Ownership, Coverage, Utilisation and Maintenance of Long-lasting insecticidal nets (LLINs) in Bamenda, Santa and Tiko Health Districts in Cameroon

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ABSTRACT

Introduction: 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.

Methods: A cross-sectional household survey involving 1,251 households was conducted in the Tiko Health District (THD) in July and June 2017 and in Bamenda and Santa Health Districts in March to May 2018. A structured questionnaire was used to collect data on LLIN ownership, utilisation and maintenance as well as demographic characteristics.

Results: The average number of LLINs per household was higher in the Bamenda Health District (BHD) compared to the Tiko Health District (THD) (2.5±1.2 vs. 2.4±1.6) as well as the household ownership at least one LLIN (93.30% vs. 89.00%). 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 SHD (p = 0.007, OR; 2.8, 95% C.I; 1.3 – 5.8), were more likely to own at least one LLIN compared to those in THD.

Conclusion: Ownership of LLINs was low in SHD and THD in comparison to the goal of one for every two household members. Overall LLINs coverage and accessibility was still low after the free MDCs, as only 14.6% of children 0 – 5 years and 16.1% of the entire population used LLIN the night before the survey.

Keywords: LLINs, Ownership, Universal coverage, Utilisation, LLINs Maintenance

INTRODUCTION

Malaria is a preventable and curable disease transmitted by the bites of 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 [2, 3].

Africa is the most affected region, with 90% of all estimated malaria cases and 91% of deaths in 2016 and 15 African countries alone contributing 80% of all cases, Nigeria and the Democratic Republic of the Congo (DRC), being the top two contributors [1, 3].

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 DRC to the south, through the Ministry of Health (MOH), completed her second national universal long-lasting insecticidal nets (LLIN) campaign in 2016. With support from the Global Fund, the MOH has made provision of free LLINs to pregnant women at antenatal care (ANC) clinics since 2008 [4, 5]. 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 [6, 7]. Malaria continues to be 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 [4]. It is the first major cause of morbidity and mortality among the most vulnerable groups [5, 8, 9]: children under five years and pregnant women, accounting respectively for 18% and 5% of the total population estimated at 19 million [10].

The main contemporary malaria control interventions are insecticide-treated bed nets (ITNs) and indoor residual spraying (IRS) [1, 5, 11, 12]. 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 where 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 [13]. The proportion of people in SSA sleeping under a LLIN rose from less than 2% to over 50% between 2000-2015, preventing an estimated 450 million malaria cases [14].

Most studies in Cameroon have focused on various aspects of net ownership and utilisation. Effective LLIN use in the prevention of malaria in parts of Mezam Division, North West Region [15], *Plasmodium falciparum* infection in Rural and Semi-Urban Communities in the South West Region [6], predictive factors of ownership and utilisation in the Bamenda Health District (BHD) [16] and socio-demographic factors influencing the ownership and utilization among malaria vulnerable groups in the Buea Health District [17]. However, there is paucity information on the indicators of LLIN ownership and utilisation. This study examines the indicators of net ownership and utilisation as well as maintenance, through analysis of household survey data collected in three health districts in Cameroon and discuss their implications for programmatic interventions designed to increase LLINs ownership and use.

MATERIALS AND METHODS

Study area

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 [18]. Generally, malaria in Cameroon is caused mainly by *Plasmodium falciparum*, with *Anopheles gambiae* as the major vector [5, 10].

The BHD (a semi-urban community) and the SHD (a rural community) are in the high western plateau altitude malaria geographical strata of Cameroon, where malaria transmission is permanent, occurring all year long, sometimes lessened by altitude though never totally absent [10, 19]. It is one of the most densely populated regions of Cameroon [5, 10].

The THD (urban and rural communities) is in the coastal strata, zone of dense hygrophile forest and mangrove swamp with the highest transmission of malaria in the country [5, 10]. Like the Buea health district, the THD has a constant variation in the trends of malaria prevalence all-round the year [20, 21].

Sampling design

This cross-sectional household survey conducted in the THD from June to July 2017 and BHD and SHD from March to May 2018 utilised a stratified multi-stage cluster sampling design. A study sampling frame included all health areas (HAs) in the study area, except those that were inaccessible for security reasons. Within each HA: urban, rural or semi-urban localities were sub-divided into quarters (the 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 and 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 also by PPS, thus totalling 31 quarters (Figure 1) in the sample.

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 leader to determine the sampling interval to select the households.

Figure 1: Multi-stage sampling (HA; Health Area, SRS; Simple Random Sampling)

Sample size determination

A minimum sample size of 384 for each health district, was determined with the Cochrane formula [22]: $n = \frac{Z^2 pq}{d^2}$

Where: n = minimum sample size, Z = 1.96, critical Z value at 95% confidence interval (95% C.I.), p = 50% estimated population of households owning mosquito bed nets = 0.5, $q = 1 - p = 0.5$, $(p)(q) = (0.5)^2 = 0.25$, d = acceptable margin of error for proportion being estimated = 0.05.

Recruitment procedures and measures

Interviewers explained the purpose of the study and obtained verbal informed consent from the head of the household or spouse. In cases where neither household head was available, any elderly person who has lived in the house for at least the last 12 months replaced him/ her.

Outcome variables

The main LLIN outcome variables were;

1. **LLINs ownership indicators**: *Household LLINs ownership*: 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, the total number of households surveyed. *Coverage*: proportion of households with at least a LLIN for every two people, where the numerator comprises all households where the ratio between number of LLINs owned and the number of *de-jure* members of that household, that is, usual members excluding visitors, is 0.5 or higher and the denominator is the total number of sampled households. *Access to LLINs within the household*: proportion of population with access to LLINs (population that could sleep under a LLIN if each LLIN in the household were used by up to two people) and proportion of the *de-facto* household population that slept under a LLIN last night. *De-facto* household members are all people present in the household on night of the survey including visitors [8, 23].

2. **LLIN utilisation indicators**: *Household universal utilisation*: proportion of population that slept under a LLIN the previous night [8, 23]. *By the vulnerable population in the household*: proportion of children under five (or pregnant women) that slept under a LLIN the previous night [8]. *Regularly sleeping under bed nets*: household heads who reported habitually using nets on a daily basis [24]. *Household head slept under a LLIN last night*: proportion of households in which the household head slept under a LLIN last night, where the numerator comprises the number of households surveyed wherein the household head slept under a LLIN last night and the denominator, the total number of households surveyed.
3. **Independent variables (IV)** considered for association with LLIN ownership, use and maintenance were age, gender, marital status, education, occupation, health district, house type and household composition.

Statistical analysis

We entered data into, and analysed with IBM-SPSS Statistics 21.0 for windows (IBM-SPSS Corp., Chicago USA). The Chi square (χ^2) test was used to compare socio-demographic characteristics with the health districts and multivariate logistic regression to identify significant correlates of the main outcomes. *p* values less than 0.05 were considered significant.

Ethics statement

The study, obtained approval from the Institutional Review Board of the Faculty of Health Sciences, University of Buea (Nº: 624-05). Administrative authorisation was obtained from the South West Regional Delegation of Public Health. Written informed consent was obtained from all participants and confidentiality was maintained at all steps of data collection.

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. There were generally more female (68.0%) household heads than males, with mean (±SD) age of participants of 36.1±10.8. The overall mean household (or family) size was 4.7±2.1 members: 4.6±2.1 in BHD and 5.0±2.5 in THD (Table 1).

Majority of the houses, 804 (64.3%) were made of cement, while households with 1 - 2 bedrooms; mean number of bedrooms 2.0±1.1 were about 1,141 (91.2%). 1,116 (89.2%) of the households were located near mosquito breeding sites: farms/ gardens, bushes or pools of water.

Table 1: Socio-demographic characteristics: by health districts

Characteristic	Health district			*n* (%)	χ^2 /F	*p* value
	Bamenda	**Santa**	**Tiko**			
Age groups (in years)	*n* = 448	*n* = 385	*n* = 418			
20	9	6	15	30 (2.4)	46.484	**< 0.001**
21 – 30	147	112	199	458 (36.6)		
31 – 40	151	115	96	362 (28.9)		
41 – 50	74	86	58	218 (17.4)		
51 – 60	67	66	50	183 (14.6)		
Mean age	36.2±9.9	38.0±11.0	34.3±11.2	36.1±10.8	12.374	**< 0.001**
Gender						
Females	282	288	281	851 (68.0)	13.572	**0.001**
Males	166	97	137	400 (32.0)		
Marital status						
Unmarried	179	232	154	565	52.021	**< 0.001**
Married	269	153	264	686		
Education						
No formal education (NFE)	70	32	14	116 (9.3)	146.672	**< 0.001**
Primary	75	105	190	370 (29.6)		
Secondary	157	143	170	470 (37.6)		
Tertiary	146	105	44	295 (23.6)		
Occupation						
Unemployed	0	140	59	199 (15.9)	748.205	**< 0.001**
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	16	0	68	84	292.502	**< 0.001**
Mixed (Block & Plank)	0	44	63	107		
Mud Block	125	131	0	256		
Cement Block	307	210	287	804		
Number of bedrooms						
1 – 3	410	353	378	1,141	0.479	0.787
4 – 7	38	32	40	110		
Mean number of bedrooms	2.0±1.0	1.9±1.1	1.9±1.2	2.0±1.1	0.728	0.483
Environmental factor						
No	85	21	29	135	48.991	**< 0.001**
Yes	363	364	389	1,116		
Household Composition						
Mean number of children < 5	1.0±1.0	1.2±1.1	0.9±0.9	1.0±1.0	12.765	**< 0.001**
Mean household size	4.6±2.2	4.5±1.7	5.0±2.5	4.7±2.1	6.734	**0.001**
Net Ownership						
Mean number of nets in HHs	2.5±1.4	2.2±1.2	2.4±1.6	2.4±1.4	5.357	**0.005**
Mean number of reserved nets	0.5±0.9	1.3±1.1	0.5±0.9	0.7±1.0	95.293	**< 0.001**
Number of HHs surveyed						
Children 0 - 5 surveyed	448	465	354	1,267	52.551	**< 0.001**
Children 6 - 17 surveyed	728	544	704	1,976	101.855	< 0.001
Persons ≥ 18	835	680	1,019	2,534	157.818	< 0.001
Expectant women surveyed	46	35	12	93	19.418	**< 0.001**
Population surveyed	2,057	1,724	2,089	5,870	90.826	< 0.001
Bednet : Person ratio	0.5	0.5	0.5	0.5		

Bolded: Statistically significant (*p* value < 0.05), HH = Household

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	**0.002**	5,577 (95.0)	2,000	1,680	1,897
Coverage	836 (66.8)	387	214	235	120.46	**< 0.001**	3,913 (66.7)	1,893	937	1,083
Accessibility	865 (69.1)	374	214	277	77.97	**< 0.001**	4,058 (69.1)	1,825	937	1,296
Utilisation										
Children 0 – 5 years	520 (41.6)	250	103	167	381.58	**< 0.001**	859 (14.6)	427	188	244
Entire household	256 (20.5)	193	4	59	238.94	**< 0.001**	942 (16.0)	767	10	165
Regularly	484 (38.7)	87	203	194	112.62	**< 0.001**	1,296 (22.1)	346	297	653
By house head last night	350 (28.0)	152	94	104	12.29	**0.002**	705 (12.0)	356	111	238

LLINs ownership and coverage

1,157 (92.5%) of the 1,251 households sampled, had at least one LLINs while 836 (66.8%) had at least one 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 in the households was 2.4±1.4. LLINs ownership and coverage were associated to health districts (Table 3), where households in the THD significantly ($p = 0.007$) owned few nets, while those in the BHD significantly ($p < 0.001$) had more coverage than other district. However, after adjusting with educational and marital status, association to heath districts was still significant. Coverage was also associated with gender of the household head and household size (Table 3), where households headed by females ($p = 0.005$) and those of household size of 1 – 4 members ($p = 0.002$) significantly influenced coverage than the others. Secondary educational and unskilled occupational status significantly influenced household ownership of nets ($p < 0.05$).

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

DV →	Ownership			Coverage			Accessibility		
IV ↓	***n* (%)**	***p* value**	**OR (95% C.I.)**	***n* (%)**	***p* value**	**OR (95% C.I.)**	***n* (%)**	***p* value**	**OR (95% C.I.)**
Age groups	*n* = 1,157			*n* = 836			*n* = 865		
20	26 (2.3)	0.668	0.7 (0.2 - 2.9)	17 (2.0)	0.584	0.8 (0.3 - 1.9)	19 (2.2)	0.588	0.8 (0.3 - 1.9)
21 – 30	421 (36.4)	0.577	1.2 (0.6 - 2.6)	308 (36.8)	0.619	1.1 (0.7 - 1.7)	320 (37.0)	0.818	1.0 (0.6 - 1.5)
31 – 40	341 (29.5)	0.435	1.4 (0.6 – 3.0)	246 (29.4)	0.926	1.0 (0.7 - 1.6)	249 (28.8)	0.464	0.9 (0. 6 - 1.3)
41 – 50	199 (17.2)	0.24	0.6 (0.3 - 1.4)	145 (17.3)	0.550	1.1 (0.7 - 1.8)	149 (17.2)	0.887	1.0 (0.6 - 1.5)
51 – 60	170 (14.7)	Ref	1.0	120 (14.4)	Ref	1.0	128 (14.8)	Ref	1.0
Gender									
Female	786 (67.9)	0.555	0.9 (0.5 - 1.4)	582 (69.6)	**0.005**	1.5 (1.1 - 2.0)	607 (70.2)	**< 0.001**	1.7 (1.3 - 2.3)
Male	371 (32.1)	Ref	1.0	254 (30.4)	Ref	1.0	258 (29.8)	Ref	1.0
Marital status									
Unmarried	512 (44.3)	0.177	0.7 (0.4 - 1.2)	360 (43.1)	**0.010**	0.7 (0.5 - 0.9)	365 (42.2)	**0.005**	0.7 (0.5 - 0.9)
Married	645 (55.7)	Ref	1.0	476 (56.9)	Ref	1.0	500 (57.8)	Ref	1.0
Education									
NFE	108 (9.3)	0.666	0.8 (0.3 - 2.2)	94 (11.2)	0.282	1.4 (0.8 - 2.5)	95 (11.0)	0.240	1.4 (0.8 - 2.5)
Primary	346 (29.9)	0.530	0..8 (0.4 - 1.7)	222 (26.6)	0.060	0.7 (0.5 - 1.0)	242 (28.0)	0.145	0.8 (0.5 - 1.1)
Secondary	421 (36.4)	**0.024**	0.5 (0.2 - 0.9)	303 (36.2)	0.054	0.7 (0.5 - 1.0)	312 (36.1)	0.071	0.7 (0.5 - 1.0)
Tertiary	282 (24.4)	Ref	1.0	217 (26.0)	Ref	1.0	216 (25.0)	Ref	1.0
Occupation									
Unemployed	182 (15.7)	**0.012**	0.2 (0.0 - 0. 7)	124 (14.8)	0.674	1.2 (0.6 - 2.3)	130 (15.0)	0.599	1.2 (0.6 - 2.3)
Agricultural	174 (15.0)	**0.007**	0.2 (0.1 - 0.6)	148 (17.7)	**0.023**	0.5 (0.3 - 0.9)	150 (17.3)	0.084	0.6 (0.3 - 1.1)
Household & domestic	50 (4.3)	**0.02**	0.1 (0.0 - 0.7)	26 (3.1)	**0.039**	0.4 (0.2 – 1.0)	33 (3.8)	**0.047**	0.4 (0.2 – 1.0)
Unskilled	408 (35.3)	**0.018**	0.2 (0.1 - 0.8)	289 (34.6)	0.509	0.8 (0.5 - 1.5)	295 (34.1)	0.446	0.8 (0. 5 - 1.4)
State/ Parastatal	197 (17.0)	**0.022**	0.2 (0.1 - 0.8)	121 (14.5)	0.166	0.6 (0.3 - 1.2)	132 (15.3)	0.176	0.7 (0.4 - 1.2)
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)	0.258	1.5 (0.7 - 3.0)	387 (46.3)	**< 0.001**	5.8 (3.6 - 9.4)	374 (43.2)	**< 0.001**	2.8 (1.8 - 4.5)
Santa	367 (31.7)	**0.007**	2.8 (1.3 - 5.8)	214 (25.6)	0.420	0.9 (0.6 - 1.3)	241 (24.7)	**0.008**	0.6 (0.4 - 0.9)
Tiko	372 (32.2)	Ref	1.0	235 (28.1)	Ref	1.0	277 (32.0)	Ref	1.0
House type									
Caraboat	77 (6.7)	0.358	1.5 (0.6 - 3.8)	52 (6.2)	0.818	1.1 (0.6 - 1.8)	61 (7.1)	0.409	1.3 (0.7 - 2.2)
Mixed	103 (8.9)	0.077	2.7 (0.9 - 7.8)	66 (7.9)	0.111	1.4 (0.9 - 2.3)	71 (8.2)	0.209	1.3 (0.9 - 2.1)
Mud Block	239 (20.7)	0.912	1.0 (0.5 - 1.9)	162 (19.4)	**0.002**	0.6 (0.4 - 0.8)	162 (18.7)	**0.011**	0.6 (0.5 - 0.9)
Cement Block	738 (63.8)	Ref	1.0	556 (66.5)	Ref	1.0	571 (66.0)	Ref	1.0
House size									
1 - 3 bedrooms	1055 (91.2)	0.866	0.9 (0.4 - 2.1)	758 (90. 7)	0.069	0.6 (0.4 - 1.0)	786 (90.9)	0.355	0.8 (0.5 - 1.3)
4 - 7 bedrooms	102 (8.8)	Ref	1.0	78 (9.3)	Ref	1.0	79 (9.1)	Ref	1.0
House composition									

0 Children 0 - 5 SHLN	417 (36.0)	0.082	0.2 (0.1 - 1.2)	329 (39.4)	0.230	0.7 (0.4 - 1.3)	339 (39.2)	0.691	0.9 (0.5 - 1.6)
1 - 2 Children 0 - 5 SHLN	639 (55.2)	0.791	0.8 (0.2 - 3.9)	439 (52.5)	0.402	0.8 (0.5 - 1.4)	456 (52.7)	0.743	0.9 (0.5 - 1.6)
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)	0.306	0.6 (0.2 - 1.7)	433 (51.8)	**0.002**	2.3 (1.4 - 3.8)	429 (49.6)	0.096	1.5 (0.9 - 2.6)
Family size 5 – 7	478 (41.3)	0.79	1.2 (0.4 - 3.5)	322 (38.5)	0.070	1.5 (1.0 - 2.5)	347 (40.1)	0.107	1.5 (0.9 - 2.3)
Family size ≥ 8	128 (11.1)	Ref	1.0	81 (9.7)	Ref	1.0	89 (10.3)	Ref	1.0

DV = Dependent variable, IV = Independent variable

Household accessibility to LLINs

Overall household accessibility to bednets was 865 (69.1%), with a significant association to health districts χ^2 (2, N = 1,251) = 77.97, $p < 0.001$ (Table 2).

Household accessibility (Table 3) to bednets was associated to gender of the household head and health districts, where household residents in housed headed by females and those in the BHD significantly ($p < 0.001$) had more access to LLINs than the other groups. After adjusting with educational and marital status, the significance between accessibility and gender and health district was maintained. 4,058 (69.1%) of the *de-facto* population, from 865 (69.1%) of the 1,251 households sampled, had access to LLINs in the household.

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). Bednet utilisation in households by all children 0 – 5 years and the entire family (Table 4), was associated to age and health district where more households with household heads in the 21 – 30 years age group ($p = 0.021$) and in the BHD ($p < 0.001$) significantly used nets than the other groups. The household utilisation of bednets by all children 0 – 5 years old (Table 4), was also associated to the gender and educational status of the household head where more households with female heads and those with primary and secondary educational status significantly ($p < 0.05$) used the nets last night than the other groups. Bednet utilisation by the entire family (Table 4) was associated to the composition of the household, where more households with no children < 5 and with fewer members (1 – 4) significantly ($p < 0.05$) used nets than the other groups.

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

DV →	Children < 5 years old			Entire household		
IV ↓	***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)	**0.048**	3.0 (1.0 - 8.6)	6 (2.3)	0.147	2.5 (0.7 - 8.6)
21 – 30	184 (35.4)	**0.021**	1.8 (1.1 - 3.0)	111 (43.4)	**0.003**	2.6 (1.4 - 4.8)
31 – 40	146 (28.1)	0.306	1.3 (0.8 - 2.2)	76 (29.7)	0.121	1.6 (0.9 - 3.1)
41 – 50	108 (20.8)	**0.003**	2.4 (1.3 - 4.2)	35 (13.7)	0.173	1.6 (0.8 - 3.3)
51 – 60	66 (12.7)	Ref	1.0	28 (10.9)	Ref	1.0
Gender						
Female	357 (68.7)	**0.008**	1.6 (1.1 - 2.3)	166 (64.8)	0.689	0.9 (0.6 - 1.4)
Male	163 (31.3)	Ref	1.0	90 (35.2)	Ref	1.0
Marital status						
Unmarried	176 (33.9)	**0.010**	0.6 (0.5 - 0.9)	98 (38.3)	**0.003**	0.6 (0.4 - 0.8)
Married	344 (66.2)	Ref	1.0	158 (61.7)	Ref	1.0
Education						
NFE	53 (10.2)	0.576	0.8 (0.5 - 1. 6)	34 (13.3)	0.271	1.5 (0.8 - 2.8)
Primary	165 (31.7)	**0.002**	2.1 (1.3 - 3.4)	60 (23.4)	0.793	1.1 (0.6 - 1.9)
Secondary	194 (37.3)	**0.035**	1.59 (1.0 - 2.4)	95 (37.1)	0.582	1.1 (0.7 - 1.8)
Tertiary	108 (20.8)	Ref	1.0	67 (26.2)	Ref	1.0
Occupation						
Unemployed	59 (11.4)	0.077	0.5 (0.3 - 1.1)	14 (5.5)	0.114	2.0 (0.8 - 4.9)
Agricultural	115 (22.1)	0.055	1.8 (1.0 - 3.4)	66 (25.8)	0.219	0.7 (0.4 - 1.2)
Household & domestic	31 (6.0)	0.770	1.2 (0.5 - 2.9)	8 (3.1)	0.891	0.9 (0.3 - 2.6)
Unskilled	151 (29.0)	0.067	0.6 (0.3 - 1.0)	77 (30.1)	0.434	0.8 (0.5 - 1.4)
State/ Parastatal	77 (14.8)	0.407	0.8 (0.4 - 1.4)	26 (10.2)	0.177	0.6 (0.3 - 1.2)
Professional	87 (16.7)	Ref	1.0	65 (25.4)	Ref	1.0
Health District						
Bamenda	250 (48.1)	**< 0.001**	3.2 (1.9 - 5.3)	193 (75.4)	**< 0.001**	7.6 (4.3 - 13.3)
Santa	103 (19.8)	**< 0.001**	3.4 (2.0 – 6.0)	4 (1.6)	**< 0.001**	0.1 (0.0 - 0.2)
Tiko	167 (32.1)	Ref	1.0	59 (23.1)	Ref	1.0
House type						
Caraboat	37 (7.1)	0.518	0.8 (0.4 - 1.5)	16 (6.3)	0.895	1.1 (0.5 - 2.1)
Mixed	35 (6.7)	**0.013**	0.5 (0.3 - 0.9)	7 (2.7)	0.601	0.8 (0.3 - 1.9)
Mud Block	115 (22.1)	0.716	0.9 (0.6 - 1.4)	58 (22.7)	0.960	1.0 (0.6 - 1.6)
Cement Block	333 (64.1)	Ref	1.0	175 (68.4)	Ref	1.0
House size						
1 - 3 bedrooms	470 (90.4)	0.446	1.2 (0.7 - 2.1)	233 (91.0)	0.162	0.6 (0.3 - 1.2)
4 - 7 bedrooms	50 (9.6)	Ref	1.0	23 (8.9)	Ref	1.0
House composition						
0 Children 0 - 5 SHLN				128 (50.0)	**0.029**	3.5 (1.1 - 10.5)
1 - 2 Children 0 - 5 SHLN				123 (48.1)	0.062	2.7 (1.0 - 7.6)
3 - 4 Children 0 - 5 SHLN				5 (2.0)	Ref	1.0
Family size 1 – 4	113 (21.7)	**< 0.001**	0.0 (0.0 - 0.1)	175 (68.4)	**< 0.001**	8.0 (3.6 – 18.0)
Family size 5 – 7	315 (60.6)	**0.007**	0.4 (0.2 - 0.8)	70 (27.3)	0.060	2.1 (1.0 - 4.4)
Family size ≥ 8	92 (17.7)	Ref	1.0	11 (4.3)	Ref	1.0
Own at least one LLIN						
No	2 (0.4)	**< 0.001**	0.0 (0.0 - 0.2)	1 (0.4)	**< 0.001**	0.0 (0.0 - 0.2)
Yes	518 (99.6)	Ref	1.0	255 (99.6)	Ref	1.0
Install nets on all beds						
No	124 (23.9)	**< 0.001**	0.5 (0.3 - 0.7)	58 (22.7)	**< 0.001**	0.4 (0.3 - 0.6)
Yes	396 (76.1)	Ref	1.0	198 (77.3)	Ref	1.0
Environmental factor						
No	64 (12.3)	**0.019**	1.9 (1.1 - 3.3)	46 (18.0)	0.735	1.1 (0.7 - 1.8)
Yes	456 (87.7)	Ref	1.0	210 (82.0)	Ref	1.0

SHLN: Slept Home Last Night

Of the 1,251 households 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 use of bednets on all nights of the week and consequently last night (Table 5) by the household head was associated to the age of the household head as well as to the health districts, where more household heads in the 21 – 30 and 31 – 40 age groups, and 20 and 41 – 50 age groups significantly ($p < 0.05$) used bednets regularly and last night than the other age groups. Also, more household heads in the SHD and BHD significantly ($p < 0.05$) used bednets on all nights of the week and last night respectively (Table 5). After adjustments of all utilisation indicators with educational and marital status, significance was maintained.

Table 5: Multinomial logistic regression of socio-demographic characteristics in association with regular use of LLINs and house head use of LLINs last night

DV →	Regular use of LLIN			Used LLIN last night		
IV ↓	***n* (%)**	***p* value**	**OR (95% C.I.)**	***n* (%)**	***p* value**	**OR (95% C.I.)**
Age groups (in years)	*n* = 484			*n* = 350		
20	9 (1.9)	0.701	1.2 (0.5 - 3.1)	12 (3.4)	**0.049**	2.4 (1.0 - 5.6)
21 – 30	189 (39.1)	**0.005**	1.7 (1.2 - 2.9)	131 (37.4)	0.064	1.5 (1.0 - 2.4)
31 – 40	151 (31.2)	**0.009**	1.8 (1.2 - 2.8)	105 (30.0)	0.073	1.5 (1.0 - 2.3)
41 – 50	75 (15.5)	0.710	1.1 (0.7 - 1.7)	64 (18.3)	**0.040**	1.7 (1.0 - 2.7)
51 – 60	60 (12.4)	Ref	1.0	38 (10.9)	Ref	1.0
Gender						
Female	347 (71.7)	0.961	1.0 (0.8 - 1.4)	238 (68.0)	0.601	0.9 (0.7 - 1.2)
Male	137 (28.3)	Ref	1.0	112 (32.0)	Ref	1.0
Marital status						
Unmarried	203 (41.9)	**0.021**	0.7 (0.5 – 1.0)	158 (45.1)	0.533	1.1 (0.8 - 1.5)
Married	281 (58.1)	Ref	1.0	192 (54.9)	Ref	1.0
Education						
NFE	33 (6.8)	0.631	1.1 (0.7 – 2.0)	27 (7.7)	0.108	0.7 (0.4 - 1.1)
Primary	149 (30.8)	0.999	1.0 (0.7 - 1.5)	84 (24.0)	**0.031**	0.7 (0.4 – 1.0)
Secondary	206 (42.6)	0.087	1.4 (1.0 – 2.0)	144 (41.1)	0.725	0.9 (0.7 - 1.3)
Tertiary	96 (19.8)	Ref	1.0	95 (27.1)	Ref	1.0
Occupation						
Unemployed	85 (17.6)	**0.034**	0.5 (0.3 – 1.0)	40 (11.4)	0.541	0.8 (0.5 - 1.5)
Agricultural	46 (9.5)	0.998	1.0 (0.6 - 1.7)	54 (15.4)	0.900	1.0 (0.6 - 1.6)
Household & domestic	32 (6.6)	0.795	1.1 (0.5 - 2.5)	19 (5.4)	0.057	2.1 (1.0 - 4.6)
Unskilled	178 (36.8)	0.199	0.7 (0.4 - 1.2)	122 (34.9)	0.456	1.2 (0.8 - 1.9)
State/ Parastatal	101 (20.8)	0.620	0.8 (0.5 - 1.5)	64 (18.3)	0.359	1.3 (0.8 - 2.2)
Professional	42 (8.7)	Ref	1.0	51 (14.6)	Ref	1.0
Health District						
Bamenda	87 (18.0)	**< 0.001**	0.3 (0.2 - 0.4)	152 (43.4)	**0.021**	1.6 (1.1 - 2.5)
Santa	203 (41.9)	**< 0.001**	2.1 (1.4 - 3.2)	94 (26.9)	0.896	1.0 (0.7 - 1.6)
Tiko	194 (40.1)	Ref	1.0	104 (29.7)	Ref	1.0
House type						
Caraboat	29 (6.0)	0.322	0.8 (0.4 - 1.3)	11 (3.1)	**0.008**	0.4 (0.2 - 0.8)
Mixed	60 (12.4)	0.462	1.2 (0.8 - 1.9)	27 (7.7)	0.836	1.0 (0.6 - 1.6)
Mud Block	78 (16.1)	**0.046**	0.7 (0.5 – 1.0)	74 (21.1)	0.703	0.9 (0.7 - 1.3)
Cement Block	317 (65.5)	Ref	1.0	238 (68.0)	Ref	1.0
House size						
1 - 3 bedrooms	156 (32.2)	0.308	0.7 (0.4 - 1.3)	127 (36.3)	0.710	0.9 (0.5 - 1.6)
4 - 7 bedrooms	275 (56.8)	0.654	0.9 (0.5 - 1.5)	192 (54.9)	0.985	1.0 (0.6 - 1.7)
House composition		Ref	1.0	31 (8.9)	Ref	1.0
0 Children 0 - 5 SHLN	225 (46.5	0.654	1.1 (0.7 - 1.9)	169 (48.3)	0.259	0.8 (0.5 - 1.2)
1 - 2 Children 0 - 5 SHLN	205 (42.4)	0.459	1.2 (0.6 - 1.9)	135 (38.6)	0.222	0.8 (0.5 - 1.2)
3 - 4 Children 0 - 5 SHLN	54 (11.2)	Ref	1.0	46 (13.1)	Ref	1.0
Family size 1 – 4	225 (46.5)	0.696	1.1 (0.7 - 1.8)	169 (48.3)	0.268	0.8 (0.5 - 1.2)
Family size 5 – 7	205 (42.4)	0.471	1.2 (0.6 - 1.9)	135 (38.6)	0.222	0.8 (0.5 - 1.2)
Family size ≥ 8	54 (11.2)	Ref	1.0	46 (13.1)	Ref	1.0
Own at least one LLIN						
No	9 (1.9)	**0.001**	0.3 (0.1 - 0.6)	27 (7.7)	0.422	1.3 (0.7 - 2.2)
Yes	475 (98.1)	Ref	1.0	323 (92.3)	Ref	1.0
Install nets on all beds						
No	98 (20.3)	**< 0.001**	0.4 (0.3 - 0.5)	113 (32.3)	0.171	0.8 (0.6 - 1.1)
Yes	386 (79.7)	Ref	1.0	237 (67.7)	Ref	1.0
Environmental factor						
No	40 (8.3)	0.835	1.1 (0.7 - 1.7)	44 (12.6)	0.739	1.1 (0.7 - 1.6)
Yes	444 (91.7)	Ref	1.0	306 (87.4)	Ref	1.0

The other uses, "out of norms", of LLINs are summarised in Table 6. 28.7% (95% C.I; 26.3 – 31.3) of 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). With the exception of harvesting and drying of melon seeds (egussi), all the other "out of norm" uses of LLINs were significantly ($p < 0.05$) associated to the health districts.

Table 6: Missuses of LLINs: 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**

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. The question of washing bednets or not (Table 7), was associated to the gender of the household head, where households with females heads significantly ($p = 0.027$) washed them compared to those headed by males. The WHO recommended washing frequency was associated to age of the household head and health district, where households with heads in the 31 – 40 years age group ($p = 0.018$) and those in the BHD ($p < 0.001$) abided more significantly to the recommended washing frequency than those in the other age groups and health districts respectively.

Table 7: Logistic regression of socio-demographic characteristics in association with LLINs maintenance

DV →	Can wash LLINs			Recommended wash frequency		
IV ↓	***n* (%)**	***p* value**	**OR (95% C.I.)**	***n* (%)**	***p* value**	**OR (95% C.I.)**
Age groups (in years)	*n* = 1089			*n* = 627		
20	24 (2.2)	0.256	0.6 (0.2 - 1.6)	10 (1.6)	0.335	0.7 (0.3 - 1.5)
21 – 30	396 (36.4)	0.449	0.8 (0.5 - 1.1)	216 (34.5)	0.653	1.1 (0.8 - 1.6)
31 – 40	313 (28.7)	0.278	0.7 (0.4 - 1.3)	208 (33.2)	**0.018**	1.6 (1.1 - 2.3)
41 – 50	194 (17.8)	0.894	1.0 (0.5 -1.8)	109 (17.4)	0.272	1.3 (0.8 - 1.9)
51 – 60	162 (14.9)	Ref	1.0	84 (13.4)	Ref	1.0
Gender						
Female	755 (69.3)	**0.027**	1.5 (1.1 - 2.1)	431 (68.7)	0.056	1.3 (1.0 - 1.9)
Male	334 (30.7)	Ref	1.0	196 (31.3)	Ref	1.0
Marital status						
Unmarried	485 (44.5)	0.477	0.9 (0.6 - 1.3)	263 (41.9)	0.359	0.9 (0.7 - 1.2)
Married	604 (55.5)	Ref	1.0	364 (58.1)	Ref	1.0
Education						
NFE	106 (9.7)	0.079	2.0 (0.9 - 4.2)	62 (9.9)	0.416	0.8 (0.5 - 1.3)
Primary	316 (29.0)	0.483	0.8 (0.5 - 1.4)	171 (27.3)	0.971	1.0 (0.7 - 1.4)
Secondary	416 (38.2)	0.229	1.3 (0.8 -2.1)	235 (37.5)	0.858	1.0 (0.8 - 1.4)
Tertiary	251 (23.1)	Ref	1.0	159 (25.4)	Ref	1.0
Occupation						
Unemployed	167 (15.3)	0.194	0.6 (0.3 - 1.3)	72 (11.5)	0.246	0.7 (0.4 - 1.3)
Agricultural	163 (15.0)	0.954	1.0 (0.5 - 1.8)	133 (21.2)	0.456	1.2 (0.7 – 2.0)
Household & domestic	54 (5.0)	0.067	7.1 (0.9 - 57.5)	19 (3.0)	**0.032**	0.4 (0.2 - 0.9)
Unskilled	389 (35.7)	0.924	1.0 (0.6 – 2.0)	202 (32.2)	0.200	0.7 (0.5 - 1.2)
State/ Parastatal	190 (17.5)	0.761	1.1 (0.6 - 2.2)	104 (16.6)	0.738	0.9 (0.6 - 1.5)
Professional	126 (11.6)	Ref	1.0	97 (15.5)	Ref	1.0
Health District						
Bamenda	379 (34.8)	0.181	0.7 (0.4 - 1.2)	306 (48.8)	**< 0.001**	2.4 (1.7 - 3.5)
Santa	341 (31.3)	0.381	1.3 (0.8 - 2.1)	146 (23.3)	0.321	0.8 (0.6 - 1.2)
Tiko	369 (33.9)	Ref	1.0	175 (27.9)	Ref	1.0

On the recommended LLINs washing frequency, heads in the BHD ($p < 0.001$, OR; 2.4, 95% C.I; 1.7 – 3.5) were significantly more likely, while those in the SHD ($p = 0.321$, OR; 0.8, 95% C.I; 0.6 – 1.2) were insignificantly less likely to respect the recommended LLINs washing frequency compared to those in the THD (Table 6).

DISCUSSION

This study examined the indicators of LLIN ownership, utilization and maintenance in the Bamenda, Santa and Tiko Health Districts. Overall, 92.5% and 20.5% of households interviewed owned at least one LLIN per household and utilisation by 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, 2], to ≥ 80%. Household ownership of at least one LLIN per household in this study is higher than rates reported elsewhere in Cameroon [6, 7, 9, 13, 15-17] and out of Cameroon [24-33]. It was however, lower than proportions reported in Uganda and Myanmar [34, 35] and in line with the 93.5% reported in Madagascar [27]. The high proportion of owning at least a LLIN per household in these health districts could be attributed to the free LLINs mass distribution campaigns (MDC) [6, 10].

The universal household coverage of 66.8% (overall LLIN: Person ratio of 0.50) though within the WHO range of 39 – 75 % [36], was lower than rates reported elsewhere in Cameroon and Myanmar [13, 35]. It was however, higher compared to rates in Madagascar and Uganda [27, 37] as well as a host of eight African countries [29].

Access to LLINs in the household of 69.1% in this study was lower compared to results reported elsewhere [27, 34], higher than 21% reported in Batwa [38], within the 57.3 – 78.8% in eight African countries [29] and 32.3 – 81.3% reported in a multi-country study [39]. The low household universal coverage and (versus) accessibility in this study, could be attributed to the significant differences amongst the health districts: 86.4% vs 83.5% for the BHD, 55.6% vs 55.6% for the SHD and 56.2% vs 66.3% for the THD; χ^2 (2, N = 1,251) = 120.457, $p < 0.001$ vs χ^2 (2, N = 1,251) = 77.969, $p < 0.001$ 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 to previous studies elsewhere in Cameroon [16, 17] and out of Cameroon [24, 27, 31, 34, 35, 37, 40]. This was however high compared to the 6.9 – 15.3% reported in Myanmar [26]. The very low household LLINs utilisation could be attributed to the significant differences amongst the health districts: 43.1% in the BHD, 1.0% in the SHD and 14.1% in the

THD; χ^2 (2, N = 1,251) = 240.400, $p < 0.001$ as well as household composition and the installation of LLINs on all beds in the household ($p < 0.05$). It could also be due to inadequate education on LLINs utilisation, the 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 the BHD [16], 52% vs 58% in the national territory [7] and elsewhere in the world [25, 27, 28, 31, 35, 37, 40]. 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 household head as well as the presence or absence of bushes or water pools around dwellings ($p < 0.05$).

Use of LLINs by 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 [6] and 47.2% in China [24]. Meanwhile the regular use of LLINs of 38.7% was low compared to 48.0% reported in China [24]. The low use of LLINs last night by household head and regular use of LLINs, could significantly be attributed to differences in the health districts and ages of the household heads ($p < 0.05$).

LLIN misuse of 2.3 – 22.7% was also similar to the 18.2% reported in Mezam Division [15] and 21% in Kenya [41]. The use of LLINs for other purposes, other than the prevention of mosquito bites could be attributed to: inadequate education on utilisation, lack of good playgrounds, as 2.8% (95% C.I, 2.0 – 3.9) of the households admitted that children used 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 [41]. The optimal LLIN washing frequency could be attributed to the age of the household head as well as the health district.

RECOMMENDATIONS

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.

The MOH should sustain another free MDC since those distributed in 2015 - 2016 will be worn out and ineffective in preventing malaria by 2019.

STRENGTHS AND LIMITATIONS OF THE STUDY

Strengths

The data used in this study was collected by trained surveyors, who had mastery of all the HAs as they are responsible for the coding of houses during the Expanded Programme on Immunisation (EPI) and MDC campaigns. All the health district offices were consulted for the mapping of the HAs, quarters and census list of households used in the last MDC and EPI campaigns. In Cameroon, the MOH carries out seasonal EPI 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 variable were measured at the same time. Data was collected through self-reporting and thus there is a possibility of bias where the respondent provides socially acceptable answers. Recall bias can also affect some of the responses and subsequently the results of the study. 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 and number of LLINs in the household was not evaluated. 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 free gift from a relation, and our study design could not capture the contribution of each intervention.

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. However, efforts had reached vulnerable populations in all health districts. 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 and mortality. 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.

ABBREVIATIONS: 95% C.I, 95% Confidence Interval; BHD, Bamenda Health District; HA, Health area; LLINs, Long-lasting insecticidal nets; NFE, No Formal Education; OR, Odds Ratio; *p*, Significance value; RBM, Roll Back Malaria; SD, Standard Deviation; SHD, Santa Health District; THD, Tiko Health District; χ^2, Chi square

DECLARATIONS

Ethics approval and consent to participate

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

Supporting information

S1 file. Questionnaire (PDF).

S2 file. Raw data and sampling files (Excel).

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Competing interests

The authors declare that they have no competing interests.

Authors contributions

CFN, NFPC and NFP conceived and designed the study. CFN, NFPC, MSF, CBM and JPK collected data and CFN analysed it. NFCT and TAN provided resources for the study. NFPC, MSF, CBM and CFN critically reviewed literature and wrote the original draft. NFP supervised the study. All authors contributed to the write up, reviewed the final draft, read and approved the final manuscript.

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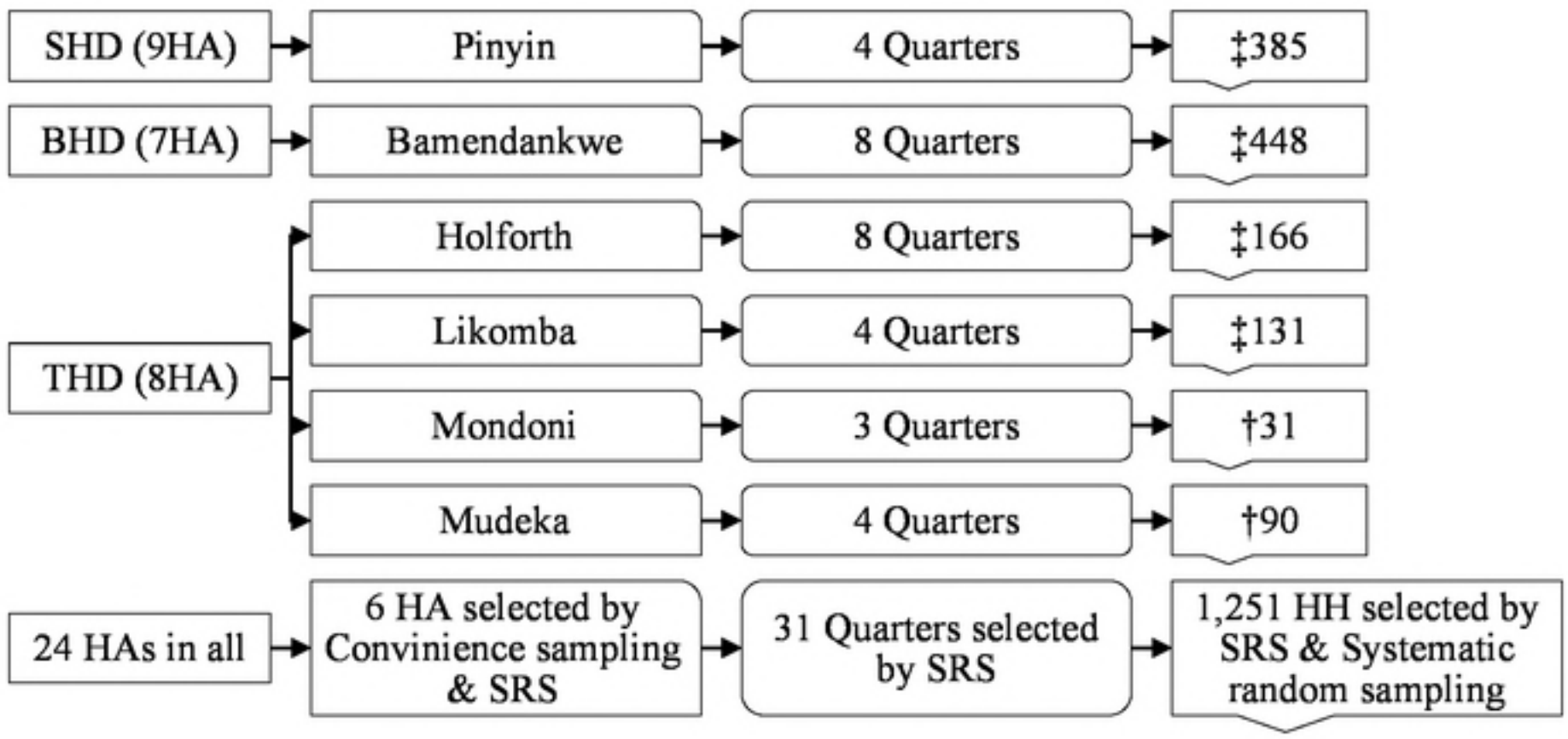

Figure 1: Multi-stage sampling (HA; Health Area, SRS; Simple Random Sampling)

‡Households sampled by systematic random sampling, †Households sampled by SRS

Figure