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Use of long-lasting insecticidal nets as malaria preventive measure among children 5 years and below, attending the Tubah District Hospital

Nfor Omarine Nlinwe[1,2], Ebanga Echi Joan Eyong[3]* and Ngenwie Vanessa Tanyi[1]

[1]Department of Medical Laboratory Science, Faculty of Health Sciences, The University of Bamenda, P. O. Box 39, Bambili, North West Cameroon.
[2]Department of Clinical Sciences, Faculty of Health Sciences, The University of Bamenda, P. O. Box 39, Bambili, North West Cameroon.
[3]Department of Microbiology and Parasitology, Faculty of Science, The University of Bamenda, P. O. Box 39, Bambili, North West Cameroon.

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The use of long-lasting insecticidal nets (LLINs) remains a key factor in preventing malaria among children under five years old. To investigate the effects of LLINs among this demographic, a study was conducted among children below five years of age attending Tubah district hospital. Data was collected over four months from February to May 2021 using a pre-tested structured questionnaire and the Care Start™ Pf Malaria HRP2 qualitative rapid diagnostic test. The risk of malaria occurrence in exposed children was determined using Chi-square (and Fisher's exact) test. The study found that 90.91% (280 out of 308) of children had access to nets, with 92.86% (286 out of 308) owning LLINs. However, the percentage of net usage was 59.09% (182 out of 308). The prevalence of *P. falciparum* among the children was 25.32% (78 out of 308), and among those with repeated infections, it was 53.48% (46 out of 86). Neighborhood bed net coverage was associated with a reduced risk of malaria (P value = 0.038), while a higher risk (P value < 0.0001) was observed among those with repeated infections. These findings suggest that providing bed nets to all household members could offer community-level protection among children in semi-urban malaria-endemic regions like Tubah Subdivision.

Key words: Children below 5 years, LLINs, Malaria, Tubah subdivision.

INTRODUCTION

According to the World Malaria Report 2022, there has been a reduction in the percentage of total malaria deaths in children below five years of age from 87% in 2000 to 76% in 2015, with no change observed since then (WHO, 2022). Consequently, malaria remains a significant health threat, especially to children under five years of age (WHO, 2022). In Cameroon, malaria remains a disease of great public health importance, with transmission being heterogeneous depending on various ecological factors affecting vector abundance (WHO,

*Corresponding author. E-mail: joan.ebangaechi@gmail.com. Tel: +237 677 67 07 24.

2021). Annually, malaria is responsible for more than two million reported cases in Cameroon, leading to absenteeism from school and work (WHO, 2021). The prevalence of malaria among children in the South West region of Cameroon was reported to be 41.7% (Teh et al., 2018). Additionally, in three different malaria-endemic countries, the general malaria prevalence among infants under six months of age was approximately 11.8%. Specifically, malaria prevalence among infants was reported as 21.7% in Guinea, 3.7% in The Gambia, and 10.2% in Benin (Ceesay et al., 2015). Improving maternal knowledge at the community level has been shown to greatly reduce child malaria (Kyu et al., 2013). However, a decrease in community motivation to use malaria preventive measures has increased malaria prevalence. With proper training, sensitization activities, and extensive distribution of LLINs in both rural and urban areas, there has been increased bed net possession and a reduced malaria burden among young children (Koudou et al., 2010; Apinjoh et al., 2015). Similarly, a five-year study in Ghana revealed that ownership of mosquito bed nets was one of the major predictors of malaria occurrence among children fewer than five years of age (Nyarko and Cobbah, 2014).

In Malawi, the use of LLINs significantly predicted malaria among children in the 2012 Malaria Indicator Survey, but not in the 2014 survey (Zgambo et al., 2017). Although LLIN usage by children increased from 54% in 2012 to 65% in 2014, malaria prevalence also increased from 28% in 2012 to 33% in 2014 (Zgambo et al., 2017), indicating a lack of the expected decrease in malaria prevalence with an increase in net usage. In a local community in Ethiopia, the use of preventive measures was low (5.6%) despite malaria being perceived as a major health problem among children, highlighting the need for intensive efforts to scale up the supply of insecticide-treated nets and increase community knowledge on malaria transmission (Deressa and Ali, 1990). Another study in Ethiopia reported a malaria prevalence of 8.7% among children, with consistent bed net use linked to reduced chances of malaria, while increased chances of malaria were associated with children who stayed outdoors at night (Tsegaye et al., 2021). In Uganda, malaria prevalence among children under five years of age was 19.7%, and the use of LLINs significantly increased between 2009 and 2014 according to the Malaria Indicator Survey (Roberts and Matthews, 2016). A study in a malaria-endemic area where prevalence among children was 22.4% found that LLIN use was strongly associated with reduced malaria prevalence regardless of resistance (Tokponnon et al., 2014). Additionally, failure to adequately increase LLIN coverage was associated with high malaria prevalence among children aged 1 to 4 years (Rehman et al., 2013). Ownership and appropriate use of mosquito nets could therefore be key predictors of malaria among children under five years (Nyarko and Cobbah, 2014; Roberts and Matthews, 2016). In 2021, while 54% of the world's exposed population had access to an insecticide-treated bed net (ITN) within their household, only 47% slept under the bed nets (WHO, 2022). Social and political conflicts further deter efforts to improve these statistics. Among children living in displacement camps in the Democratic Republic of Congo, malaria prevalence was higher at 17% compared to 7.5% among non-displaced children (Charchuk et al., 2016). In Edo state, Nigeria, malaria prevalence among children of internally displaced persons was 55.2% (Ajakaye and Ibukunoluwa, 2020). The ongoing socio-political conflict in the study area could similarly hinder efforts to combat malaria in children. Therefore, this study was designed to assess the effect of LLINs among children less than five years of age attending the Tubah district hospital.

METHODS

Study area

This study was conducted at the Tubah district hospital, situated in Bambui, which serves as the headquarters of the Tubah subdivision. Tubah subdivision is one of the seven subdivisions of the Mezam division, with the others being Bamenda I, Bamenda II, Bamenda III, Bafut, Bali, and Santa subdivisions. The Tubah district hospital serves as a referral center for other rural communities such as Bafut, Baforkum, Bambili, and Babanki-Finge. This region has been affected by the socio-political crises that have been ongoing in the North West and South West regions of Cameroon. Bambui has a population of approximately 37,000 inhabitants, with a population density of 145 persons per square kilometer, covering a considerable surface area of 365 square kilometers (Ngoran and Xue, 2015). Malaria transmission in this area is highly stable, with the disease primarily transmitted by the main species of Anopheles mosquitoes found in the Western Highlands of Cameroon, namely Anopheles gambiae s.s. and A. funestus, which are efficient vectors in Cameroon and other African countries. These vectors have been observed to bite between midnight and 2 am (Antonio-Nkondjio et al., 2006; Fontenille and Simard, 2004; Githeko et al., 2006). The incidence of infection among children aged 5 years or younger increased from 188 to 218 per 1,000 children between 2015 and 2018 (www.severemalaria.org/pays/cameroon).

Study design/participants

This was a hospital-based cross-sectional study conducted over a period of four months from February to May 2021. The study included febrile children aged 5 years or younger, encompassing both sexes.

Estimation of sample size

The minimum estimated sample size (N) for the study was calculated as follows (Charan and Biswan, 2013):

$N = z^2 pq/d^2$

Where $z^2 = (1.96)^2$, p = previous malaria prevalence and q = 1-p, p = 0.224 (12), $d^2 = (0.05)^2$, Estimated minimum sample size = 267 children.

The estimated minimum sample size for this study was 267 children; however, 308 children were enrolled so as to take care of

any participants who drop off, in order not to affect the statistical analysis.

Ethical consideration

The study obtained ethical clearance from the Ethical Review Committee of the University of Bamenda, with clearance number 2021/186H/UBa/IRB. Signed informed assents were obtained from parents who agreed to enroll their children in the study. All parents or guardians who presented febrile children for consultation during the study period and agreed to participate by signing the assent form and completing the questionnaire were included. The inclusion criteria for children were being febrile and under five years of age, brought by their parents or guardians for consultation at the Bambui district hospital during the study period. Children who did not exhibit malaria symptoms and whose parents or legal guardians declined to participate were excluded from the study.

Data collection

Data were obtained using a pre-tested structured questionnaire and laboratory examinations of capillary blood.

Administration of questionnaire

A well-structured questionnaire written in English was provided to the parents or legal guardians for completion. For those who were French-speaking or unable to read or write English, the questionnaire was read out to them. The questionnaire aimed to gather information on the socio-demographic characteristics of parents or guardians and their children, as well as LLINs distribution, ownership, and utilization among the children. The socio-demographic characteristics included the duration of stay in the study area, age and sex of the child, and the displacement status of the parent or guardian.

Examination of blood for malaria by RDT

Approximately 5µL of capillary blood was obtained via a finger prick, and malaria diagnosis was performed using the CareStart™ Pf Malaria HRP2 qualitative rapid diagnostic test method (WHO, 2018). The test results were interpreted approximately 30 minutes after the application of the blood sample. A test was considered positive if two colored bands appeared for the "test" and "control" lines, negative if only the "control" line was present, and invalid if no lines appeared or if only a test line showed without the control line.

Data analysis

Excel was utilized to calculate baseline characteristics related to the acquisition and use of LLINs, as well as socio-demographic factors of children with or without malaria, including summations and mean percentages. Regression analysis was conducted to assess the association between the socio-demographic factors of children and malaria occurrence. The frequency distribution for the use and acquisition of LLINs was presented in a fourfold (2 × 2) contingency table using GraphPad Prism version 8.2.1. Each cell in the contingency table contained frequencies for LLIN acquisition or deprivation and LLIN use or nonuse among both negative and positive malaria cases. The attributable risk, odds ratio, relative risk, and likelihood ratio of malaria occurrence in children exposed to malaria were determined using the Chi-square (and Fisher's exact) test. Results were evaluated at a 95% confidence level using GraphPad Prism version 8.2.1.

RESULTS

Socio-demographic characteristics with respect to *Plasmodium falciparum* RDT positivity

A total of 308 children were enrolled in this study, with a prevalence of *Plasmodium falciparum* among the children recorded at 25.32% (78 out of 308). The male-to-female ratio was approximately 1.17:1, and overall, 13.64% (42 out of 308) of the children had parents or guardians who were internally displaced. Malaria was most prevalent among children aged five years, accounting for 38.46% of cases (Table 1).

Relationship between socio-demographic characteristics and malaria

The duration of stay in the study area, age, and sex of the child were not found to be significantly associated with malaria infection. However, the number of persons who used bed nets in a household showed a significant association with malaria infection. Additionally, being an internally displaced child was significantly associated with malaria (P = 0.0027), as shown in Table 2.

Plasmodium falciparum positivity rate in line with net distribution, ownership and usage

Overall, net coverage was high, with 90.91% (280/308) of the participants reporting owning nets at home. Among them, 92.86% (286/308) actually owned nets. Out of those who used bed nets the previous night (59.09% or 182/308), 19.78% (36/182) tested positive for malaria. Conversely, among those who did not use bed nets (40.9% or 126/308), 33.33% (42/126) tested positive for malaria. Additionally, among those who reported with repeated infections (27.92% or 86/308), 53.48% (46/86) tested positive for malaria (Table 3).

Infection risk associated with LLINs

Children without net coverage had 0.55 times the risk of those with net coverage. Additionally, 19% of malaria incidence could possibly be attributed to the absence of net coverage. Conversely, those with net coverage were 41% less likely to test positive for malaria. Moreover, the likelihood ratio of 0.91 indicates a 9.1% decrease in the probability of testing positive for malaria among children with net coverage.

Furthermore, children with repeated malaria infections had 3.71 times the risk of those without, and 39% of

Table 1. Participant's socio-demographic characteristics with respect to *P. falciparum* RDT positivity.

Parameter		Pos RDT	Total (%)
Total (%)		**78 (25.32)**	**308**
Duration of stay in study area	<1 year (%)	2 (20)	10(3.25)
	>1 year (%)	76 (25.0)	298 (96.75)
Age of child	0-1 year (%)	36 (22.78)	158 (51.3)
	2 years (%)	14 (28)	50 (16.23)
	3 years (%)	8 (23.53)	34 (11.04)
	4 years (%)	0	14 (4.55)
	5 years (%)	20 (38.46)	52 (16.88)
Sex of child	Male (%)	46 (27.71)	166 (53.9)
	Female (%)	32 (22.54)	142 (46.1)
Displacement status of parent/guardian	IDP (%)	18 (42.86)	42 (13.64)
	Non-IDP (%)	60 (22.56)	266 (86.36)
Number of bed net users per household	0	21(18.1)	116(37.66)
	1 to 3	20(20)	100(32.47)
	4 to 6	16(18.18)	88(28.57)
	>6	0	4(1.3)

POS=positive, IDP=internally displaced person, RDT=rapid diagnostic test.

Table 2. Association between socio-demographic characteristics and malaria.

Variable	Estimate	Standard error	95% CI	|t|	P value
Intercept	0.2955	0.2152	-0.1281 to 0.7191	1.373	0.1708
Duration of stay in Tubah	0.05049	0.03517	-0.0187 to 0.1197	1.436	0.1521
Age of child	0.02269	0.0159	-0.0086 to 0.054	1.427	0.1547
Sex of child	0.08752	0.04861	-0.0081 to 0.1832	1.8	0.0728
Displacement status of parent/guardian	0.2192	0.07244	0.0767 to 0.3618	3.026	0.0027**
Number of bed net users per household	-0.03949	0.01495	-0.0689 to -0.0101	2.641	0.0087**

CI= confidence interval.

malaria incidence could be attributed to repeated infections. Additionally, children with repeated infections had 6.83 times the odds of testing positive for malaria compared to those without repeated infections. The likelihood ratio of 3.39 indicates an increase in the probability of testing positive for malaria among those with repeated infections (Table 4).

DISCUSSION

The overall prevalence of malaria among the participants in this study was high (25.32%), with children aged 5 years being the most vulnerable (38.46%). This vulnerability may be attributed to the fact that these children have had numerous exposures to the parasites. This finding aligns with reports from North Eastern Tanzania, where a shift in malaria transmission towards older children of 5-13 years was observed (Winskill et al., 2011).

In this study and other related research, the percentage of net usage among children was low, and the risk of malaria was significantly lower among those who used bed nets and those who benefited from community coverage (Odeyemi et al., 2022; Tokponnon et al., 2014; Tsegaye et al., 2021; WHO, 2022). This indicates that if augmented, net usage will surely ensure a reduction in malaria among children. Malaria prevalence was significantly higher among children of internally displaced persons (IDPs), who may have been exposed due to poor living conditions. Some of these displaced persons may not have benefited from community coverage in the

Table 3. Overall *P. falciparum* positivity rate in line with net distribution, ownership and usage.

Parameter		Pos RDT	Total (%)
Total (%)		**78 (25.32)**	**308**
LLINs distributed in neighbourhood	Yes	66 (23.57)	280 (90.91)
	No	12 (42.86)	28 (9.09)
Own LLINs	Yes	72 (25.17)	286 (92.86)
	No	6 (27.27)	22 (7.14)
Used LLINs the previous night	Yes	36 (19.78)	182 (59.09)
	No	42 (33.33)	126 (40.9)
Repeated malaria infections	Yes	46 (53.49)	86 (27.92)
	No	32 (14.41)	222 (72.08)

LLINs=long-lasting insecticide treated bednets, Pos RDT=positive rapid diagnostic test.

Table 4. Measurement of infection risk associated with LLINs.

Variable	Relative risk (95%)	Attributable risk (95%CI)	Odds ratio (95% CI)	LR	P-value
LLINs distributed in neighborhood	0.55(0.36 to 0.93)	0.19(0 to 0.38)	0.41(0.18 to 0.93)	0.91	0.038*
Own LLINs	0.92 (0.5 to 1.96)	0.02 (-0.22 to 0.19)	0.9(0.34 to 2.32)	0.99	0.8024
Used LLINs the previous night	0.59(0.35 to 1.02)	0.14 (-0.01 to 0.28)	0.49(0.24 to 1)	0.73	0.0625
Repeated malaria infections	3.71(2.55 to 5.40)	0.39 (0.27 to 0.51)	6.83(3.88 to 11.98)	3.39	<0.0001***

LLINs=long-lasting insecticide treated bednets.

study area due to recent relocation.

As earlier indicated, an estimated 19% of malaria incidence was attributed to the absence of community coverage among the study participants. Population displacement induced by violent conflict has also been shown to be a risk factor for malaria among children in the Democratic Republic of Congo (DRC) and in Nigeria (Ajakaye and Ibukunoluwa, 2020; Charchuk et al., 2016). The social crisis affecting the North West and South West regions of Cameroon, with a displaced population, could be affecting malaria epidemiology in the area, posing a challenge for malaria elimination and control efforts in these regions and neighboring areas (Antonio-Nkondjio et al., 2019). Displaced persons and refugees, including children, are very vulnerable to malaria (Anderson et al., 2011). Population displacement is a possible deterrent factor to community coverage of bed nets, which should typically be fairly distributed.

The high mobility of a population is one of the main limitations for malaria control and elimination, particularly on the Myanmar-Thai border (Guyant et al., 2015). This migration may facilitate the spread of anti-malaria drug-resistant parasites from one region to another. However, in Uganda and Tanzania, despite free distribution of bed nets, usage was disproportionately lower among the poorest children due to lack of ownership (Njau et al., 2013). This indicates possible biased distribution of nets, with the poorest communities lagging behind. Conversely, in Central Uganda, household wealth status did not affect net ownership and usage after a targeted campaign (Wanzira et al., 2014), perhaps due to unbiased distribution.

Similar to findings from the current study, malaria incidence was attributed to the absence of bed net distribution in rural settings in the West region of Cameroon (Nlinwe et al., 2022). In Lilongwe, Malawi, bed net community coverage protected children who used it, indicating the importance of consistent community coverage (Levitz et al., 2018). The results of studies in various parts of the world revealed that the use of insecticide-treated nets is an effective tool against anopheline mosquitoes and reduces morbidity and mortality due to malaria (Sharma et al., 2006; Hill et al., 2006). Treated bed nets have an influential impact on mosquito density and sporozoite rates. However, the effectiveness of bed net use is dependent on attitudes and socio-cultural context of the population (Atkinson et al., 2009).

Malaria prevalence was also significantly higher among children with repeated infections, indicating consistent exposure among them. Malaria risk was also higher among children who experienced mosquito bites while

using the net, which may be an indicator of net misuse. This may also explain why in Malawi, despite an increase in bed net usage, there was an increase in malaria prevalence among children (Zgambo et al., 2017). Thus, correct use of bed nets should be emphasized as one of the key predictors of malaria among children, while misuse, on the other hand, may not predict. For example, among children in Ghana, the use of mosquito bed nets was not linked to reduced malaria prevalence (Tetteh et al., 2023), suggesting that bed net misuse may be a contributing factor. Additionally, complementary use of LLINs with other control methods was shown to yield a greater impact in the fight against malaria in children (Githinji et al., 2020; Killeen et al., 2013; Nlinwe et al., 2021).

Conclusion

In this study, the prevalence of malaria among children was high, especially among those aged 5 years. The percentage of bed net coverage was high and associated with a reduced risk of malaria among the children. At the individual household level, although the percentage of net usage by the children was low, there was a significant reduction in the risk of malaria in households with an increased number of net users. Repeated malaria infections and internal displacements or relocations due to conflicts were additional factors associated with the risk of malaria among the children under study. Therefore, consistent net coverage and increased net usage by individuals in a household will possibly reduce malaria among children below five years of age, especially in malaria-endemic conflict zones.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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