

Qualitative Study on the Use and Maintenance of Long-Lasting Insecticidal Nets (LLINs) in Bouaké (Côte d'Ivoire), 17 Months After the Last Mass Distribution Campaign

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1 **Qualitative study on the use and maintenance of Long-Lasting Insecticidal Nets**
2 **(LLINs) in Bouaké (Côte d'Ivoire), 17 months after the last mass distribution**
3 **campaign**

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23

24 **Abstract**

25 **Background:** The long-lasting insecticide-treated net (LLIN) is one of the main malaria
26 prevention tool promoted by the WHO in Côte d'Ivoire. LLIN-coverage has reached
27 95% since 2015 and nearly 16 million LLINs were distributed in 2017. Despite these
28 efforts, malaria incidence at the national level remains high (120‰ in 2012 to 164‰ in
29 2017) although this could be partly explained by increased screening efforts. Our goal
30 was to determine the means of protection against mosquitoes as well as the LLIN
31 maintenance practices of the populations in the city Bouaké, capital city of the Gbêkê
32 region with a malaria incidence of 257‰ in 2017.

33 **Methods:** An exploratory-descriptive qualitative investigation took place in Bouaké, in
34 four neighbourhoods that were selected through purposive sampling based on their
35 social composition. Data were collected using a questionnaire based on convenience
36 sampling.

37 **Results:** The study revealed that LLINs are the most used means of protection
38 (66.4%). Environmental hygiene was second (28.8%), smoke coils third (23.5%) and
39 aerosol cans last (18.8%). The proportion of the respondent that slept with an LLIN the
40 night before was of 53%. 57.7% of respondents washed their LLINs, 12.1% did not
41 wash them, and 4% replaced dirty ones with new ones. The LLINs washing methods
42 described by the respondents did not comply with the WHO recommend actions and
43 there was no mention of LLINs repairs.

44 **Conclusion:** Despite mass distributions of LLINs in Côte d'Ivoire, this key malaria
45 control tool remains underused by the population. Regarding LLIN maintenance, more
46 than half of the population did wash the nets but without following the
47 recommendations or repairing them.

48 **Keywords:** Malaria, LLINs, Usage, Maintenance, Washing, Côte d'Ivoire

49 **Background**

50 Malaria is a disease caused by Plasmodium parasites, transmitted to humans by the
51 bite of a female Anopheles mosquito. Malaria is a leading cause of morbidity and
52 mortality in the 91 countries where it is endemic [1]. In Côte d'Ivoire, malaria remains
53 the primary reason for consultation in health facilities despite a national coverage of
54 Long-Lasting Insecticidal Nets (LLINs) estimated at 95% since 2015 [2]. The number
55 of malaria related cases and deaths recorded in 2017, are 4,032,381 and 3,886
56 respectively [3]. In 2018, the Regional Health Directorate of Gbêkê, a region located in
57 the centre of the country, recorded 206,378 cases and 106 deaths related to malaria
58 for the capital city of Bouaké. Children under 5 years of age in this city paid the highest
59 price with 58,906 cases and 84 deaths.

60 Malaria control combines the control of the parasite and of the vector. The former is
61 based on preventive or curative drug treatments and the latter aims at protecting
62 populations from mosquito bites and reducing the intensity of local transmission [4, 5,
63 6, 7]. Vector control reduces human-vector contact, vector longevity and mosquito
64 densities. It is mainly based on the distribution of LLINs and Indoor Residual Spraying
65 (IRS) [5, 8, 9, 10].

66 At present, LLINs play a very important role in the fight against malaria worldwide by
67 providing a physical and chemical barrier to mosquitoes and they are one of the most
68 effective tools to prevent malaria transmission [9, 11, 12]. In malaria-prone areas, many
69 countries have adopted a LLIN universal coverage policy, as a LLIN coverage of at
70 least 80% should indeed reduce the malaria burden [1, 13, 14, 15, 16]. According to
71 the 2016 Multiple Indicator Cluster Survey (MICS), 75.1% of households in Côte

72 d'Ivoire have at least one LLIN and 50.1% of people slept under LLINs the night before
73 the survey.

74 Well-maintained LLINs can retain their physical integrity and effectiveness for at least
75 three years [6, 17, 18, 19]. To do so, they should be washed with cold water and mild
76 soap, using gentle strokes. They should not be washed more than once every three
77 months and should be dried in the shade. They should also be repaired immediately
78 when they are punctured. It is advised to tie them up when they are not in use [18, 20,
79 21].

80 Factors such as tears, dirt, or improper washing practices may reduce their
81 effectiveness and increase users' risk of contracting malaria [15, 20, 22, 23]. LLINs
82 with holes in them greatly reduce personal protection [24]. Another study in Kenya
83 showed that repeated washing of LLINs over short intervals leads to their biological
84 ineffectiveness [23] demonstrating the importance of following the recommendations.
85 It was confirmed by a study in Benin for Olyset® and PermaNet®. However, some nets
86 may be more resistant to improper washing as in the same study the LifeNet® net
87 remained highly effective against *Anopheles gambiae* s.s. after repeated washings
88 [25].

89 Research on community-based LLIN washing practices in Benin has shown that
90 people use traditional soap or Marseille soap to wash their LLINs. LLINs lose their
91 effectiveness when people soak or wash them with traditional soap and let them dry in
92 the sun compared to LLINs washed with Marseille soap and that dry in the shade [26].
93 A previous study on user perceptions and effectiveness of LLINs in Côte d'Ivoire [27],
94 showed that the use of industrial soap powder and a moderate frequency of washing
95 with tap water maintained the effectiveness of LLINs. An evaluation of the use and
96 maintenance of LLINs conducted as part of an integrated control strategy in a malaria

97 endemic area in the Brazilian Amazon, showed that LLINs distributions were not
98 combined with educational strategies conducive to long-term use [28].

99 Underutilization of LLINs, as well as poor maintenance practices, could therefore
100 reduce LLINs effectiveness at the community level. These factors may explain why,
101 despite the large-scale distribution of LLINs, the number of cases and deaths related
102 to malaria remains high, especially in Côte d'Ivoire and particularly in the Gbêkê region.
103 The objective of this qualitative study was to determine the preventative measures
104 used by the population against mosquitoes as well as the maintenance and use of
105 LLINs in Bouake.

106 **Methods**

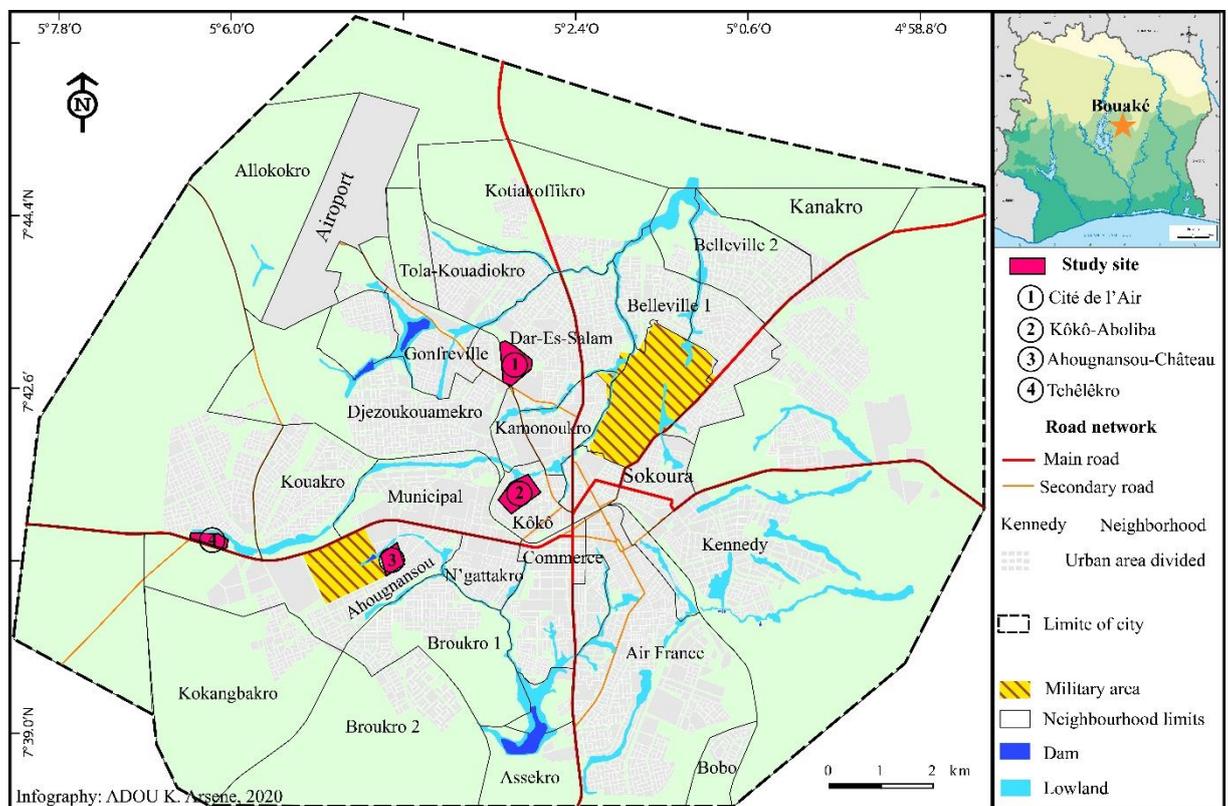
107 We aimed to understand the knowledge, attitudes, and practices of LLINs use and
108 maintenance regarding the information received. An exploratory-descriptive qualitative
109 investigation was performed, and social representations were collected using the
110 discursive production method [31]. Interviews were conducted on February 26th to 28th
111 , 2019.

112 **Study sites**

113 The study took place in the city of Bouaké (7°41'00' north, 5°01'59' west), capital of the
114 Gbêkê region in central Côte d'Ivoire. Four neighbourhoods were selected by reasoned
115 choice based on their contrasting social composition and housing (Figure 1):

- 116 • Cité de l'Air is a recent residential neighbourhood, sparsely populated with
117 modern houses (some still in construction) and bare land covered with scrub.
- 118 • Kôkô Aboliba is an old and working-class neighbourhood located downtown and
119 marked by the presence of lowlands. It is characterized by a high population
120 density. It is made up of a population of varied socio-linguistic origin.

- 121 • Ahougnansou Château is a more recent working-class district, located in the
 122 third urban extension ring, which began between 1970 and 1980. The built
 123 environment is relatively dense with a mix of modern and older housing. There
 124 are numerous lowlands.
- 125 • Tchèlèkro is a peripheral neighbourhood with a rural characteristic. It is
 126 surrounded by a lowland with rice cultures and market gardening. The
 127 neighbourhood is growing in density by expanding into cultivated land. The
 128 population of this neighbourhood is less cosmopolitan than that of Kôkô Aboliba.



130 **Figure 1:** The city of Bouaké and the location of four study districts

131 **Data collection**

132 Data was collected using an interview guide and the personal interview method
 133 (interviewer facing the respondent) [32]. The interview guide consists of 12 questions:
 134 three closed questions on the socio-demographic characteristics of the respondents,

135 two open questions on their knowledge of vector control tools, three closed questions
136 on the use of LLINs, and four questions, two of which are closed, on LLINs
137 maintenance. The non-probability sampling technique was used to construct the
138 sample. In each neighbourhood, the sample was defined on the basis of the saturation
139 of the collected information. Individuals were randomly selected from households and
140 workplaces based on their availability.

141 **Data analysis**

142 The Sphinx V5 software was used to calculate the relative frequencies of the LLINs
143 usage and maintenance indicators. It was also used to extract the content of text
144 variables from the answers to the open-ended questions (verbatim). The excerpts were
145 then presented in lists organized by response category. Content analysis was then
146 used to synthesize the information provided by the open-ended questions and to make
147 sense of it in relation to the context of the study.

148 **Results**

149 **Characteristics of the study population**

150 A total of 149 individuals, 83 men and 66 women, who received LLINs at health centres
151 and during free distribution campaigns were surveyed (Table 1). The age of the
152 respondents ranged from 15 to 73 years old. Two-thirds were 15 to 39 years old, and
153 the remaining third were 40 to 73 years old.

154 **Table 1** Sample of respondents by neighbourhood in Bouake

Neighbourhood	Sample size
Kôkô Aboliba	26
Cité de l'Air	50
Tchèlèkro	22

Ahognansou château	51	158
Total	149	159

160 Source: Field survey data, 2019

161 More than a quarter of the respondents have never attended school and almost 21%
 162 went to university (Table 2). There was an important heterogeneity among the
 163 neighbourhoods.

164 **Table 2** Educational level of the respondents

Educational level	Kôkô Aboliba n (%)	Cité de l'Air n (%)	Tchèlèkro n (%)	Ahognansou Château n (%)
None	10 (38.5)	15 (30)	9 (41)	5 (9.8)
Primary	4 (15.4)	6 (12)	3 (13.6)	10 (19.6)
Middle school	7 (26.9)	2 (4)	6 (27.3)	9 (17.6)
Secondary	4 (15.4)	14 (28)	1 (4.5)	13 (25.5)
University	1 (3.8)	13 (26)	3 (13.6)	14 (27.5)

165 Source: Field survey data, 2019

166 **Means of protection against mosquito bites cited by respondents**

167 Respondents mentioned various vector control methods of which LLINs are the most
 168 cited (47%) (Table 3).

169 **Table 3:** Vector control tools and methods mentioned by respondents

Vector control tools and methods	n (%)
	(N=289)
LLINS	136 (47.0)
Aerosol cans	63 (21.8)
Smoke coils	50 (17.3)

Hygiene of the living environment	33 (11.4)
Fans	4 (1.4)
Community mosquito spraying	2 (0.7)
Housing Improvement	1 (0.4)

170 Source: Field survey data, 2019

171 *A respondent could cite several means of control methods

172 **Vector control tools and methods used by the respondents**

173 LLINs were the more commonly used vector control tools in each neighbourhood. The
 174 hygiene of the living environment was less used in Tchèlèkro and Kôkô Aboliba
 175 compared to Cité de l'Air and Ahougnansou. A low use of smoke coils was observed
 176 at Cité de l'Air. Aerosol cans were used to a greater extent in Cité de l'Air and Tchèlèkro
 177 (Table 4).

178 **Table 4:** Vector control tools and methods used by the respondents and by
 179 neighbourhoods

Vector control tools and methods used	Kôkô Aboliba N = 33 n (%)	Cité de l'Air N = 76 n (%)	Tchèlèkro N = 28 n (%)	Ahougnansou Château N = 72 n (%)	Overall N = 209 n (%)
LLINs	18 (54.6)	37 (48.7)	11 (39.3)	33 (45.8)	99 (47.4)
Aerosol cans	4 (12.1)	11 (14.5)	5 (17.9)	8 (11.1)	28 (13.4)
Smoke coils	7 (21.2)	8 (10.5)	7 (25)	13 (18.0)	35 (16.7)
Hygiene of the living environment	4 (12.1)	19 (25.0)	4 (14.3)	16 (22.2)	43 (20.6)
Fans	-	1 (1.3)	1 (3.5)	2 (2.9)	4 (1.9)

180 Source: Field survey data, 2019

181 * A respondent could cite several means of control methods

182 **Willingness to sleep under an LLIN**

183 Overall, 87.9% (131/149) of respondents said they were in favour of using an LLIN and
 184 53% had used it the night before the survey (Table 5). The average use of LLINs the
 185 previous night was similar in each neighbourhood. Whatever the neighbourhood,
 186 29.5% of respondents said they could not remember the last time they had slept under
 187 an LLIN. Kôkô Aboliba and Tchèlèkro had higher proportions of respondents who could
 188 not remember their last night under a LLIN compared to the average of the four
 189 neighbourhoods (38.5%, 41% and 29.5% respectively). 47% of people having received
 190 nets did not use them regularly.

191 **Table 5:** LLIN usage by the respondents by neighbourhood

Last night's sleep under LLINs	Koko Aboliba n (%)	Cité de l'Air n (%)	Tchèlèkro n (%)	Ahoughnansou Château n (%)	Overall n (%)
The night before	12 (46.2)	29 (58)	11 (50)	27 (52.9)	79 (53)
Three days ago		1 (2)		3 (5.8)	4 (2.7)
Last week	2 (7.7)	1 (2)		1 (2)	4 (2.7)
Two weeks ago	1 (3.8)	2 (4)			3 (2)
One month ago		3 (6)			3 (2)
Two months ago			1 (4.5)	1 (2)	2 (1.3)
Three months ago	1 (3.8)	2 (4)	1 (4.5)	6 (11.8)	10 (6.8)
I don't know	10 (38.5)	12 (24)	9 (41)	13 (25.5)	44 (29.5)
Total	26 (100)	50 (100)	22 (100)	51 (100)	149 (100)

192 Source: Field survey data, 2019

193 **Attitude of the respondents in regard of washing their LLINs**

194 Of the populations surveyed, 87.2% (130/149) knew that LLINs must be maintained to
 195 keep them effective. Only 14.8% (22/149) of respondents mentioned having received

196 training on how to maintain LLINs. Respondents' knowledge about LLINs maintenance
 197 was dominated by their knowledge and representation of household laundry care.
 198 Overall, 57.7% (86/149) of respondents washed their LLINs, 12.1% (18/149) did not
 199 wash them, and 4% (6/149) replaced their dirty LLINs with new ones. 26.2% of the
 200 individuals surveyed did not answer questions about the maintenance of their LLINs.

201 The proportions of people who washed their LLINs were higher in Ahougnansou
 202 Château and Cité de l'Air compared to the other two neighbourhoods (60.8%, 70%,
 203 42.3% and 40.9% respectively). Tchèlèkro had the highest proportion of people who
 204 did not respond to this question (Table 6).

205 **Table 6:** Attitude to washing LLINs of respondents by neighbourhood

LLINs washing	Koko Aboliba n (%)	Cité de l'Air n (%)	Tchèlèkro n (%)	Ahougnansou Château n (%)	Overall n (%)
I wash my LLIN	11 (42.3)	35 (70)	9 (40.9)	31 (60.8)	86 (57.7)
I don't wash my LLIN	7 (27)	5 (10)	2 (9.1)	4 (7.8)	18 (12.1)
I replace my LLIN when it is dirty	3 (11.5)	2 (4)	1 (4.5)		6 (4)
No answer	5 (19.2)	8 (16)	10 (45.5)	16 (31.4)	39 (26.2)
Total	26 (100)	50 (100)	22 (100)	51 (100)	149 (100)

206 Source: Field survey data, 2019

207 **Detergents used by the respondents to wash the LLINs**

208 Four types of detergents were used by the respondents who washed their LLINs.
 209 These were OMO (powdered detergent), Savon de Marseille soap, bleach, and
 210 Kabakourou (traditional soap). The study revealed that the detergents were either used

211 individually or in combination (OMO + Savon de Marseille soap, OMO + bleach).
 212 Overall, the most used detergent was OMO (37.3%, 28/75), followed by Savon de
 213 Marseille soap (24%, 18/75) and the combination of OMO + Savon de Marseille soap
 214 (17.3%, 13/75) (Table7). 10.7% (8/75) of respondents washed their LLINs without
 215 using any detergent.

216 OMO, Savon de Marseille soap and the combination of OMO and Savon de Marseille
 217 soap were used in equal proportions in Kôkô Aboliba (30%). OMO was the most used
 218 detergent in Cité de l'Air (46.7%) and Ahougnansou (34.6%). OMO, Savon de Marseille
 219 soap, water and the combination of OMO + Savon de Marseille soap was the most
 220 used in Tchèlèkro (22.2%). The use of OMO + bleach, bleach, Kabakourou, or no
 221 detergent at all was infrequent in the different neighbourhoods.

222 **Tableau 7:** Detergents used to wash the LLINs by respondents

LLINs washing	Koko Aboliba n (%)	Cité de l'Air n (%)	Tchèlèkro n (%)	Ahougnansou Château n (%)	Overall n (%)
OMO	3 (30)	14 (46,7)	2 (22,2)	9 (34,6)	28 (37,3)
Savon de Marseille soap	3 (30)	9 (30)	2 (22,2)	4 (15,4)	18 (24)
Kabakrou	-	-	1 (11,2)	-	1 (1,35)
Bleach	1 (10)	-	-	-	1 (1,35)
Water	-	-	2(22,2)	6 (23,1)	8 (10,7)
Omo + Savon de Marseille soap	3 (30)	5 (16,7)	2 (22,2)	3 (11,15)	13 (17,3)
Omo + Bleach	-	2 (6,6)	-	4 (15,4)	6 (8)

Total	10 (100)	30 (100)	9 (100)	26 (100)	75 (100)
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223 Source: Field survey data, 2019

224 **LLINs washing frequency by the respondents**

225 Among the 57.7% of respondents who wash their LLINs, the frequency of washing
 226 varied by neighbourhood. Two washing frequencies stood out for respondents who
 227 wash their LLINs: only 16.3% (14/86) wash their LLINs at least once every three
 228 months and the majority 52.3% (45/86) at least once a month (Table 8).

229 **Table 8:** LLINs washing frequency

Washing frequency	Koko Aboliba n (%)	Cité de l'Air n (%)	Tchèlèkro n (%)	Ahougansou n (%)	Overall n (%)
At least once a month	6 (54,5)	22 (62,9)	-	17 (54,9)	45 (52,3)
At least once every two months	-	1 (2,9)	1 (11,1)	5 (16,1)	7 (8,1)
At least once every three months	2 (18,2)	7 (20,0)	3 (33,3)	2 (6,4)	14 (16,3)
At least once every four months	1 (9,1)	4 (11,3)	-	2 (6,4)	7 (8,3)
At least once every six months	1 (9,1)	-	4 (44,5)	4 (13,0)	9 (10,4)
At least once a year	1 (9,1)	1 (2,9)	1 (11,1)	1 (3,2)	4 (4,6)
Total	11 (100)	35 (100)	9 (100)	31 (100)	86 (100)

230 Source: field survey data, 2019

231 Some excerpts from the respondents' open discourse on the maintenance of the LLIN.

232 *"I wash every month with OMO by hand". (Woman, 48-year-old, Tchèlèkro)*

233 *"I wash my net when it is dirty. I wash it like I wash my clothes. I wash it once a month*
234 *with OMO". (Woman, 28-year-old, Koko Aboliba)*

235 *"I wash once a month with OMO and bleach". (Woman, 36-year-old, Tchèlèkro)*

236 *"I wash every two months when it is dirty with OMO and savon de Marseille soap".*
237 *(Woman, 32-year-old, Koko Aboliba)*

238 *"I wash by hand with soap and OMO every three months". (Man, 19-year-old,*
239 *Ahougnansou château)*

240 *"I wash with OMO, rinse and dry in shade three time a year". (Man, 20-year-old, Cité*
241 *de l'Air)*

242 *"I wash three time a year with soap". (Woman, 19-year-old, Tchèlèkro)*

243 *"I wash with OMO, and by hand every six months". (Woman, 24-year-old, Cité de l'Air)*

244 *"I wash with soap and water just every six months". (Man, 65-year-old, Ahougnansou*
245 *château)*

246 *"I wash once a year with plain water". (Man, 56-year-old, Ahougnansou château)*

247 Source: field survey data, 2019

248 Finally, two trends could be found: "traditional" (Tchèlèkro and Koko Aboliba) and
249 "modern" (Ahougnasou and Cité de l'Air). It can be observed that in Cité de l'Air, the
250 behaviours seemed to be rather in line with the WHO recommendations concerning
251 the recognition of the LLIN as a means of protection against mosquito bites, the need
252 to sleep under the LLIN and to wash it. This is not the case in Tchèlèkro. In Koko
253 Aboliba and Ahougnansou Chateau, the findings were more heterogeneous, but the
254 trend is consistent.

255 **Tableau 8** Summary of results on knowledge, use and washing LLINs by
 256 neighbourhood

	Tchèlèkro	Koko Aboliba	Ahougansou	Cité de l'Air	Overall
LLINs knowledge	50.0	69.2	64.7	74.0	66.4
Slept the night before under LLIN	50.0	46.2	52.9	58.0	53.0
Wash LLIN	40.9	42.3	60.8	70.0	57.7
Wash LLIN every 3 months	33.3	18.2	6.4	20.0	16.3
No answer	45.5	19.2	31.4	16.0	26.2

257 Source: field survey data, 2019

258 Discussion

259 Respondents in the different neighbourhoods reported using several vector control
 260 methods to protect themselves from mosquito bites. The LLIN was the most used
 261 method (66.4%). However, this rate clearly shows that the populations of Bouaké are
 262 under-using LLINs. Respondents also consider the hygiene of their living environment
 263 as a method of protection against mosquito bites. It is less used in traditional
 264 neighbourhoods (Kôkô Aboliba and Tchèlèkro) compared to modern ones (Cité de l'Air
 265 and Ahougansou Château). As in modern neighbourhoods, most of respondents have
 266 at least secondary education, it could be inferred that socio-economic level and/or
 267 education come into play in making people aware that hygiene is important to protect
 268 themselves from mosquitoes. Indeed, unhealthy environments appear to favour the
 269 exposure to mosquito bites. This component must therefore be taken into account in
 270 malaria vector control as it is the case for Aedes control [9].

271 There was a moderate use of LLINs the night before in each neighbourhood. This may
272 be due to the lack of community-based health education systems that would encourage
273 people to sleep under LLINs. Only 53% of all respondents slept under an LLIN the
274 night before the survey even though 87% were in favour of using them. This rate is
275 well below the 80% threshold recommended by the WHO, and is roughly equal to the
276 50.1% reported by the MICS which dates from 2016 [33] or the 51% reported in 2020
277 during the evaluation of an LLIN distribution program in western India [19]. In Nigeria,
278 however, 92% of respondents reported having slept under an LLIN the night before the
279 survey [34]. Our results indicate that 30.2% of respondents could not remember the
280 last time they had slept under an LLIN, which makes it clear that LLINs are not
281 frequently used by these persons. As previously hypothesised in another study [28],
282 LLINs were distributed without an educational strategy allowing for their long-term use.
283 The lack of LLINs use can often be explained by several hindering factors such as the
284 feeling of suffocation, the feeling of heat and low densities of nuisance mosquitoes
285 [35]. In the case of the four districts studied, the lack of LLIN use may firstly be
286 explained by the use of alternative malaria vector control tools within the populations.

287 Regarding LLIN maintenance, 87.2% of the respondents know that LLINs must be
288 maintained to assure their long-term effectiveness but only 14.8% of respondents
289 declared having received training on their maintenance. 26.2% of respondents did not
290 answer the question about their attitudes towards washing LLINs. This can be
291 understood either as embarrassment from not washing their LLINs, not being able to
292 afford washing them, or as a lack of awareness about washing methods. To wash their
293 LLINs, respondents use different types of detergents: traditional soap (kabakrou),
294 Savon de Marseille soap, industrial powder detergent (OMO) and some use bleach.
295 Most respondents wash their LLINs at least once a month. The heterogeneity in the

296 discourses collected on LLINs washing in the different neighbourhoods of our study
297 indicates that the correct washing practices are unknown to the population. This was
298 observed in the four neighbourhoods, which enables us to affirm that awareness of
299 LLIN washing is not associated with the population's living standard and/or education.
300 The practices of the respondents in regard to LLINs maintenance show that their
301 knowledge is dominated by their representation of the maintenance of household linen.
302 This is not suitable for LLINs that should be washed with cold water and mild soap in
303 gentle strokes to maintain their physical integrity and effectiveness for at least three
304 years [6, 17, 18, 19].

305 Similar results were obtained in Ilorin Kwara State, Nigeria [34] showing that 88% of
306 the washing was inappropriate. The present study reveals poor maintenance practices
307 for LLINs, in contrast to a previous study in western Kenya [36]. Six respondents said
308 that they do not wash dirty LLINs but replace them with new ones. Replacing LLINs
309 once they are dirty may be due to the fact people are not informed about maintenance,
310 do not say what they actually do, or have enough LLINs to replace the dirty ones. This
311 raises questions about the effectiveness of the mass LLIN distribution strategy [28].

312 **Conclusion**

313 Our study showed that despite the favourable attitude of the population to sleeping
314 under an LLIN, LLINs remain underused. The different washing methods described
315 show that people are unaware of the WHO recommendations for proper washing of
316 LLINs. It also appears that people's knowledge of how to maintain their LLINs is
317 incomplete, as repairing and knotting were not mentioned in the responses to the open-
318 ended question on LLIN maintenance. Under-use and lack of knowledge of good
319 maintenance practices for this key malaria control tool can be interpreted as one of the
320 key factors that explains why, despite high coverage of LLINs, the number of malaria

321 cases and deaths remains high in Bouake. Identifying the factors limiting the proper
322 use, washing and maintenance of LLINs, and consequently the parameters that could
323 enhance LLIN use, will allow the establishment of community-based health education
324 system to sensitize and train people in the use and maintenance of their LLINs. This
325 could largely contribute to the reduction of malaria transmission in Côte d'Ivoire and
326 more widely.

327 **Statements**

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332 **Authors' contribution**

333 GKDN, FHC and ET made contributions to the conception and design of the study.
334 GKDN, FHC and AMGB analysed the data. GKDN and FHC drafted the manuscript
335 with the contribution of AMGB. All authors were involved in critical revision for important
336 intellectual content. All authors read and approved the final manuscript.

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340 **Availability of data and materials**

341 All data generated or analysed during this study are included in this published article.

342 **Ethics approval and consent to participate**

343 This study is approved by the National Malaria Control Program of Côte d'Ivoire. It is
344 part of the fourth policy and strategic orientation of the fight against malaria in Côte

345 d'Ivoire, specifically malaria prevention which includes malaria control interventions as
346 well as their surveillance, monitoring and evaluation. Verbal consent was obtained from
347 the respondents prior to the interviews. For those between the ages of 15 and 20,
348 verbal permission from an adult family member was required in addition to consent.

349 **Consent to publication**

350 Not applicable.

351 **Conflict of interest**

352 The authors declare having no conflict of interest.

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