8)†
Professional	126 (11.6)	Ref	1.0	97 (15.5)	Ref	1.0
Health District						
Bamenda	379 (34.8)	0.33	1.3 (0.8 – 2.1)†	306 (48.8)	**3.14×10^{-7}**	0.4 (0.3 – 0.6)
Santa	341 (31.3)	0.35	0.8 (0.5 - 1.3)	146 (23.3)	0.61	1.1 (0.8 - 1.5)†
Tiko	369 (33.9)	Ref	1.0	175 (27.9)	Ref	1.0

Boldface numbers indicate significant *p* values, O.R; Odds ratio, 95% C.I.; 95% Confidence interval, †; more likely group(s), Ref; Reference