Effects of long-lasting insecticide net (LLINs) ownership/utilisation indicators on annual household malaria episodes (AHMEs) in three Health Districts in Cameroon

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ABSTRACT

Introduction: Household residents in malaria endemic areas are at high risk of multiple malaria episodes per year. This study investigated the annual household malaria episodes (AHMEs) in three health districts in Cameroon.

Methods: A community-based cross-sectional household survey using a multi-stage cluster design was conducted 2 – 3 years post campaign to assess long-lasting insecticide net (LLINs) ownership, utilisation, and maintenance as well as demographic characteristics. Multinomial regression analysis was used to identify factors associated with household LLIN ownership, utilization, and AHME.

Results: Household LLINs ownership, *de-facto* population with universal utilisation, and AHME were respectively, 92.5%, 16.0%, and 83.4%; thus, 4 out of 25 household residents effectively used LLINs the previous night. AHME was significantly ($p < 0.05$) associated with age and gender (OR; 1.6, 95% C.I; 1.1 – 2.3) of household head, health district (OR; 2.8, 95% C.I; 1.1 – 7.2) and tiredness (OR; 2.6, 95% C.I; 1.0 – 6.3). LLINs ownership and insufficiency also significantly contributed to AHME. The overall average cost for the treatment of malaria was 6,399.4±4,892.8Fcfa (11.1±8.5US$).

Conclusions: The proportion of households with at least one LLIN and those with at least one AHME were high. Findings are of concern given that average cost for the treatment of malaria represents a potentially high economic burden. The results outlined in this paper provide an important tool for the examination of the deficiencies in LLINs regular and universal utilisation.

Keywords: Annual household malaria episodes, Ownership, Universal coverage, Utilisation

RÉSUMÉ

Introduction: Les maisons résidant dans les zones d'endémie du paludisme courent un risque élevé de subir plusieurs épisodes de paludisme par an. Cette étude a examiné les épisodes annuels de paludisme dans les maisons (EAPM) dans trois Districts Sanitaires du Cameroun.

Méthodes: Une enquête transversale de ménage basée sur la communauté utilisant une conception de grappe à plusieurs étapes a été conduite 2 - 3 ans après la campagne pour évaluer la possession, l'utilisation et l'entretien des moustiquaires imprégnées d'insecticide à longue durée (MILD) ainsi que les caractéristiques démographiques. Une analyse de régression multinomiale a été utilisée pour identifier les facteurs associés à l'appropriation, l'utilisation et l'entretien des MILD par les maisons.

Résultats: L'appropriation de MILDs par les maisons, la population *de-facto* avec l'utilisation universelle, et l'EAPM étaient respectivement, 92.5%, 16.0%, et 83.4% ; donc, 4 sur 25 résidents des maisons ont effectivement utilisé des MILDs la nuit précédente. EAPM était significativement ($p < 0.05$) associé avec l'âge et le sexe (OR ; 1.6, 95% C.I ; 1.1 - 2.3) du chef de ménage, le district sanitaire (OR ; 2.8, 95% C.I ; 1.1 - 7.2) et la fatigue (OR ; 2.6, 95% C.I ; 1.0 - 6.3). La possession et l'insuffisance de MILD ont aussi contribué significativement à l'EAPM. Le coût moyen global pour le traitement du paludisme était de 6,399.4±4,892.8Fcfa (11.1±8.5US$).

Conclusions: La proportion des maisons avec au moins une MID et ceux avec au moins un EAPM étaient élevés. Les résultats sont préoccupants étant donné que le coût moyen pour le traitement du paludisme représente un fardeau économique potentiellement élevé. Les résultats décrits dans cet article fournissent un outil important pour l'examen des déficiences dans l'utilisation régulière et universelle des MILDs.

Mots clés: Épisodes annuels de paludisme dans les maisons, Propriété, Couverture universelle, Utilisation.

1. INTRODUCTION

Studies have identified the factors influencing the ownership and utilisation of long-lasting insecticide nets (LLINs) [1-11] in Cameroon and beyond. The utilisation rate of LLINs, especially amongst children less than five years old and pregnant women are widely low [2, 3, 12, 13], and is dropping with time from the date of ownership from a free mass distribution campaign (MDC) or purchase [14].

In malaria-endemic countries, especially those plagued with *Plasmodium falciparum* [15], malaria rates are still high, especially amongst the vulnerable population [16-18]. Malaria is a preventable and curable disease transmitted by the bites of the female Anopheles mosquitoes [16, 17, 19] and a serious global public health problem with an estimated 216 million cases in 91 countries in 2016 [17, 19-22]. Ninety per cent (90%) of all worldwide estimated malaria cases and 91% of deaths in 2016 occurred in 15 African countries alone contributing 80% of all cases [16, 20]. The epidemiology of malaria varies geographically depending on the local malaria transmission intensity or endemicity class as well as the *Plasmodium* species [15, 23]. The prevalence of malaria in Cameroon is 29% [24] and 15.0% in the North West and 46.1% in the South West Region amongst children under five in Cameroon [25].

The determinants of LLINs ownership, coverage, accessibility and utilisation are multiple and their contributions vary according to geographical location, sample size, and season of study [1, 8, 26-28]. Indicators of LLINs ownership and utilisation involve differences between health districts/localities, socio-demographic and economic statutes [12, 13, 29, 30].

The effective utilisation of LLINs has been reported to be invariably associated with ownership [4, 31], although annual household malaria episodes (AHME) is not primarily related to LLINs ownership. It is thought that poor LLINs utilisation by mostly the vulnerable is mostly due to behavioural attitudes of the population [6, 7, 13, 32], while the persistence of malaria is due in

part to, underutilisation of LLINs, the use of other preventive methods, and negligence as well as vector resistance.

Studies in Cameroon and beyond have shown consistently that malaria is, and remains a public health problem [12, 22, 25, 33], with children in the ages of five or younger suffering between one-to-five or more malaria episodes per year [18]. Thus, in this study, the question is, "In health districts with high malaria endemicity and high LLINs ownership, what is the proportion and determinants of AHME, 2 – 3 years after the mass distribution campaign (MDC)?".

2. MATERIALS AND METHODS

2.1 Free Mass Distribution Campaign

The Cameroonian Ministry of Public Health undertook a nationwide free LLIN distribution campaign from health facilities to all households in the country at the end of 2011, with the objective to provide an insecticide-treated net (ITN), with an optimal lifespan of 3 - 5 years [34], to all household beds or a LLIN for every two individuals per household, to a maximum of three ITNs per household, as described elsewhere [10, 12, 35].

2.2 Study area

The study was carried out in the BHD, SHD, and THD which constitute part of the most impoverished populations in Cameroon. These health districts are located in the North West and South West Regions of Cameroon. The characteristics of the study area have been described elsewhere [36].

2.3 Sampling design

This study is part of a prospective cross-sectional survey carried out in the THD in July and June 2017 and in Bamenda and Santa Health Districts in March to May 2018 [36].

2.4 Sample size determination

A minimum sample size of 385 for each health district was calculated as described elsewhere [36].

2.5 Recruitment procedures and measures

At enrolment, a structured questionnaire was used to record ownership of LLINs, utilisation of LLINs, and socio-demographic characteristics as well as housing and AHMEs.

2.6 Outcome variables

The main LLIN outcome variables were;

1. **LLINs ownership indicators**: *Ownership of LLINs, Coverage,* and *Access to LLINs within the household* were defined as described in other studies [10, 11, 37, 38].
2. **LLIN utilisation indicators**: *Household universal utilisation of LLINs* was defined as described in earlier studies [37-39]. *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 [37]. *Regularly sleeping under bed nets*: household heads who reported habitually using nets daily [40]. *Slept under LLINs the previous night (SULPN)*: proportion of household heads who slept under a LLIN the previous night, as described in earlier studies [10, 11].
3. **Annual household malaria episodes (AHME)**: proportion of households which experienced at least one malaria episode in the last one year, where the numerator comprises the number of households surveyed wherein at least one household member suffered a malaria attack and the denominator, the total number of households surveyed.
4. **Independent variables** considered for association with LLIN ownership, use and AHME were age, gender, marital status, education, occupation, health district, house type, and household composition.

2.7 Statistical analysis

Data were 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 AHME and multivariate logistic regression to identify significant correlates of the main outcomes. The level of statistical significance was set at $p < 0.05$.

3. RESULTS

3.1 Characteristics of study participants

A total of 1,251 household heads were surveyed, in the three health districts. The mean (±SD) age of study participants was 36.1 ±10.8, while the overall mean (±SD) household size was 4.7 ±2.1 members: 4.6 ±2.2 in BHD, 4.5 ±1.7 in SHD and 5.0 ±2.5 in THD. The overall mean AMHE was 2.2 ±1.7: 3.1 ±1.8 in BHD, 1.4 ±1.1 in SHD and 2.0 ±1.5 in THD. There was a significant association between AHME and house type as well as health district. Most (68.0%) households were headed by females, while majority (54.8 %) of the respondents were married. About 37.6% of the study participants had attained at least secondary school education and only 9.3% had no formal education (NFE). The greater percentage (35.3%) of the respondents was realised to be doing unskilled labour. Annual household malaria episodes (AHMEs) were frequent (89.2%) in households with surrounding bushes/farms or water pools (**Table 1**). Pregnant women were recorded in 93 (7.43%) of the households and children under the age of five in 766 (61.23%) of the households.

Of the 5,870 individuals (*de-facto* population) covered in the study, 4,908 (82.2%) spent the night in the 1,043 (83.4%) households which had suffered at least an AHME.

Table 1: Socio-demographic characteristics: by AHME

	Dependent variable:	**AHME**				
Independent variable	**Subclass**	**No**	**Yes**	***n* (%)**	***p* value**	**OR (95% C.I.)**
Age groups (in years)	20	13	17	30 (2.4)	**< 0.001**	0.2 (0.1 - 0.4)
	21 – 30	81	377	458 (36.6)	0.233	0.7 (0.4 - 1.2)
	31 – 40	54	308	362 (28.9)	0.620	0.9 (0.5 - 1.5)
	41 – 50	32	186	218 (17.4)	0.935	1.0 (0.6 - 1.8)
	51 – 60	28	155	183 (14.6)	Ref	1.0
	Mean age	34.9±11.4	36.4±10.6	36.1±10.8		
Gender	Females	135	716	851 (68.0)	0.057	1.4 (1.0 - 2.0)
	Males	73	327	400 (32.0)	Ref	1.0
Marital status	Unmarried	102	463	565 (45.2)	0.464	1.1 (0.8 - 1.6)
	Married	106	580	686 (54.8)	Ref	1.0
Education	NFE	13	103	116 (9.3)	0.476	1.3 (0.6 - 2.6)
	Primary	62	308	370 (29.6)	0.215	1.3 (0.8 - 2.1)
	Secondary	83	387	470 (37.6)	0.624	1.1 (0.7 - 1.7)
	Tertiary	50	245	295 (23.6)	Ref	1.0
Occupation	Unemployed	48	151	199 (15.9)	0.728	1.2 (0.5 - 2.5)
	Agricultural	18	173	191 (15.3)	0.337	0.7 (0.3 - 1.5)
	Household & domestic	6	49	55 (4.4)	0.283	1.8 (0.6 - 5.7)
	Unskilled	79	362	441 (35.3)	0.873	1.1 (0.5 - 2.2)
	State/Parastatal	43	173	216 (17.3)	0.871	1.1 (0.5 - 2.3)
	Professional	14	135	149 (11.9)	Ref	1.0
House type	Caraboat	10	74	84 (6.7)	0.205	1.6 (0.8 - 3.4)
	Mixed	21	86	107 (8.6)	0.286	1.3 (0.8 - 2.3)
	Mud Block	35	221	256 (20.5)	**0.043**	1.6 (1.0 - 2.5)
	Cement Block	142	662	804 (64.3)	Ref	1.0
House size	1 - 3 bedrooms	190	951	1,141 (91.2)	0.801	1.1 (0.6 - 1.9)
	4 - 7 bedrooms	18	92	110 (8.8)	Ref	1.0
	Mean number of bedrooms	1.9±1.1	2.0±1.1	2.0±1.1		
Environmental factor	No	21	114	135 (10.8)	0.329	0.8 (0.4 - 1.3)
	Yes	187	929	1,116 (89.2)	Ref	1.0
Family size	1 – 4 members	103	519	622 (49.7)	0.620	1.1 (0.7 - 2.0)
	5 – 7 members	83	413	496 (39.6)	0.768	1.1 (0.6 - 1.9)
	≥ 8 members	22	111	133 (10.6)	Ref	1.0
	Mean family size	4.6±2.2	4.7±2.1	4.7±2.1		
Health District	Bamenda	29	419	448 (35.8)	**< 0.001**	4.5 (2.5 - 8.2)
	Santa	98	287	385 (30.8)	**0.014**	0.6 (0.4 - 0.9)
	Tiko	81	337	418 (33.4)	Ref	1.0
	Total	208	1,043	1,251		

OR = Odds Ratio; C.I. = Confidence Interval; Ref = Reference group; **Boldface** numbers indicate significant *p* values

3.2 Ownership and utilisation of LLINs

A total of 2,958 LLINs were enumerated in the three health districts, overall LLINs density of 2.4 ±1.4. Long-lasting insecticide nets ownership, coverage and accessibility were 92.5%, 66.7% and

69.1% respectively. The utilisation rates were 14.6% for children less than five years old, 4.7% for expectant mothers and 16.0 % for entire households.

Table 2: Indicators of LLINs ownership/utilisation and AHMEs

	Households						*De-facto* population in households			
Indicator	***n* (%)**	**BHD**	**SHD**	**THD**	**χ^2**	***p* value**	***n* (%)**	**BHD**	**SHD**	**TH**
Ownership										
At least one LLIN	1,157 (92.5)	418	367	372	12.23	**0.002**	5,577 (95.0)	2,000	1,680	1,89
Coverage	836 (66.8)	387	214	235	120.46	< **0.001**	3,913 (66.7)	1,893	937	1,08
Accessibility	865 (69.1)	374	214	277	77.97	< **0.001**	4,058 (69.1)	1,825	937	1,29
Utilisation by										
Entire household	256 (20.5)	193	4	59	238.94	< **0.001**	942 (16.0)	767	10	165
Children 0- 5 years	520 (41.6)	250	103	167	381.58	< **0.001**	859 (14.6)	427	188	244
Expectant mothers	59 (4.7)	32	15	12	9.61	**0.008**	273 (4.7)	173	46	54
Regular utilisation	484 (38.7)	87	203	194	112.62	< **0.001**	1,296 (22.1)	346	297	653
Household head last night	350 (28.0)	152	94	104	12.29	**0.002**	705 (12.0)	356	111	238
Installation	811 (64.8)	275	235	301	14.21	**0.001**	4,017 (68.4)	1,347	1,138	1,53
AHME	1,043 (83.4)	419	287	337	57.24	< **0.001**	4,908 (83.6)	1,900	1,290	1,71
Mean AHME	2.2±1.7	3.1±1.8	1.4±1.1	2.0±1.5						

3.3 Determinants of household ownership and utilisation of LLINs

To investigate the determinants of LLINs ownership, coverage as well as utilisation in the three health districts, multinomial logistic regression was performed allowing adjustments for possible confounders. Households in the SHD (OR; 3.7, 95% C.I; 1.9 – 7.5, p <0.001) were significantly associated with LLINs ownership (**Table 3**). A majority of households with at least one LLIN (36.1%; 418/1,157) were found in the BHD, while (32.2%; 372/1,157) were in the THD. The difference was not statistically significant (p = 0.243). Secondary educational status, occupational status, and family size of 1 – 4 members were significantly (p >0.05) not associated with the ownership of at least one LLIN per household.

Being a household head in all the age groups except the 31 – 40 years old group, female, primary, and secondary educational level, BHD, and SHD and with no environmental factor were significant determinants associated with the use of LLINs by all children 0 – 5 years old in the household (**Table 3**). It is worth noting that the majority of the households with heads in the age group 21 – 30 years (35.4%; 184/520), females (68.7%; 357/520), secondary education (37.3%; 194/520) and BHD (48.1%; 250/520), had all children 0 – 5 years using LLINs compared with

their contemporaries. Similarly, there was a significant association between household heads in the 21 – 30 years age group, BHD, families with sizes 1 – 4, and 5 – 7 members in the household and the use of LLINs by the entire household.

Table 3: Multinomial logistic regression of socio-demographic determinants of LLINs ownership and use by all children < 5 and entire household

Dependent variable:	**Ownership of at least one LLIN**			**Used by children < 5 years old**			**Used by entire household**		
	***n* (%)**	***p* value**	**OR (95% C.I.)**	***n* (%)**	***p* value**	**OR (95% C.I.)**	***n* (%)**	***p* value**	**OR (95% C.I.)**
Independent variable	*n* = 1,157			*n* = 520			*n* = 256		
Age groups (in years)									
20				16 (3.1)	**0.048**	3.0 (1.0 - 8.6)	6 (2.3)	**0.197**	2.3 (0.7 - 7.8)
21 – 30				184 (35.4)	**0.021**	1.8 (1.1 - 3.0)	111 (43.4)	**0.003**	2.5 (1.4 - 4.7)
31 – 40				146 (28.1)	0.306	1.3 (0.8 - 2.2)	76 (29.7)	0.133	1.6 (0.9 - 3.0)
41 – 50				108 (20.8)	**0.003**	2.4 (1.3 - 4.2)	35 (13.7)	0.141	1.7 (0.8 - 3.4)
51 – 60				66 (12.7)	Ref	1.0	28 (10.9)	Ref	1.0
Gender									
Female	786 (67.9)	0.751	0.9 (0.6 - 1.5)	357 (68.7)	**0.008**	1.6 (1.1 - 2.3)	166 (64.8)	0.583	0.9 (0.6 - 1.3)
Male	371 (32.1)	Ref	1.0	163 (31.3)	Ref	1.0	90 (35.2)	Ref	1.0
Marital status									
Unmarried	512 (44.3)	0.082	0.6 (0.4 - 1.1)	176 (33.9)	**0.010**	0.6 (0.5 - 0.9)	98 (38.3)	**0.005**	0.6 (0.4 - 0.8)
Married	645 (55.7)	Ref	1.0	344 (66.2)	Ref	1.0	158 (61.7)	Ref	1.0
Education									
NFE	108 (9.3)	0.577	0.8 (0.3 - 2.0)	53 (10.2)	0.576	0.8 (0.4 - 1.6)	34 (13.3)	0.291	1.4 (0.7 - 2.7)
Primary	346 (29.9)	0.814	0.9 (0.4 - 2.0)	165 (31.7)	**0.002**	2.1 (1.3 - 3.4)	60 (23.4)	0.973	1.0 (0.6 - 1.7)
Secondary	421 (36.4)	**0.035**	0.5 (0.2 - 1.0)	194 (37.3)	**0.035**	1.6 (1.0 - 2.4)	95 (37.1)	0.749	1.1 (0.7 - 1.7)
Tertiary	282 (24.4)	Ref	1.0	108 (20.8)	Ref	1.0	67 (26.2)	Ref	1.0
Occupation									
Unemployed	182 (15.7)	**0.007**	0.1 (0.0 - 0.6)						
Agricultural	174 (15.0)	**0.011**	0.2 (0.1 - 0.7)						
Household & domestic	50 (4.3)	**0.035**	0.2 (0.0 - 0.9)						
Unskilled	408 (35.3)	**0.014**	0.2 (0.1 - 0.7)						
State/Parastatal	197 (17.0)	**0.014**	0.2 (0.0 - 0.7)						
Professional	146 (12.6)	Ref	1.0						
Health District									
Bamenda	418 (36.1)	0.243	1.5 (0.8 - 3.1)	250 (48.1)	**< 0.001**	3.2 (1.9 - 5.3)	193 (75.4)	**< 0.001**	7.4 (4.2 - 13.0)
Santa	367 (31.7)	**< 0.001**	3.7 (1.9 - 7.5)	103 (19.8)	**< 0.001**	3.4 (2.0 - 5.9)	4 (1.6)	**< 0.001**	0.0 (0.0 - 0.1)
Tiko	372 (32.2)	Ref	1.0	167 (32.1)	Ref	1.0	59 (23.1)	Ref	1.0

House type									
Caraboat	77 (6.7)	0.357	1.5 (0.6 - 3.6)	37 (7.1)	0.518	0.8 (0.4 - 1.5)	16 (6.3)	0.92	1.0 (0.5 - 2.1)
Mixed	103 (8.9)	0.141	2.2 (0.8 - 6.5)	35 (6.7)	**0.013**	0.5 (0.3 - 0.9)	7 (2.7)	0.703	0.8 (0.3 - 2.1)
Mud Block	239 (20.7)	0.756	0.9 (0.5 - 1.7)	115 (22.1)	0.716	0.9 (0.6 - 1.4)	58 (22.7)	0.954	1.0 (0.6 - 1.6)
Cement Block	738 (63.8)	Ref	1.0	333 (64.1)	Ref	1.0	175 (68.4)	Ref	1.0
House size									
1 - 3 bedrooms	1,055 (91.2)	0.96	1.0 (0.5 - 2.3)						
4 - 7 bedrooms	102 (8.8)	Ref	1.0						
Family size									
1 – 4 members	551 (47.6)	**0.010**	0.3 (0.1 - 0.7)	113 (21.7)	**< 0.001**	0.0 (0.0 - 0.1)	175 (68.4)	**< 0.001**	12.4 (6.0 - 25.7)
5 – 7 members	478 (41.3)	0.912	0.9 (0.3 - 2.7)	315 (60.6)	**0.007**	0.4 (0.2 - 0.8)	70 (27.3)	**0.007**	2.7 (1.3 - 5.6)
≥ 8 members	128 (11.1)	Ref	1.0	92 (17.7)	Ref	1.0	11 (4.3)	Ref	1.0
Own LLINs									
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 LLINs 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)	0.916	1.0 (0.6 - 1.7)
Yes				456 (87.7)	Ref	1.0	210 (82.0)	Ref	1.0

3.4 Annual household malaria episodes with LLINs ownership/utilisation indicators

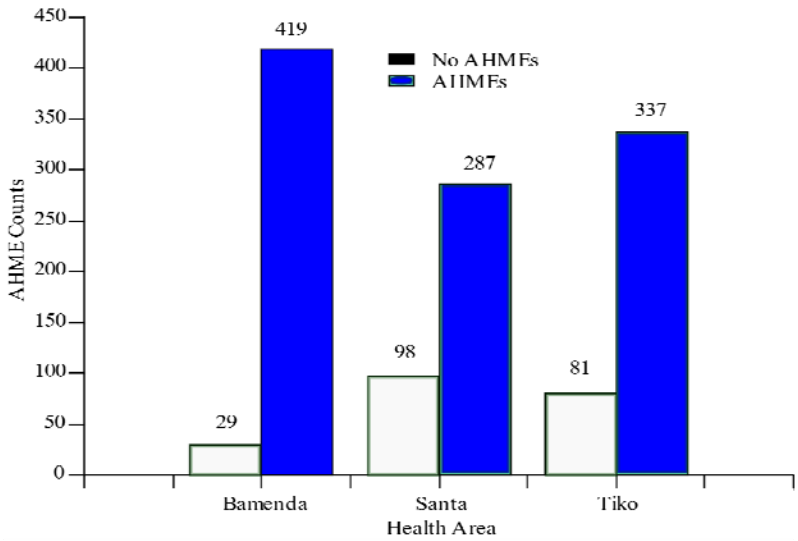

Figure 1: AHMEs by Health Districts

A total of 4,908 (83.6%) of the 5,870 *de-facto* individuals were sampled in the 1,043 (83.4%) of households with at least one AHME in the last one year (**Table 2; Figure 1**). In terms of ownership indicators; AHMEs were associated with household accessibility (AOR; 1.2, 95% C.I; 0.6 – 2.5) to LLINs. Annual household malaria episodes were influenced by the use of LLINs by expectant mothers (AOR; 1.0, 95% C.I; 0.5 – 2.3), use of LLINs last night by the household head (AOR; 1.1, 95% C.I; 0.8 – 1.6), and regular utilisation of LLINs by the household head (AOR; 1.7, 95% C.I; 1.3 – 2.4), of which regular LLINs utilisation was significant (**Table 4**).

Table 4: Multinomial logistic regression of LLINs ownership/utilization indicators in association with AHME

		Dependent variable:			**AHMEs**		
			***n* (%)**	***p* value**	**OR (95% C.I.)**	***Ap* value**	**AOR (95% C.I.)**
S/N	**Independent variable**	**Subclass**	n = 1,043				
1.	At least One LLIN	No	70 (6.7)	**0.018**	0.5 (0.3 -0.9)	**0.017**	0.5 (0.3 - 0.9)
		Yes	973 (93.3)	Ref	1.0	Ref	1.0
2.	Coverage	No	335 (32.1)	0.625	0.8 (0.4 - 1.7)	0.601	0.8 (0.4 - 1.7)
		Yes	708 (67.9)	Ref	1.0	Ref	1.0
3.	Accessibility	No	312 (29.9)	0.602	1.2 (0.6 - 2.5)	0.566	1.2 (0.6 - 2.5)
		Yes	731 (70.1)	Ref	1.0	Ref	1.0
4.	Children 0 – 5 years	None	458 (43.9)	0.293	0.8 (0.6 - 1.2)	0.347	0.8 (0.6 - 1.2)
		No	135 (12.9)	**0.001**	0.5 (0.3 - 0.7)	**0.001**	0.5 (0.3 - 0.8)

5.	Expectant mother	No	992 (95.1)	0.957	1.0 (0.5 - 2.2)	0.938	1.0 (0.5 -2.3)
		Yes	51 (4.9)	Ref	1.0	Ref	1.0
6.	Entire household	No	814 (78.0)	0.103	0.7 (0.4 - 1.1)	0.109	0.7 (0.4 - 1.1)
		Yes	229 (22.0)	Ref	1.0	Ref	1.0
7.	By house head last night	No	755 (72.4)	0.529	1.1 (0.8 - 1.6)	0.533	1.1 (0.8 - 1.6)
		Yes	288 (27.6)	Ref	1.0	Ref	1.0
8.	Regularly	No	660 (63.3)	**0.001**	1.7 (1.3 - 2.4)	**0.001**	1.7 (1.3 - 2.4)
		Yes	383 (36.7)	Ref	1.0	Ref	1.0

AOR = Adjusted Odds Ratio; Ref = Reference group; **Boldface** numbers indicate significant *p* values

3.5 Determinants of annual household malaria episodes

Annual household malaria episodes were associated with the age of the household head whereby households whose heads were 20 years old had the fewest AHMEs (p = 0.003) (**Table 5; Figure 2**). Multinomial analysis showed that the gender of the household head significantly (p = 0.017) influenced AHME. Households in the BHD had a higher AHME (p = 0.031) than those in the Santa and Tiko health districts ($p > 0.05$).

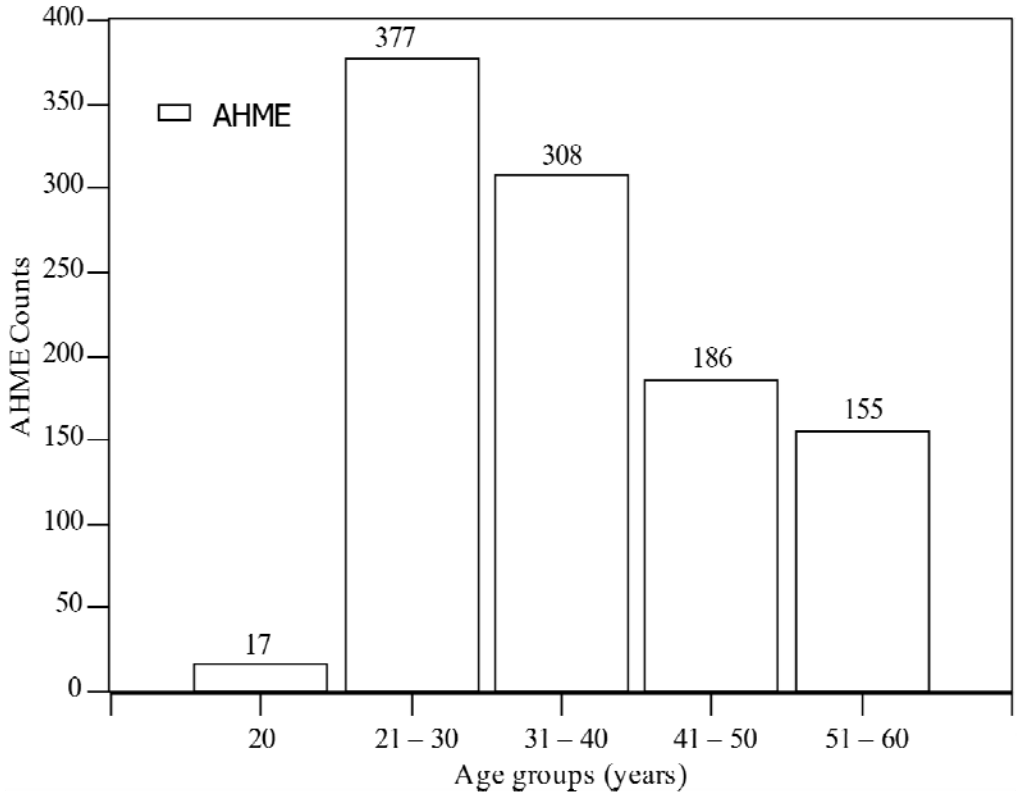

Figure 2: AHMEs by Age Groups

Table 5: Determinants of AHMEs

	Dependent variable:		AHME	
Independent variable	**Subclass**	***n* (%)**	***p* value**	**OR (95% C.I.)**

	21 – 30	377 (36.1)	0.332	0.8 (0.4 - 1.3)
	31 – 40	308 (29.5)	0.649	0.9 (0.5 - 1.5)
	41 – 50	186 (17.8)	0.846	1.1 (0.6 - 1.9)
	51 – 60	155 (14.9)	Ref	1.0
Gender	Female	716 (68.6)	**0.017**	1.6 (1.1 - 2.3)
	Male	400 (31.4)	Ref	1.0
Health District	Bamenda	419 (40.2)	**0.031**	2.8 (1.1 - 7.2)
	Santa	287 (27.5)	0.251	0.7 (0.3 - 1.4)
	Tiko	337 (32.3)	Ref	1.0
Own LLINs	No	70 (6.7)	**0.045**	0.5 (0.2 - 1.0)
	Yes	973 (93.3)	Ref	1.0
Household LLINs sufficiency	No	964 (92.4)	**0.002**	0.1 (0.0 - 0.5)
	Yes	79 (7.6)	Ref	1.0
Tiredness	No	975 (93.5)	**0.042**	2.6 (1.0 - 6.3)
	Yes	68 (6.5)	Ref	1.0

4. DISCUSSION

This study examined the possible causes of AHMEs in the Bamenda, Santa and Tiko Health Districts amidst high LLINs ownership, 2 – 3 years post nationwide free MDC. Overall, LLINs ownership was 92.5%, coverage was 66.8% (overall LLIN: Person ratio of 0.50) while the proportion of the *de-facto* population with universal utilisation was 16.0%, that of children less than five years old was 14.6% and AHMEs was experienced in 1,043 (83.4%) of the 1,251 households sampled. The overall average cost for the treatment of malaria was 6,399.4±4,892.8Fcfa (11.1±8.5US$): 9,010.3±5,297.2Fcfa (15.6±9.2US$) in BHD, 4,039.6±3,314.8Fcfa (7.0±5.7US$) in SHD and 5,774.5±4,325.1Fcfa (10.0±7.5US$) in THD.

4.1 Determinants of household LLINs ownership and utilisation

Long-lasting insecticidal nets (LLINs) ownership frequency is higher than 47 – 89.9% obtained elsewhere in Cameroon [3, 8, 12, 28], as well as 15.5 – 89.9% in Nigeria, Ethiopia and Myanmar [41-45] and in line with the 93.5% reported in Madagascar [46]. It was however, low compared to the 98.8% reported in Uganda [47]. The high frequency of LLINs ownership in this study could be attributed to the 2011 and 2015 free MDCs. However, the differences in LLINs ownership when compared with other studies, could be attributed to fluctuating ownership and universal coverage with time from the date of the MDC, and study designs [14, 44, 48], and study designs.

With respect to LLINs utilisation by the entire household, 16.0% of the *de-facto* population in 20.5% of the households and 14.6% of all the children less than five years in 41.6% of the households had at least used it the previous night. This low usage by the population is confirmed by other findings [41, 43, 46, 49] for the entire household and [8, 46, 47] for all children less than five years in the household. The very low levels of LLINs utilisation could be attributed to the fact that, even though the ownership of at least one LLIN per household was high; coverage was low, differences in the health districts, socio-demographic differences of the household heads, as well as the lack of sufficient space.

4.2 Annual household malaria episodes with LLINs ownership/utilisation indicators

The average cost for the treatment of uncomplicated malaria in Cameroon is 2,940Fcfa (6US$) [50]. The 83.4% AHMEs realised in this study is high compared to 50.8 – 77% reported in Nigeria, and Ghana [41, 49, 51, 52]. Associations were obtained between AHMEs and health districts (the BHD) as well as tiredness by the household head. The high AHMEs in this study is in line with a WHO report which states that the burden of malaria in low income countries is still high [16]. The AHME in this study is attributed to *Plasmodium falciparum* as opposed to *P. vivax* in Peru [53]. In this study, AHME was associated with LLINs accessibility as well as utilisation by expectant mothers, which is in line with a study reported in Zaria in Nigeria [49].

The average direct cost for the treatment of uncomplicated malaria in this study was 6,399.4Fcfa (11.1US$). This is low compared to the 65.1 US$ reported elsewhere in Cameroon [54], the 12.6 – 308 US$ reported elsewhere in Africa [51, 55-57], as well as 461.4 – 2,020.7US$ in the Slovak Republic [58]. It was however, in line with the 11.8 US$ reported in Vietnam [59] and higher than the 6US$ reported in Cameroon [50], 4.9 – 5.1US$ in Ghana and Ethiopia [60, 61]. The differences in the cost of the treatment of malaria might be due to, study designs, sample size and time of the study.

5. RECOMMENDATIONS

The Ministry of Health together with stakeholders should intensify education on the effective use of LLINs by all in the household, especially the vulnerable populations.

6. STRENGTHS AND LIMITATIONS OF THE STUDY

6.1 Strengths

The data used in this study was collected by trained surveyors, who had mastery of all the health areas in the study area. All the health district offices were consulted for the mapping of the health areas, 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.

6.2 Limitations

This was a cross sectional community-based study, carried out only in three health districts. Data was collected through self-reporting, with neither question on expenditure on malaria, nor one on diagnosis and type of malaria, rather, there was a question on the AHMEs.

In the calculation of the average expenditure on malaria, we did not distinguish simple from severe malaria.

7. CONCLUSIONS

In conclusion, the proportion of households with at least one LLIN and those with at least one AHME were high. The average cost for the treatment of malaria in the North and South West of Cameroon represents a potentially high economic burden, mainly to the Internally Displaced Persons and to the national economy as a whole. An implication is that increasing the universal utilisation could contribute to poverty reduction. The Ministry of Health, the National Malaria Control Program and other stakeholders need to identify mechanisms for ensuring that everybody has uninterrupted easy access to LLINs as well as regular utilisation.

Data Availability

The dataset used for analysis in this study, was collected with the data collection tool as described in another study by PN Fru, FN Cho, AN Tassang, CN Fru, PN Fon and AS Ekobo [10], with DOI: https://doi.org/10.1155/2021/8848091 and cited in this study. A preprint with DOI: https://doi.org/10.1101/488445 of this study is also available online at www.biorxiv.org.

ABBREVIATIONS

95% C.I: 95% Confidence Interval

AHME: Annual household malaria episodes

BHD: Bamenda Health District,

LLINs: Long-lasting insecticide nets

MDC: Mass distribution campaign

NFE: No Formal Education

OR: Odds Ratio

p: Significance value

SD: Standard Deviation

SHD: Santa Health District

THD: Tiko Health District

χ^2: Chi square

DECLARATIONS

Ethics approval and consent to participate

The study, obtained approval from the Institutional Review Board of the Faculty of Health Sciences, University of Buea. All participants gave oral/written consent prior to data collection.

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, BMC, SFM, 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. Frederick Nchang Cho, Paulette Ngum Fru, and Patrick Kofon Jokwi contributed equally to this work.

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REFERENCES

1. Biadgilign S, Reda A, Kedir H: **Determinants of Ownership and Utilization of Insecticide-Treated Bed Nets for Malaria Control in Eastern Ethiopia**. *J Trop Med* 2012, **2012**:1 - 7.
2. Vanden Eng J, Thwing J, Wolkon A, Manisha AK, Ayub M, Erskine M, Hightower A, Slutsker L: **Assessing bed net use and non-use after long-lasting insecticidal net distribution: a simple framework to guide programmatic strategies**. *Malar J* 2010, **9**(133).
3. Ntonifor NH, Veyufambom S: **Assessing the e□ective use of mosquito nets in the prevention of malaria in some parts of Mezam division, Northwest Region Cameroon**. *Malar J* 2016, **15**(390):1 - 8.

4. Ye Y, Patton E, Kilian A, Dovey S, Eckert E: **Can universal insecticide-treated net campaigns achieve equity in coverage and use? The case of northern Nigeria**. *Malar J* 2012:1 - 10.

5. Liu H, Xu J-w, Guo X-r, Havumaki J, Lin Y-x, Yu G-c, Zhou D-L: **Coverage, use and maintenance of bed nets and related influence factors in Kachin Special Region II, northeastern Myanmar**. *Malar J* 2015, **14**(212):1 - 12.

6. Graves PM, Ngondi JM, Hwang J, Getachew A, Gebre T, Mosher WA, Patterson EA, Shargie EB, Tadesse Z, Wolkon A *et al*: **Factors associated with mosquito net used by, individuals in households owning nets in Ethiopia**. *Malar J* 2011, **10**(354):1 - 12.

7. Moon TD, Hayes CB, Blevins M, Lopez ML, Green AF, González-Calvo L, Olupona O, The Ogumaniha-SCIP Zambézia Consortium: **Factors associated with the use of mosquito bed nets: results from two cross-sectional household surveys in Zambézia Province, Mozambique**. *Malar J* 2016, **15**(196):1 - 10.

8. Fokam EB, Kindzeka GF, Ngimuh L, Dzi KTJ, Wanji S: **Determination of the predictive factors of long-lasting insecticide-treated net ownership and utilisation in the Bamenda Health District of Cameroon**. *BMC Public Health* 2017, **17**(263):1 - 10.

9. Taylor C, Floreya L, Ye Y: **Equity trends in ownership of insecticide-treated nets in 19 subSaharan African countries**. *Bulletin of World Health Organization* 2017, **95**:322–332.

10. Fru PN, Cho FN, Tassang AN, Fru CN, Fon PN, Ekobo AS: **Ownership and Utilisation of Long-Lasting Insecticidal Nets in Tiko Health District, Southwest Region, Cameroon: A CrossSectional Study**. *Journal of Parasitology Research* 2021, **2021**:1 - 10.

11. Cho NF, Fru NP, Munguh FS, Cho MB, Jokwi KP, Fru NC, Fon NP, Tassang NA, Ekobo SE: **Predictors of Ownership/ Utilisation indicators of Long-lasting Insecticide Nets in the Bamendankwe Health Area of Cameroon: A Cross-Sectional Study**. *Pan African Journal of Life Sciences* 2020, **4**(3):112 - 120.

12. Apinjoh TO, Anchang-Kimbi JK, Mugri RN, Tangoh DA, Nyingchu RV, Chi HF, Tata RB, Njumkeng C, Njua-Yafi C, Achidi EA: **The Effect of Insecticide Treated Nets (ITNs) on *Plasmodium falciparum* Infection in Rural and Semi-Urban Communities in the South West Region of Cameroon**. *PLoS One* 2015, **10**(2):e0116300.

13. Elmosaad YM, Elhadi M, Khan A, Malik EM, Mahmud I: **Communication for behavioural impact in enhancing utilization of insecticide-treated bed nets among**

mothers of under-five children in rural North Sudan: an experimental study. *Malar J* 2016, **15**(509):1 - 11.

14. Solomon T, Loha E, Deressa W, Gari T, Overgaard HJ, Lindtjørn B: **Low use of longlasting insecticidal nets for malaria prevention in south-central Ethiopia: A community-based cohort study**. *PLoS One* 2019, **14**(1):e0210578.
15. Lawpoolsri S, Sattabongkot J, Sirichaisinthop J, Cui L, Kiattibutr K, Rachaphaew N, Suk□uam K, Khamsiriwatchara A, Kaewkungwal J: **Epidemiological profiles of recurrent malaria episodes in an endemic area along the Thailand-Myanmar border: a prospective cohort study**. *Malar J* 2019, **18**(124):1 - 11.
16. WHO: **Malaria prevention works: Let's close the gap**. In: *World Malaria day 2017*. Edited by WHO Global Malaria Programme. France: World Health Organization; 2017: 1 - 24.
17. WHO: **World malaria report 2020: 20 years of global progress and challenges**. In: *World malaria report.* Geneva: World Health Organization; 2020: 1 - 151.
18. Rono J, Färnert A, Murungi L, Ojal J, Kamuyu G, Guleid F, Nyangweso G, Wambua J, Kitsao B, Olotu A *et al*: **Multiple clinical episodes of *Plasmodium falciparum* malaria in a low transmission intensity setting: exposure versus immunity**. *BMC Med* 2015, **13**(114):1 - 11.
19. WHO: **Malaria**. In. Edited by News room; Fact sheets. Switzerland: World Health Organisation; 2018: 1 - 196.
20. RBM: **RBM Partnership to end Malaria**. In: *RBM Partnership Annual Report 2017*. Edited by Mpanju-Shumbusho Winnie. Geneva, Switzerland: RBM Partnership to end Malaria; 2017.
21. European Alliance Against Malaria: **Malaria and poverty**. In. Edited by Institute TE. University of Colombia: Red Cross EU Offce; n.d: 1 - 4.
22. WHO: **World malaria report 2017**. In. Edited by Programme GM. Geneva: World Health Organization; 2017.
23. Nkumama IN, O'Meara WP, Osier FHA: **Changes in Malaria Epidemiology in Africa and New Challenges for Elimination**. *Trends in Parasitology* 2017, **33**(2):128 - 140.
24. Fokam EB, Dzi KTJ, Ngimuh L, Enyong P: **The Effect of Long-Lasting Insecticide Bed Net Use on Malaria Prevalence in the Tombel Health District, South West Region-Cameroon**. *Hindawi Publishing Corporation Malaria Research and Treatment* 2016, **2016**:1 - 6.
25. MOH: **Health Analytical Profile 2016 Cameroon**. In. Yaoundé Observatoire National de la Sante Publique; 2017: 1 - 120.

26. Obala AA, Mangeni JN, Platt A, Aswa D, Abel L, Namae J, O'Meara WP: **What Is Threatening the Effectiveness of Insecticide-Treated Bednets? A Case-Control Study of Environmental, Behavioral, and Physical Factors Associated with Prevention Failure**. *PLoS One* 2015, **10**(7):e0132778.

27. Oyekale AS: **Do Ownership of Mosquito Nets, Dwelling Characteristics and Mothers' Socio-Economic Status Influence Malaria Morbidity among Children under the age of 5 in Cameroon?** *Int J Occup Med Environ Health* 2015, **28**(3):479–497.

28. Kimbi HK, Nkesa S, Ndamukong-Nyanga JL, Sumbele IUN, Atashili J, Atanga MBS: **Socio-demographic factors influencing the ownership and utilization of insecticide-treated bed nets among malaria vulnerable groups in the Buea Health District, Cameroon**. *BMC Res Notes* 2014, **7**(624):1 - 8.

29. Wanzira H, Katamba H, Rubahika D: **Use of long-lasting insecticide-treated bed nets in a population with universal coverage following a mass distribution campaign in Uganda**. *Malar J* 2016, **15**(311):1 - 8.

30. Zegers de Beyl C, Koenker H, Acosta A, Onyefunafoa EO, Adegbe E, McCartney-Melstad A, Selby RA, Kilian A: **Multi-country comparison of delivery strategies for mass campaigns to achieve universal coverage with insecticide-treated nets: what works best?** *Malar J* 2016, **15**(58):1 - 14.

31. Wanzira H, Yeka A, Kigozi R, Rubahika D, Nasr S, Sserwanga A, Kamya M, Filler S, Dorsey G, Steinhardt L: **Long-lasting insecticide-treated bed net ownership and use among children under five years of age following a targeted distribution in central Uganda**. *Malar J* 2014, **13**(185):1 - 8.

32. Kilian A, Lawford H, Ujuju CN, Abeku TA, Nwokolo E, Okoh F, Baba E: **The impact of behaviour change communication on the use of insecticide treated nets: a secondary analysis of ten post-campaign surveys from Nigeria**. *Malar J* 2016, **15**.

33. Antonio□Nkondjio C, Ndo C, Njiokou F, Bigoga JD, Awono□Ambene P, Etang J, Ekobo AS, Wondji CS: **Review of malaria situation in Cameroon: technical viewpoint on challenges and prospects for disease elimination**. *Parasites & Vectors* 2019, **12**(501):1 - 23.

34. Santos EM, Coalson JE, Jacobs ET, Klimentidis YC, Munga S, Agawo M, Anderson E, Stroupe N, Ernst KC: **Bed net care practices and associated factors in western Kenya**. *Malar J* 2019, **18**(274):1 -12.

35. Tchinda HM, Socpa A, Keundo AA, Zeukeng F, Seumen CT, Leke RGF, Moyou RS: **Factors associated to bed net use in Cameroon: a retrospective study in Mfou health district in the Centre Region**. *Pan Afr Med J* 2012, **12**(112):1 - 10.

36. Cho FN, Fru PN, Cho MB, Munguh SF, Kofon PJ, Ngah YE, Fru CN, Tassang AN, Nde PF, Ekobo AS: **Ownership, Coverage, Utilisation and Maintenance of Long-lasting insecticidal nets in Three Health Districts in Cameroon: A Cross-Sectional Study**. *bioRxiv 465005* 2021:1 - 16.

37. CDC: **Household Survey Indicators for Malaria Control**. In. Edited by United States Agency for International Development. USA: CDC, USAID, President's Malaria Initiative, RBM, UNICEF, WHO; 2013: 1 - 61.

38. Kilian A, Koenker H, Baba E, Onyefunafoa EO, Selby RA, Lokko K, Lynch M: **Universal coverage with insecticide-treated nets – applying the revised indicators for ownership and use to the Nigeria 2010 malaria indicator survey data**. *Malar J* 2013, **12**(314):1 - 12.

39. Polec LA, Petkovic J, Welch V, Ueffing E, Ghogomu ET, Pardo JP, Grabowsky M, Attaran A, Wells GA, P T: **Strategies to Increase the Ownership and Use of Insecticide-Treated Bednets to Prevent Malaria**. *Cochrane Database of Systematic Reviews* 2015, **17**(3):1 - 129.

40. Xu J-w, Liao Y-m, Liu H, Nie R-h, Havumaki J: **Use of Bed Nets and Factors That Influence Bed Net Use among Jinuo Ethnic Minority in Southern China**. *PLoS One* 2014, **9**(7):e103780.

41. Obembe A, Anyaele OO, Adedayo OO: **Lessons from the implementation of LLIN distribution campaign in Ilorin Kwara State, Nigeria**. *BMC Public Health* 2014, **14**(514):1 - 8.

42. Seyoum D, Speybroeck N, Duchateau L, Brandt P, Rosas-Aguirre A: **Long-Lasting Insecticide Net Ownership, Access and Use in Southwest Ethiopia: A Community-Based Cross-Sectional Study**. *Int J Environ Res Public Health* 2017, **14**(1312):1 - 16.

43. Aung T, Wei C, McFarland W, Aung YK, Khin HSS: **Ownership and Use of Insecticide-Treated Nets among People Living in Malaria Endemic Areas of Eastern Myanmar**. *PLoS One* 2016, **11**(9):e0162292.

44. Babalola OJ, Sambo MN, Idris SH, Ajayi I-OO, Ajumobi O, Nguku P: **Factors associated with utilization of LLINs among women of child-bearing age in Igabi, Kaduna State, Nigeria**. *Malar J* 2019, **18**(412):1 - 9.

45. Tassew A, Hopkins R, Deressa W: **Factors influencing the ownership Factors influencing the ownership for malaria prevention in Ethiopia**. *Malar J* 2017, **16**(262):1 - 9.

46. Finlay AM, Butts J, Ranaivoharimina H, Cotte AH, Ramarosandratana B, Rabarijaona H, Tuseo L, Chang M, Jodi VE: **Free mass distribution of long-lasting insecticidal nets lead to high levels of LLIN access and use in Madagascar, 2010: A cross-sectional observational study**. *PLoS One* 2017, **12**(8):e0183936.

47. Nuwamanya S, Kansiime N, Aheebwe E, Akatukwasa C, Nabulo H, Turyakira E, Bajunirwe F: **Utilization of Long-Lasting Insecticide Treated Nets and Parasitaemia at 6 Months after a Mass Distribution Exercise among Households in Mbarara Municipality, Uganda: A Cross-Sectional Community Based Study**. *Malaria Research and Treatment* 2018, **2018**:1 - 11.

48. Tapera O: **Determinants of long-lasting insecticidal net ownership and utilization in malaria transmission regions: evidence from Zimbabwe Demographic and Health Surveys**. *Malar J* 2019, **18**(278):1 - 7.

49. Aliyu AA, Alti-Mu'azu M: **Insecticide-treated nets usage and malaria episodes among boarding students in Zaria, northern Nigeria**. *Ann Afr Med* 2009, **8**(2):85 - 89.

50. Sieleunou I, Betsi E, Kouontchou JC, Nguela AT, Yumo HA: **Removing the User Fees for the Under-Fives' Simple Malaria Treatment in Cameroon: Effect on the Health Services Utilization**. *Journal of Community Medicine & Health Education* 2015, **5**(6):1 - 8.

51. Onwujekwe O, Uguru N, Etiaba E, Chikezie I, Uzochukwu B, Adjagba A: **The Economic Burden of Malaria on Households and the Health System in Enugu State Southeast Nigeria**. *PLoS One* 2013, **8**(11):e78362.

52. Du Mond J: **Epidemiology Of Malaria Infection Among School Aged Children In Kintampo North District, Ghana**. *Masters.* Yale: Yale University; 2013.

53. Rosas-Aguirre A, Ponce OJ, Carrasco-Escobar G, Speybroeck N, Contreras-Mancilla J, Gamboa D, Pozo E, Herrera S, Llanos-Cuentas A: ***Plasmodium vivax* malaria at households: spatial clustering and risk factors in a low endemicity urban area of the northwestern Peruvian coast**. *Malar J* 2015, **14**(176):1 - 11.

54. Maka DE, Chiabi A, Obadeyi B, Mah E, Nguefack S, Nana P, Mbacham W, Mbonda E: **Economic evaluation of artesunate and three quinine regimens in the treatment of severe malaria in children at the Ebolowa Regional Hospital-Cameroon: a cost analysis**. *Malar J* 2016, **15**(587):1 - 15.

55. Ezenduka CC, Falleiros DR, Godman BB: **Evaluating the Treatment Costs for Uncomplicated Malaria at a Public Healthcare Facility in Nigeria and the Implications**. *Pharmacoeconomics* 2017, **1**:185–194.

56. Ilunga-Ilunga F, Levêque A, Ngongo LO, Kandolo FT, Dramaix M: **Costs of treatment of children affected by severe malaria in reference hospitals of Kinshasa, Democratic Republic of Congo**. *The Journal of Infection in Developing Countries* 2014, **8**(12):1574 -1583.

57. Obieche AO, Odili UV: **Evaluation of cost of treatment of malaria in adults in Benin City, Nigeria: patients' perspective**. *Malaria World Journal* 2016, **7**(12):1 - 7.

58. Svihrova V, Szilagyiova M, Novakova E, Svihra J, Hudeckova H: **Costs analysis of the treatment of imported malaria**. *Malar J* 2012, **11**(1):1 - 5.

59. Morel MC, Thang ND, Xa NX, Hung LX, Thuan LK, Van Ky P, Erhart A, Mills JA, D'Alessandro U: **The economic burden of malaria on the household in south-central Vietnam**. *Malar J* 2008, **7**(166):1 - 7.

60. Dalaba MA, Welaga P, Oduro A, Danchaka LL, Matsubara C: **Cost of malaria treatment and health seeking behaviour of children under-five years in the Upper West Region of Ghana**. *PLoS One* 2018, **13**(4):e0195533.

61. Hailu A, Lindtjørn B, Deressa W, Gari T, Loha E, Robberstad B: **Economic burden of malaria and predictors of cost variability to rural households in south-central Ethiopia**. *PLoS One* 2017, **12**(10):e0185315.