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Distribution arrangements and long-lasting insecticidal nets usage rates in households of Soba and Natio Kobadara, two neighbourhoods in Korhogo (Northern Côte d'Ivoire)

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Abstract
Malaria remains a major public health problem in Côte d'Ivoire. To strengthen prevention efforts, a campaign to distribute long-lasting insecticidal treated nets (LLINs) was conducted in 2024 in Soba and Natio Kobadara, two neighbourhoods of Korhogo. A descriptive cross-sectional study was conducted among households in both neighbourhoods. The overall objective of this study was to evaluate the distribution methods of LLINs and determine the LLINs using ratein these two neighbourhoods.
Data were collected through face-to-face questionnaires covering socio-demographic characteristics, availability and LLINs using rate, and sources of information on distribution. The results revealed high availability of LLINs, especially in Soba (98.18%) compared to 87.16% in Natio Kobadara. Actual use was also high (95.45% in Soba, 85.13% in Natio-Kobadara), but disparities remain depending on the area and household profile. The LLINs using rate in the study area was 89.53%. Television and local authorities are the main sources of information. LLINs using rate is most prevalent among parental couples, to the detriment of children. The study highlights the effectiveness of LLINs distribution but emphasises the need for targeted awareness-raising and post-distribution monitoring to ensure optimal protection for all household members and sustainably reduce malaria in Korhogo.

Keywords: LLIN, Malaria, Soba, Natio Kobadara, Korhogo

1. Introduction
Malaria is a disease transmitted by the bites of infected Anopheles mosquitoes [1]. It is a major public health problem affecting approximately 247 million people worldwide, with more than 600,000 deaths each year [2]. In Africa, the burden of this disease is particularly heavy, accounting for approximately 95 % of deaths [3]. Children under the age of 5 and pregnant women are the most vulnerable [4]. In Côte d'Ivoire, the number of malaria cases fell from 53,320 to 38,438 between 2019 and 2020, accounting for 33 % of hospital consultations in the country [5]. Despite this decline, malaria remains the leading cause of morbidity among children under 5, with an incidence of 440.97 per 1,000 compared to 173.43 per 1,000 in the general population [6]. Many methods are used in the fight against malaria. Among these methods, vector control is at the forefront and constitutes an important component of the global strategy to combat malaria [7]. It complements the fight against the parasite (chemoprophylaxis) [7]. Today, it remains the most effective means of preventing the transmission of this disease. This control is possible thanks to the use and application of certain tools such as impregnated mosquito nets, larvicides, insecticide sprays and indoor spraying [8].
The use of long-lasting insecticidal treated nets is strongly recommended by the WHO as a means of preventing malaria, thanks to the progress made in West and East Africa. Between 2000 and 2019, efforts to combat malaria contributed to an approximately 27% reduction in the global malaria mortality rate [9]. Countries such as Rwanda and Swaziland have also seen significant declines of more than 50% in malaria cases thanks to effective vector control programmes.

The implementation of these strategies and control measures has had an impact on malaria-related mortality, particularly among children under 5 years of age [7]. The current coverage rate of LLINs and indoor spraying in Africa has prevented 220,000 deaths among children under five each year, leading to a significant increase in life expectancy in the WHO African Region [2]. However, progress remains uneven. Furthermore, despite the efforts made and progress achieved in the fight against malaria, it remains endemic in tropical areas such as Côte d'Ivoire. In addition, the low use of these LLINs in many African countries considerably complicates the fight against malaria. It is important to update data on the use of LLINs. The overall objective of this study is to assess the distribution terms and conditions and usage rates of LLINs following the 2024 mass distribution campaign in Soba and Natio Kobadara, two neighbourhoods of Korhogo in Côte d'Ivoire.

2. Material and methods

2.1 Study site : The study was conducted in two neighbourhoods in the city of Korhogo : Soba and Natio Kobadara (Fig 1). The Soba neighbourhood is a central neighbourhood and one of the city's oldest. It is characterised by a high level of urbanisation, with medium and low-end housing [10]. The Natio Kobadara neighbourhood is an old village that has been swallowed up by the city's growing urbanisation. It is located northeast of Korhogo and combines urban and rural peripheral characteristics. This neighbourhood is crossed by an intermittent watercourse (the name of the watercourse), on which a dam has been built, promoting market gardening and rice field irrigation. These are the neighbourhoods with the highest number of malaria cases per year. Both neighbourhoods are large in area and have a high population.

2.2 Data collection : After obtaining the necessary institutional authorisations, a survey was conducted in January 2025, five months after LLIN's mass distribution campaign. The survey population consisted of heads of households or their representatives, aged 18 years or older. A sample of households was randomly selected from neighbourhoods. Data collection was carried out by a team of two people, using questionnaires prepared in French and translated into the local language where necessary. The households to be interviewed were selected using spatial sampling with QGIS software (version 3.34). Using satellite imagery (Google Satellite), the buildings were digitised and exported as shapefiles for transfer to QGIS. The QGIS tool was used to generate random points corresponding to the sample size, with each point representing a household to be surveyed. The geographical coordinates were saved in GPX format and transferred to the OsmAnd application, which is compatible with smartphones. The informed consent of the participants was obtained, ensuring the confidentiality of the information collected. The data was collected through a qualitative and quantitative survey, based on questionnaires sent to household heads or their representatives at home. These questionnaires were used to collect information on socio-demographic characteristics, as well as perceptions of malaria risk and mosquito net use. If the head of the household was absent, his wife could answer the questions. The aim was to sample at least 50 households. A total of 57 households were sampled in Natio Kobadara and 50 households in Soba. The number of households

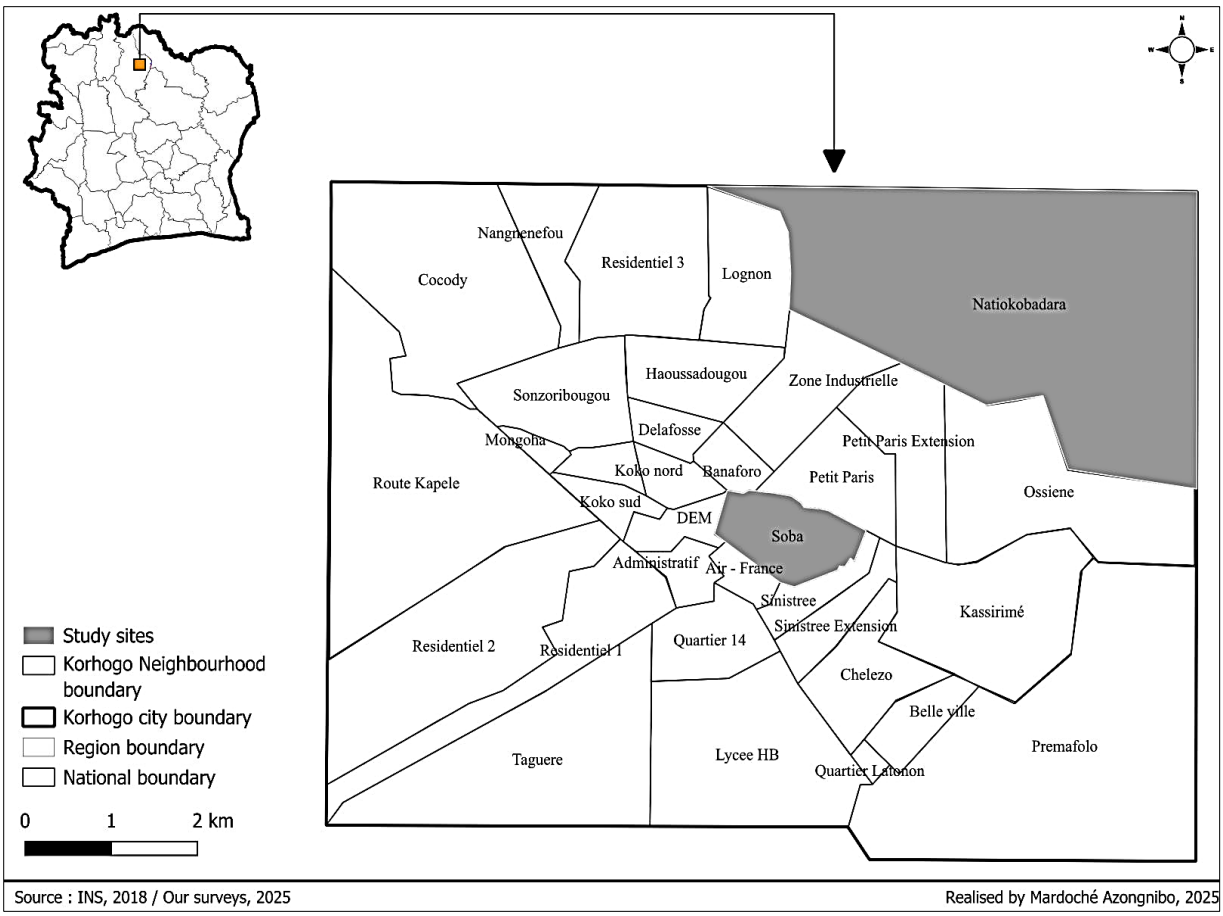

Fig 1: Location of study sites

selected was determined using the SCHWARTZ formula, which was used to obtain the minimum size of households to be sampled :

$$n = (z)^2 p (1 - p) / d2$$

n = sample size
z = confidence level according to the reduced normal distribution (for a confidence level of 95%, z = 1.96)
p = LLIN usage rate in Côte d'Ivoire. According to the NMCP, p=63%.
q= 1-p=1-0.63=0.37.
d = tolerated margin of error (for example, we want to know the actual proportion to within 5%).

2.3 Data analysis
The information collected was recorded in an Excel database. Descriptive analyses were performed to measure various socio-demographic indicators associated with MILDA ownership and use. The χ^2 test was used to compare the frequency of disparities between the two sites. In addition to the sociodemographic characteristics of household heads in Soba and Natio Kobadara, some variables were analysed such as i) religion of households, ii) source of information on community health activities, iii) level of knowledge of household heads regarding the last date of LLIN distribution, iv) knowledge and sources of information on malaria, v) place of LLIN distribution, vi) level of appreciation of LLIN distribution and vii) availability and use of LLINs in Natio Kobadara and Soba.

3. Results
3.1 Sociodemographic characteristics of household heads in Soba and Natio Kobadara
The population surveyed in our study sites revealed a predominance of females. In both Natio Kobadara and Soba, women accounted for approximately 78 % of those surveyed, compared to 22 % for men (Table I). The data revealed a predominance of 'monogamous' heads of household in both neighbourhoods, with approximately 70 % of heads of household concerned in Natio Kobadara and Soba. In addition, a moderate proportion of heads of household in polygamous situations (approximately 10 %) was observed at both sites, and approximately 20% were single. So, there was a clear disparity between the two sites in terms of the educational status of heads of households (Khi 2 : 17.16; p-value < 0.0001). In Natio Kobadara, the majority (approximately 72%) have never attended school. Conversely, Soba presents the opposite situation, with nearly 58% of heads of households having attended school.

Table 1: Summary of socio-demographic indicators for households in Soba and Natio Kobadara

		Natio Kobadara		Soba	
		Staff	**%**	**Staff**	**%**
Gender	Female	44	77.2	39	78.0
	Male	13	22.8	11	22.0
marital status	Single	9	15.8	9	18.0
	Married Monogamous	41	71.9	36	72.0
	Married polygamous	6	10.5	5	10.0
	Widow (er)	1	1.8	0	0.0
Schooling	Yes	15	26.3	32	64.0
	No	42	73.7	18	36.0
Level of schooling	Primary	9	60.0	15	48.4
	Secondary	6	40.0	13	41.9
	University education	0	0.0	3	9.7
Profession	Shopkeeper	15	40.5	22	44.0
	Cultivator	5	13.5	6	12.0
	Student	1	2.7	5	10.0
	Housewife	31	83.5	17	34.0
	Employee	1	2.7	0	0.0
	Other	4	7.0	0	0.0

It appears that the level of education of heads of households remains predominantly focused on primary education, particularly in Natio Kobadara (60%), compared to 50% in Soba. Secondary education accounts for around 40-42% in both neighbourhoods, indicating a certain degree of homogeneity at this level (Khi 2 = 8.96; p-value = 0.011). There is therefore no significant difference between these two sites (Table I). However, only Soba has access, albeit limited (8%), to university education. There are notable disparities between Natio Kobadara and Soba in terms of the occupations of heads of households (Khi 2 = 20.66; p-value < 0.001). In Natio Kobadara, the overwhelming majority of women were housewives (83%). In contrast, Soba shows greater occupational diversity, with a strong presence of traders (44%) and a significant proportion of pupils or students (10%).

3.2 Religion of households surveyed in Soba and Natio Kobadara : The majority of heads of households in both neighbourhoods are muslim, reaching approximately 46% in Natio Kobadara and 50% in Soba. In Soba, there are more animists (approximately 30%) than in Natio Kobadara (nearly 24%). Christians are more represented in Natio Kobadara (30%) than in Soba (20%) (Fig 2).

3.3 Distribution of age groups among respondents in Soba and Natio Kobadara
Age groups revealed a significantly younger population in Soba. Indeed, 60% of households are in the 26-35 age group, while in Natio Kobadara, this proportion is 44%. In addition, the 19-25 age group accounts for 14% of households in Soba, compared to only 2% in Natio Kobadara. However, Natio Kobadara has a more diverse population ; 33% of households

are in the 36-50 age group, and 21% of households are over 51. Thus, although Soba has a majority of young adults, Natio Kobadara shows a more balanced age distribution (Fig 3).

3.4 Type of housing occupied by our respondents in Soba and Natio Kobadara : In Soba, the majority of households live in two-room houses, accounting for 56%, while three-room houses account for 14%. In contrast, in Natio Kobadara, two-room houses are less common, accounting for only 51%, with a very small proportion of three-room houses at 2%. However, Natio Kobadara stands out with a higher proportion of three-room houses, at 44%,

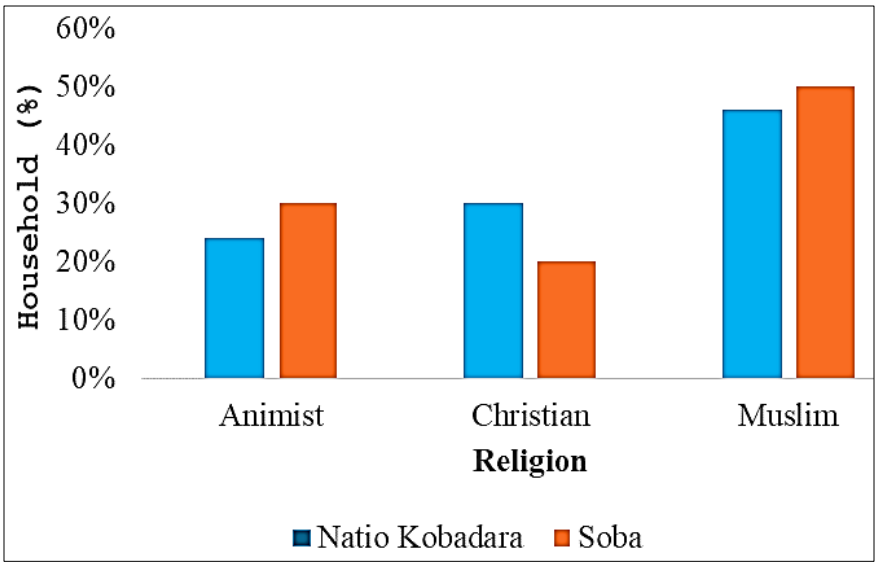

Fig 2: Religions of households in Soba and Natio Kobadara

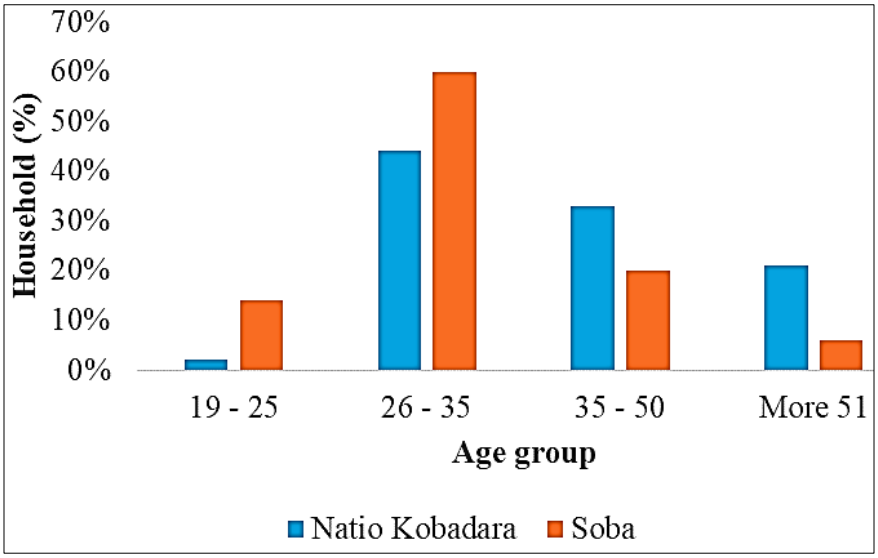

Fig 3: Distribution of age groups among respondents in Soba and Natio Kobadara

compared to 30% in Soba. In addition, it should be noted that four-room houses were only identified in Natio Kobadara, representing 3% of dwellings (Fig 4).

3.5 Number of individuals per household in Soba and Natio Kobadara

In Soba, households of 3 to 4 people are the most common, accounting for nearly 24% of households with 3 people and 20% of those with 4 people. In contrast, in Natio Kobadara, households of 3 and 7 people dominate, accounting for 18% and 29% respectively. Larger households (9 to 15 persons) are more common in Natio Kobadara, at 12% and 2%, than in Soba, reflecting a more extended family structure. Overall, Soba has smaller household sizes, while Natio Kobadara shows greater variability (Fig 5).

3.6 Source of information on community health activities in the neighbourhoods

Three main sources were cited: newspapers, radio and television. Television is the most widely used medium in both neighbourhoods, with 84% in Natio Kobadara and 90% in Soba, indicating a strong preference for this channel. In contrast, radio usage is moderate, with lower rates of 16% in Natio Kobadara and 10% in Soba. Thus, although television clearly dominates preferences, radio remains a source of information, albeit less popular (Fig 6).

As television is the main source of information for the populations studied, the frequency with which households consult this tool highlights its use for information. In Soba, 82% of respondents watch television every day, compared to 18% who watch weekly. In Natio Kobadara, more than 78%

of respondents watch television every day, compared to 10% who watch weekly and 16% who watch irregularly (households with irregular television viewing) (Fig 7).

3.7 Level of knowledge among heads of households regarding the last date of LLIN distribution in Korhogo

In Natio Kobadara, 81% of respondents said they knew the date of the last LLIN distribution, while 14% did not know the last LLIN distribution date and 5% were unsure. In Soba, 74% of respondents knew the date of the last LLIN distribution, 16% do not know it and 10% are unsure (Fig 8). Therefore, in Natio Kobadara, the hospital is the main source of information, with 30%, closely followed by television at 29% (Fig 9). The chiefdom also plays a significant role, accounting for 26%, while radio has little influence, with only 5%. Around 10% of respondents mentioned other sources of information (Market, school, etc…). In contrast, in the Soba neighbourhood, television dominates, accounting for 40%, closely

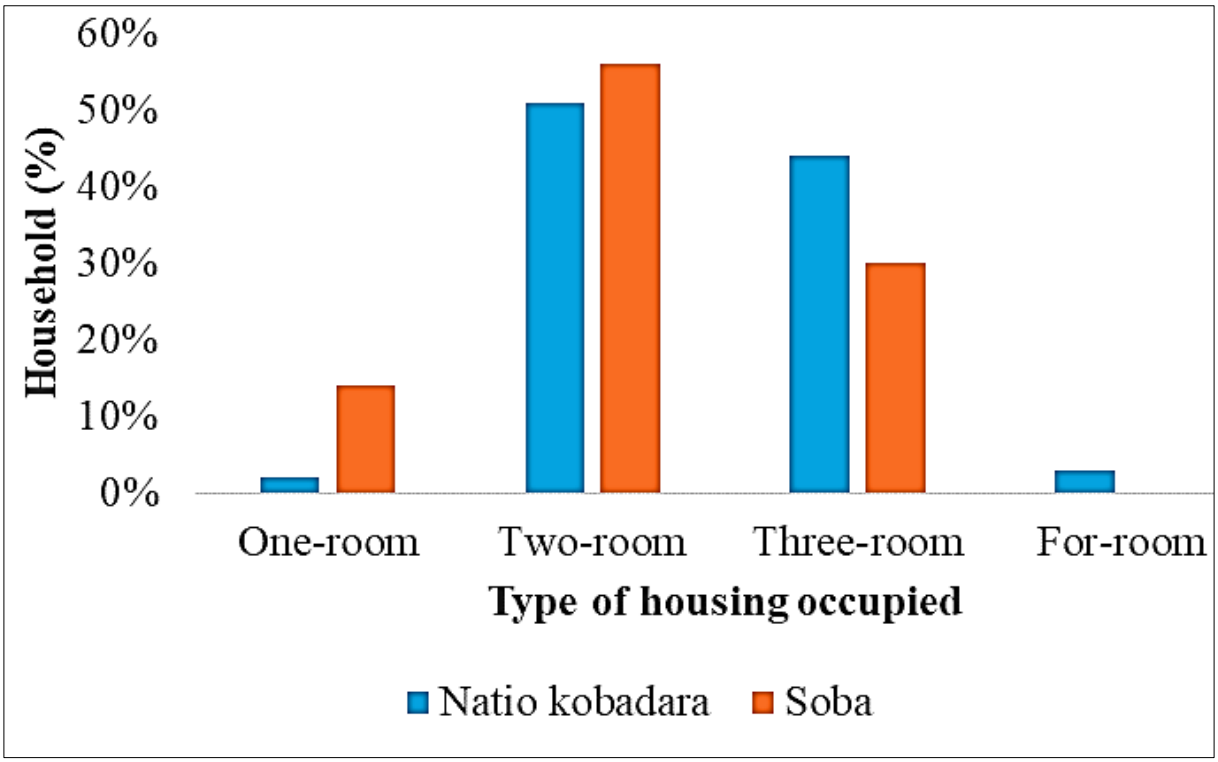

Fig 4: Type of housing occupied by our respondents in Soba and Natio Kobadara

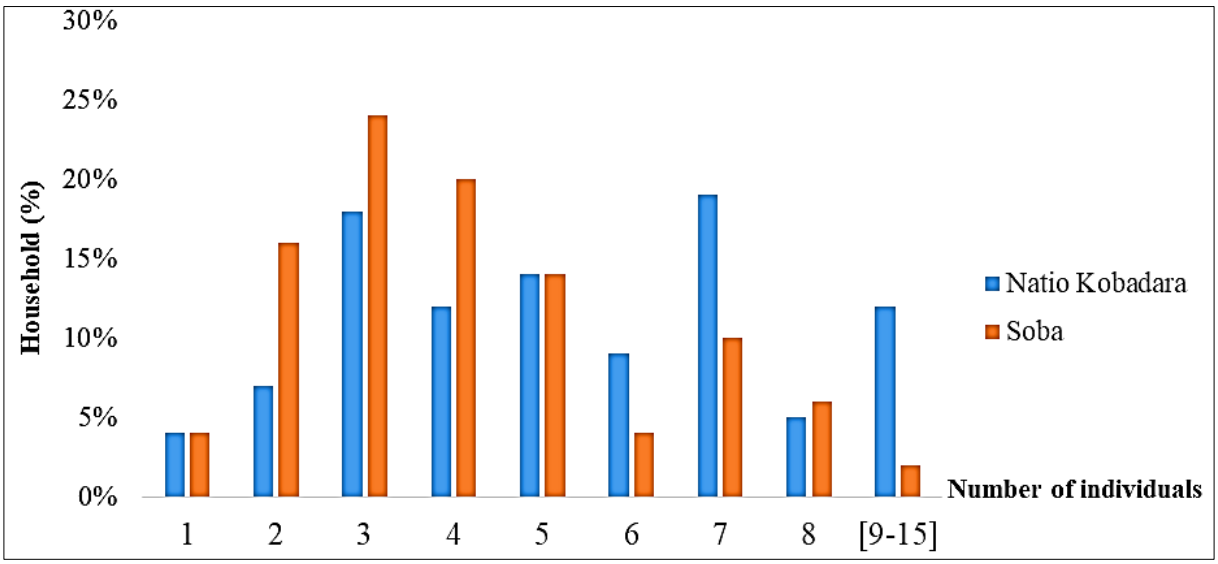

Fig 5: Number of individuals per household in Soba and Natio Kobadara

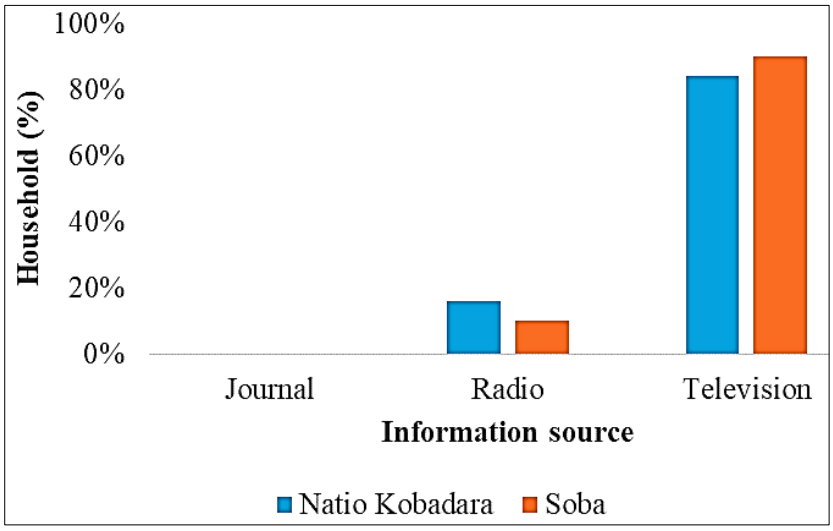

Fig 6: Household information source

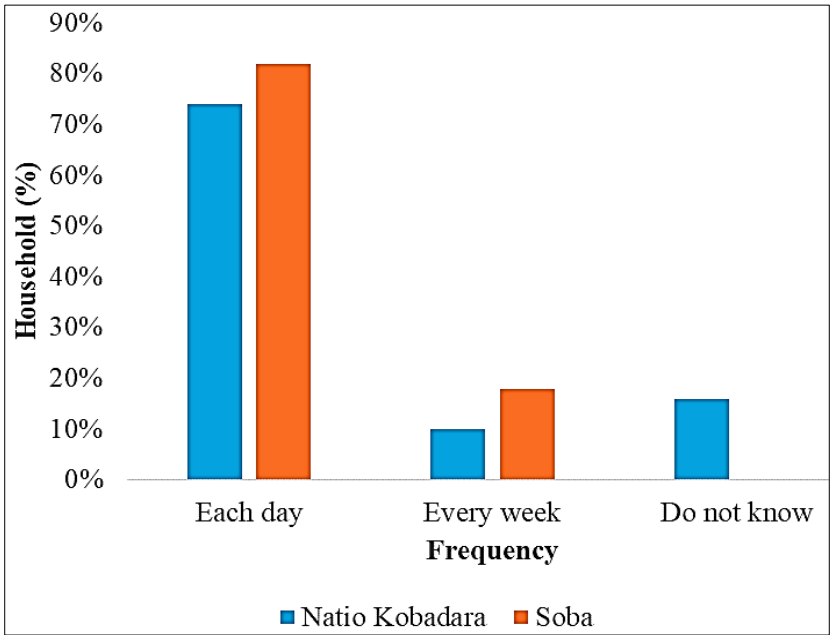

Fig 7: Frequency of consultation of information sources

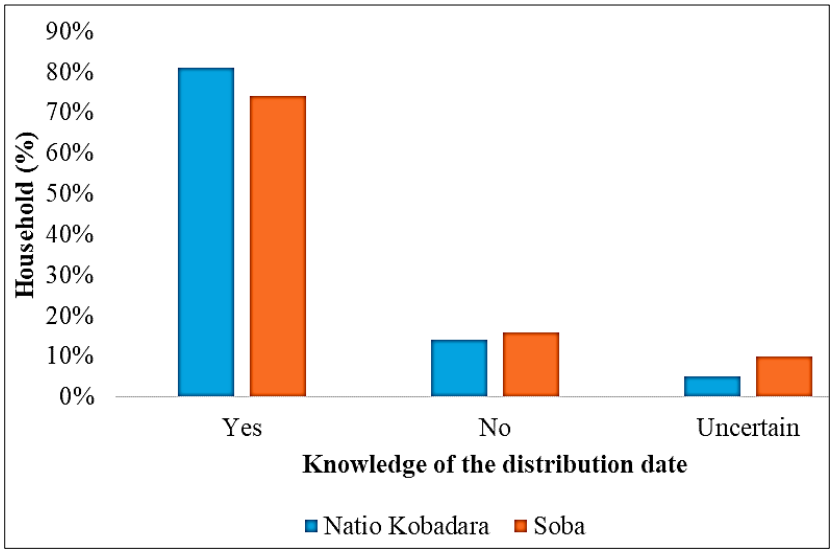

Fig 8: Knowledge of the date of the last mass distribution of LLIN in Korhogo

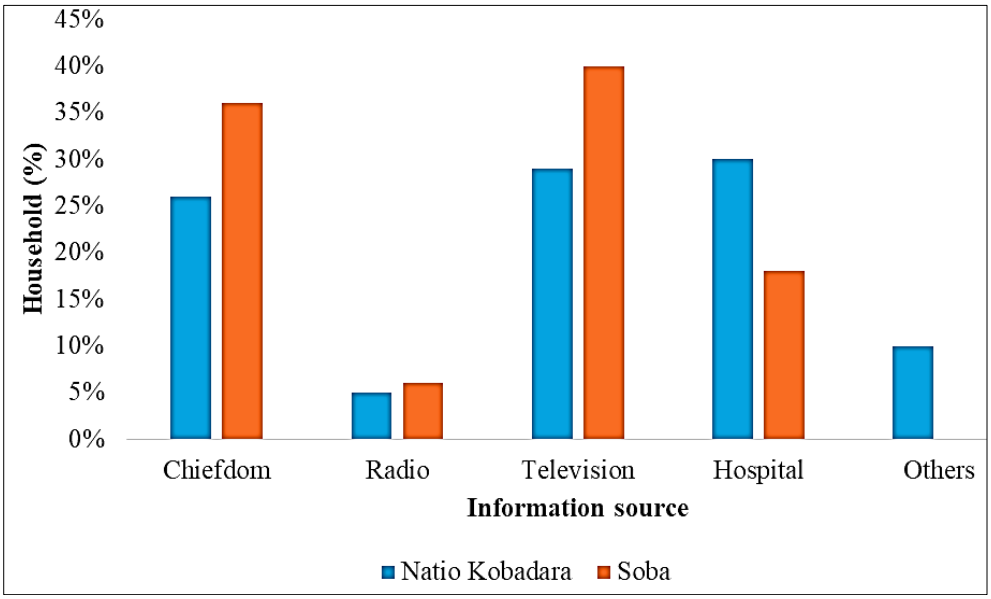

Fig 9: Source of information on the distribution of LLIN among respondents

followed by the chiefdom at 36%. The hospital also plays an important role with 18%, while radio remains marginal at 16%.

3.8 Knowledge and source of information on malaria

In both sampled neighbourhoods, all respondents reported having knowledge about malaria (Fig 10). The source of knowledge about malaria was analysed. It reveals that in these two neighbourhoods, health facilities are the main source of information about malaria. In Natio Kobadara, approximately 75% of households reported having been informed by these health facilities, while in Soba, this rate is even higher, reaching approximately 94% (Fig 11). The family is a source of information for 20% of households in both Natio Kobadara and Soba. The category 'Other' (school, media, etc.) appears only in Natio Kobadara, concerning approximately 6% of households. This comparison reveals significant disparities in information channels between the two neighbourhoods.

3.9 LLIN distribution location

In Natio Kobadara, the maternity ward is the main distribution point, serving approximately 93% of households. The Natio Kobadara hospital plays a secondary role, with only 7% of distributions. In Soba, the canton chief appears to be the main distributor, serving approximately 84% of households. The neighbourhood chief plays a marginal role (approximately 16%). (Fig 12).

3.10 Level of appreciation of LLIN distribution

The opinions on the level of satisfaction with LLIN distribution are divided into the two neighbourhoods. In Natio Kobadara, 67% of respondents find the distribution well structured, while in Soba, this rate reaches around 85%. The differences between the two neighbourhoods become more pronounced for the other categories. In Natio Kobadara, around 21% of respondents find it 'moderately structured', compared to only 9% in Soba. Similarly, Natio Kobadara has a low percentage (approximately 5%) of respondents who consider it 'very poorly structured', a category that is absent in Soba. For the 'poorly structured' category, the two neighbourhoods have similar rates (7%) in Natio Kobadara and (6%) in Soba (Fig 13).

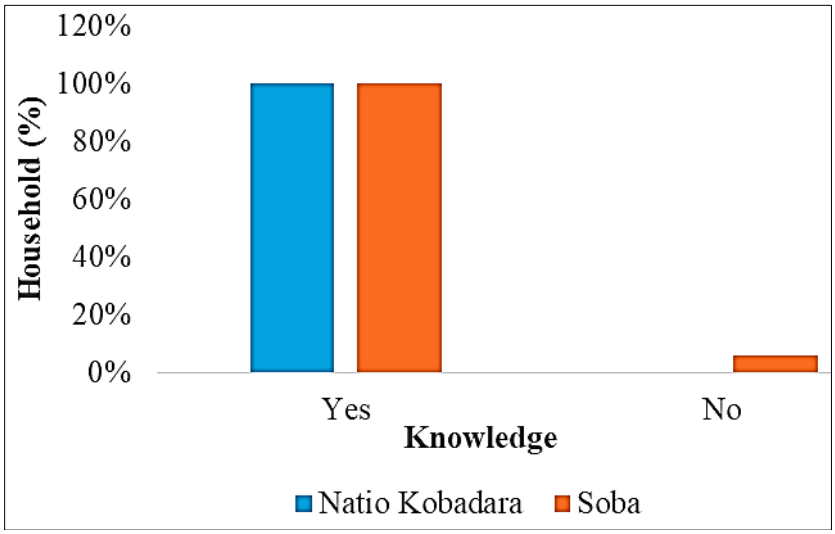

Fig 10: Household knowledge of malaria in Soba and Natio Kobadara

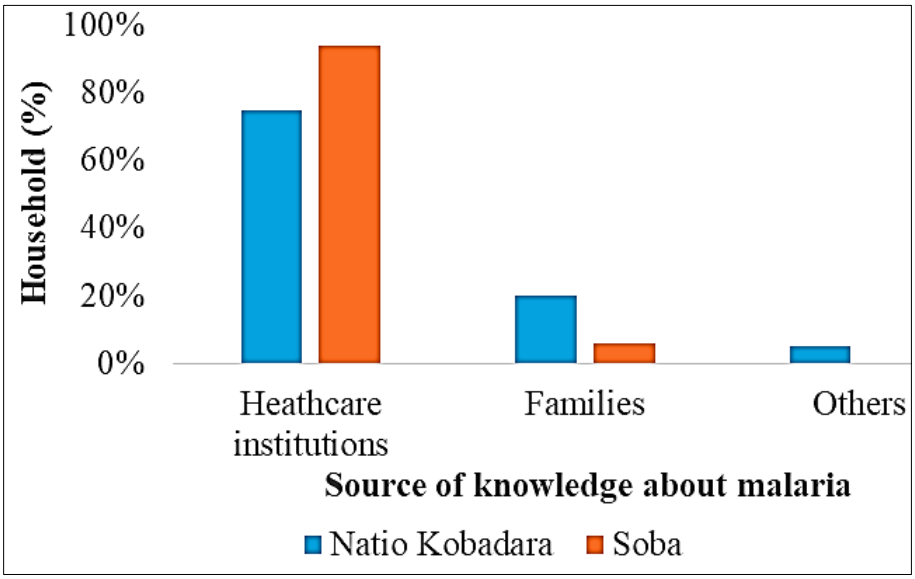

Fig 11: Source of knowledge about malaria in Soba and Natio Kobadara

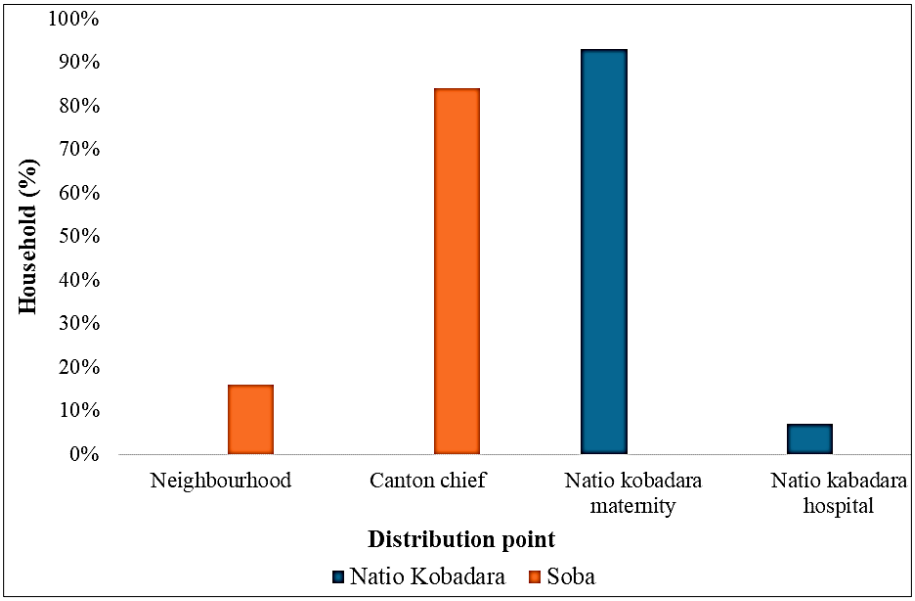

Fig 12ss: Location of LLIN distribution in Soba and Natio Kobadara

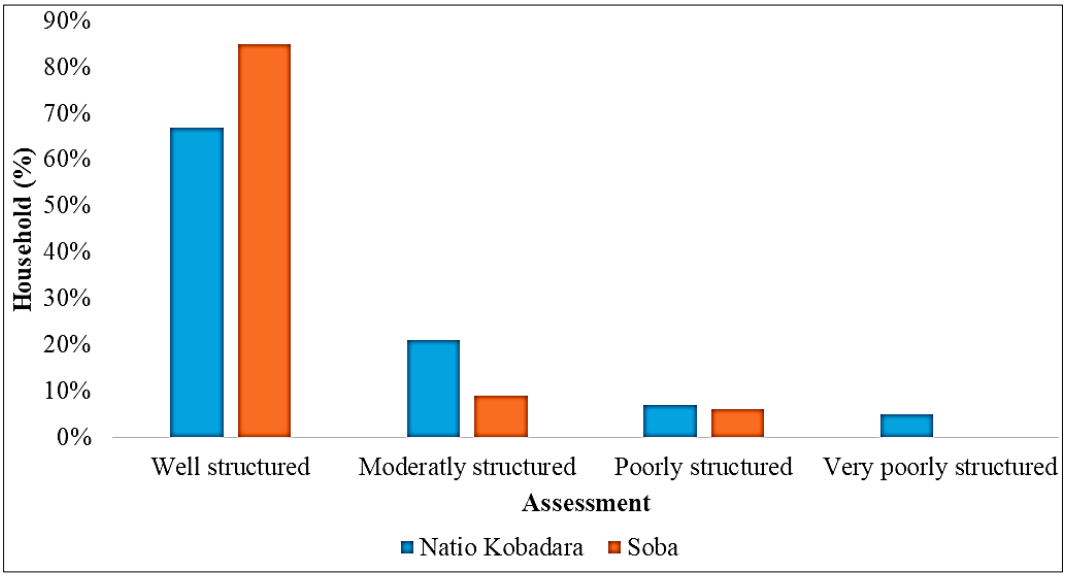

Fig 13: Assessment of LLIN distribution in Soba and Natio Kobadara

3.11 Availability and use of LLINs in Natio Kobadara and Soba

The LLINs ownership ratewas 87.16% in Natio Kobadara, while in Soba it was 98.18%. The LLIN usage rate was 85.13% in Natio Kobadara and 95.45% in Soba. Of the 258 LLINs distributed to households surveyed in the two neighbourhoods, 231 were actually used, representing a LLIN usage rate of 89.53% (Table II).

Table 2: Availability and use of LLINs in Natio Kobadara and Soba

	Number of LLIN distributed	Number of LLIN available (%)	Number of LLIN used (%)
Natio Kobadara	148	129 (87. 16)	126 (85. 13)
Soba	110	108 (98. 18)	105 (95. 45)
Total	258	237 (91. 86)	231 9. 53)

4. Discussion

Our study reveals a predominance of women in both neighbourhoods, which is probably explained by the times at which the surveys were conducted (8am to 12pm). These hours coincide with the absence of men, often due to their professional activities. This corroborates the observations of Kouadio *et al* [11], who note a similar over-representation of women in household surveys in urban areas of Côte d'Ivoire.

Monogamy is the norm in marital status, in line with contemporary trends observed by Traoré *et al* [12] in West Africa. In terms of schooling, although disparities exist, primary education predominates in both neighbourhoods. This is partly due to the majority presence of women, where girls are less educated and those who are educated rarely complete primary school. Our results differ in part from those of Diop *et al* [13], who report improved access to secondary education in medium-sized towns, while confirming educational inequalities.

Sources of information vary considerably between neighbourhoods : Soba favours traditional chieftainship and television, while Natio Kobadara relies mainly on the hospital. Television is the dominant media in both areas, with slightly higher daily viewing rates in Soba. These observations are consistent with studies by Amodu *et al* [14] on the influence of the media on health behaviours in West Africa. In addition, the Natio Kobadara hospital, located in the centre of the neighbourhood, facilitates access to information for the population.

However, precise knowledge of LLIN distribution methods remains limited in both localities, with insufficient recall of exact dates. This shortcoming has also been identified by Mensah *et al* [15] as a factor limiting the effectiveness of mass campaigns. The assessment of the distribution structure is generally positive, although more favourable in Soba than in Natio Kobadara. This difference is potentially attributable to the cultural appropriateness of the approaches, as indicated by Odhiambo *et al* [16]. This perception directly influences the adoption and subsequent use of LLIN, as demonstrated by Olapeju [17] in their post-distribution longitudinal evaluation. The unfavourable opinions gathered during the distribution assessment survey were often due either to the absence of these individuals during distribution or to the short duration of distribution. Some respondents reported that the number of people present did not correspond to the number of mosquito nets available and received.

As for knowledge of malaria, it is generally satisfactory, with distinct sources of information : Soba favours healthcare facilities, while Natio Kobadara emphasises the increased role of the family and diverses sources.

This diversity of information, as shown by Adjah and Panayiotou [18], indicates that it is important to use different communication methods. Both areas studied follow the recommendations of Ashton *et al* [19] to optimise malaria control interventions.

The availability of LLINs is high in Natio Kobadara and Soba, in line with recent research[20] showing that logistical optimisation can reach 94% in urban areas, with regional variations similar to those observed between our sites. Soba has a higher use of LLINs than Natio Kobadara due to its central location, while Natio Kobadara, which is more remote and industrialised, has a varied distribution of LLINs. This indicates that individual and socio-economic factors have a greater influence on ownership than geographical factors. This intra-neighbourhood heterogeneity is also documented by Mogeni [21], who emphasise the importance of micro-targeted approaches in urban interventions. It should be noted that the use of LLINs often favours parents at the expense of children, a trend also observed by Ricotta *et al* [22], who attribute this to differing perceptions of vulnerability and the limited availability of mosquito nets per household. This practice calls for specific interventions to promote the priority protection of children, a particularly vulnerable population, according to Ahorlu *et al* [23], although ownership of LLINs is high, this does not guarantee their effective use due to lack of space in the home, breathing difficulties, and heat, an issue documented by Watiro and Awoke [24] and recently re-evaluated by Pulford [25], who identify various obstacles : thermal discomfort, unsuitability for local dwellings, cultural factors, or lack of awareness of health benefits.

5. Conclusion

This study revealed high availability and usage rates of LLINs, particularly in Soba compared to Natio-Kobadara. The predominance of female heads of household and the majority of monogamous households indicate family stability conducive to the adoption of prevention strategies. However, the disparity in educational attainment between the two neighbourhoods highlights inequalities that may affect understanding of health messages. Despite these high utilisation rates, it would be beneficial to strengthen educational programmes on malaria prevention and treatment and to concentrate resources in areas with high prevalence.

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