Tracking Study on the Efficacy and the Durability of three types of LLINs Distributed in Benin in 2014

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30 Months after distribution

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Background

In Benin, more than 4 million of Olyset® treated nets were freely given to the population during the national distribution campaign carried out in 2011, but the effective lifespan of these nets was less than expected (<3 years) [1-2]. After two years, 56% of them were removed from their initial position probably due to a lack of interest from people in the Olyset® nets [3]. Furthermore, a fast physical deterioration of nets was observed 24 months after the distribution since 90% have been found with holes. In addition, the bioavailability of the insecticide (permethrin) on the nets decreased quickly.

The state of rapid degradation of these mosquito nets is worrying. Though, extrinsic factors related to humans and their immediate environments are responsible for the noted rapid deterioration, the quality of the Olyset nets texture was also questionable [4-5]. This is one of the reasons why, in 2014, other types of LLINs were distributed by the National Malaria Control Program (NMCP). Polyethylene Olyset LLINs treated with permethrin distributed in 2011 were replaced by three other types of polyester and polyethylene LLINs. These include PermaNet 2.0 nets and DawaPlus 2.0 nets treated with deltamethrin, DuraNet nets impregnated with alphacypermethrin.

To achieve high Insecticide Treated Nets (ITN) coverage, Benin's NMCP and its financial partners have to acquire and distribute various types of LLINs. But their follow-up is necessary in the field to identify those that attract more people and those that resist more to external aggressions. Though the distributed nets are licensed by the WHOPES, this is the first time the opportunity has been given to compare their performance in the community. Based on standards for monitoring LLIN sustainability [6-7], the NMCP considered that nets last three years and that the proportion of remaining nets predicted by NetCalc is plausible [8]. This article describes the follow-up performed to validate this hypothesis.

LLIN sustainability monitoring relies mainly on three indicators: nets survival, an estimate of coverage that is the percentage of nets still present and used in the households in which they were distributed; physical integrity, quantification of the number and size of holes in the net and bioefficacy, a measure of the insecticidal effect. The term "hole" is used as a general term to describe all types of damages: tears, burn holes, rodent-related damage, tears in the corners and sewing faults present on the nets. Although the three indicators are evaluated in Benin, two of them (survival and integrity of the LLINs) are discussed here. Both need to be assessed together because an LLIN which is counted for the survival, but in poor physical condition provides little protection to the user. Therefore, the survival data alone will unlikely underestimate the loss of the net. This study undertaken by the Center for Research in Entomology of Cotonou (CREC), presents the results of a prospective and longitudinal assessment of LLINs to monitor both their survival and integrity. It aims at (i) monitoring the survivorship of each type of the LLIN, (ii) assessing community's motivation to use them and estimating LLINs loss rate (loss of fabric integrity).

Methods

Study sites

Following the distribution of the LLINs, a net tracking activity to monitor their durability was implemented in three districts (Tori-Bossito, Toffo and Ouesse) shown in Table 1. The three districts were randomly selected from a list of coded districts (using numeric codes) according to the type of LLINs received. This selection was performed online using the random number generator [9] (Table 1).

Table 1. Study districts and characteristics of LLINs followed

LLINs products	Code number of districts	Numbers selected	Corresponding district	Type of material	Insecticide	Concentration of insecticide (mg/m²)
DawaPlus 2.0	1 - 23	7	Tori- Bossito	Polyester	Deltamethrin	80mg/m²
DuraNet	24-76	33	Ouesse	Polyethylene	Alphacypermethrin	261mg/m²
PermaNet 2.0	77	77	Toffo	Polyester	Deltamethrin	55mg/m²

Two of the three selected districts are located in the Atlantic department with Tori-Bossito and Toffo in the southern and the northern part respectively (Figure 1). The third district, Ouesse is located in the Colline department (Figure 1). In each selected district, two sub-districts (one rural and one urban) were also selected from their sub-districts list, applying thus a similar process (list of sub-districts, numeric code, random number generator) for the selection of the districts mentioned below (Table 2).

Table 2. Sub-districts selected in each district

Selected districts	Code number of the sub-districts	Number selected	Corresponding sub-districts
Ouesse	1-9	6 and 8	Ouesse, Laminou
Toffo	10 -19	10 and 12	Houegbo, Kpome
Tori- Bossito	20-25	20 and 21	Tori-Cada, Tori-Gare

Study design

This is a study whose biannual follow-up was based on a longitudinal prospective evaluation of the observational and descriptive type. It compares the survival and the physical integrity of three different types of LLINs distributed in Benin, West Africa in 2014. The three types of LLINs are conventional nets treated only with pyrethroids (DawaPlus 2.0, PermaNet 2.0 in

polyester and DuraNet in polyethylene). The study was conducted from October 2014 to June 2017.
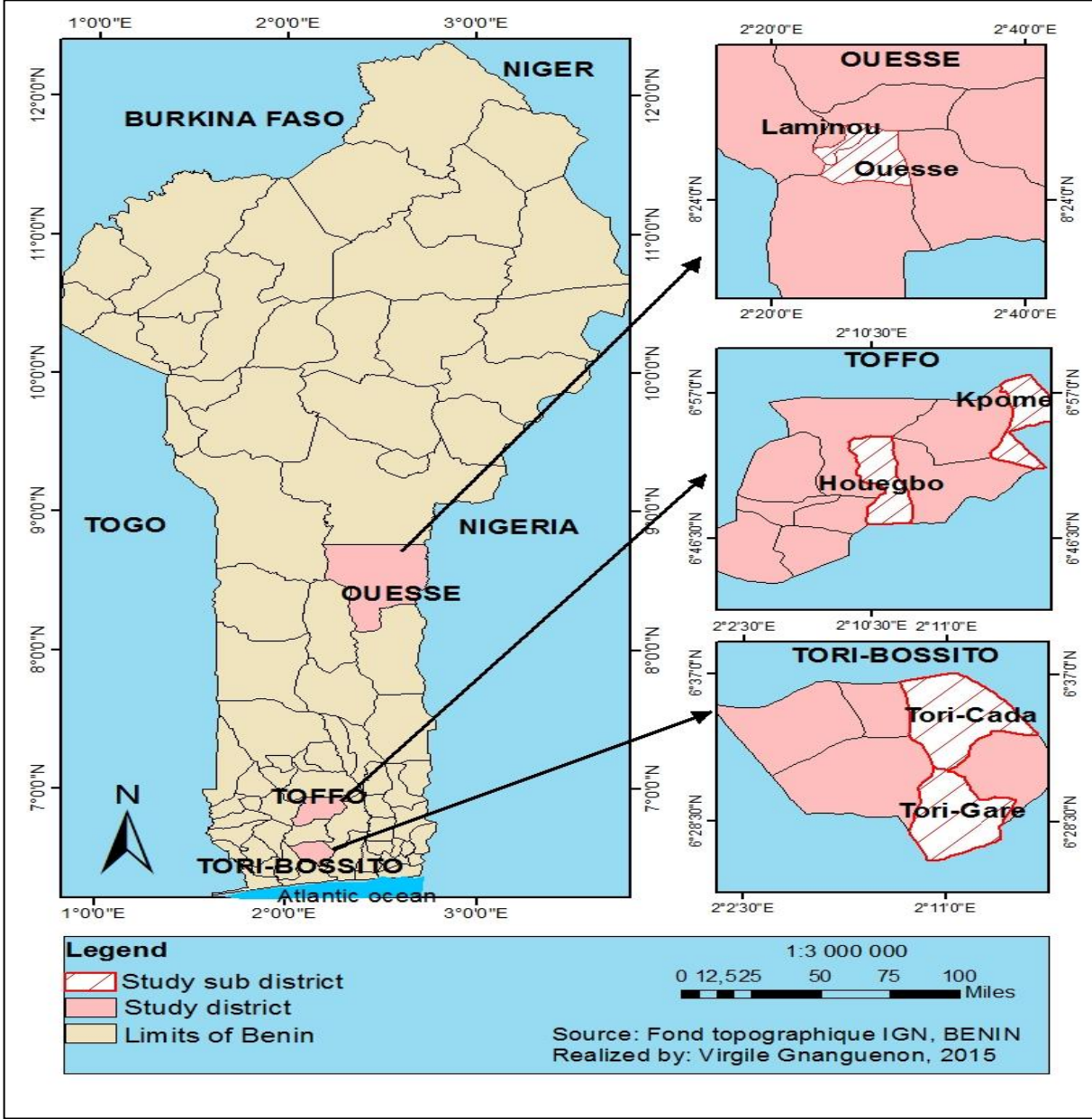
Figure 1.Map of the study area

Household selection and tagging of nets (T0)

About 900 households were randomly selected on a basis of 300 per district (150 in rural area and 150 in urban area).[1]Households' selection at each site took into account all villages to ensure a representative sampling [10]. Assessment teams identified a 2014-distributed LLIN in each selected household and checked whether the net was suspended and used. Each selected LLIN was tagged to ensure correct identification during later visits. During the follow-up of the

sustainability of the selected LLINs, the teams entered the houses where the LLINs were set up as recommended by the World Health Organization (WHO) guideline [11].

Baseline survey and questionnaire

A model questionnaire developed by the WHO guideline (WHO, 2011) was reviewed and adapted to the need of the study. This questionnaire was used to identify household's characteristics, sleeping material, education level etc… The questionnaire was programmed into Samsung Galaxy Tablets 10.1 using ODK Collect 1.2.2. All interviews were carried out using Samsung Galaxy Tablets to record responses.

Assessment of LLINs survival and integrity
Monitoring Survivorship of LLINs

Survival at baseline was 100 percent. Also, no LLIN was torn (durability 100%). After every six months of use, the selected households were visited in order to evaluate the survival and durability of LLINs. For each household, LLINs survival was assessed by visual verification of the presence of a LLIN distributed during the national campaign and involved in the net tracking study, then holding both a bar code and a color code.

Monitoring integrity of LLIN

The tracked LLINs were visually examined, without removal from where they were hung in the targeted houses. Total holes observed were counted and categorized according to four general size categories:

(i)   size1 – hole smaller than a thumb (0.5-2.0cm),
(ii)   size2 – hole larger than thumb but smaller than fist (2-10 cm),
(iii)   size3 – hole larger than fist but smaller than head (10-25cm) and
(iv)   size4 – hole larger than head (>25cm).

Data on LLINs durability (hole size and number of holes) were collected using the personal data assistant (PDAs) (Samsung Galaxies tablets) as data terminals. Tablets are directly connected to internet via a SIM card and, collected data are then submitted to a cloud server. The data are retrieved and analyzed from the cloud. This technique is faster and more efficient than recording data by writing them on hard copies. It also secures data transmission, limits errors and avoids losses.

Data analysis

To achieve the objectives of the study, we used a descriptive analysis to highlight trends and determine the LLINs usage rate. The comparison of the average proportionate holes index (pHI) with respect to the different modes of use of the LLINs was made using the Kruskall Wallis test. The calculation of the proportions and the determination of their confidence intervals were done by the binomial test.

Survivorship/Attrition

The most optimistic equation for quantifying overall survivorship, also called attrition, was:

$$\frac{\text{Total coded LLINs still present in the households selected}}{\text{Total coded LLINs at the enrollment (T}_0)} \times 100$$

If a household is closed, during an assessment visit, it was treated according to the non-parametric survival method of Kaplan-Meier [12]. Survivorship, plotted against time (T6, T12, T19, T24, and T30) was compared with NetCalc net loss model curves based on the assumptions according to which the LLINs serviceable life is around 2 to 3 years [13]. Equations for the calculation of LLIN survivorship/attrition associated with three different reasons for which an assessed net had been missing were:

Attrition rate-1 (reason: physical damage):

$$\frac{\text{Total number of coded LLIN reported as thrown out due to wear and tear in surveyed households}}{\text{Total coded LLINs at the enrollment (T}_0)} \times 100$$

Attrition rate-2 (reason: removal):

$$\frac{\text{Total number of coded LLIN reported as given away, stolen, sold or used in another location}}{\text{Total coded LLINs at the enrollment (T}_0)} \times 100$$

Attrition rate-3 (reason: re-purposed):

$$\frac{\text{Total number of coded LLIN reported as being used for another purpose in surveyed households}}{\text{Total coded LLINs (T}_0)} \times 100$$

Two sites were reported to show significantly different survivorship / attrition if the 95% confidence limits did not overlap.

Integrity was quantified based on two measurements:

1) The proportion of LLINs without a hole.

2) The proportionate holes index (pHI) for each net (13) was determined in the following way:

$1 \times$ number of holes of size $1 + 23 \times$ number of holes of size $2 + 196 \times$ number of holes of size $3 + 578 \times$ number of size 4 holes

Descriptive statistics were used to compare pHI values at each assessed site (mean, median, interquartile range). Based on the pHI score, LLINs were assigned to one of the three condition categories.

$\text{pHI} \leq 64$ - good (< than 100 cm^2 of estimated total hole surface)
$\text{pHI} \leq 768$ - serviceable (than 100-1000 cm^2 of estimated total hole surface)
$\text{pHI} > 768$ - need to be replaced (> than 1000 cm^2 of estimated total hole surface)

Descriptive analysis was also used to highlight trends and levels of use of mosquito nets. The comparison of the average proportion of holes (pHI) of the LLINs was made using the Kruskall Wallis test. The calculation of the proportions and their confidence interval was made by the binomial test.

Study clearance

The protocol of this study was reviewed and approved by the (Institutional Ethics Committee of CREC) Community leaders were informed and all gave their verbal consent before the start of the study. Written consent was then obtained on the day of the study from all participating households.

Results

Net survivorship

A total of 900 LLINs were enrolled at the beginning (T0) in the study. During the 30 months of survey, respectively, 651, 511, 556, 283 and 183 LLINs were found and evaluated after 6, 12, 18, 24 and 30 months of usage (Table 3). A significant difference between the survival rates of the different types of LLINs ($p < 0.05$), with a low survival rate of polyethylene nets (DuraNet) was registered.

After 6 months, the average survival rate was 98% (95% CI: 95.06-98.94) for DawaPlus 2.0, 95% (95% CI: 91.36-97.06) for PermaNet®2.0, and 86% (95% CI: 80.14-89.81) for DuraNet®.

Two years later, the average survival decreases to 53% (95% CI: [47.17-58.76]) for DawaPlus®2.0, 53.33% (95% CI): [47.84-59.41]) for PermaNet®2.0 and 34.33% (95% CI: [28.97-40]) for DuraNet®.

Overall, after 30 months, the combined data of the 3 types of LLINs showed a survival rate of about 29.89%. By analyzing each type of nets, it can be deduced that the average survival was 30.33% (95% CI: 25.18 – 35.88) for DawaPlus 2.0, 36.33% (95% CI: 30.88-42.06) for PermaNet®2.0 and 23% (95% CI: 18.36-28.18) for DuraNet®. Overall, Polyethylene nets (DuraNet) had the low survival rate compared to Polyester nets 'DawaPlus and PermaNet 2.0). There is no statistically significant difference between the survival rates of the two polyester nets (DawaPlus 2.0 and PermaNet 2.0) ($p > 0.05$). However, there is a statistically significant difference between these two LLINs and the polyethylene net (DuraNet) ($p < 0.05$). In addition, we noted LLINs have lower survival in the urban areas compared to rural areas. This is probably due to the proximity and availability of water for washing in the urban areas of the districts. The observed survival rates were compared to those of the NetCalc model that predicted 62% survival with LLINs that have been used during 3 years. In this study, the survival rate was significantly lower than that predicted for the three types of LLINs.

In summary, the survival rate (all three types of LLINs combined) was 95% after 6 months, 81% after one year, 47% after 2 years and 29.89% after 30 months (Figure 3).
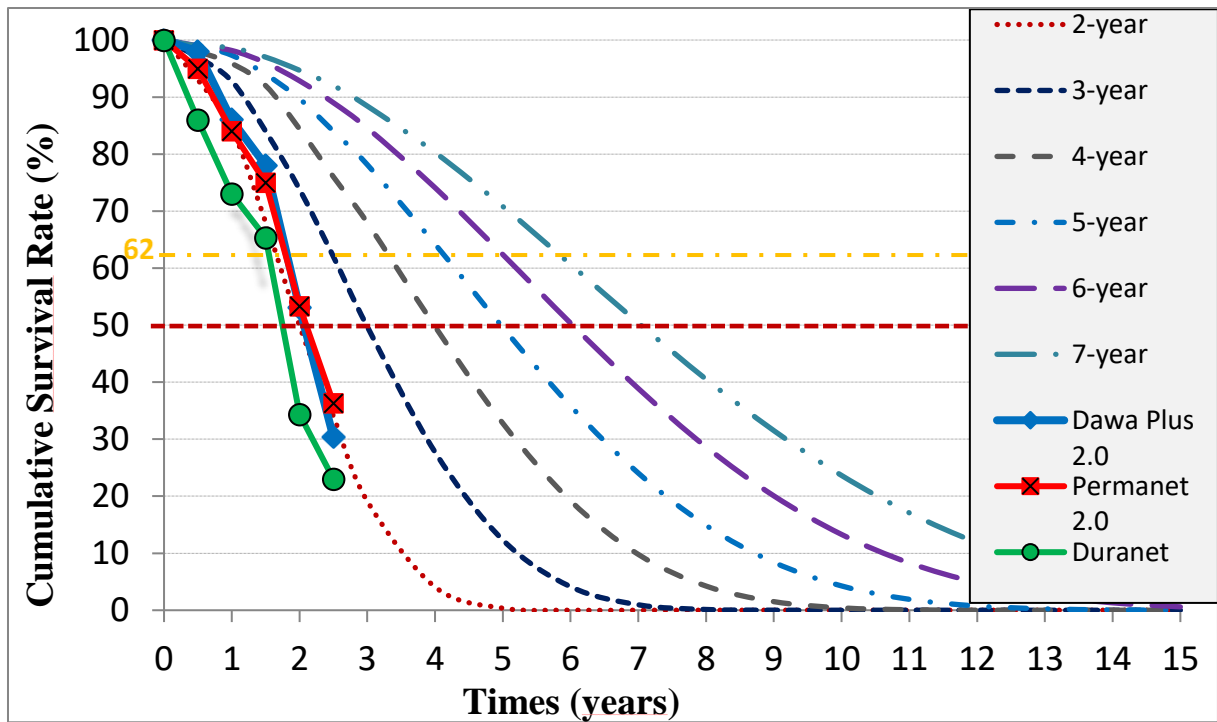
Figure 3: Estimated LLINs survival at 6, 12, 18, 24 and 30 months in four communities compared with NetCalc model of curves of nets loss over 2, 3, 4,5, 6 and 7 years).

Table 3.LLINs survivorship by assessment site at thirty months after distribution.

		DawaPlus 2.0		PermaNet 2.0		DuraNet		
		Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	**Total**
Baseline (T0)	Households selected (T0)	150	150	150	150	150	150	900
After 6 months (T6)	Eligible households	150	150	150	150	150	150	900
	Opened households	136	124	128	109	104	98	694
	Coded LLINs found	131	123	120	105	91	82	651
	Number of lost LLINs	-5	-1	-8	-4	-13	-16	-51
	Survivorship (%)	96	99	95	97	91	89	95
	95% Confidence interval	91.68-98.42	96.32-99.88	89.83-97.27	93.34-98.96	85.74-94.87	83.38-93.33	93.63-96.43
After 12 months (T12)	Eligible households	145	149	142	146	137	134	853
	Opened households	112	125	103	102	104	90	636
	Coded LLINs found	98	103	79	89	76	66	511
	Number of lost LLINs	-14	-22	-24	-13	-28	-24	125
	Survivorship (%)	87.33	84.66	78.67	88.66	72.67	73.33	80.89
	95% Confidence interval	81.06-91.74	78.04-89.56	71.44-84.46	82.60-92.80	65.04-79.17	65.74-79.76	78.19-83.32
After 18 months (T19)	Eligible households	131	127	118	133	109	110	728
	Opened households	104	110	100	116	76	81	587
	Coded LLINs found	101	89	90	100	76	59	514
	Number of lost LLINs	-27	-38	-28	-17	-33	-29	172
	Survivorship (%)	85.33	70.67	72	78	72	58.67	72.78
	95% Confidence interval	78.64 -90.57	62.69 - 77.81	64.09 - 79.02	70.51 - 84.35	64.09 - 79.02	50.35 - 66.64	69.74 - 75.66
After 24 months (T24)	Eligible households	104	89	90	116	76	81	556
	Opened households	75	78	67	75	74	47	416
	Coded LLINs found	60	59	42	55	37	30	283
	Number of lost LLINs	-15	-19	-25	-20	-37	-17	-133
	Survivorship (%)	59.33	46.67	43.33	64	26	42.67	47
	95% Confidence interval	51.02-67.27	38.49-47.63	35.27-51.66	55.76-71.67	19.18-33.78	34.63-50.99	43.69-50.32

	Eligible households	89	70	65	96	39	64	423
	Opened households	66	72	50	71	32	46	337
After 30 months (T30)	Coded LLINs found	35	35	25	44	20	24	183
	Number of lost LLINs	31	37	25	27	12	22	154
	Survivorship (%)	38.67	22	26.67	46	18	28	29.89
	95% Confidence interval	30.84 - 46.95	15.65 - 29.49	19.78 - 34.49	37.84 - 54.32	12.21 - 25.10	20.98 - 35.91	26.91 - 33.00

LLIN fabric integrity

According to the WHO, during an assessment of the physical integrity of mosquito nets, only mosquito nets with pHI<64 may be considered in good condition. On this basis, after 6 months of use, the 3 types of LLINs involved in our study, still present in the households and holding at least one hole varied from 25% to 41% according to the type (tables 4 & 5). The median pHI values were similar for the 3 types of LLINs and were null. The categorization of LLINs as, "in good condition," "useful and repairable" or "need to be replaced," shows that 0 to 6 percent of nets need replacement 6 months after utilization. In addition, the number of LLINs in the "good status" category was similar (p> 0.05) between communities and LLIN types (76-92%) (Tables 4 & 5).

After 12 months, LLINs found with at least one hole are between 44% and 54% (table 4 & 5) depending on the type of LLIN. No significant difference was observed between the rates of loss of integrity of LLINs in rural and urban areas (Table 4). The median pHI values were similar in all communities and were around zero. 2-10% of LLINs need to be replaced. In addition, the number of LLINs in the "good status" category was similar (p> 0.05) between communities and LLIN types (63-87%) (Tables 4 & 5).

After 24 months (T24), the mean proportionate holes indices (pHI) in rural communities were similar (754-870) compared to urban communities (663-929). More than half of the LLINs were in the "usable" category (53.63%). The proportion of LLINs that could be used after 2 years varies according to the type. This proportion was high in PermaNet 2.0 (73.81% in the Toffo urban area and 61.42% in the rural area of the same district). At the same time, it was in the DuraNet mosquito net category that more nets need to be replaced after 2 years of use (82.85% in urban areas and 52% in rural areas in Ouesse) (Table 4).

The proportion of LLINs considered being in good condition ranged from 7% to 56% (all LLINs combined) after 30 months of use. Those still usable were from 21 to 64% according to the type. Figure 4 illustrates the condition of the different categories of LLINs from the 6th month to the 30th month of usage.
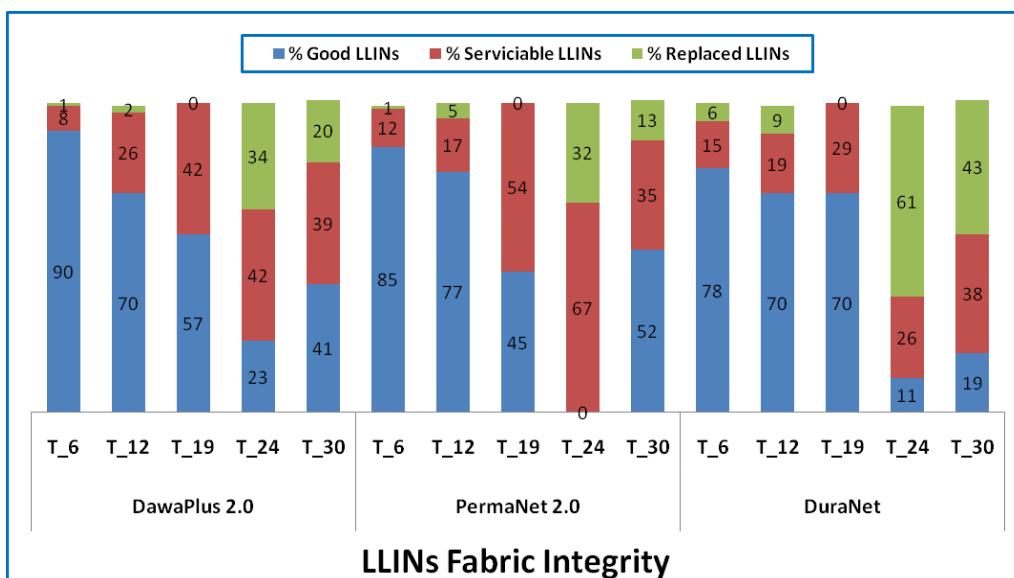

Figure 4: LLINs fabric integrity

Table4. Fabric integrity (pHI) of DawaPlus 2.0 LLINs at 6, 12, 19, 24 and 30 months after use.

	DawaPlus 2.0 (Tori-Bossito)									
	T6		T12		T19		T24		T30	
	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area
Households selected (T0)	150	150	150	150	150	150	150	150	150	150
Tagged LLINs found	131	123	98	103	104	89	60	59	35	35
n (%) of nets found with any hole (s)	33(25)	41(33)	43(44)	54(52)	41(39)	41(46)	40(66.67)	51(86.44)	23(65.71)	26(74.28)
CI 95 (%)	18.54-33.26	25.40-41.74	34.47-53.75	42.87-61.81	30.12 - 49.51	35.56 - 56.92	53.31-78.31	75.01 - 93.96	47.78 - 80.88	56.74 - 87.51
Mean PHI	28.26	44.07	82.3	153.2	61.2	66.2	767.5	829.6	365.5	662.6
Median PHI	0	0	0	8	56	72	605.5	627	47	225
IQR	0.5	3.5	31.8	119	60	58	207	425	304.5	1107.5
n (%) of nets in pHI<64 ('good' category)	120(91.6)	109(88.62)	76(77.55)	65(63.11)	23(22.11)	19(21.34)	0(0)	0(0)	13(56.52)	7(26.92)
CI 95 (%)	85.47- 95.73	81.32- 93.41	68.34–84.68	53.47–71.80	14.8 - 31.53	13.65 - 31.56	0- 8.81]	0- 6.98	34.49 - 76.81	11.57 -47.79
n (%) of nets in 64<pHI<768 ('serviceable' category)	11(8.40)	10(8.13)	20(20.41)	34(33.01)	41(39.42)	41(46.06)	24(40)	26(50.98)	7(30.43)	12(46.15)
CI 95 (%)	4.27 - 14.23	4.18 - 14.81	13.62- 29.43	24.68 -42.56	30.12 - 49.51	35.56 - 56.92	43.32 - 75.14	36.59 - 65.25	13.21 - 52.92	26.58 - 66.63
n (%) of nets in pHI>768 'needs ('replacement' category)	0(0)	4(3.25)	2(2.04)	4(3.88)	0(0)	0(0)	16(40)	25(49.02)	3(13.04)	7(26.92)
CI 95 (%)	0 – 2.78	1.05 - 8.62	00.56 – 7.14	1.52 - 9.56	0 - 4.43	0 - 5.15	24.87 - 56.67	34.75 - 63.40	2.77 - 33.59	11.57 -47.79

Table 5. Fabric integrity (pHI) of PermaNet LLINs 2.0 at 6, 12, 19, 24 and 30 months after use.

	PermaNet 2.0 (Toffo)									
	T6		T12		T19		T24		T30	
	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area
Households selected (T0)	150	150	150	150	150	150	150	150	150	150
Tagged LLINs found	120	105	79	89	90	116	42	55	25	44
n (%) of nets found with any hole (s)	37(31)	43(41)	35(44)	48(54)	51(56)	62(53)	42(100)	55(100)	16(64)	35(79.55)
CI 95 (%)	23.27-39.58	32.03-50.52	33.87-55.27	43.63-63.91	45.82 - 66.94	43.98 - 62.68	91.59 - 100	93.51 - 100	42.52 - 82.03	64.69 - 90.20
Mean PHI	41.02	89.5	120.4	140	61.02	56.56	663.2	754.4	279	505.7
Median PHI	0	0	0	6	57	53	603	654	46.5	52
IQR	6.5	46	26	107.5	62.5	52.75	96	207.5	1397	7766
n (%) of nets in pHI<64 ('good' category)	107(89.17)	86(81.90)	69(87.34)	61(68.54)	28(31.11)	35(30.17)	0(0)	0(0)	9(56.25)	18(51.43)
CI 95 (%)	81.85 - 93.87	72.93 - 88.49	78.24 - 92.98	58.30 - 77.25	21.99 - 41.87	22.18 - 39.49	0 - 8.41	0 - 6.45	29.87 - 80.25	33.98 -68.62
n (%) of nets in 64<pHI<768 ('serviceable' category)	12(10)	17(16.19)	6(7.59)	23(25.84)	51(56.66)	62(53.44)	31(73.81)	34(61.82)	5(31.25)	13(37.14)
CI 95 (%)	5.50 - 17.16	9.98 - 24.94	3.53 - 15.60	17.88–35.80	45.82 - 66.94	43.98 - 62.68	57.96 - 86.14	47.72 - 74.59	11.01 - 58.66	21.47 - 55.08
n () of nets in pHI>768 'needs ('replacement' category)	1(0.83)	2(1.90)	4(5.06)	5(5.62)	0(0)	0(0)	11(26.19)	21(38.18)	2(12.5)	3(11.43)
CI 95 (%)	0.04 – 5.24	0.33 - 7.38	1.99 – 12.31	2.42 - 12.49	0 - 5.10	0 - 3.99	13.86 - 42.04	25.40 - 52.27	1.55 - 38.35	3.20 - 26.74

Table 6. Fabric integrity (pHI) of DuraNet LLINs at 6, 12, 19, 24 and 30 months after use.

	DuraNet (Ouesse)									
	T6		T12		T19		T24		T30	
	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Urban area	Rural area
Households selected (T0)	150	150	150	150	150	150	150	150	150	150
Tagged LLINs found	91	82	76	66	76	81	37	30	20	24
n (%) of nets found with any hole (s)	36(40)	27(33)	41(54)	32(48)	28(36)	18(22)	35(94.59)	25(83.33)	14(70)	23(95.83)
CI 95 (%)	30.13-49.83	23.72- 43.66	42.82-64.69	36.85- 60.29	26.28 - 48.74	14.03 - 33.08	81.80-99.34	65.27-84.36	45.72 - 88.11	78.87 - 99.89
Mean PHI	169.6	184.7	212.3	179.9	48.32	59.89	929	870	467.6	2453
Median PHI	0	0	1.5	0	36	55	833	729	311	1259
IQR	84	23	69.8	158.3	45.5	42.25	301	434	1310.8	12091
n (%) of nets in pHI<64 ('good' category)	67(73.63)	69(84.15)	56(73.68)	44(66.67)	19(25.00)	11(13.58)	0(0)	0(0)	1(7.14)	6(26.09)
CI 95 (%)	63.17 - 82.06	74.05 - 90.96	62.82 - 82.27	54.66 - 76.84	16.08 - 36.48	7.29 - 23.42	0 - 10	0 - 13.72	0.18 -33.87	10.22 - 48.40
n (%) of nets in 64<pHI<768 ('serviceable' category)	18(19.78)	8(9.76)	13(17.11)	15(22.73)	28(36.84)	18(22.22)	6(17.14)	12(48)	9(64.29)	5(21.74)
CI 95 (%)	12.45 - 19.72	4.61 -18.83	10.28 - 27.10	14.29 - 34.17	26.28 - 48.74	14.03 - 33.08	6.56 - 33.65	27.79 - 68.69	35.13 - 87.24	7.46 - 43.07
n (%) of nets in pHI>768 'needs ('replacement' category)	6(6.59)	5(6.10)	7(9.21)	7(10.61)	0(0)	0(0)	29(82.85)	13(52)	4(28.54)	12(52.17)
CI 95 (%)	2.71 - 14.34	2.29 - 14.28	4.53- 17.81	5.23 - 20.31	0 - 5.99	0 - 5.64	63.65 93.44	31.30 - 72.20	8.38 - 58.10	30.58 - 73.18

Reasons for loss of LLINs

Overall, 6 months after distribution, 46 LLINs were absent from their initial location. "Displacement", the most frequently cited reason to justify the absence of the LLINs, seemed the main factor (cited 37 times) during the interviews. The LLINs thrown away because of "physical damages" were cited 9 times. The loss rate-1 (LLINs thrown away due to physical deterioration) was of 1% compared to 4% for loss rate-2 (Displaced LLINs) and 0% for loss rate-3 (LLINs used for "other purposes"). The rates of physical deterioration were similar in all communities, and then, for the 3 types of LLINs. "Displacement", the most common fate of a non-found LLIN, was the most frequently cited reason in the Ouesse district where people moved their nets on their farm to protect themselves from malaria during the 2-3 months of agricultural activities in the villages.

After 12 months, the interview on the disappearance of LLINs was carried out in 125 households where LLINs were not found. "Displacement" was mentioned in 80 interviewed households (Table 7). LLINs thrown away due to physical deterioration were evoked 45 times. Loss rate-1 was 6% compared to 13% for loss rate-2 and 0% for loss rate-3.

At 6 months, displacement was the main reason for losing LLINs from their original location while at 24 months, physical deterioration was the main factor. This explains a relatively high rate of loss of type 1 (9.56%) (86/900) while types 3 (5.22%) (47/900) were low.

During the visit made 30 months after the distribution of the LLINs, 154 households had no longer their mosquito nets. The interview with these 154 households showed that most of the missing LLINs were discarded due to physical deterioration (151 responses out of 154). The loss rates 1 were high (8 to 23%) and varied according to the sites. "Physical deterioration" was similar in the three districts. This deterioration was function of the type of bedding, the number of washing and several other risk factors.

Table 7. Reasons for nets loss (attrition) T6 at T30

		DawaPlus 2.0		PermaNet 2.0		DuraNet		
		Urban area	Rural area	Urban area	Rural area	Urban area	Rural area	Total
Baseline (T$_0$)	Households selected	150	150	150	150	150	150	900
	Lost LLINs	-5	-1	-8	-4	-13	-16	-46
	Administered questionnaires	5	0	8	4	13	16	46
	''Physical damage'' responses	0	0	2	2	5	0	9
After 6 months (T6)	''Removal'' responses	5	1	6	2	8	16	37
	''Re-purposed'' responses	0	0	0	2	2	0	0
	(%) Attrition rate-1	0	0	1	1	3	0	1
	95% confidence interval	0-02.50	0-02.50	0.37-04.73	0.37-4.73	1.43-7.57	0-02.50	0.53-1.89

(%) Attrition rate-2	3	1	4	1	5	11	4
95% confidence interval	1.43-7.57	0.12-03.68	1.85-08.45	0.37-04.73	2.73-10.17	6.67-16.62	3-4.11
(%) Attrition rate-3	0	0	0	0	0	0	0
95% confidence interval	0-2.5	0-2.5	0-2.5	0-2.5	0-2.5	0-2.5	0-0.43
% of nets loss (total attrition)	3	1	5	3	9	11	5

After 12 months (T12) Lost LLINs	-14	-22	-24	-13	-28	-24	-125
Administered questionnaires	14	22	24	13	28	24	125
''Physical damage'' responses	4	6	7	6	18	4	45
''Removal'' responses	10	16	17	7	10	20	80
''Re-purposed'' responses	0	0	0	0	0	0	0
(%) Attrition rate-1	2.67	04.00	6.00	05.33	15.33	02.67	6
95% confidence interval	01.04-6.66	1.85-08.45	3.19-11.01	2.73-10.17	10.44-21.96	1.04-06.66	4.63-7.75
(%) Attrition rate-2	10	11.33	15.33	6	12	24.00	13
95% confidence interval	6.15-15.84	7.2-17.40	10.44-21.96	3.19-11.01	7.73-18.17	17.87-31.47	10.96-15.36
(%) Attrition rate-3	0	0	0	0	0	0	0
95% confidence interval	0-2.5	0-2.5	0-2.5	0-2.5	0-2.5	0-2.5	0-0.43
% of nets loss (total attrition)	12.67	14.67	21.33	11.33	27.33	26.67	19

After 19 months (T19) Lost LLINs	-27	-38	-28	-17	-33	-29	172
Administered questionnaires	27	38	28	17	33	29	172
''Physical damage'' responses	18	19	18	9	23	12	99
''Removal'' responses	1	0	0	0	0	0	1
''Re-purposed'' responses	8	19	10	8	10	17	72
(%) Attrition rate-1	14.66	16.66	18	11.33	30.66	10.66	17
95% confidence interval	9.61 - 21.58	11.27 - 23.82	12.39 - 25.29	6.93 - 17.79	23.54 - 38.80	6.41 - 17.01	14.63 - 19.65
(%) Attrition rate-2	10.66	11.33	15.33	6	12	24	13.11
95% confidence interval	6.41 - 17.01	6.93 - 17.79	10.16 - 22.33	2.95 - 11.42	7.46 - 18.55	17.57 - 31.79	11.01 - 15.53
(%) Attrition rate-3	5.33	12.66	6.66	6.66	8	11.33	8
95% confidence interval	2.5 - 10.59	7.99 - 19.32	3.42 - 12.25	3.42 - 12.25	4.38 - 13.86	6.93 - 17.79	6.35 - 10.01
% of nets loss (total attrition)	30.66	40.66	40	24	50.66	46	38.11

After 24 months (T24) Lost LLINs	15	19	25	20	37	17	133
Administered questionnaires	15	19	25	20	37	17	133
''Physical damage'' responses	11	13	21	14	20	7	86
''Removal'' responses	0	0	0	0	0	0	0
''Re-purposed'' responses	4	6	4	6	17	10	47
(%) Attrition rate-1	7.33	8.67	14	9.33	13.33	4.67	9.56
95% confidence interval	3.71 - 12.74	4.69 - 14.36	8.87 - 20.60	5.19 - 15.16	8.33 - 19.84	1.89 - 9.38	7.71 - 11.67
(%) Attrition rate-2	0	0	0	0	0	0	0
95% confidence interval	0 - 2.43	0 - 2.43	0 - 2.43	0 - 2.43	0 - 2.43	0 - 2.43	0 - 0.41
(%) Attrition rate-3	2.66	4	2.66	4	11.33	6.67	5.22
95% confidence interval	0.73 - 6.69	1.48 - 8.50	0.73 - 6.69	1.48 - 8.50	6.74 - 17.52	3.24 - 11.92	3.86 - 6.88
% of nets loss (total attrition)	10	12.67	16.67	13.33	24.67	11.33	14.78

Lost LLINs	31	37	25	27	12	22	154
Administered questionnaires	31	37	25	27	12	22	154

After 30 months (T30)								
	''Physical damage'' responses	30	35	25	27	12	22	151
	''Removal'' responses	1	2	0	0	0	0	3
	''Re-purposed'' responses	0	0	0	0	0	0	0
	(%) Attrition rate-1	20	23.33	16.66	18	8	14.66	16.77
	95% confidence interval	13.91- 27.3	16.82 -30.93	11.08 -23.61	12.2 - 25.1	4.2 - 13.56	9.42 -21.36	14.39 - 19.38
	(%) Attrition rate-2	0.66	1.33	0	0	0	0	0
	95% confidence interval	0.01 - 3.66	0.16 - 4.73	0 - 2.43	0 - 2.43	0 - 2.43	0 - 2.43	0.06 - 0.97
	(%) Attrition rate-3	0	0	0	0	0	0	0
	95% confidence interval	0 - 2.43	0 - 2.43	0 - 2.43	0 - 2.43	0 - 2.43	0 - 2.43	0 - 0.41
	% of nets loss (total attrition)	20.67	24.67	16.67	18	8	14.67	17.11

Principle causes of the damage to LLIN

When holed LLINs were categorized by the nature of holes, the 'rip in the fabric' category accounted for 70 to 92% of the damages while burn holes accounted for 2 to 15%, open seams for 5 to 15% and rodent damages for 0 to 5 % (Table 8). LLINs repair practice was very low (0-6%) after six months.

After 12 months, the 'rip in the fabric only' category was between 68 and 88% of the damages, "burn holes only" accounted for 0 to 14% and, "open seams only" for 2 to 8%. Rodent damages were 0 % (Table 8) while "rip in the fabric associated with rip in the seam" category represented 0 to 20% (Table 8).

The category of "simple tears", after 30 months, represented 91 to 100% of the causes of deterioration, while burn holes accounted for 0 to 5% for the three types of LLINs. There is a significant difference in the proportion of LLINs with seam openings: 30.43% to 37.50% for PermaNet 2.0 and DuraNet against 4.35% to 7.69% for DawaPlus 2.0 nets. Rodent damages were almost non-existent in DawaPlus 2.0 nets and PermaNet 2.0 while they were about 13% for DuraNet. LLIN repair practices were remarkable after 30 months of follow-up. We noted that 3 to 75% of torn LLINs were repaired in all three sites.

Table 8: Principal causes of the damage to LLIN from 6 to 30 months assessment visits

		DawaPlus 2.0		PermaNet 2.0		DuraNet	
		Urban area	Rural area	Urban area	Rural area	Urban area	Rural area
After 6 months(T6)	n of nets found with any hole (s)	33	41	37	43	36	27
	n (%) of nets with 'rip in the fabric'	26 (79)	33 (81)	29 (78)	37 (86)	33(92)	19 (70)
	CI 95%	62.25-89.32	65.99-89.77	62.80-88.61	72.74-93.44	78.17-97.13	51.52-84.15
	n (%) of nets with 'rip in the seam'	2 (6)	5 (12)	5 (14)	3 (7)	2 (5)	4 (15)
	CI 95%	01.68-19.61	05.32-25.54	05.91-27.98	02.40-18.61	01.54-18.14	05.92-32.48
	n (%) of nets with 'burn holes'	4(12)	1 (2)	3 (8)	2(5)	1 (3)	4 (15)
	CI 95%	04.82-27.33	00.43-12.60	02.80-21.30	01.28-15.46	00.49-14.17	05.92-32.48
	n (%) of nets chewing by rodent	1(3)	2 (5)	0(0)	1(5)	0 (0)	0(0)
	CI 95%	00.54-15.32	01.35-16.14	00.00-09.41	01.28-15.46	00.00-09.64	00.00-12.46

	Col1	Col2	Col3	Col4	Col5	Col6
n(%) of nets repaired	2(6)	1(2)	3(8 n)	0(0)	1(3)	0(0)

After 12 months(T12)						
n of nets found with any hole (s)	43	54	35	48	41	32
n (%) of nets with 'rip in the fabric only'	34(79)	38 (70)	27(77)	32 (67)	36(88)	26(81)
CI 95%	64.79-88.58	57.17-80.86	60.98-87.93	52.54-78.32	78.17-97.13	64.69-91.11
n (%) of nets with 'rip in the seam'	1 (2)	3 (6)	2 (6)	4 (8)	1(2)	1(3)
CI 95%	00.41-12.06	01.91-15.11	01.58-18.61	03.29-19.55	00.43-12.60	00.55-15.74
n (%) of nets with 'burn holes only'	6(14)	1 (2)	0(0)	1(2)	1(2)	0 (0)
CI 95%	06.56-27.26	00.33-09.77	0.00-09.81	00.37-10.90	00.43-12.60	00.00-10.72
n (%) of nets chewing by rodent	0(0)	0 (0)	0(0)	0(0)	0 (0)	0 (0)
CI 95%	00.00-08.25	00.00-6.64	0.00-09.81	00.00-7.41	00.00-08.57	00.00-10.72
n (%) of nets with ' rip in the fabric and burn holes'	1 (2)	1 (2)	1(3)	4 (8)	0 (0)	0 (0)
CI 95%	00.41-12.06	00.33-9.77	0.51-14.53	03.29-19.55	00.00-08.57	00.00-10.72
n (%) of nets with ' rip in the fabric and rip in the seam'	0(0)	11(20)	5(14)	6(13)	4(10)	5(16)
CI 95%	00.00-08.25	11.77-39.20	6.26-29.38	5.86-24.70	03.86-22.55	06.86-31.75
n (%) of nets with ' rip in the fabric. burn holes and rip in the seam'	1 (2)	0 (0)	0(0)	1(2)	0 (0)	0 (0)
CI 95%	00.41-12.06	00.00-6.64	0.00-9.81	00.37-10.90	00.00-08.57	00.00-10.72

After 19 months(T19)						
n of nets found with any hole (s)	41	41	90	116	76	81
n (%) of nets with 'rip in the fabric only'	31(75)	32(78)	41(45)	56(48)	25(32)	16(19)
CI 95%	59.35 - 87.09	61.96 - 88.88	35.13 - 56.35	38.97 - 57.69	22.80 - 44.73	12.04 - 30.39
n (%) of nets with 'rip in the seam'	0(0)	3(7)	1(1)	1(0.8)	2(2)	0(0)
CI 95%	0 - 10.67	1.90 - 21.00	0.05 - 6.90	0.04 - 5.41	0.45 - 10.04	0 - 5.64
n (%) of nets with 'burn holes only'	0(0)	0(0)	1(1)	1(0.8)	0(0)	0(0)
CI 95%	0 - 10.67	0 - 10.67	0.05 - 6.90	0.04 - 5.41	0 - 5.99	0 - 5.64
n (%) of nets chewing by rodent	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
CI 95%	0 - 10.67	0 - 10.67	0 - 5.10	0 - 3.99	0 - 5.99	0 - 5.64
n (%) of nets with ' rip in the fabric and burn holes'	7(17)	5(12)	2(2)	0(0)	0(0)	1(1)
CI 95%	7.69 - 32.65	4.57 - 27.00	0.38 -8.35	0 - 3.99	0 - 5.99	0.06 - 7.63
n (%) of nets with ' rip in the fabric and rip in the seam'	2(4)	1(2)	6(6)	4(3)	1(1)	1(1)
CI 95%	0.84 - 17.80	0.13 - 14.40	2.73 - 14.49	1.11 - 9.11	0.06 - 8.11	0.06 - 7.63
n (%) of nets with ' rip in the fabric. burn holes and rip in the seam'	1(2)	0(0)	0(0)	0(0)	0(0)	0(0)
CI 95%	0.13 - 14.40	0 - 10.67	0 - 5.10	0 - 3.99	0 - 5.99	0 - 5.64

After 24 months(T24)						
n of nets found with any hole (s)	40	51	42	55	35	25
n (%) of nets with 'rip in the fabric only'	38(95)	47(92.16)	41(97.62)	51(92.73)	34(97.14)	24(96)
CI 95%	83.08 - 99.39	81.11 - 97.82	87.43 - 99.94	82.41 - 97.98	85.08 - 99.93	79.64 - 99.90
n (%) of nets in the seam'	3(7.5)	14(27.45)	7(16.67)	5(9.09)	10(28.57)	9(36)
CI 95%	1.57 - 20.39	15.89 - 41.74	6.97 - 31.36	0.01 - 19.95	14.63 - 46.30	17.97 - 57.48
n (%) of nets with 'burn holes only'	3(7.5)	2(3.92)	3(7.14)	5(9.09)	0(0)	0
CI 95%	1.57 - 20.39	0.48 - 13.46	1.49 - 19.48	0.01 - 19.95	0.00 - 10.00	0.00 - 13.72

	n (%) of nets chewing by rodent	0(0)	1(1.96)	0	0	0(0)	2(8)
	CI 95%	0 - 8.81	0.48 -10.45	0 - 8.41	0 - 6.49	0.00 - 10.00	0.98 - 26.03
	n (%) LLINs repaired	0	0	0	0	0	0
After 30 months(T30)	n of nets found with any hole (s)	23	26	16	35	14	23
	n (%) of nets with 'rip in the fabric only'	21(91)	26(100)	15(93.75)	34(97.14)	14(100)	23(100)
	CI 95%	71.96 - 98.93	88.77 -100	69.76- 99.84	85.08 - 99.93	76.83 100	85.18 - 100
	n (%) of nets in the seam'	2(8.7)	2(7.69)	3(37.5)	11(31.43)	0(0)	7(30.43)
	CI 95%	1.07- 28.04	0.94 - 25.13	15.19 - 64.57	16.85 - 49.29	0 - 23.16	13.21 - 52.92
	n (%) of nets with 'burn holes only'	1(4.35)	0(0)	0(0)	2(5.71)	1(7.14)	1(4.35)
	CI 95%	0.11 - 21.95	0 - 13.23	0- 20.59	0.69 - 19.16	0.18 - 33.87	0.11 - 21.95
	n (%) of nets chewing by rodent	0(0)	0(0)	0(0)	0(0)	0(0)	3(13.04)
	CI 95%	0- 14.82	0 - 13.23	0- 20.59	0 - 10	0 - 23.16	2.77 - 33.58
	n (%) LLINs repaired	2(8.7)	1(3.95)	12(75)	9(25.71)	9(64.29)	11(47.53)

Distribution of factors related to LLINs durability

Table 9 shows the results of the interviews on the washing frequency of the LLINs, LLIN usage and maintenance, and LLIN position during the day. Six months after distribution, around 50% of LLINs were washed 2-5 times. The other 50% were washed only once or have never been washed. Washing frequency was higher in urban area than rural (Table 8). Most households indicated that LLINs were used nightly (77-90%). Nets maintenance was good in all locations (Table 9).

30 months after distribution, 25% of the LLINs were washed 2-5 times except at Toffo where the proportion was below 20%. Contrary to what was observed 6 months after distribution, in all sites, the washing frequency was higher in rural areas than in urban areas (Table 14). In all sites, less than 25% of LLINs were washed 8 times. Most people (35-92%) used their LLINs every night and the majority of LLINs were found in a suspended position during our visit, confirming their regular use (30-88%). The majority of LLINs were dirty (50-68%) at all sites (Table 9).

There was a strong relationship (p<0.05) between LLINs use and the loss of their fabric integrity (Figure 5 & 6).

Although there was no correlation (p>0,05) between the washing frequency, the position of the LLINs (hanged, folded, stored) and the pHI (Figure 7), it was noted that the LLINs at high pHI found stored were those washed more than 10 times.

Table 9: Responses to the administered questionnaire in each site from T6 to T30

Period	Factors	Modalities	DawaPlus 2.0		PermaNet 2.0		DuraNet	
			Urban area	Rural area	Urban area	Rural area	Urban area	Rural area
	Washing frequency (%)	None	29.41	34.15	14.06	20.18	13.46	12.37

		1 time	27.21	30.89	21.09	23.85	22.12	25.77
		2 - 5 times	43.38	33.33	64.06	53.21	63.46	58.76
		6 - 10 times	0	1.63	0	2.75	0.96	3.09
		10 and more	0	0	0.78	0	0	0
After 6 months (T6)	LLINs use (%)	not at all	0	4.07	0.78	0	0.96	4.12
		Often	17.5	17.07	6.25	6.42	14.42	10.31
		every night	79.14	79.86	89.06	89.91	80.77	77.32
		Nsp	2.94	0	3.91	3.67	3.85	8.25
	LLINs maintenance (%)	Clean	43.38	47.97	54.69	54.13	44.23	72.16
		Dirty	56.62	52.03	45.31	11.93	55.77	27.84
	LLINs position (%)	hanged	72.06	74.8	75	84.4	71.15	68.04
		bent	11.76	6.5	12.5	3.67	23.08	16.49
		Row	16.18	18.7	12.5	11.93	5.77	15.46
		None	29.41	34.15	14.06	20.18	13.46	12.37
After 12 months (T12)	Washing frequency (%)	None	6.12	7.76	3.79	0	9.21	3.03
		1 time	19.38	16.50	6.32	8.98	10.52	4.54
		2 - 5 times	65.30	69.90	70.88	64.04	76.31	83.33
		6 - 10 times	9.18	4.85	15.18	22.47	3.94	9.09
		10 and more	0	0.97	3.79	4.49	0	0
	LLINs use (%)	not at all	0	0	1.26	2.24	2.63	3.03
		Often	17.34	22.33	12.65	6.74	5.26	7.57
		every night	82.65	77.66	86.07	91.011	92.10	89.39
	LLINs maintenance (%)	Clean	38.77	40.77	35.44	26.96	67.10	54.54
		Dirty	61.22	59.22	64.55	73.03	32.89	45.45
	LLINs position (%)	hanged	76.53	74.75	73.41	79.77	72.36	77.27
		bent	11.22	6.79	5.06	8.98	19.73	13.63
		Row	12.24	18.44	21.51	11.23	7.89	9.09
After 19 months (T19)	Washing frequency (%)	None	0	0	0	1.2	2.38	0
		Once	1.35	2.77	0	0	2.38	0
		2 – 5time	39.19	31.94	27.77	43.37	42.85	26.66
		6 - 10 time	6.76	19.44	34.72	22.89	11.9	26.66
		>10 time	8.11	2.77	8.33	7.22	7.14	6.66
	LLINs use (%)	Not at all	1.35	0	0	0	0	3.33
		often	16.21	8.33	9.72	8.54	16.66	16.66
		Everynight	82.44	91.67	90.27	91.46	83.33	80
	LLINs maintenance (%)	Clean	16.21	6.94	37.5	53.02	59.52	50
		Dirty	39.18	50	62.5	46.98	40.48	50

|							
	LLINs position (%)	Hanging	78.39	87.51	79.16	89.15	71.42	73.33
		Folded	17.56	8.33	8.33	8.43	21.43	16.67
		Store away	4.05	4.16	12.5	2.41	7.14	10
After 24 months (T24)	Washing frequency (%)	None	2.50	1.96	0.00	0.00	0.00	4.00
		Once	5.00	0.00	9.52	1.82	0.00	4.00
		2 – 5time	57.50	60.78	52.38	61.82	80.00	56.00
		6 - 10 time	12.50	29.41	33.33	23.64	8.57	28.00
		>10 time	22.50	7.84	4.76	12.73	11.43	8.00
	LLINs use (%)	Not at all	11.67	1.69	2.38	1.82	13.51	6.67
		often	10.00	11.86	11.90	9.09	5.41	6.67
		Everynight	78.33	86.44	85.71	89.09	81.08	86.67
	LLINs maintenance (%)	NSP	0	0	0	0	0	0
		Clean	45.00	49.15	30.95	41.82	43.24	40.00
		Dirty	55.00	50.85	69.05	58.18	56.76	60.00
	LLINs position (%)	Hanging	71.67	76.27	73.81	80.00	56.76	70.00
		Folded	10.00	6.78	9.52	12.73	35.14	26.67
		Store away	18.33	16.95	16.67	7.27	8.11	3.33
After 30 months (T30)	Washing frequency (%)	None	36.36	31.94	36	30.99	34.38	39.13
		Once	0	0	16	2.82	15.63	6.52
		2 – 5time	43.94	29.17	12	8.45	43.75	26.09
		6 - 10 time	15.15	26.39	10	7.04	3.13	15.22
		>10 time	4.55	12.5	26	50.7	3.13	13.04
	LLINs use (%)	Not at all	5.71	0	0	6.82	0	20.83
		often	2.86	20	8	6.82	65	25
		Everynight	91.43	80	92	86.36	35	54.17
	LLINs maintenance (%)	Nsp	0	0	0	0	0	0
		Clean	40	31.43	64	31.82	50	41.67
		Dirty	60	68.57	36	68.18	50	58.33
	LLINs position (%)	Hanging	88.57	77.14	80	72.73	30	45.83
		Folded	5.71	11.43	4	9.09	45	4.17
		Store away	5.71	11.43	16	18.18	25	50
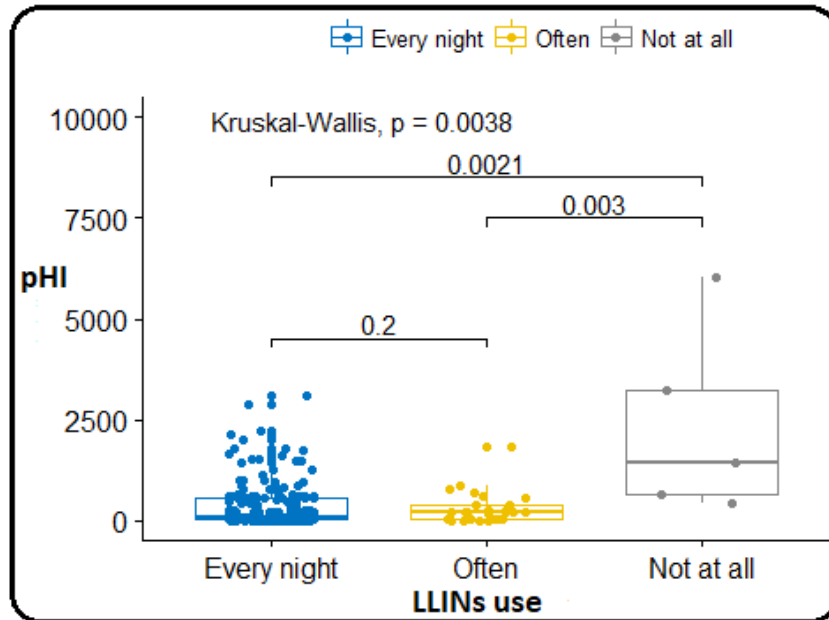
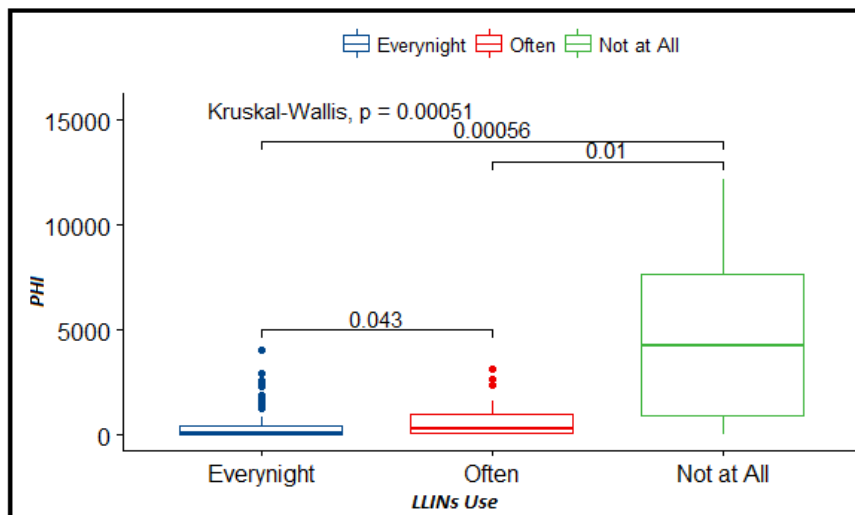**Figure 5:** Relationship between pHI and use of LLINs after 12 months

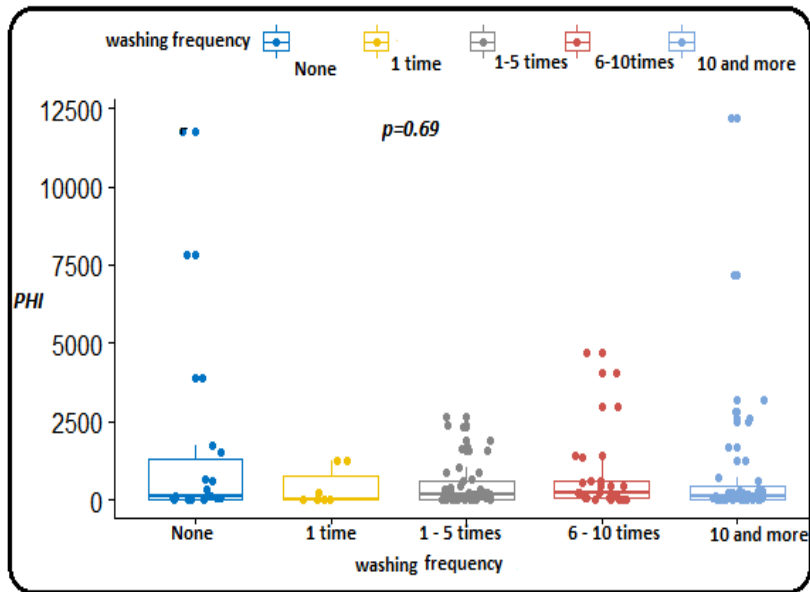**Figure 6:** Relationship between pHI and use of LLINs after 30 months

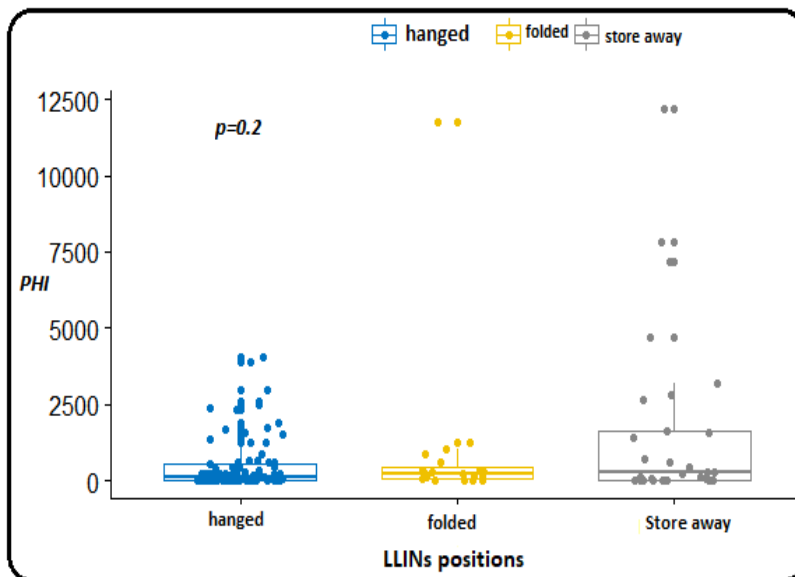**Figure 7.1:** Relationship between washing frequency

Figure 7.2: Relationship between LLINs position and pHI

Other risk factors of households

The sustainability of LLINs is based on several factors. An average of 29 to 90% of study participants report keeping food in the bedroom in the three districts. About 32 to 64% of households cook in the bedroom compared to 35 to 67% who never do it (Table 5).

Overall, children and adults slept under the same net (48% and 70%). The proportion of LLINs used only by adults was low (25% to 48%). An even lower percentage (0 to 12.5%) was recorded for the use of LLINs for children only (Table 5). However, households involved in the study and that no longer have the cohort LLINs were not unprotected. They used other LLINs. This means that most of the nets in the cohort that have disappeared for various reasons have been replaced. This is proof that people appreciate the use of mosquito nets.

The figure 8 shows that unlike Toffo and Tori-Bossito, the district of Ouesse was the place where the use of mats and bamboos was higher. This could also explain the increased physical deterioration in this district. Indeed, the figure 9 displays that the loss of LLINs physical integrity was strongly correlated with the type of sleeping materials used (p=0.0016). Conversely, there was no relationship between the type of LLINs users, the frequency of cooking in room and the LLINs fabric integrity (Figure 9).

Table 5: Other household risk factors after 30 months

|		DawaPlus 2.0		PermaNet 2.0		DuraNet	
		Urban areas	Rural areas	Urban areas	Rural areas	Urban areas	Rural areas
In-room food		41.07	29.03	53.19	52.94	90.32	71.11
Cook in room	Never (%)	50	62.9	42.55	35.29	67.74	46.67
	Sometimes (%)	50	37.1	57.45	64.71	32.26	53.33
Use of the study's LLINs	% adult only	34.29	25.71	48	25	30	25
	% Adult and children	57.14	62.86	48	65.91	70	62.5
	% Children only	8.57	11.43	4	9.09	0	12.5
Use of non-study LLINs	% adult only	0	33.33	18.18	16.67	0	0
	% Adult and children	95.24	62.96	77.27	79.17	100	95.24
	% Children only	4.76	3.7	4.55	4.17	0	4.76
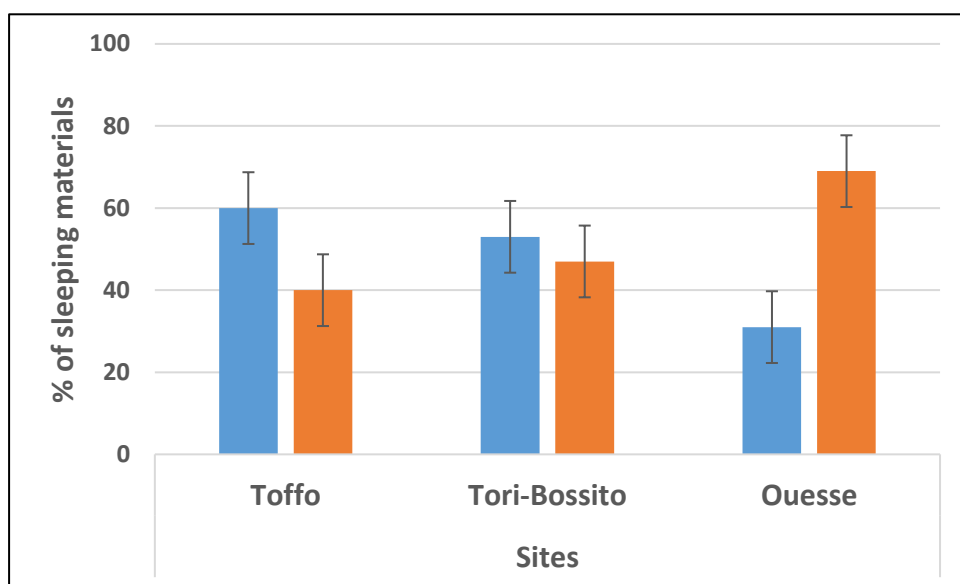
Figure 8: Main type of sleeping materials covered by the 2014 distributed LLINs by site
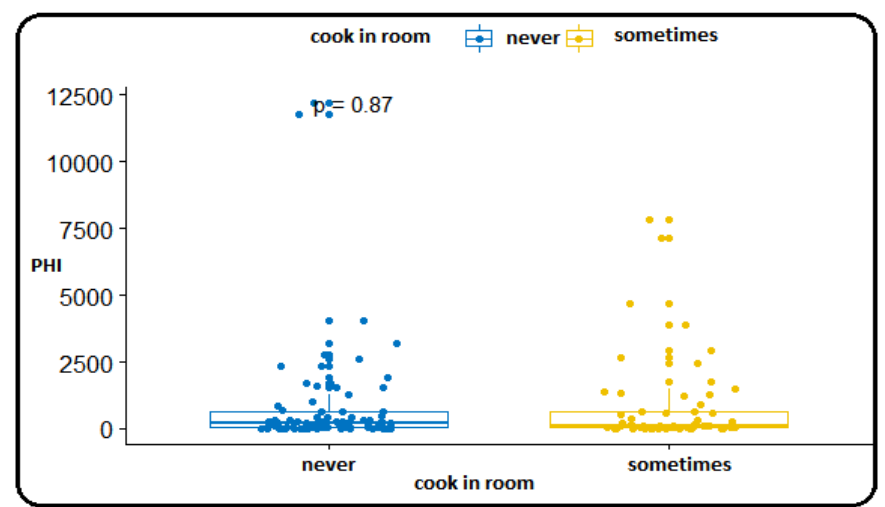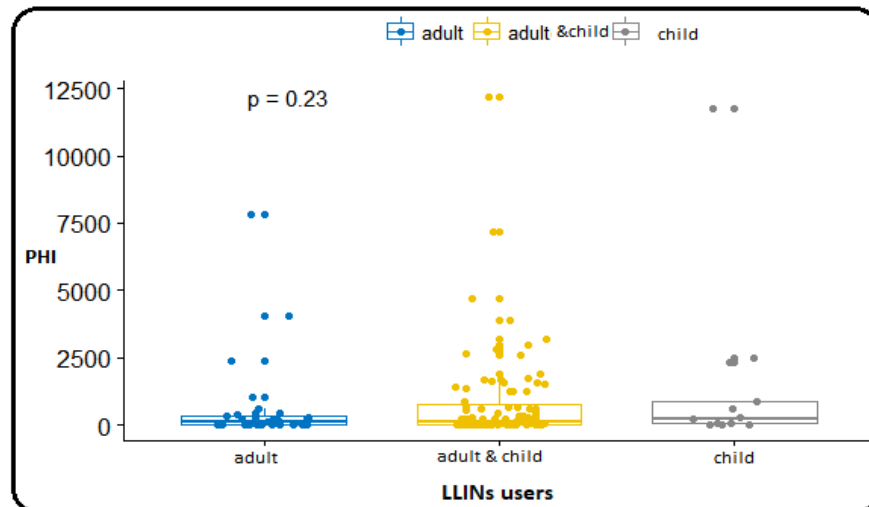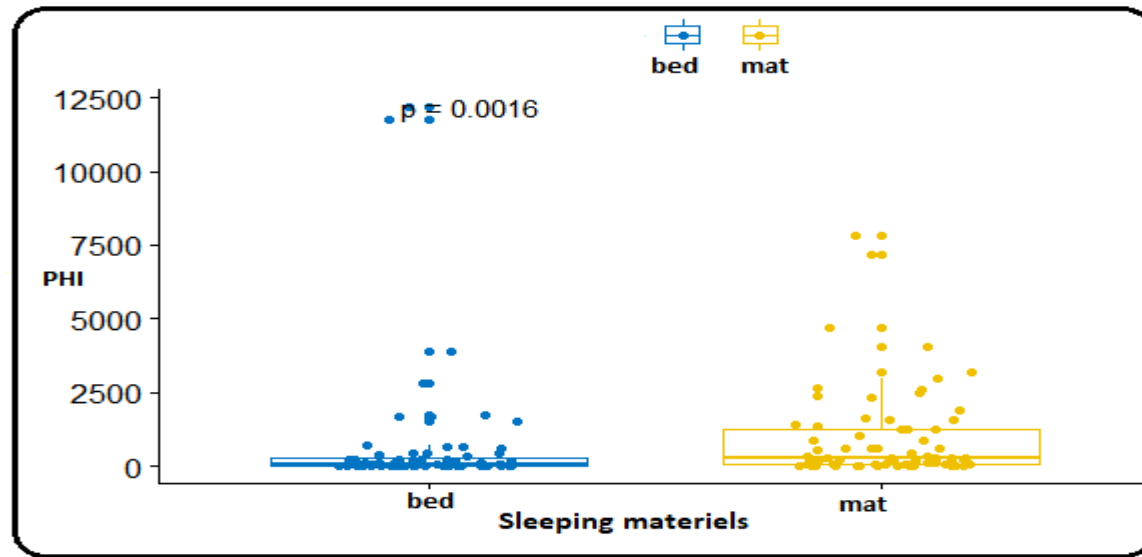
Figure 9: Relationship between sleeping materials, LLINs users, frequency of cooking in room and pHI

Conclusion

Thirty months after the 2014 mass campaign, mosquito net survival was below the WHO threshold. Only 183 LLINs out of 900 LLINs (1/5) were found and evaluated. More surprisingly, one year after the distribution, the LLINs had a loss of integrity to a degree that called into question their ability to play their protective role in the third year. The survival of LLINs in our study area followed a 2-year life curve. The monitoring and evaluation of the three types of LLINs 30 months after use in real conditions also shows that the PermaNet 2.0 net seems to be the best LLIN by considering the two indicators namely: survival (presence of LLINs), durability (physical integrity) followed by DawaPlus and DuraNet LLINs.