

Situational Analysis of Malaria Control Following the 2021 Distribution of Long Lasting Insecticide-Treated Bed Nets in the Tiko Health District, South West Region, Cameroon

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Abstract

Malaria is still a major public health concern in Cameroon as more than 20 million people are at risk of the disease. Despite the government's effort to scale up the distribution of long lasting insecticide-treated bed nets (LLINs), full ownership and optimal use is still limited. In 2021, over a million LLINs were made available for distribution in the South West Region. However, the current situation of malaria has not yet been ascertained following the 2021 mass distribution campaign (MDC). Therefore, the aim of this study was to determine LLIN ownership, coverage, usage and the prevalence of malaria following the 2021 MDC in the Tiko Health District (THD), South West Region of Cameroon. A cross-sectional study was carried from May 1 to 27, 2022 in which a multi-stage sampling technique was used to enroll eligible participants. Data were collected from household heads using questionnaires and capillary blood samples collected from consented household members were used to test for malaria. Data were analyzed using SPSS version 25 at 0.05 significance level. From the 150 households surveyed, 96 (64.0%) owned a mosquito net before the recent MDC. There was an overall significant increase ($p < 0.001$) in LLIN ownership from 64.0% before to 91.3% after the recent MDC. LLIN coverage and usage rates were 87.1% and 70.9% respectively. There was no significant difference ($p = 0.644$) in LLINs ownership between areas where door-to-door (79.5%) and fixed "Hit and Run" (75.8%) strategies were used in the distribution of LLINs in THD. The prevalence of malaria was 10.2%. The regular use of LLINs was significantly associated ($p = 0.007$) with low malaria prevalence. The 2021 MDC had an impact on malaria prevalence in those who properly used them.

Keywords

Long Lasting Insecticide Treated-Bed Nets, Ownership, Coverage, Use, Malaria Prevalence

1. Introduction

According to the recent world malaria report, an estimated 241 million cases and 627,000 deaths due to malaria were recorded in 2020. This is about 14 million more cases in 2020 compared to 2019 and 69,000 more deaths [1]. Africa still has the heaviest burden of malaria as 95% of cases and 96% of deaths resulting from malaria are concentrated in Sub-Saharan Africa (SSA). About 80% of all malaria deaths in Africa are estimated among children less than five years [2]. In Central Africa, Cameroon has the third highest number of malaria cases accounting for 12.7% of malaria cases. In 2019, there were 243 malaria cases per 1000 of the population at risk, thereby accounting for 24.3% [3]. Malaria is still a major public health concern in Cameroon as more than 20 million people are at risk of the disease [4]. WHO estimates that about 11,000 people die from malaria in Cameroon every year and 30% of all out-patient visits to health care facilities are for malaria, making it a disease of importance in the country [5]. In the South West Region, the proportional morbidity rates of the disease in 2020 and 2021 were 28.4% and 26.7% respectively. The incidence of the disease in 2021 was 103 per 1000 in the region [6]. In the Tiko Health District (THD), there was a slight increase in proportional morbidity from 55.9% in 2020 to 56.5% in 2021 [7].

Different strategies such as the use of chemotherapeutic agents and vector control measures have been put in place to control malaria. The vector control measures include environmental hygiene for the reduction of mosquito breeding sites and the distribution of long lasting insecticide-treated bed nets (LLINs) [4]. LLINs repel and kill mosquitoes which carry the malaria parasite as these nets are treated with insecticides [8]. LLINs are the major preventive efforts of malaria in SSA. The use of LLINs has increased significantly in the past decade. Nevertheless, gaps in coverage still persist [9]. There have been several mass distribution campaigns (MDCs) of LLINs with the goal to reach 100% LLIN coverage [10]. So far, MDCs were conducted in 2011 and 2015 and the recent one launched in 2019 by the Cameroon Ministry of Public Health [11]. Hence, there is the necessity to determine LLIN ownership, coverage, usage and malaria prevalence following the recent MDC.

In the South West Region, two main strategies were adopted for the MDC of LLINs because of insecurity and the COVID-19 health crisis. There was the door-to-door strategy in health areas with low and moderate insecurity and the fixed “Hit and Run” strategy in health areas with high insecurity. In the Tiko Health District (THD), the fixed “Hit and Run” strategy took place only in the Mondoni health area while the door-to-door strategy was conducted in the other

health areas [7]. The door-to-door strategy was a mobile distribution strategy involving house to house distribution of LLINs with both household headcount and simultaneous distribution of LLINs [12]. On the other hand, the fixed “Hit and Run” strategy was a fixed-point distribution strategy in which the distribution of LLINs was done at a fixed site the day after the headcount [7]. The objective of the recent MDC was aimed at achieving universal coverage through the distribution of LLINs to 100% of the population [12]. Despite government’s effort to scale up the distribution of LLINs in Cameroon, full ownership and optimal use is still limited as a result of the lack of steady distribution and other issues related to LLIN maintenance [13]. In 2021, over a million LLINs were made available for distribution in the South West Region before the end of the year with no allowance for misuse [14]. After the recent MDC in the country, a study by Bamou *et al.* [11] reported overall LLIN coverage, ownership and usage rates in some villages in the South and Centre Regions to be 96%, 96.8% and 90% respectively. However, no study has so far been carried out to assess ownership, coverage and usage in the South West Region following the 2021 MDC. Moreover, the current situation of malaria has not yet been ascertained following the 2021 MDC. Thus, the aim of this study was to determine LLIN ownership, coverage, usage and the prevalence of malaria following the 2021 MDC in the Tiko Health District, South West Region of Cameroon.

2. Materials and Methods

2.1. Study Area

This study was carried out in the Tiko Health District (THD), found in Fako Division, South West Region of Cameroon (**Figure 1**). It is located between latitude 9°32'2"N to 9°40'9"N and longitude 9°25'7"E to 9°55'7"E [15]. This area experiences changes in climate from the hot coastline of the Tiko plain to the cold slopes of Mount Cameroon [16]. The area is characterized by poor drainage patterns with the presence of stagnant waters especially during the rainy season and as such favours the breeding of mosquitoes. THD is located in Tiko Subdivision with an extension in Limbe 3 Subdivision. It has an estimated population of about 157,784 inhabitants [12] who are distributed over a surface area of about 484 km² [17]. The district has 8 health areas, namely; Kange, Holforth, Likomba, Missellele, Mondoni, Mudeka, Mutengene and Tiko Town.

2.2. Study Design

A cross-sectional study was carried out in the Tiko Health District, South West Region of Cameroon, in which data were collected from May 1 to 27, 2022. The health district was selected by convenient sampling and because of the paucity of published information on the prevalence of malaria in the area. Two health areas (Likomba and Mondoni) were purposely selected for the study. This selection was based on the two different LLIN distribution strategies (door-to-door and fixed “Hit and Run”) used during the 2021 MDC within the district. The fixed

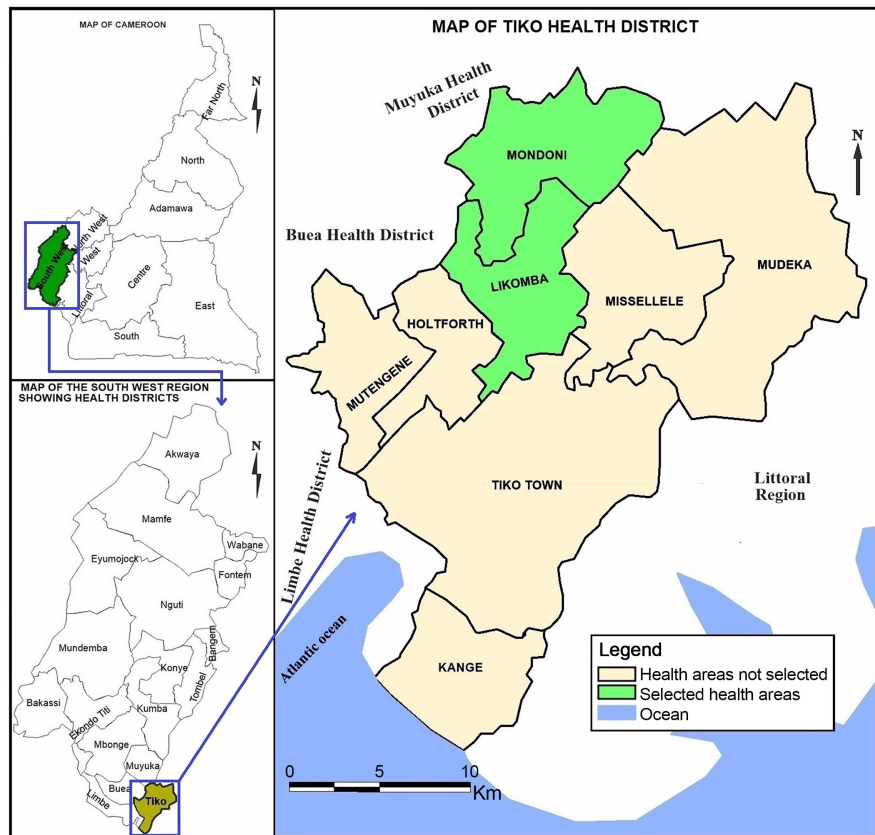


Figure 1. A map of Tiko Health District showing the study areas (drawn using MapInfo Professional 11.5 software).

“Hit and Run” was adopted only in the Mondoni health area while the door-to-door strategy took place in the other health areas including Likomba [7]. The door-to-door strategy was a distribution strategy involving house to house distribution of LLINs with both household headcount and simultaneous distribution of LLINs [12]. The fixed “Hit and Run” strategy was a distribution strategy involving a fixed point distribution of LLINs. The distribution was done at a fixed site the day after the headcount [7]. In this study, households (HHs) constituted the basic sampling unit. The study determined the proportion of LLIN ownership, coverage and usage by administering questionnaires to consented participants (household heads) in the health district. In addition, the study examined capillary blood samples collected from consented household members to determine the prevalence of malaria.

2.3. Ethical Considerations

The study was approved by the Faculty of Health Sciences Institutional Review Board of the University of Buea (Ref: 2022/1735-03/UB/SG/IRB/FHS). An administrative authorization was obtained from the Regional Delegation of Public Health for the South West Region (Ref N°: R11/MINSANTE/SWR/RDPH/PS/520/714). A similar authorisation was obtained from the District Health Service of Tiko

(Ref N° 2022/28Vol.IV/MINSANTE/PDRHSW/THD-193). All the participants were informed of the study goals, procedure, potential harm and benefits of the study. A signed informed consent was obtained from every participant before any interview was conducted. All consented participants were enrolled into the study. Assent was obtained from all parents/guardians for the participation of their children. Data obtained from participants were handled with high level of confidentiality.

2.4. Sample Size Determination and Sampling Method

2.4.1. Sample Size Determination

The minimum sample size was estimated using the Kish Leslie formula [18]. It was calculated by considering an estimated proportion of households owning LLINs of 89% obtained in 2017 by Fru *et al.* [17] in the THD.

$n = p(1 - p) * (Z_{\alpha/2}/d)^2$, where the proportion of households owing LLINs, $p = 0.89$, $1 - p = 0.11$. At 95% confidence interval, the critical value $Z_{\alpha/2} = 1.96$. An error margin (d) of 5% was used for this study. Thus, $n = (0.89) (1 - 0.89) (1.96/0.05)^2 = 150$. Therefore, the estimated sample size was 150.

2.4.2. Sampling Method

A multi-stage sampling method was used for this study. THD was conveniently selected for the study. Two health areas were purposely selected; Likomba and Mondoni. At least two communities were randomly selected from each health area. Thereafter, systematic random sampling (SRS) technique was used to select households. Every third unit household was selected based on probability proportionate to size. The various household heads were interviewed using questionnaires. Members of households who consented for interview and blood collection were sampled. Consented household heads were interviewed and if the household head was not present at the time of interview, the alternative household head (the person representing the household head) was interviewed. Malaria test was carried out among members of households who consented to be tested for malaria by collection of capillary blood for microscopic examination.

2.5. Data Collection

2.5.1. Administration of Questionnaires

The questionnaire that was used for this study was designed by the authors. Forty questionnaires were pre-tested in the Moliwe health area of the Limbe Health District for verification of reliability and validity. The questions were well understood by the respondents and as such, were not adjusted after pretesting. The questionnaires were administered by the principal investigator with the help of an assistant. The research assistant was trained before the start of data collection. The questionnaires were administered to household heads from house to house. In the absence of the head of the household, any adult (representing the household head) able to provide reliable information was interviewed. Partici-

pants were interviewed in either English (national language) or pidgin (local language) to document socio-demographic characteristics, LLIN ownership, coverage and usage.

2.5.2. Data Collection in Logbook

The logbook was used to capture responses given by consented household members before blood sample collection. Every consented household member in the THD was asked to provide information regarding sex, age, frequency of sleeping under LLINs, whether the participants slept under LLINs the previous night and frequency of tucking LLINs to the beds. Provision was made in the logbook to record the results of the malaria diagnosis.

2.5.3. Blood Sample Collection

The area on the middle finger was cleaned with 70% alcohol using a wet swab and allowed to dry. It was followed by a firm, quick puncture with a disposable lancet while simultaneously applying a little pressure to ensure the free flow of blood. The first drop of blood was wiped to ensure that the drop of blood does not contain tissue fluid. Two freefall drops of blood were collected on a microscope slide. They were smeared in a circular motion with the corner of another slide, taking care not to make the film too thick, and allowed to air-dry without fixative. After drying, the slides were kept inside a slide folder while in the field, and later transported to the Laboratory for staining and examination.

2.5.4. Laboratory Analysis

The blood films were stained with diluted Giemsa (1:20, vol/vol) for 20 minutes, and later rinsed with water. The slides were allowed to air-dry in a vertical position and later examined using a light microscope at X100 objective (oil immersion). A thick blood smear was declared negative after observing more than 100 fields at X100 high power magnification, and no malaria parasite seen. The parasite density was determined by counting the number of parasites present; ≥ 100 parasites per 200 white blood cells or ≤ 99 parasites per 500 white blood cells in the thick smear as recommended by WHO [19].

2.6. Statistical Analyses

Data collected were analyzed using SPSS version 25 for windows (SPSS Inc, Chicago USA). Descriptive summary of the data was presented on frequency tables, percentages and graphs. Descriptive statistics was mostly used to describe outcome variables by percentages. The major indicators estimated were coverage, ownership, use of LLINs and malaria prevalence. The Chi square (χ^2) test was used to compare LLIN ownership before and after the last distribution campaign. It was also used to compare LLIN ownership between health areas. The Pearson's Chi square test was used to examine the associations between malaria prevalence and each health area. Parasite densities were found not to have a normal distribution. The Mann-Whitney U test was used to compare the parasite densities for two groups (gender, health areas and the use of LLINs the pre-

vious night). The Kruskal-Wallis H test was used to compare the parasite densities for three (age group, frequency of sleeping under LLINs and frequency of tucking LLINs) or more groups (communities). All were considered significant at 0.05 significance level.

3. Results

3.1. LLIN Ownership before and after the 2021 Distribution Campaign

Out of the 150 households sampled in the Tiko Health District, 96 (64.0%) owned a mosquito net before the 2021 distribution campaign (**Figure 2**). LLIN ownership in Mondoni (69.7%) did not significantly differ ($\chi^2 = 0.596$, $p = 0.440$) from that in Likomba (62.4%). After the 2021 MDC, 91.3% (137/150) owned a mosquito net. There was no significant difference ($\chi^2 = 0.363$, $p = 0.547$) in LLIN ownership between Mondoni (93.9%) and Likomba (90.6%) health areas. However, there was an overall significant increase ($\chi^2 = 20.903$, $p < 0.001$) in LLIN ownership after the recent MDC (91.3%) compared to the ownership before the campaign (64.0%).

3.1.1. Sources of LLIN Acquisition in Households before and after the 2021 MDC

The study revealed that there was a variety of sources of LLINs before the 2021 MDC; 60.2%, 17.7% and another 17.7% acquired their LLINs from the previous MDC (2015), Antenatal care (ANC) and purchase respectively, while 4.4% acquired their mosquito nets via others sources (**Table 1**) such as from friends and relatives. After the 2021 MDC, there was another variation with respect to sources of LLIN acquisition in households. About 69.0%, 8.8%, 11.7%, 8.8% and 1.7% of households acquired their mosquito nets from the recent MDC (2021), previous MDC (2015), ANC, purchase and other sources respectively.

3.1.2. State of Mosquito Nets before and after the 2021 MDC

About 51.0% of mosquito nets were still in good state before the 2021 distribution campaign in the Tiko Health District (**Figure 3**). However, the proportion of good nets (51.0%) was not significantly different ($\chi^2 = 0.042$, $p = 0.838$) from torn nets (49.0%). More than half of the mosquito nets were in good state (78.7%) after the 2021 distribution campaign, and less than half of mosquito nets (21.3%) were reported to be torn. There was a significant difference ($\chi^2 = 41.127$, $p < 0.001$) between those in good state before (51.0%) and after (78.7%) the 2021 MDC.

3.1.3. LLIN Ownership from the 2021 Distribution Campaign

From the 2021 MDC, LLIN ownership was 78.7% (118/150) in the THD (**Table 2**). LLIN ownership in the area with door-to-door strategy (79.5%) was not significantly different ($\chi^2 = 0.213$, $p = 0.644$) from the one with fixed “Hit and Run” strategy (75.8%).

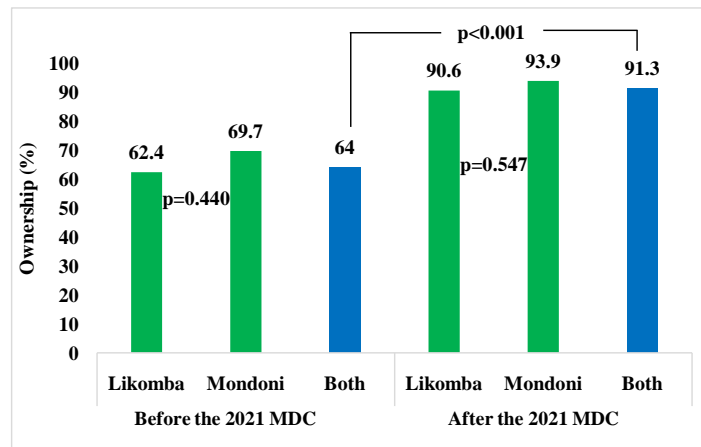


Figure 2. LLIN ownership before and after the 2021 distribution campaign.

Table 1. Sources of LLIN acquisition in households before and after the 2021 MDC.

	Before the 2021 MDC		After the 2021 MDC	
	No.	(%)	No.	(%)
MDC (2021)	-	-	118	69.0
MDC (2015)	68	60.2	15	8.8
ANC	20	17.7	20	11.7
Bought	20	17.7	15	8.8
Other sources	5	4.4	3	1.7
Total	113	100.0	171	100.0

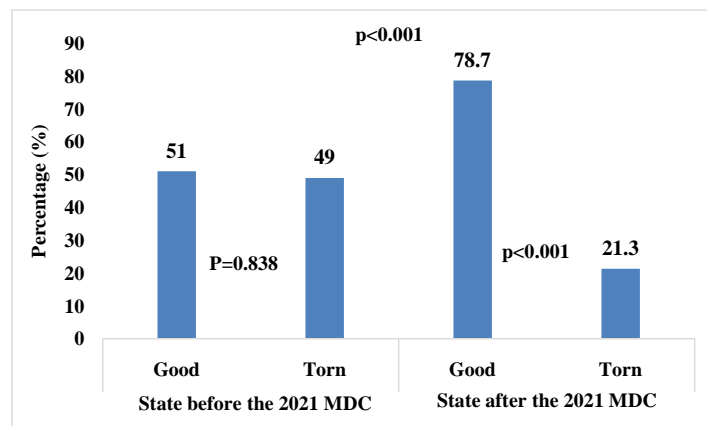


Figure 3. State of mosquito nets before and after the 2021 MDC.

Table 2. LLIN Ownership from the 2021 distribution campaign.

Health district	Health area	Ownership from the 2021 distribution campaign		χ^2	P-value
		Yes	No		
Tiko	Likomba (Door-to-door)	93 (79.5%)	24 (20.5%)	0.213	0.644
Health District	Mondoni (Fixed “Hit and Run”)	25 (75.8%)	8 (24.2%)		
	Total	118 (78.7%)	32 (21.3%)		

χ^2 = chi square test.

3.2. LLIN Coverage and Reasons for Non-Ownership of the 2021 LLINs

3.2.1. LLIN Coverage Following the 2021 Distribution Campaign

A coverage of 67.0% from the recent MDC was observed in the THD (**Table 3**). After considering other sources of mosquito nets (2015 MDC, ANC, Bought and Others), the overall coverage increased from 67.0% to 87.1% in the health district.

3.2.2. Reasons for Non-Ownership of the 2021 LLINs

Out of the households ($n = 32$) that did not acquire the 2021 MDC LLINs, 50.0% and 28.1% declared, not being available at home and the census team not visiting their house as major reasons for not acquiring LLINs during the 2021 MDC (**Table 4**). The minor reasons were, not being censured (6.3%) not being aware when the distribution took place (6.3%), and other reasons (9.4%) such as not being aware of the MDC.

3.3. Use of Mosquito Nets by Household Members

Out of the 150 households surveyed, 70.9% of household members slept under LLINs the previous night. LLIN usage among expectant mothers was 77.8% within their category (**Table 5**). LLIN usage among children < 5 and those 5 - 14 was 76.2% and 76.7% respectively.

Table 3. LLIN coverage following the 2021 MDC.

Health district	Health area	Coverage		
		MDC (2021) (%)	Other sources [MDC (2015), ANC, Bought, Others] (%)	Total (%)
Tiko Health District	Likomba (Door-to-door)	71.3	14.0	85.3
	Mondoni (Fixed “Hit and Run”)	62.7	26.3	89.0
	Total	67.0	22.1	87.1

Table 4. Reasons for non-ownership of the 2021 LLINs.

Reasons for not receiving 2021 LLINs	Frequency	Percentage
I was not censured	2	6.3
No one was available at home	16	50.0
The census team did not visit the house	9	28.1
I was not aware when the distribution took place	2	6.3
Other reasons*	3	9.4
Total	32	100.0

*Other reason for not receiving LLINs; 3 “Not aware of the MDC”.

Table 5. Use of mosquito nets by household members.

Health district	Health area	Household residents				Total
		Children < 5	Children 5 - 14	Persons ≥ 15	Pregnant Women	
		(%)	(%)	(%)	(%)	
Tiko	Likomba	74.2	76.8	68.1	87.5	71.7
Health	Mondoni	83.3	76.3	58.9	0.0	68.0
District	Total	76.2	76.7	66.3	77.8	70.9

3.4. Malaria Prevalence among Household Members

Out of the 283 household members tested for malaria, the overall prevalence of malaria was 10.2% (29/283) with a geometric mean parasite density (GMPD) of 2110.3 parasites/ μ L (range: 208 - 9440). Within the health areas, Likomba and Mondoni had 8.4% and 16.2% prevalence respectively (**Table 6**). There was no significant association between malaria prevalence and health areas.

3.4.1. Malaria Parasitaemia with Respect to Socio-Demographic Characteristics

The prevalence of malaria was significantly higher ($p = 0.022$) in male participants (14.5%) compared to females (6.2%), though the parasite density was significantly higher ($U = 9164.5$, $p = 0.020$) in females than males (**Table 7**). There was no significant difference in malaria prevalence among the three age groups ($p = 0.378$). The prevalence of malaria did not vary significantly within communities ($p = 0.280$) and within health areas ($p = 0.064$).

3.4.2. Prevalence and Parasite Density of Malaria with Respect to Utilization of LLINs

The prevalence of malaria was significantly higher ($p = 0.004$) among those who did not sleep under LLINs the previous night (21.2%) than those who slept under LLINs the previous night (7.8%) (**Table 8**). In terms of frequency of sleeping under LLINs, those who did not sleep under LLINs significantly had higher ($p = 0.007$) malaria prevalence (26.7%) than those sleeping under LLINs every night (8.1%) and some nights (8.7%). Malaria prevalence was significantly higher ($p = 0.020$) among those who did not tuck LLINs to the beds (20.8%) compared to those who tucked LLINs to the beds every night (6.5%) and some nights (9.9%).

4. Discussion

Out of the 150 households surveyed in this study, 64.0% of households owned a mosquito net before the 2021 distribution campaign in the THD. LLIN ownership in Mondoni (69.7%) did not significantly differ from that in Likomba (62.4%). These ownership rates are close to that of a study carried out in some rural and semi-urban communities in the South West Region where LLINs ownership was 69.3% [20]. It is also similar to the results of another study carried out in the Bamenda Health District with an ownership rate of 63.5% [4].

However, it is contrary to the findings from a study in the Mbengwi Health District with an ownership rate of 93.5% [21]. After the 2021 MDC, 91.3% owned a mosquito net. There was no significant difference in LLIN ownership between Mondoni (93.9%) and Likomba (90.6%) health areas. The LLINs ownership

Table 6. Prevalence of malaria by health areas.

Health area	Community	Number		Prevalence (%)	χ^2	P-value
		Examined	Positive			
Likomba	Upper Costen	54	4	7.4	0.386	0.943
	Water Tank	50	5	10.0		
	Middle Costen	55	5	9.1		
	SS Club	56	4	7.1		
	Total	215	18	8.4		
Mondoni	Marte	31	7	22.6	1.723	0.189
	Koke	37	4	10.8		
	Total	68	11	16.2		
Total	Total	283	29	10.2		

χ^2 = chi square test.

Table 7. Malaria parasitaemia with respect to socio-demographic characteristics.

Variable	Category	Number examined	Number positive (%)	GMPD (Parasite/ μ L)
Gender	Male	138	20 (14.5)	1600.9
	Female	145	9 (6.2)	2339.6
Significance			$p = 0.022$	U = 9164.5, $p = 0.020$
Age group	<5	22	4 (18.2)	4066.0
	5 - 14	61	7 (11.5)	576.9
	≥ 15	200	18 (9.0)	4936.0
Significance			$p = 0.378$	H = 2.666, $p = 0.264$
Community	Upper Costen	54	4 (7.4)	760.0
	Water Tank	50	5 (10.0)	697.6
	Middle Costen	55	5 (9.1)	1572.8
	SS Club	56	4 (7.1)	1686.0
	Marte	31	7 (22.6)	3364.6
	Koke	37	4 (10.8)	4128
Significance			$p = 0.280$	H = 6.644, $p = 0.248$
Health area	Likomba	215	18 (8.4)	1174.2
	Mondoni	68	11 (16.2)	3642.2
Significance			$p = 0.064$	U = 6708.0, $p = 0.052$

Pvalue computed from chi square test, H = Kruskal-Wallis test, U = Mann-Whitney test.

Table 8. Prevalence and parasite density of malaria with respect to utilization of LLINs.

Characteristics	Category	Number examined	Number positive (%)	GMPD (Parasite/ μ L)
Slept under LLINs the previous night	Yes	231	18 (7.8)	2287.6
	No	52	11 (21.2)	1820.4
Significance			$p = 0.004$	$U = 5206.5, p = 0.004$
Frequency of sleeping under LLINs	Every night	149	12 (8.1)	2094.0
	Some nights	104	9 (8.7)	1994.7
	Don't do it	30	8 (26.7)	2265.0
Significance			$p = 0.007$	$H = 10.067, p = 0.007$
Frequency of tucking LLINs	Every night	124	8 (6.5)	812.0
	Some nights	111	11 (9.9)	3194.9
	Don't do it	48	10 (20.8)	1956.0
Significance			$p = 0.020$	$H = 7.863, p = 0.020$

P value computed from chi square test, H = Kruskal-Wallis test, U = Mann-Whitney test.

(91.3%) in this study corroborates with the results obtained by Fru *et al.* [17] where 89% was reported in the same health district after the 2015 MDC. There was an overall significant increase in LLIN ownership from 64.0% before to 91.3% after the 2021 MDC. This outcome is similar to that of a study in a rural district in North West Tanzania where ownership increased from 62.6% before the distribution campaign to 90.8% afterwards [22]. However, a slight increase from 67.1% before the 2015 MDC to 69.7% after the campaign was observed in Cameroon [23]. The increase in this present study could be attributed to the fact that most LLINs (69.0%) at the household level were acquired from the recent MDC (2021).

Most of the mosquito nets before (60.2%) and after (69.0%) the 2021 MDC were obtained for free from the previous MDC (2015) and the recent MDC (2021) respectively. These results are contrary to findings obtained by Apinjoh *et al.* [20] where 91.3% of mosquito nets were gotten from the MDC. LLINs from households were also gotten via ANC, purchase and other sources. This is also in line with a previous study conducted in the THD [17] where these sources of LLINs were considered major channels of LLINs acquisition. About 51.0% of the mosquito nets were still in a good state before the 2021 distribution campaign. It is contrary to that of a study along the Mount Cameroon area by Njumkeng *et al.* [13] in which torn LLINs constituted a greater proportion (53.6%). However, the proportion of good nets (51.0%) in the present study was not significantly different from torn nets (49.0%). The state of LLINs after the recent MDC (2021) revealed that most of the LLINs (78.7%) were in good state. This is similar to findings obtained by Apinjoh *et al.* [20] with a greater proportion (74.7%) of good LLINs but contrary to that by Njumkeng *et al.* [13] with a smaller proportion (46.4%) of good LLINs. The difference in this study could be attributed to

the fact that most of the LLINs were acquired from the recent MDC (2021). The state of LLINs showed a significant difference before and after the 2021 MDC.

From the recent MDC (2021), LLIN ownership was 78.7% (118/150). The rate of LLIN ownership in our study corroborates the results obtained along the Mount Cameroon area with similar ownership of 77.6% [13]. It is also similar to the results obtained from Batoke-Limbe, with LLIN ownership of 78.8% [24]. However, LLIN ownership in this study was lower compared to that obtained in the South (Nyabessan) and Centre (Olama) Regions where the overall ownership was 96.8% as a result of the recent MDC in the country [11]. This difference could be attributed to the insufficient quantity of LLINs received in the THD. It should be noted that the 2021 MDC of LLINs was supposed to take place in 2019 nationwide when the census was conducted but was carried forward to 2021. The quantity of LLINs received in the THD was based on the 2019 census which was not a true picture of the population in 2021. Based on the 2021 MDC, no significant difference was observed between the two distribution strategies (door-to-door and fixed “Hit and Run”). The door-to-door strategy did not significantly increase the 2021 LLIN ownership as well as the fixed “Hit and Run” strategy. None of these strategies had an impact on LLIN ownership. It is the first time such findings are revealed about these LLIN distribution strategies since they were adopted for the 2021 MDC of LLINs in the South West Region.

A coverage of 67.0% from the 2021 MDC was observed in THD. LLIN coverage was higher in Likomba (71.3%) than Mondoni (62.7%). The coverage (67.0%) in our study is similar with findings of another study carried out in the Bamenda Health District of the North West Region of Cameroon where the coverage was 68.9% [4]. Other sources of LLINs (2015 MDC, ANC, purchase and others) increased LLIN coverage from 67.0% to 87.1%. However, this coverage rate was below the objective of the recent MDC aimed at achieving universal coverage through the distribution of LLINs to 100% of the population of the South West Region [12]. Although the 2021 MDC of LLINs significantly increased the overall LLIN ownership, coverage did not reach its full target (100%) as prescribed by WHO [10]. Nevertheless, overall LLIN coverage was above the minimum target (80%) [25] in the district. The limitation of LLIN coverage/ownership was due to the fact that some households did not receive the 2021 MDC LLINs. The major reasons were; no one being available at home (50.0%) and the census team not visiting their house (28.1%). Out of the 150 households surveyed, 70.9% of household members slept under LLINs the previous night. A similar observation (64.1%) was recorded in the Mbonge Health District [26]. The use of LLINs among pregnant women was 77.8% within their category. LLIN usage among children < 5 years (76.2%) and those 5 - 14 years (76.7%) are in contrast to findings by Teh *et al.* [24] who reported LLIN usage rate of 54.7% among children (≤ 14) residing in Batoke-Limbe, South West Region of Cameroon.

The overall prevalence of malaria in THD was found to be 10.2%. This is similar to 11.1% and 12.0% prevalence reported from studies in the North West (Mbengwi Health District) and South West (Nkongho-mbeng) Regions of Ca-

meroon [21] [27], respectively. However, the prevalence was lower than those observed in the Mount Cameroon area from previous studies; 20.1%, 20.1% 25.6%, 45.3%, 30.0%, 33.7%, 33.3%, and 27.7% [13] [20] [28]-[33] respectively. The prevalence was higher in Mondoni (16.2%) than Likomba (8.4%). The low prevalence in this study could be attributed to the period the study was conducted (May), with frequent rains which might have washed off breeding sites of the malaria vectors. There was no significant association between malaria prevalence and health areas. The overall geometric mean parasite density (GMPD) was 2110.3 parasites/ μ L of blood. This is similar to GMPD of 1721 parasites/ μ L reported in a study carried out in rural and semi-urban communities of the South West Region [20]. However, it is contrary to 6,869 parasites/ μ L reported in Nkongho-mbeng [27]. The prevalence of malaria was higher in male participants (14.5%) compared to females (6.2%). A similar observation was reported around the Mount Cameroon area [32], though contrary to findings obtained in the same area by Teh *et al.* [33] with higher prevalence in females than males. There was no significant difference in the prevalence of malaria among the three age groups. It is in line with results obtained in Mbengwi Health District [21]. The prevalence of malaria was significantly higher among those who did not sleep under LLINs the previous night (21.2%) than those who slept under LLINs (7.8%), which showed that LLIN use was less associated with malaria. In terms of frequency of sleeping under LLINs, those who did not sleep under LLINs significantly had higher malaria prevalence (26.7%) than those sleeping under LLINs every night (8.1%) and some nights (8.7%). A similar observation was reported in the Mbengwi Health District with a significant difference in malaria prevalence among participants who used and did not use LLINs [21]. However, it is contrary to findings reported in Nkongho-mbeng where no significant difference in malaria prevalence was observed among those who used and did not use LLINs [27]. This current study showed that not sleeping under LLINs was more associated with malaria. Tucking LLINs to the bed appeared to protect against malaria as prevalence was significantly higher among those who did not tuck LLINs to the beds (20.8%) compared to those who tucked LLINs to the beds every night (6.5%) and some nights (9.9%). As such, not tucking LLINs to the bed also proved to be more associated with malaria. This study proved that the recent MDC (2021) of LLINs had an impact on the prevalence of malaria five months after the distribution campaign in the Tiko Health District.

5. Conclusions

The increase in LLIN ownership was as a result of the 2021 MDC. The 2021 MDC of LLINs had an impact on malaria prevalence in those who properly used them which suggests that an increase in the frequency of MDC of LLINs should be the right thing to do. People should be sensitized to continually use LLINs and to frequently tuck LLINs to their beds in order to prevent malaria.

This study had some limitations. The prevalence of malaria was estimated us-

ing microscopy which is not very sensitive. A more sensitive tool like the Polymerase Chain Reaction (PCR) on a larger sample size could yield better results.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix: Questionnaire

Instruction: Fill in the blanks & Tick “√” where appropriate.

Preliminary information

Respondent's ID: _____ Health district: _____ Health area: _____
Community: _____

LLIN distribution strategy: _____

Section A: Socio-demographic characteristics

Q.1. Sex of respondent: (a) Male [] (b) Female []

Q.2. Age (years):

Q.3. Marital status: (a) Single [] (b) Married [] (c) Divorced [] (d) Widowed []

Q.4. Occupation: (a) Civil Servant [] (b) Private Sector [] (c) Business [] (d) CDC Worker [] (e) Farmer [] (f) House Wife [] (g) Unemployed [] (h) Student [] (i) Others [] (specify): _____

Q.5. Level of education: (a) No formal education [] (b) Primary education [] (c) Vocational training [] (d) Secondary/High school education [] (e) Tertiary education []

Q.6. Religion: (a) Christian [] (b) Muslim [] (c) Others []

Q.7. Major ethnic group: (a) Bantu [] (b) Semi-bantu [] (c) Sudanese []

Q.8. What type of building do you live in? (a) Block [] (b) Wood [] (c) Mixed []

Section B: LLIN ownership before the last distribution campaign

Q.9. Did you have any mosquito net in your household before the last distribution campaign?

(a) Yes [] (Continue) (b) No [] (Skip to Q.12)

Q.10. If Yes, how did you acquire it (them)? Please specify if applicable, the approximate date of acquisition and give the number of mosquito nets from the source(s). (Multiple options can be selected)

(a) [] The previous Mass Distribution Campaign (2015), how many?

(b) [] Ante-Natal Clinic, how many?

(c) [] I bought it, how many?

(d) [] Others (specify): _____ how many?

Q.11. What was the state of the mosquito net(s) before the last distribution campaign?

(a) Good [] (b) Torn []

Section C: LLIN ownership, coverage and usage after the last distribution campaign

I) LLIN ownership and coverage after the last distribution campaign

Q.12. Do you presently have mosquito net(s) in your household?

(a) Yes [] (Continue) (b) No [] (Skip to Q.14, move to Q.15 and end at Q.23a)

Q.13. If Yes, how did you acquire it (them)? Please specify if applicable, the approximate date of acquisition and give the number of mosquito nets from the

source(s). (Multiple options can be selected)

(a) The recent Mass Distribution Campaign (2021), how many?

(Skip to Q.15)

(b) The previous Mass Distribution Campaign (2015), how many?

(c) Ante-Natal Clinic, how many?

(d) I bought it, how many?

(e) Others (specify):_, how many?

Q.14. If you did not receive any mosquito net from the recent Mass Distribution Campaign (2021), what is the reason? (Tick; \surd , only one option) (a) I was not censured (b) No one was available at home (c) The census team did not visit the house (d) I was not aware when the distribution took place (e) I did not go for collection (f) I was late for collection (g) Others (Specify): _____

Q.15. How many household members were recently living in the household during that period of the distribution campaign? (Please write the number of persons, say 0, 1, 2, 3... in the box below the option).

Children less than 5 years	Children 5 to 14 years	Persons 15 years and above	Pregnant women	Total
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Q.16. If you did receive mosquito net(s) from the recent Mass Distribution Campaign (2021), are you satisfied with the quality?

(a) Yes (**Skip to Q.18**) (b) No

Q.17. If **No**, give the reason(s). (Multiple options can be selected)

(a) The net is too long (b) The net is too short (c) The size of the net is too big (d) The size of the net is too small (e) Torn with holes (f) The smell of the net is repulsive (g) Others (specify): _____

Q.18. What is the state of the mosquito net(s)?

(a) Good (b) Torn

Q.19. Does your household have one mosquito net for every person?

(a) Yes (**Skip to Q.21**) (b) No

Q.20. Does your household have one mosquito net for every 2 persons?

(a) Yes (b) No

II) Usage of LLINs after the last distribution campaign

Q.21. Are there mosquito net(s) hung over beds or sleeping places?

(a) Yes (b) No (**Skip to Q.23a and end at Q.28**)

Q.22. If **Yes**, give the source(s) of those mosquito net(s) hanging over beds or sleeping places? Please specify if applicable, the approximate date of acquisition and give the number from the source(s). (Multiple options can be selected)

(a) The recent Mass Distribution Campaign (2021), how many?

(b) The previous Mass Distribution Campaign (2015), how many?

(c) Ante-Natal Clinic, how many?

(d) I bought it, how many?

(e) Others (specify):_____, how many?

Q.23. How many people in the household in general **(a)** slept last night and if applicable, specify those who slept under the LLINs last night? (Please write the number of persons, say 0, 1, 2, 3... in the appropriate box below the option).

	Children less than 5 years	Children 5 to 14 years	Persons 15 years & above	Pregnant women	Total
(a) In general					
(b) Slept under LLINs					

Q.24. In the past week, how often were the mosquito nets used? (Please tick; \surd , in the square bracket to the right of the option).

7 nights [] 5 - 6 nights [] 3 - 4 nights [] 1 - 2 nights [] 0 nights [] I don't know []

Q.25. If mosquito nets were not used every night, give the reason(s). (Multiple options can be selected).

(a) They were dirty [] **(b)** it gives heat [] **(c)** No mosquitoes [] **(d)** The Coil/Spray/Repellent was used [] **(e)** Forgot [] **(f)** Don't like the smell of the net [] **(g)** Others [] (specify): _____

Q.26. How often do you tuck the net(s) to the bed(s) when brought down in the evening? (Tick; \surd , only one). **(a)** Every Night [] **(b)** Some of the nights [] **(c)** Don't do it []

Q.27. If you have mosquito net(s) hung over beds or sleeping places, from who did you learn how to use it (them)? (Tick; \surd , all that apply). **(a)** I have not learned yet [] **(b)** From mass media (Television, Radio, Newspaper, Internet) [] **(c)** From the agents of distribution campaign [] **(d)** From hospital staff [] **(e)** Others [] (Specify): _____

Q.28. Apart from using bed nets to protect from mosquito bites, what else do people use the mosquito net(s) for around your quarter? (Tick; \surd , all that apply)

(a) To fence garden/nursery [] **(b)** For fishing [] **(c)** Wire mesh on window [] **(d)** Chicken Shed [] **(e)** None [] **(f)** Others [] (specify): _____