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Evaluation of the Use of Long-Lasting Impregnated Mosquito Nets (LLINs) in the Health District of Dimbokro (Center of Côte d'Ivoire)

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Abstract

The Dimbokro health district has one of the highest incidences of malaria in Côte d'Ivoire, despite numerous campaigns to distribute Long-Acting Impregnated Mosquito Nets (LLINs). Given this observation, what are the population's attitudes towards LLINs that could explain the high endemicity of malaria in Dimbokro? The aim of this study is to assess the knowledge, attitudes and practices of people in the health area of Nofou, one of the villages in the Dimbokro health district where malaria is most prevalent, with a view to strengthening malaria control strategies. A collection of historical health data (malaria cases and LLIN usage rates) and a cross-sectional questionnaire survey was carried out from July 20 to August 03, 2022 in 400 households selected by systematic random sampling. Data were entered using Epi Info 7 and multivariate statistical analyses were performed using IBM SPSS 22 software. In the Dimbokro health district, the rate of LLIN use was negatively correlated (r = −0.771) with malaria incidence over the six years of historical data collection. Households had an average of 53% good knowledge, 68.6% good practices and 28.4% good attitudes towards LLINs. The study also revealed that the main factors explaining LLIN use in the Nofou health area are

mosquito bite (ORa = 5.29 (1.12 - 25.04)), age of household members (ORa = 1.07 (1.01 - 1.14)) and marital status (ORa = 8.45 (1.70 - 45.02)). Awareness-raising on the use of LLINs should be intensified in the Dimbokro health district. Other control strategies, such as vector control and environmental sanitation, should be considered to combat malaria.

Keywords

Malaria, LLINs, Knowledge, Attitudes, Practices, Dimbokro, Côte d'Ivoire

1. Introduction

Long-Acting Insecticide-Treated Mosquito Nets (LLINs) are the main means of combating malaria in regions of the world where this disease is rife [1]. Indeed, at global level, the number of deaths due to malaria decreased from 625,000 to 619,000 from 2020 to 2021, but remained higher than the 568,000 deaths estimated in 2019. Malaria cases continued to rise in 2021, but at a slower rate than in 2019-2020. They were estimated at 247 million in 2021, 245 million in 2020 and 232 million in 2019 [2]. The use of LLINs is one of the prevention strategies recommended by the World Health Organization (WHO) in malaria control programs. However, this method of universal coverage of populations with LLINs in the fight against malaria still presents difficulties in its possession and use by households.

Sub-Saharan Africa is the hardest hit, with 95% of cases and 96% of deaths, 80% of which occur in children under 5 [3]. Given this situation, one of the most effective methods of combating malaria recommended by the WHO is the use of LLINs in households in malaria-affected countries [4].

However, morbidity and mortality due to this disease are still high in sub-Saharan Africa, despite the many efforts made by national and international public health organizations. According to [5], in Africa 46% of the population did not have an LLIN, and 53% of children under the age of five did not sleep under one. In Benin, [6] emphasized the importance of using LLINs to protect against culicidal nuisance. However, less than 50% of children aged 0 to 5 sleep under an LLIN. The parents of these children use LLINs to protect young vegetable plants. In recent years, Sierra Leone has undertaken extensive efforts to prevent malaria, and the use of impregnated mosquito nets among children under five has increased by 66% [7]. In Niger, cultural beliefs are not the main barrier to the use of LLINs. On the other hand, knowledge as well as social, technical, environmental and economic dimensions explain the non-use of LLINs at community level [8]. In Cameroon, the level of education, and both sociological and anthropological considerations play their part in this refusal to use mosquito nets. Complaints related to discomfort, suffocation under a net, irritation due to the insecticide contained in the LLIN, damage to bedroom walls due to the installa-

tion of the net and the white color of the LLIN associated with the shroud are also reasons cited [9] [10].

Côte d'Ivoire, like other tropical African countries, is not spared the threat of malaria. It is one of the major causes of hospitalization in First Contact Health Establishments (FCHEs), with an incidence rate in 2020 of 173‰ generally in population and 441‰ in children under 5 years of age [11]. In Côte d'Ivoire, over 73% of the population lives in regions where the annual incidence of malaria ranges from 150‰ to over 300‰ inhabitants [11]. With a view to curbing this endemic, the Ivorian government, aided by international partners, has organized several LLIN distribution campaigns. As a result, the LLIN usage rate, which was 33% in 2012, rose to 50% in 2016 and to over 63% in 2019, following the distribution of over 15 million LLINs in 2017 and 2018. However, this utilization rate (63%) remains below the national target set at 80% [12] [13]. In Côte d'Ivoire, [14] also mentioned that the reasons for non-use of the LLIN are its shape, color and cost of acquisition.

Like other health districts in Côte d'Ivoire, the Dimbokro health district has benefited from two LLIN distribution campaigns, in 2017 and 2021 respectively. However, despite the efforts made by the health authorities to reduce the incidence of malaria, this health district still has one of the highest incidences in Côte d'Ivoire. Indeed, in 2021, in the general population, the incidence of malaria in Dimbokro was 262.75 ‰ versus 173.43 ‰ at national level and 633‰ versus 441‰ at national level in children under five [11].

In view of the above, it is necessary to know the knowledge, attitudes and practices of the population of the Dimbokro health district with regard to LLINs, hence the interest of this study.

The aim of our work is to assess household use of long-acting insecticide-impregnated mosquito nets (LLINs) in order to better orient malaria control strategies in the Dimbokro health district, where this disease remains prevalent.

2. Methods

2.1. Study Area

This study was carried out in the Nofou health area, part of the Dimbokro health district in central Côte d'Ivoire, around 80 km from Yamoussoukro (political capital) and 240 km from Abidjan (economic capital). Located between 6°36 and 7°00 N latitude North and 4˚36 and 4˚48 longitude West, the Dimbokro health district has a Baoulean equatorial climate, influenced by harmattan and monsoon. It is characterized by a long (October to March) and short (August to September) dry season, as well as a long (April to June) and short (July - August) rainy season. Average monthly temperatures range from 27 to 30˚C. The N'ZI river, the most important watercourse, crosses the department from north to south [15].

2.2. Choix de la Zoned'étude

The choice of this survey locality was justified by the fact that retrospective data collection of malaria casescarried out at the Dimbokro Departmental Health Directorate, where public health data are archivedshowed the Nofou health area to be the most prevalent malaria zone in the Dimbokro health district. In addition, the insalubrious situation in Nofou prompted the installation of Local Sanitation, Health and Hygiene Committees (CLASH) and the organization of a major household clean-up and sanitation operation (grass, household waste, puddles, etc.) initiated by the sub-prefectoral authority with technical and material support from the Yamoussoukro Regional Sanitation and Health Department. The choice of Nofou is also justified by the population's reliance on river water, whose poor quality has been the cause of many diarrhoeal diseases and infant mortality over the past two years.

2.3. Study Population and Inclusion Criteria

Our study population consisted of households in the Nofou health area. During the survey, we included households that owned an LLIN and had lived in the study area for 6 months or more, but excluded households that did not own an LLIN, had not given written consent, or had lived in the study area for less than 6 months.

2.4. Type of Study

Retrospective study: collection of historical health data

Historical malaria cases from seventeen (17) public health centers were collected at the Dimbokro Departmental Health Directorate, where all health data from public health establishments are archived. In addition to malaria cases, annual rates of LLIN use were also recorded. The cases of malaria and rates of LLIN use collected cover the period 2017-2022, from July 20 to August 03, 2022.

Descriptive study: cross-sectional household survey

A descriptive cross-sectional household survey was carried out from July 20 to August 03, 2022 in the Nofou health area. The survey was preceded by training on data collection tools and survey methodology.

2.5. Sample Size

The size (n) of households to be surveyed in the Nofou health area, increased by 10%, was calculated using the following formulain "Equation (1)" [16]:

$$n = t^2 \times p(1-p)/e^2 \quad (1)$$

t: confidence level deduced from the confidence interval. We generally take the value 1.96 for a 95% confidence level (centered reduced normal distribution).

p: net usage rate set at 63% [17].

e: margin of error set at 5%.

n = 400 households.

A total of 400 households were surveyed in the Nofou health area.

2.6. Data Collection

2.6.1. Data Collection Tools

A questionnaire was drawn up and submitted to public health experts at the Institut National d'HygiènePublique (INHP) for correction and validation.

Next, a pre-survey was carried out from April 4 to 5, 2021 among 25 households in a district of the town of Bocanda with the same socio-demographic characteristics as the study area, with the aim of testing the questionnaire, correcting any errors and ambiguities, familiarizing interviewers with the various questions and assessing the duration of questionnaire administration.

The questionnaire was structured in three parts:

- Socio-demographic characteristics (Sex, Age, Social Status, Educational level, Marital status, Household size).
- Household knowledge of malaria and LLINs (Mode of transmission of malaria, Malaria serious illness, Methods to combat malaria, Role of the LLIN, when to use the LLIN, People who must use the LLIN, Period for sleeping under MILDA).
- Household Attitudes and Practices towards LLINs (use the night before, Regular use of the LLIN, Reasons for not using the LLIN regularly, LLIN interview, LLIN wash type, Drying of LLIN, LLIN installation, Action taken before MILDA installation, Checking the status of the installed LLIN.

2.6.2. Data Collection Technique

The households to be surveyed were selected at random, in order to respect the principle of independence of the choice of households to be surveyed from the interviewer through systematic random sampling [16] [18]. Within the household, the respondent was the head of the household, represented by the father or mother. If these people were absent during the survey, the questionnaire was administered to an adult member of the household, aged 18 or over, who had lived in the household for at least six (06) months. If all the people in the household were minors (age < 18) or if the household did not consent, it was replaced by another household, following the methodology defined above.

Accompanied by a translator, the information gathered in the households concerned socio-demographic characteristics, knowledge, attitudes and practices regarding the use of LLINs.

Direct observations were made on a number of variables: the actual installation of the LLIN, its expiration date, its cleanliness and whether or not it was torn.

2.7. Data Processing and Analysis

The historical malaria cases collected were entered and analyzed using Excel software. These historical data were used to calculate the average incidence of

malaria in the various localities of the Dimbokro health district.

The Pearson correlation test was performed to establish the association between average malaria incidence and the rate of household use of LLINs over the period 2017-2022.

Data from the cross-sectional household survey were entered using Epi Info version 7 software, and analyses were carried out using IBM SPSS 22.0 for Windows. Analyses focused on the knowledge, attitudes and practices of the population of the Nofou health area with regard to malaria and the use of LLINs.

A scale of one point per question was awarded in each section. For the eight (08) point score on household knowledge and attitudes to the use of LLINs, a score of less than or equal to four (04) points was considered poor knowledge of LLINs, equivalent to less than 50% correct answers. A score of between four (04) and six (06) points was considered acceptable knowledge, with a proportion of between 50 and 80% correct answers, and a score of over six (06) points was considered good knowledge of malaria and the LLIN, with a proportion of over 80% correct answers.

Household practices in relation to LLINs were scored out of four (04) points. A score of less than two (02) points was considered poor practice, i.e. less than 50% correct answers, and a score of two (02) points was considered acceptable practice, i.e. 50% correct answers. A score of three (03) and four (04) points was considered good practice with regard to LLINs, equivalent to 75% to 100% correct answers.

The Chi-square test was used to compare the proportions of categorical variables at the 5% threshold.

A conditional multivariate analysis by logistic regression using the top-down stepwise method was carried out to identify explanatory factors for LLIN use and control for confounding factors. LLIN use was the dependent variable, while population knowledge, attitudes and practices were the independent variables. At each regression, factors associated with use whose Wald test p-value (Z statistic) was greater than 0.1 were eliminated. Explanatory variables with a p-value between 0.05 and 0.1 were then removed one by one, until the final model contained variables associated with LLIN use with a p-value of 0.05 or less.

2.8. Ethical Considerations

To carry out this study, a research authorization signed by the Direction des Etablissements et des Professionnels Sanitaires (DEPS) was obtained. This authorization was presented to the Regional Health Director of N'ZI, the Departmental Health Director of Dimbokro and the Head Nurse of the CSR of Nofou. The various chiefdoms in the Dimbokro health area were also informed.

During the survey, each household was informed of the purpose of this study as well as the free and voluntary nature of their participation. Written informed consent was obtained from the different household heads before answering the questions. All those surveyed were reassured that the information collected in

this study will remain anonymous and strictly confidential.

3. Results

3.1. Malaria Incidence in Dimbokro Health District

The highest average incidence of malaria over the period 2017 to 2022 was recorded in the Nofou health area (63‰) making this village the most malaria endemic locality in the Dimbokro health district. The other health areas had an average incidence of at least 20‰ (Figure 1).

3.2. Socio-Demographic Characteristics of Participants

Table 1 shows the various socio-demographic characteristics that influence LLIN use and exposure to malaria.

The proportion of women surveyed, 58.5%, is statistically more significant than the proportion of men surveyed ($p < 0.001$). The average age was 45, and the over-50 age group was surveyed in a more significant proportion than the others ($p = 0.005$). The proportion of unemployed, at 45.3%, is statistically significant ($p < 0.001$) compared with the other social strata. Almost 61% of respondents are not in school, a proportion that is statistically more significant ($p < 0.001$) than other levels of education. In terms of household size, the proportion of households with more than five people (42.8%) remains significantly higher than other household size proportions ($p < 0.001$). Finally, 57% of respondents were married, a proportion that is statistically more significant than singles and widowers ($p < 0.001$).

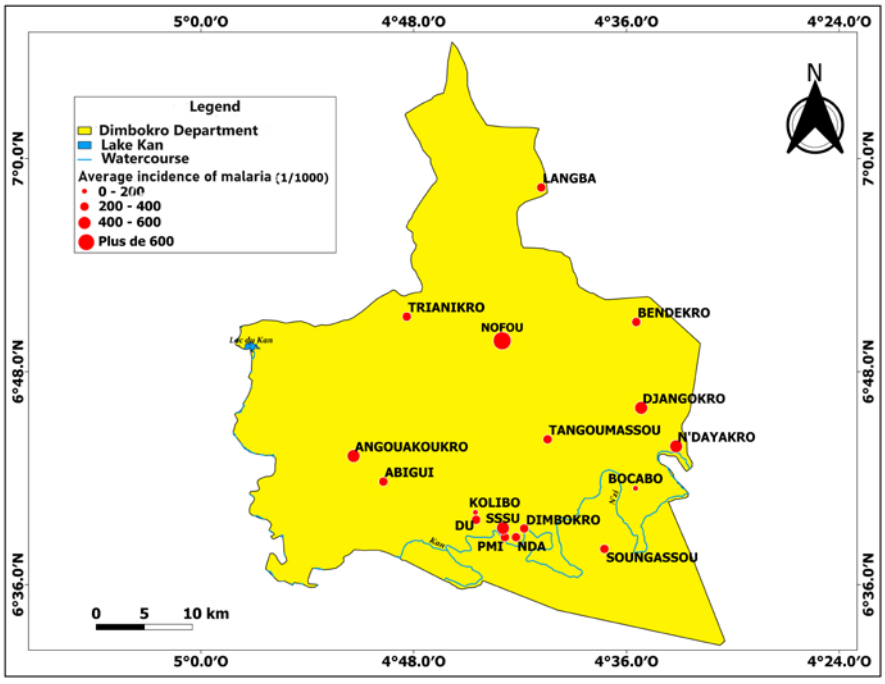

Figure 1. Spatial distribution of average malaria incidence in the Dimbokro health district, central Ivory Coast over the period 2017-2022.

Table 1. Sociodemographic characteristics of households surveyed in the Nofou health area (Dimbokro health district, August 2022).

Sociodemographic characteristics (n = 400)	Number (n)	Percentage (%) and 95%CI[a]	p-value
Sex			0.001
Female	234	58.5 (53.5 - 63.4)	
Male	166	41.5 (36.6 - 46.5)	
Age			0.005
18 - 35	104	26.0 (21.8 - 30.6)	
35 - 50	141	35.3 (30.6 - 40.2)	
Over 50	155	38.8 (33.9 - 43.7)	
Social Status			<0.001
Farmer	342	85.5 (81.7 - 88.6)	
Functionary	06	1.5 (0.6 - 3.2)	
Other social statuses	52	13.0 (10.1 - 16.7)	
Educational level			<0.001
Not in school	244	61.0 (56.0 - 65.8)	
Primary	97	24.3 (20.1 - 28.8)	
Secondary	50	12.5 (9.4 - 16.1)	
Superior	09	2.3 (1.0 - 4.2)	
Marital status			<0.001
Bachelor	144	36.0 (31.3 - 40.9)	
Bride	228	57.0 (52.0 - 61.9)	
Widower/ widow	28	7.0 (4.7 - 10.0)	
Household size			<0.001
Five and more	171	42.8 (37.8 - 47.8)	
Four	77	19.3 (15.5 - 23.5)	
Three	89	22.3 (18.3 - 26.6)	
Two	35	8.8 (6.2 - 12.0)	
One	28	7.0 (4.7 - 10.0)	

a: 95% Confidence Interval.

3.3. Household Knowledge

The results in Table 2 show people's knowledge of malaria, which influences their exposure to the disease and consequently their willingness to use LLINs.

Nearly 68% of households in the Nofou health area report malaria transmission by mosquito bite, which is more significant ($p < 0.001$) than exposure to the sun.

In the Nofou health area, almost 98% of those surveyed knew that malaria is a dangerous disease, and at least 64% of people in households who said they had

Table 2. Knowledge of malaria and LLIN by households in the Nofou health area (Dimbokro health district, August 2022).

Knowledge (n = 400)	Number (n)	Percentage (%) and 95%CI[a]	p-value
Mode of transmission of malaria (yes)			<0.001
Mosquito bite	273	68.3 (63.4 - 72.8)	
Sun exposure	46	11.5 (8.5 - 15.0)	
Do not know	59	14.8 (11.4 - 18.6)	
Malaria serious illness			<0.001
Yes	392	98.0 (96.1- 99.1)	
No	08	2.0 (0.9 - 3.9)	
Visiting a health service			<0.001
Yes	257	64.3 (59.3 - 69.0)	
No	143	35.8 (31.0 - 40.7)	
Methods to combat malaria (yes)			<0.001
Use MILDA	270	67.5 (62.7 - 72.1)	
Sanitation of the living environment	111	27.8 (23.4 - 32.4)	
Use insecticide	13	3.3 (1.7 - 5.5)	
Role of the LLIN (yes)			
Protect yourself against mosquitoes	375	93.8 (90.9 - 95.9)	<0.001
When to use the LLIN (yes)			<0.001
All day	18	4.5 (2.7 - 7.0)	
All night long	379	94.8 (92.1 - 96.7)	
Do not know	03	0.8 (0.1 - 2.2)	
People who must use the LLIN (yes)			<0.001
Everyone	347	86.7 (83.0-89.9)	
Child under 5 years old	25	6.3 (4.1 - 9.1)	
Pregnant woman	23	5.8 (3.7 - 8.5)	
The elderly	05	1.3 (0.4 - 2.9)	
Period for sleeping under MILDA (yes)			<0.001
In rainy season	76	19 (15.3 - 23.2)	
In dry season	08	2.0 (0.9 - 3.9)	
Knowledge Score Level			<0.001
Bad ≤ 3 or ≤50%	69	17.3 (13.7 - 21.3)	
Acceptable 4 - 6 or 50% - 79%	57	14.3 (11.0 - 18.1)	
Good 6 - 8 or 80% - 100%	274	68.5 (63.7 - 73.0)	

A: 95% Confidence interval.

been ill had attended a health center.

The use of LLINs was perceived by 67.5% as the primary method of combating malaria, ahead of sanitation and the use of insecticides.

In the study area, almost 94% of households knew that LLINs were used for protection against mosquito bites, and slept under them at night.

In the Nofou health area, less than 7% of pregnant women, children under 5 and the elderly use LLINs.

Households surveyed use LLINs more in the rainy season (19%) than in the dry season (2%). There was a significant difference between the proportion of households using LLINs in the rainy and dry seasons ($p < 0.001$). 21% of households surveyed knew that the duration of effectiveness of the LLIN was three years. Finally, with regard to the score, in the Nofou health area, the proportion of households with good knowledge (68.5%) of pa-ludism and LLINs was more significant than poor and acceptable knowledge ($p < 0.001$).

3.4. Household Attitudes

Table 3 shows the various attitudes that condition the correct use of LLINs by the population and could reduce the incidence of malaria in the Nofou health area.

InNofou, 79.8% of people claimed to have used the LLIN the night before the survey, astatistically significant proportion ($p < 0.001$) compared with those who did not sleep under the LLIN.

The proportion of 60% of households who stated that heat was the main reason for not using the LLIN on a regular basis is significant compared to other reasons for non-use ($p < 0.05$). Nearly 10% of households gave no reason for not using the LLIN on a regular basis.

With regard to the maintenance of LLINs, nearly 74% of households washed their LLINs. Nearly 41% of households washed it using soap. On the other hand, 33.2% used plain water for washing. Detergent washing (bleach) was used by 26%.

In the Nofou health zone, 63.4% of households dried their LLINs in the shade, while 36.6% dried them in the sun.

Regarding the score in the Nofou health area, the proportion of households (71.3%) with a bad and an acceptable attitude towards LLINs was statistically more significant ($p =< 0.001$) than the good attitude (28.8%).

3.5. Household Practices

Table 4, which presents people's practices, is a continuation of the table on attitudes. The results presented in this table reveal the need for people to adopt good LLIN practices in order to reduce the prevalence of malaria.

In our survey, 88.3% of households had installed an LLIN. The results of our survey show that 80.7% of households opened and spread the LLIN in the shade for 24 hours before installing it. On the other hand, 16.1% of households opened it and set it up in the sun.

Table 3. Attitudes towards the LLIN reported by households in the Nofou health area (August 2022).

Attitudes (n = 400)	Number (n)	Percentage (%) and 95%CI[a]	p-value
LLIN use the night before (yes) (n = 400)			<0.001
Yes	319	79.8 (75.5 - 83.6)	
No	81	20.3 (16.4 - 24.5)	
Regular use of the LLIN (n = 400)			<0.001
Yes	183	45.8 (40.8 - 50.8)	
No	217	54.3 (49.2 - 59.2)	
Reasons for not using the LLIN regularly (n = 217)			0.002
Heat	131	60.4 (53.5 - 66.9)	
No reason	43	19.8 (14.7 - 25.7)	
Cause of inconvenience	43	19.8 (14.7 - 25.7)	
LLIN interview (yes) (n = 400)			<0.001
Washing the LLIN	295	73.8 (69.1 - 78.0)	
No Washing the LLIN	105	26.3 (22.0 - 30.7)	
LLIN wash type (yes) (n = 295)			<0.001
Wash with soap and water	120	40.7 (35.0 - 46.5)	
Simple water wash	98	33.2 (27.8 - 38.9)	
Wash with detergent	77	26.1 (21.2 - 31.5)	
Drying of LLIN (yes) (n = 295)			<0.001
Drying in the shade	187	63.4 (57.6 - 68.9)	
Sun drying	108	36.6 (31.1 - 42.4)	
Level Score for Attitude (n = 400)			<0.001
Bad ≤ 2 or ≤50%	62	15.5 (12.1 - 19.4)	
Acceptable = 2 or 50%	223	55.8 (50.7 - 60.7)	
Good 3 - 4 or ≥75%	115	28.8 (24.4 - 33.5)	

a. 95% Confidence interval.

Table 4. Practices towards the LLIN reported by households in the Nofou health area (August 2022).

Pratiques (n = 400)	Number (n)	Percentage (%) and 95%CI[a]	p-value
LLIN installation (n = 400)			<0.001
Yes	353	88.2 (84.7 - 91.2)	
No	47	11.8 (8.8 - 15.3)	
Action taken before MILDA installation (yes) (n = 353)			<0.001
Open and install in the shade for 24 hours	285	80.7 (76.2 - 84.7)	
Open and install on the bed	11	3.1 (1.6 - 5.5)	
Open and install in the sun	57	16.1 (12.5 - 20.4)	

Continued

Checking the status of the installed LLIN (yes) (n = 353)			<0.001
Torn	18	5.1 (3.0 - 7.9)	
Own	258	73.1 (68.1 - 77.6)	
Expired	77	21.8 (17.6 - 26.5)	
Level Score for practice (n = 400)			<0.001
Bad < 2 or <50%	69	17.3 (13.7 - 21.3)	
Acceptable = 2 or 50%	57	14.3 (11.0 - 18.1)	
Good 3 - 4 or ≥75%	274	68.5 (63.7 - 73.0)	

a. 95% Confidence interval.

In our study, 73.1% of households had a clean LLIN and 21.8% had an out-of-date LLIN. The proportion of torn LLINs averaged 5.1%.

In conclusion, the proportion of good LLIN practices (68.5%) was more significant ($p < 0.001$) than bad and acceptable practices in the Nofou health area.

3.6. Identification of LLIN Use Factors in the Nofou Health Area

The initial and final model of the logistic regression analysis (Table 5) made it possible to identify three (03) main factors explaining the use of the LLIN in the Nofou health area. These are: the mosquito bite (ORa = 5.29 (1.12 - 25.04)), the age of the respondents (ORa = 1.07 (1.01 - 1.14)) and marital status (ORa = 8.45 (1.70 - 45.02)).

4. Discussion

The aim of this study, which took place in the Dimbokro health district where malaria remains prevalent in Côte d'Ivoire, was to assess household use of LLINs.

The low level of schooling among respondents is not a barrier to the use of LLINs, nor is marital status or the high number of people living in a household.

The majority of households (nearly 70%) were aware that malaria is transmitted by mosquito bite. This can be explained by the intensification of communication campaigns to raise awareness of malaria through the media, health personnel, national and local health authorities and community health workers (CHWs). This result is in line with those of [19] [20], who respectively found a proportion of knowledge about malaria of 72.80% in Darsalam, Mali, and 82% in Moanda, Gabon. Household perception of the seriousness of malaria in the Nofou health area was 98%, which would mean that most respondents were aware of the dangers of this disease. This could be explained by the high incidence of malaria (over 201‰) in the Dimbokro health district [11], higher than the national level of 173‰. Reference [21] also found that malaria was considered a dangerous disease by 60.24% of respondents in a study carried out in Chad.This high level of knowledge (68.6%) of malaria is therefore an essential reason why people use LLINs.

Table 5. Initial and final model of the multivariate analysis by logistic regression (step by step descending) of the factors explaining the use of the LLIN in the Nofou health area (August 2022).

INITIAL MODEL OF MULTIVARIATE ANALYSIS			
Factors studied	OR (95%CI)[b]	Coef[c]	p-value
Age of respondents	1.077 (0.996 - 1.165)	0.074	0.064
Sex	2.103 (0.218 - 20.293)	0.743	0.521
Social status	0.923 (0.519 - 1.639)	−0.081	0.783
Study level	1.239 (0.401 - 3.834)	0.215	0.710
Marital status	11.377 (1.514 - 85.486)	2.432	0.018
Habitat type	2.950 (0.939 - 9.271)	1.082	0.064
Mosquito bite or noise	102.588 (2.12 - 4961.71)	4.631	0.019
Malaria is a dangerous disease	0.000	−20.071	0.999
Sanitation of the living environment	0.618 (0.115 - 3.307)	−0.481	0.574
Children under 5 years old	0.000	−21.814	0.998
Pregnant woman	0.000	−23.003	0.998
Elderly person	0.000	−24.986	0.999
During the rainy season	0.286 (0.039 - 2.118)	−1.251	0.220
During the dry season	1256747.157 (0.000)	14.044	0.999
CONSTANT	-	53.776	0.998
FINAL MODEL OF MULTIVARIATE ANALYSIS			
Explanatory factors	ORa (95%CI) [d]	Coef[c]	p-value
Mosquito bite or noise (Yes/No)	5.29 (1.12 - 25.04)	1.66	0.035[e]
Age of respondents	1.07 (1.01 - 1.14)	0.07	0.020[e]
Marital status	8.45 (1.70 - 45.02)	2.13	0.009[e]
CONSTANT	-	33.20	0.998

b: Odd Ratio (95% Confidence Interval); c: Coefficient; d: Odd Ratio adjust (95% Confidence Interval); e: Statistically significant.

However, our study may have limitations of recall and information bias, which certainly affect our results. However, these biases were minimized by applying a well-designed and pre-tested questionnaire, followed by a multivariate analysis using logistic regression, which enabled us to retain significant explanatory factors and control for confounding factors. The final multivariate model identified mosquito bite/noise, age and marital status as factors significantly associated with LLIN use in the Nofou health area. The requirement of a spouse in the couple may influence regular use of LLINs.

Most households (68%) perceive the use of LLINs as the primary method of combating malaria, followed by environmental sanitation (nearly 28%). This low level of awareness of environmental sanitation shows that people do not perceive it as a real solution for preventing malaria. Our results corroborate those of [22], who also consider environmental sanitation as a means of preventing malaria in

Sunyani, Ghana.

The majority of households (94%) knew that the LLIN was used for protection against mosquito bites and noise, and slept under it at night. The population of Nofou therefore has a good perception of the LLIN as a means of preventing malaria. Our results are in line with those of [23], who found an 80% rate of LLIN use in Samè, Mali.

Nearly 80% of households surveyed were unaware of the duration of effectiveness of the LLIN, which was 3 years [24]. This high proportion reflects households' lack of awareness of the expiry date of the LLIN, and hence its use beyond that date. This finding on ignorance of the duration of effectiveness of the LLIN in Nofou is identical to that of [25] in Cameroon.

In our study, less than 7% of pregnant women and children under 5 used LLINs, which may also explain the high incidence of malaria in the Nofou Health Area. The low rate of LLIN use among pregnant women and children found in our study is contrary to that found by several authors [26] [27].

According to seasonal variability, 19% and 2% of households used LLINs in the rainy and dry seasons respectively. Reasons for non-use included heat, suffocation, fatigue due to daily activities such as field work, and neglect. The proportions found in our study are lower than those of [28], for whom nearly 50% of households use an LLIN depending on the season. For this author, the dry season was identified as one during which people slept less under a mosquito net than the rainy season (86.8%).

In the Nofou health area, the reported rate of daily use of LLINs is 46%. The high incidence of malaria in this health area could therefore be explained by the low rate of daily use of LLINs. This result is in line with that of [23], who found a usage rate of 46% in a study carried out in Mali.

On the night before the survey, almost 93% of households claimed to have used an LLIN. This high proportion can be explained by the fact that the survey was carried out during the rainy season, when mosquitoes were more prevalent and households were cooler. In rural areas in the south of Côte d'Ivoire, [29] also found a high rate of LLIN use (97.5%) during the rainy season.

Over 66% of households washed their LLINs with soap and water, and dried them in the shade or sun. This practice results in the deterioration of LLINs. [30] in Senegal also concluded that the way in which LLINs are cared for contributes to the deterioration of their physical integrity.

The study showed that 5.1% of households had their nets torn and 30% of households had their LLINs out of date (more than three years of use). We can deduce that these households were not properly protected and were exposed to malaria. Our results are in line with those of [31] in Cameroon, who noted a breakdown in the physical integrity of the LLINs, given the duration of use (over 36 months) and the maintenance of the latter.

Washing the net with soap and exposing it to the sun can deteriorate the insecticide and contribute to the tearing of the LLIN. The population's positive at-

titude towards the use of LLINs is low (28%). On the whole, this could have a negative influence on the use of LLINs, although practices are fairly acceptable.

There is a strong negative correlation (r = −0.77; p-value = 0.07) between malaria incidence and the rate of LLIN use over the 2017-2022 period when historical malaria cases were collected. However, the short series of historical health data available could influence the non-significance of the correlation coefficient r between the rate of LLIN use and malaria incidence. Indeed, the negative sign of the correlation coefficient means that a decrease in the rate of LLIN use leads to an increase in the incidence of malaria. The increase in the LLIN usage rate over the years 2018 to 2020 and 2021 to 2022 could be explained by the recent distribution of LLINs over these periods. These new, still-new LLINs are attracting the interest of households in using them.

Finally, the use of LLINs therefore depends on people's knowledge, attitudes and practices towards them. A study by [32] in the communities of Wolaita also showed that the use of LLINs depends on these factors.

5. Conclusion

This study has shown us that the use of LLINs depends on the knowledge, attitudes and practices of households towards them. The majority of households had a good knowledge and practice of LLINs, as well as acceptable attitudes towards them. However, the incidence of malaria remains high in the Nofou health area, despite the acceptable rate of LLIN use. The acceptable rate of LLIN use by households in the Nofou health area, part of the Dimbokro health district, is justified by good knowledge and practices vis-à-vis the LLIN, but is influenced by less positive attitudes towards the latter. The convincing results of this study highlight the need to intensify awareness-raising campaigns on the use of LLINs, despite people's knowledge of them. In addition, the study showed the urgent need to implement other control policies and strategies, such as vector control and environmental sanitation, to control the incidence of malaria in this region and others with similar characteristics, where malaria remains a public health problem.

Authors' Contributions

EAMY, TASRN, BYGZ conceived, developed the idea and wrote the article.MB, APG helped verify the analyses and interpret the results. NAA participated in data acquisition and IT supervised the project. All authors discussed the results and contributed to the final manuscript.

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Conflicts of Interest

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

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