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THE PMI VECTORLINK BURKINA FASO 2019 ITN DURABILITY MONITORING 36-MONTH FOLLOW-UP STUDY REPORT

Recommended Citation: The PMI VectorLink Project. November 2022. *The PMI VectorLink Burkina Faso 2019 ITN Durability Monitoring 36-Month Follow-Up Study Report*. Washington, DC. The PMI VectorLink Project, Population Services International (PSI).

Contract: AID-OAA-I-17-00008

Task Order: AID-OAA-TO-17-00027

Submitted to: United States Agency for International Development/PMI

Submitted on: November 9, 2022

Approved on:

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ACRONYMS

ANC	Antenatal Care
AI	Active Ingredient
BFI	Blood Feeding Inhibition
CEIRES	Comité d'Ethique Institutionnel pour la Recherche en Science de la Santé / Institutional Ethics Committee for Health Science Research
CRA-W	Walloon Agricultural Research Centre
DHS	Demographic Health Survey
IQR	Interquartile Range
IRSS	Institut de Recherche en Sciences de la Santé/ Health Research Sciences Institute
ITN	Insecticide-Treated Net
KD60	60-minute Knock-Down rate
MIS	Malaria Indicator Survey
NMCP	National Malaria Control Program
PBO	Piperonyl Butoxide
pHI	Proportionate Hole Index
PMI	U.S. President's Malaria Initiative
PCR	Polymerase Chain Reaction
PSI	Population Services International
REB	Research Ethics Board
WHO	World Health Organization

EXECUTIVE SUMMARY

The importance of insecticide-treated net (ITN) field durability and estimating the average useful life of an ITN is one of the critical factors National Malaria Programs (NMP) need to know to determine the frequency with which ITNs are replaced. The World Health Organization (WHO) recommends that countries routinely monitor ITN durability following mass distribution campaigns, and that standard guidance for monitoring has been developed.[1]

In Burkina Faso, the U.S. President's Malaria Initiative (PMI) is supporting ITN durability monitoring of three types of ITNs, in different study sites, distributed during the 2019 mass campaign: Interceptor® G2, a dual-active ingredient (AI) ITN in Banfora health district (Comoé province); Interceptor®, a standard pyrethroid ITN in Gaoua health district (Poni province); and PermaNet® 3.0, a pyrethroid ITN with the insecticide synergist piperonyl butoxide (PBO), in Orodara health district (Kénédougou province). The 2019 mass distribution campaign took place in three stages between July – October 2019, and distribution timings for the study sites differed from those used for the rest of the country. In the study sites, PermaNet® 3.0 ITNs were distributed between June 28 – July 3, 2019, standard Interceptor® ITNs were distributed between August 2-6, 2019, and dual-AI Interceptor® G2 ITNs were distributed from October 29 – November 2, 2019. Baseline data collection was conducted December 9-20, 2019, an average of one to six months after the distribution campaign. During the baseline survey, all campaign ITNs in sampled households were identified and labeled with a unique identification number.

The 12-month survey was carried out between August 31 – November 12, 2020, the 24-month survey between July 4 – November 8, 2021, and the 36-month survey between July 4 – August 20, 2022. Fieldwork was conducted by the Health Sciences Research Institute/Institut de Recherche en Sciences de la Santé (IRSS) with supervision from VectorLink Burkina Faso. During each of the surveys, ITNs labeled at baseline were followed-up with; the physical integrity of nets still present in the household was measured through a hole assessment and details were recorded for any nets no longer present in the household (attrition). Potential factors affecting net durability were explored through a household interview. These included environmental factors (house structure, cooking fuel, type of sleeping place), net handling (folding nets up when hanging, drying washed nets on bushes, etc.) as well as attitudes towards nets, net care, and repair.

During each survey, two campaign ITNs per cluster were randomly sampled from households outside the cohort but within the same study site to undergo bio-effectiveness and chemical content analysis. At 24-months, three clusters in Banfora district could not be visited due to security concerns, therefore, only 24 nets were collected for laboratory testing. Again at 36-months, these three clusters could not be visited secondary to local insecurity, however, in anticipation of this challenge, six additional nets were collected in Banfora to ensure a total of 30 nets were available for testing. Bioassays were conducted by IRSS, and chemical content analysis was conducted by Walloon Agricultural Research Center/Centre Wallon de Recherches agronomiques (CRA-W) on samples from the ITNs selected for cone bioassays.

Household and ITN Follow-Up

A total of 288 out of 362 (80%) eligible households were interviewed for the 36-month study. Of these, 230 (80%) households still had one or more cohort nets while 58 (20%) had lost all their cohort nets. Of the 74 households not interviewed, 13 (18%) had no eligible respondent available for interview, 31 (42%) had moved out of the study area, two households refused the interview (3%), and 28 (38%) households had an unknown

[1] www.durabilitymonitoring.org

status (of which 27 were located in study clusters within the Banfora health district that could not be visited because of security concerns). No households had positive COVID-19 screenings.

Of the 534 nets eligible for follow-up at the 36-month study round, 295 (55%) were still in the house and seven (1%) were with family elsewhere. There were 96 (18%) nets that had been discarded, 22 (4%) nets given away or stolen, 10 (2%) nets lost for unknown reasons, and 62 (12%) nets that had an unknown outcome (43 of which belonged to households that could not be visited due to insecurity). A further 42 (8%) nets were unavailable because the household had moved outside the study area or refused to participate. In total, 664 out of 959 (69%) nets received at baseline were no longer present in households.

Durability Risk Factors

At 36-months, food storage, cooking, and washing risk factors differed considerably across study sites. Overall, durability risk factors assessed at 36-months suggest that cohort nets in Gaoua are subject to higher overall risk of damage. At 36-months, the proportion of households storing food in a room used for sleeping (64% in Banfora, 100% in Gaoua, 50% in Orodara; $p<0.001$) and the proportion of households ever cooking in a room used for sleeping (26% in Banfora, 45% in Gaoua, 4% in Orodara; $p<0.001$) was highest in Gaoua district. Nets were most commonly hung over a mat or the ground in Gaoua (28% in Banfora, 83% in Gaoua, 28% in Orodara; $p<0.001$). The highest proportion of cohort nets last washed with detergent or bleach was in Banfora (50%), with a lower proportion in Gaoua (31%), and the lowest proportion in Orodara (13%) ($p=0.015$). The proportion of nets last dried on a bush or fence was low and did not differ between districts (7% in Banfora, 6% in Gaoua, 2% in Orodara). Among nets reported as hanging, the proportion of nets not folded or tied up during the 36-month survey differed between sites, being highest in Orodara (93%) and lower in Banfora (44%), and Gaoua (44%%) ($p<0.001$).

At 36-months, exposure to net messaging in the six months before the survey was lowest in Gaoua, where no respondents reported exposure (0%), and higher in Banfora (39%) and Orodara (47%) differed. A low proportion of respondents had favorable attitudes towards nets and net care and repair in all study sites, especially in Gaoua where respondents weren't exposed to messaging (favorable net attitudes: 36% in Banfora, 7% in Gaoua, 26% in Orodara, [$p<0.001$]; favorable net care and repair attitudes: 18% in Banfora, 6% in Gaoua, 3% in Orodara, [$p=0.014$]).

ITN Ownership and Use

From baseline to 36-months, use of cohort nets the night before the survey increased from 29% to 90% in Banfora, 50% to 88% in Gaoua, and from 72% to 87% in Orodara. Cohort net use patterns did not differ between sites except for higher net use every night last week, which was highest in Orodara (79%), lower in Banfora (62%) and lowest in Gaoua (47%) ($p=0.031$). Approximately, one-third of households owned one or more non-cohort nets (36% in Banfora, 31% in Gaoua, 29% in Orodara). Non-cohort nets were most commonly received from antenatal care (ANC) visits in Orodara (34%), and from friends/family in Gaoua (54%) and Banfora (50%). The proportion of non-cohort nets ever used, used the night before the survey, and used every night during the last week were similar to that of cohort nets. At 36-months, approximately half of cohort and non-cohort nets were used by adults only in all districts (cohort nets: 50% in Banfora, 60% in Gaoua, 66% in Orodara, [$p=0.070$]; non-cohort nets: 58% in Banfora, 53% in Gaoua, 44% in Orodara). The proportion of nets used by users of different age groups was not statistically different between sites for cohort or non-cohort nets. Cohort nets were commonly found hanging in all sites (87% in Banfora and Gaoua, 90% in Orodara), however, the proportion of nets found hanging and tied up, versus untied, differed between sites. Approximately half of nets in Banfora and Gaoua were found hanging and tied (48% in Banfora, 49% in Gaoua, 6% in Orodara; $p<0.001$) while most nets in Orodara were found hanging untied (38% in Banfora, 38% in Gaoua, 84% in Orodara; $p<0.001$).

From the baseline survey to the 36-month survey, household access to all ITNs decreased from 83% to 49% in Banfora, from 56% to 32% in Gaoua, and from 78% to 43% in Orodara. Similarly, during the same time period, population access to all ITNs decreased from 79% to 69% in Banfora, from 62% to 58% in Gaoua, and from 81% to 63% in Orodara. At 36-months, household and population access to all ITNs and to campaign

cohort ITNs did not differ between districts. Population use differed significantly between districts with population use of any ITN and campaign cohort ITNs being highest in Banfora (67% and 51%), lower in Orodara (62% and 46%), and lowest in Gaoua (45% and 34%) (p=0.034 for any ITN, p=0.046 for campaign cohort ITN).

ITN Survivorship (Attrition and Physical Integrity)

Total cohort ITN attrition increased from 4% at baseline to 70% at 36-months in Banfora, from 4% to 64% in Gaoua and from 3% to 54% in Orodara. At 36-months, total cohort ITN attrition did not differ significantly between districts (p=0.066). At 36 months in Gaoua and Orodara, the most common reason for attrition was ITNs being discarded (41% and 31% respectively), while ITNs were most commonly given away to others in Banfora (48%). The second most common reason for attrition was given away to others in Gaoua and Orodara (18% and 16% respectively) and discarded in Banfora (20%).

At 36-months, the proportion of cohort nets with any holes differed between districts and was highest in Orodara (90%), lower in Banfora (83%), and lowest in Gaoua (80%) (p=0.027). The proportion of cohort nets classified as "good" (52% in Banfora, 54% in Gaoua, 52% in Orodara), "too torn" (20% in Banfora, 20% in Gaoua, 10% in Orodara), and "serviceable" (80% in Banfora, 80% in Gaoua, 90% in Orodara) was similar across study sites at 36 months.

Cohort net survival (nets present in the household and in serviceable condition, out of all cohort nets present or previously discarded) was estimated to be 48% in Banfora, 37% in Gaoua, and 54% in Orodara, corresponding to an estimated median survival time of 2.6 (95% CI: 1.9-3.2), 2.4 (95% CI: 1.9-2.9) and 3.2 (95% CI: 2.5-4.0) years for Interceptor® nets in Gaoua, Interceptor® G2 nets in Banfora, and PermaNet® 3.0 nets in Orodara.

Insecticidal Effectiveness

A separate sample of 30 campaign nets per net brand from the 2019 distribution were randomly selected at each study site to undergo bioassays and chemical content testing. Standard WHO cone and tunnel tests were used with an insectary-reared pyrethroid susceptible strain (*An. gambiae* Kisumu) and a pyrethroid resistant strain (*An. coluzzii* VKPER).

After 36 months of field use, 60% of Interceptor® field samples had optimal effectiveness against the susceptible *An. gambiae* Kisumu strain, a sharp decline from the 100% optimal effectiveness measured during previous rounds. Mean KD60 was 76% and 24-hour mortality was 71% after 36 months.

PermaNet® 3.0 field samples achieved 72% 24-hour mortality against pyrethroid-susceptible mosquitoes 36 months after distribution. Against the resistant VKPER strain, field roof samples, incorporating PBO, showed three times lower mortality than at baseline (26% vs 72%). Field roof samples performed more poorly than new PermaNet® 3.0 positive control roof samples, (100% KD60 and 100% mortality for new PermaNet® 3.0 samples, compared to 45% and 26%, respectively, for field samples).

After 36 months, Interceptor® G2 field samples achieved 93% 72-hour mortality and 79% blood-feeding inhibition (BFI) against pyrethroid-susceptible mosquitoes. Against the resistant VKPER strain, 72-hour mortality was 51% and BFI was 54%. Similar 72-hour mortality performance was measured in new Interceptor® G2 and Interceptor® positive control nets that were tested against the VKPER strain (63% and 64%, respectively). BFI was slightly higher among the Interceptor® pyrethroid-only samples (40%) compared to new Interceptor® G2 positive controls (27%).

Chemical Content

Samples from nets used for bio-effectiveness monitoring were shipped to CRA-W in Belgium for chemical content analysis. The mean alpha-cypermethrin content of Interceptor® ITNs, 36 months after distribution, corresponded to an 84% loss compared to the original target dose. After 36 months, the mean deltamethrin content on PermaNet® 3.0 side panels corresponded to an 86% loss compared to the original target dose.

Mean roof deltamethrin corresponded to a 32% loss and the mean roof PBO corresponded to an 84% loss compared to the original target dose. The mean alpha-cypermethrin content of Interceptor® G2, 36 months after distribution, corresponded to a 29% loss compared to the original target dose while the mean chlorfenapyr content corresponded to a 67% loss. After 36 months of use in the field, mean chemical content loss compared with manufacturer target doses were between 29% and 86%, which helps to explain lower insecticidal efficacy across the three net brands under study.

A summary of key results from all four rounds of data collection is presented in Table 1.

TABLE 1: BASELINE, 12-MONTH, 24-MONTH AND 36-MONTH ROUND RESULTS

Site	Survey round and time since distribution (months)	Attrition wear and tear (%)	Remaining nets in serviceable condition % (N)	Remaining nets hanging over sleeping space (%)		24/72-hour mortality against susceptible or resistant mosquito strain (%)
				Campaign	Other	
Banfora (Interceptor® G2)	Baseline (1.4)	0.0%	100% (N=294)	28.9%	81.9%	84.5[a] (79.6-89.3)
	12m (10.1)	1.4%	96.5% (N=231)	63.2%	81.6%	66.2 [a] (58.6-73.7)
	24m (24.1)	13.9%	84.2% (N=101)	68.4%	88.1%	71.8 [a] (57.2-86.3)
	36m (33.1)	20.3%	80.0% (N=60)	86.6%	89.3%	50.5a (39.1-61.8)
Gaoua (Interceptor®)	Baseline (4.3)	0.0%	98.9% (N=282)	52.8%	84.9%	99.9[b] (99.7-100.0)
	12m (13.1)	9.7%	97.1% (N=206)	75.2%	80.9%	99.2[b] (98.2-100.0)
	24m (24.1)	26.0%	88.4% (N=138)	75.3%	82.1%	99.5 [b] (98.8-100.0)
	36m (36.1)	41.4%	79.8% (N=94)	87.2%	81.1%	70.8b (58.0-83.7)
Orodara (PermaNet® 3.0)	Baseline (5.5)	0.0%	94.7% (N=346)	72.9%	63.1%	71.7[c] (63.9-79.6)
	12m (14.4)	5.1%	95.7% (N=280)	81.4%	72.6%	75.1 [c] (69.2-81.1)
	24m (24.2)	15.9%	90.4% (N=209)	84.7%	83.0%	51.8 [c] (38.5-64.7)
	36m (36.1)	31.0%	90.1% (N=141)	90.1%	90.5%	25.7c (15.7-35.6)

[a] Result for 72-hour mortality when tested against resistant strain
[b] Result for 24-hour mortality when tested against susceptible strain
[c] Result for 24-hour mortality when tested against the resistant strain on the PBO roof panel

Conclusion

Cohort net physical integrity was similar between study sites (nets serviceable: 80% for Interceptor® G2 in Banfora, 80% for Interceptor® in Gaoua, 90% for PermaNet® 3.0 in Orodara; p=0.057). Similarly, total cohort ITN attrition did not differ significantly between sites (70% in Banfora, 64% in Gaoua, 54% in Orodara; p=0.066). The estimated median useful life (with 95% CIs) was 2.6 (95% CI: 1.9-3.2) years for Interceptor® G2 nets in Banfora, 2.4 (95% CI: 1.9-2.9) years for Interceptor® nets in Gaoua, and 3.2 (95% CI: 2.5-4.0) years for PermaNet® 3.0 nets in Orodara.

1. BACKGROUND

To support the NMCP in achieving their National Malaria Strategic Plan goal of at least 80% of the population of children under five and pregnant women at risk of malaria sleeping under an ITN, more than 35 million ITNs have been imported from manufacturers to Burkina Faso since 2004[2]. Burkina Faso implemented ITN mass distribution campaigns in 2010-2011, 2013, 2016, and 2019.

The proportion of households owning at least one ITN has decreased in Burkina Faso in recent years, from 87% (2014 Malaria Indicator Survey [MIS]) to 74% (2017-18 MIS) in urban zones and from 91% to 76% during the same period in rural areas. Population access to an ITN measures the proportion of the population that would be able to use an ITN if each ITN in a household was used by two people; in 2017-2018, this was 56% in urban areas and 54% in rural areas. The proportion of the population that slept under an ITN the previous night also declined from 2014 levels, from 62% to 49% in urban areas, and from 79% to 43% in rural areas. As ITN use first requires access to an ITN, these two indicators can be combined in an ITN use: access ratio, which measures population-level use in relation to population-level access to an ITN. The use: access ratio is classified as "good" (value of 0.8 and above) for nine out of thirteen of Burkina Faso's regions, "below target" in three regions (a value ≥0.6-<0.8), and "poor" (<0.6) in one region.[3]

While vector control has contributed substantially to the global reduction in malaria burden recorded since 2000, global progress towards malaria control and elimination has stalled in recent years and the long-term effectiveness of malaria vector control is threatened by the emergence and intensification of insecticide resistance in key mosquito populations. New ITN tools that use more than one active ingredient (AI) and are effective against insecticide resistant mosquitoes have been developed, but large-scale uptake has been slow for various reasons, among which are higher costs associated with new ITN products and a lack of sufficient evidence to support broad policy recommendations. In September 2018, the Global Fund and Unitaid launched the New Nets Project to support the creation of an evidence base to inform the introduction of ITNs with two AIs. Burkina Faso is one of eleven New Nets Project countries and receives support for incorporating new ITN products into mass distribution campaigns and routine distribution channels in project sites.

The NMCP, in discussion with the PMI and the Global Fund, chose to incorporate dual-AI Interceptor® G2 ITNs from BASF and PermaNet® 3.0 ITNs, that contain a pyrethroid AI plus the insecticide synergist piperonyl butoxide (PBO), into the 2019 mass distribution campaign. Interceptor® G2 and PermaNet® 3.0 ITNs were targeted to provinces in southwest Burkina Faso with well-documented pyrethroid resistance in local vector populations and high malaria prevalence rates for children under five, as recorded during the 2017 MIS.

The 2019 mass distribution campaign supplied 1.5 million PBO-synergist PermaNet® 3.0 ITNs and 2 million dual-AI Interceptor® G2 ITNs, in addition to 9.3 million standard pyrethroid Interceptor® ITNs. The campaign was implemented in three phases: PBO-synergist ITNs were distributed between June 28 – July 3, 2019; standard ITNs were distributed between August 2-6, 2019; and the dual-AI ITNs were distributed to select health districts in the West and Southwest between October 29 – November 2, 2019.

[2] Milliner, J. The Alliance for Malaria Prevention. Net Mapping Project. [Online] Available at: http://netmappingproject.allianceformalariaprevention.com/

[3] Breakthrough Action. ITN use and access report. [Online] Available at: https://breakthroughactionandresearch.org/resources/itn-use-and-access-report/burkina-faso/.

The importance of ITN field durability and estimating the average useful life of an ITN is one of the critical factors NMCPs need to know to determine the frequency with which ITNs are replaced. The WHO (World Health Organization) recommends that countries routinely monitor ITN durability following mass distribution campaigns. To this end, standard guidance has been developed with funding from PMI.[4] Durability monitoring generates data on survivorship (attrition and physical integrity), insecticidal effectiveness, and insecticide chemical content of ITNs over three years following a mass distribution campaign and permits comparisons to be made across brands or geographic areas. The study also explores risk factors, such as net care and repair behaviors, and their association with attrition and physical integrity. Given the limited deployment of PBO-synergist and dual-AI ITNs to date, durability monitoring data for these types of nets are sparse and come predominantly from field trials.

In 2019, PMI began supporting ITN durability monitoring of different types of ITNs distributed during the 2019 mass campaign in three health districts: Interceptor® G2 in Banfora (Comoé province), Interceptor® in Gaoua (Poni province), and PermaNet® 3.0 in Orodara (Kénédougou province).

This study will provide the NMCP, PMI, and ITN partners with data on survivorship (attrition and physical integrity) and insecticidal effectiveness of ITNs under "real life" conditions to inform programmatic decisions on timing and net brands for future mass distribution campaigns and continuous distribution.

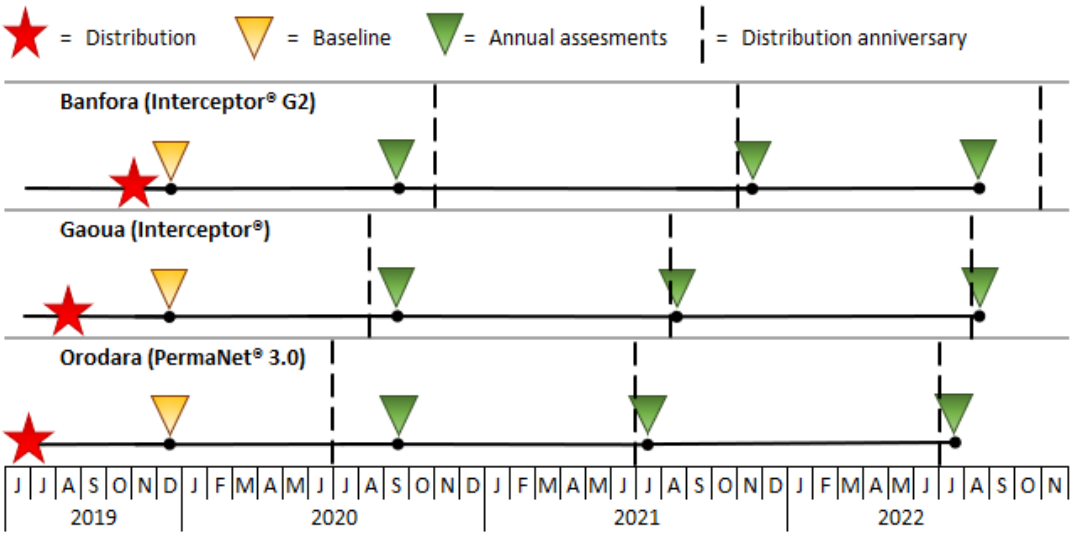
The durability monitoring study in Burkina Faso intended to:

1. Assess the physical durability of Interceptor® G2, PermaNet® 3.0, and Interceptor®, estimate median ITN survival, and identify major determinants of field performance.
2. Describe major behavioral aspects of net care and repair and their impact on physical integrity.
3. Assess insecticidal effectiveness (through bioassay and chemical content analysis) after three years of field use.

Baseline data collection was conducted from December 9-20, 2019. Data collection for the 12-month study round was conducted August 31 – November 12, 2020; the 24-month study round was conducted July 4 – November 8, 2021 (July 4-11 in Orodara, August 4-14 in Gaoua, November 2-8 in Banfora), and the 36-month study round was conducted July 4 – August 19, 2022 (Figure 1). For the 36-month survey, data collection in Banfora was conducted 33 months post-campaign in order to complete data collection prior to a mass distribution campaign that was scheduled to begin in the third quarter of 2022.

[4] www.durabilitymonitoring.org

FIGURE 1: DURABILITY MONITORING TIMELINE

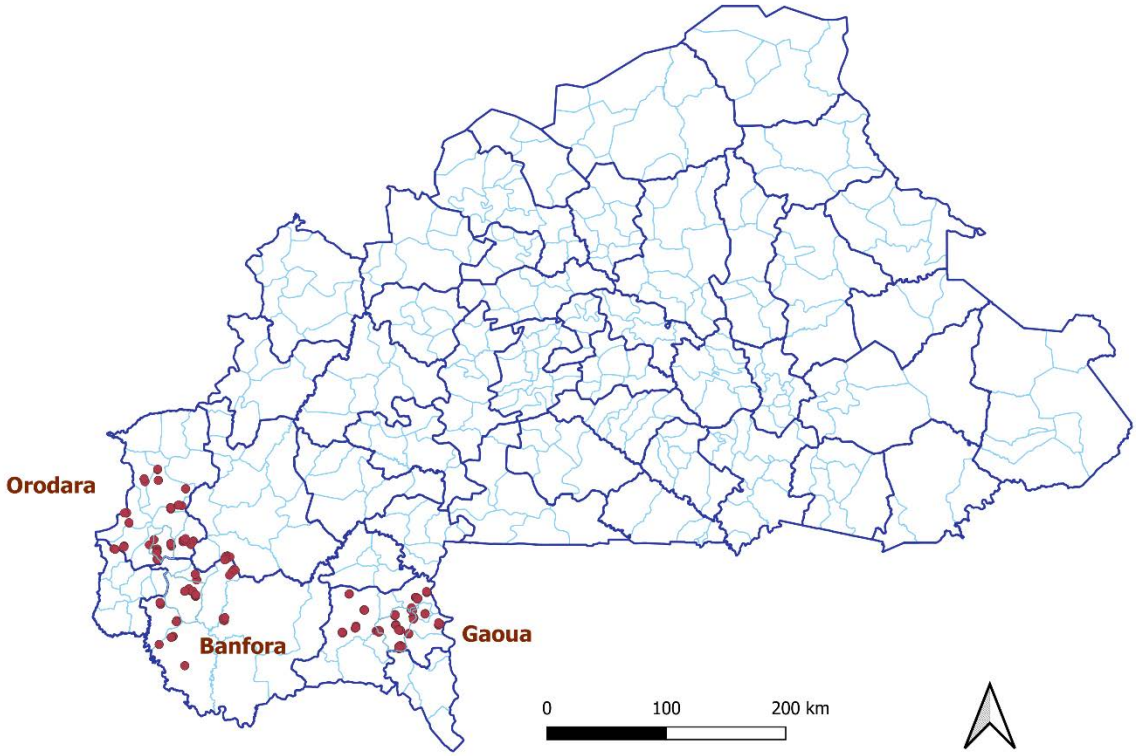


2. METHODS

2.1 STUDY SITES

The study was conducted in three health districts receiving different types of ITNs, selected in collaboration with the NMCP and PMI: Banfora health district in Comoé province (Interceptor® G2 ITNs), Gaoua health district in Poni province (Interceptor® ITNs), and Orodara health district in Kénédougou province (PermaNet® 3.0 ITNs) (Figure 2).

FIGURE 2: STUDY SITE MAP WITH GPS POINTS OF HOUSEHOLD CLUSTERS



All districts have similar environmental, epidemiological, and population profiles. The health districts are in the western region of Burkina Faso. The southwest is the wettest region of Burkina Faso, and the rainy season typically lasts at least six months from May to October, though it may extend either side of these months. Agriculture is the main economic activity of the populations in all three districts. Malaria is endemic throughout the year in Burkina Faso, although more cases are reported between the months of June and October. According to Heath Management Information System data reported in the Annuaire Statistique, the malaria incidence per 1,000 people has decreased from 729 in 2017 to 538 in 2021 in Banfora, and from 631 in 2017 to 542 in 2021 in Orodara but has increased from 722 in 2017 to 860 in 2021 in Gaoua . All districts experience a hot dry climate with hyperendemic malaria transmission. According to the 2017-18 MIS, rates of ITN ownership, access, and use were highest in Banfora's region (Cascades), followed by Orodara (Hauts-Bassins),

and then Gaoua (Sud-Ouest). The ITN use:access ratio is classified as "good" in Cascades and Orodara, but "below target" in Sud-Ouest (Table 2).

TABLE 2: KEY MALARIA CHARACTERISTICS IN NORTHERN REGION

District (Region)	Proportion of households or population			
	Households with at least one ITN	Population with access to an ITN in their household	Population using ITN the night before survey	Use/Access Ratio
Banfora (Cascades)	87.4%	64.2%	61.7%	0.96
Gaoua (Sud-Ouest)	58.0%	36.2%	25.6%	0.71
Orodara (Hauts-Bassins)	69.6%	46.3%	39.9%	0.86

Source: MIS 2017-2018 and https://breakthroughactionandresearch.org/resources/itn-use-and-access-report/burkina-faso/
Population access: proportion of population that would be able to use an ITN if each ITN in a household was used by two people. Use/Access ratio: ratio of population access to population using an ITN.

2.2 ITN BRANDS MONITORED

The material, insecticide, loading dose, campaign distribution dates, and locations for the ITN brands are presented below (Table 3). Interceptor® G2 is a dual-AI ITN combining a pyrethroid with a pyrrole, and was prioritized for distribution in the Sud-Ouest region based on well-documented pyrethroid resistance in local vector populations. These nets were distributed later in the year compared to the other two brands (Interceptor®, a pyrethroid-only ITN, and PermaNet® 3.0, an ITN with pyrethroid and the insecticide synergist PBO), and thus the average amount of time elapsed from distribution of Interceptor® G2 to baseline in Banfora was 1.4 months, compared to 4.3 months for Interceptor® in Gaoua and 5.5 months for PermaNet® 3.0 in Orodara. In total, 246,131 Interceptor® G2 ITNs (Banfora district) were distributed in Comoé province, 113,420 PermaNet® 3.0 ITNs in Kénédougou province (Orodara district) and 125,070 Interceptor® ITNs in Poni province (Gaoua district).

TABLE 3: ITN BRANDS DISTRIBUTED IN STUDY SITES

	Interceptor® G2	Interceptor®	PermaNet® 3.0
Province	Comoé	Poni	Kénédougou
District	Banfora	Gaoua	Orodara
Quantity	246,131	125,070	113,420
Distribution date	October 29 - November 2, 2019	August 2 - 6, 2019	June 28 - July 3, 2019
ITN type	Dual-AI	Standard	PBO-synergist
Chemical content	Alpha-cypermethrin (100 mg/m^2) Chlorfenapyr (200 mg/m^2)	Alpha-cypermethrin (200 mg/m^2)	Deltamethrin (2.8 g/kg sides, 4.0 g/kg roof; equivalent to approx. 118 mg/m^2 and 180 mg/m^2) PBO (25 g/kg roof only; equivalent to approx. 1100 mg/m^2)
Fabric	Polyester	Polyester	Sides: polyester Roof: polyethylene
Denier	100	75	Sides: 75 Roof: 100
Shape	Rectangular	Rectangular	Rectangular
Manufacturer	BASF	BASF	Vestergaard
Study site	Banfora	Gaoua	Orodara
Average time in months between distribution and:			
Baseline data collection	1.4	4.3	5.5
12-month data collection	10.1	13.1	14.1
24-month data collection	24.1	24.1	24.2
36-month data collection	33.1	36.1	36.1

2.3 STUDY DESIGN SUMMARY

The principal study design was a prospective study of a cohort of nets distributed through a mass campaign. The baseline round was conducted one to five months following the mass campaign, during which a representative sample of campaign nets from the study locations was identified through a cluster household survey with all campaign nets from consenting households forming the study cohort. These nets were labeled with a unique identifier and their presence and physical condition were assessed. At each subsequent annual survey (12-, 24-, and 36-months following distribution) the presence and physical condition of each net in the study cohort were reassessed and recorded, together with household characteristics and use, care, and repair behaviors for nets. These characteristics were used to identify household- and respondent-level risk factors for net survivorship.

The sample size follows the standard www.durabilitymonitoring.org guidance of 150 households per study site (15 clusters with 10 households each), or 450 households in total. Given the mass distribution campaign strategy of one net for every 1.8 people in a household, assuming an average household size of 6.2 persons in the study sites, this would have resulted in the registration of 525 ITNs in each district, or 1,575 ITNs in total.[5] However, during baseline fieldwork, mean household size for sampled households was recorded as 3.4 to 4.5 people, therefore, two additional cluster were randomly selected (17 clusters, 170 households) to ensure the expected number of ITNs would be sampled. This number of ITNs is estimated to be sufficient to detect a seven percentage-point difference in median survival time across study sites, assuming the median survival is three

[5] Mean household size was assumed to be 6.2, the value for rural areas reported in the 2014 MIS.

years. These figures correspond to a median survival difference across sites of less than 0.5 years, the minimum difference which has historically been considered important to detect for the purposes of campaign planning.

Health districts in Burkina Faso are subdivided into villages. At the first sampling level, 17 villages were selected in each health district with probability proportionate to population size from a list of all villages in the health district. At the second sampling level, within each selected village, the field team mapped the whole area (i.e., listed all inhabited houses where people live) and from the compiled list of eligible households, the supervisor randomly selected 10 households with equal probability for each household using random number lists. During the 24- and 36-month studies, only 14 clusters were visited in Banfora district because clusters Nadrifa, Kankounadeni II, and Ouangolodougou could not be visited due to security concerns in the region.

In addition to the labeled ITNs from the campaign, all other mosquito nets present in the selected households were recorded to capture full and comparable data on all nets in each household. At baseline, 12-, and 24-months, two campaign nets per cluster were randomly selected from households outside the cohort but within the same study site (from within the original 15 clusters) to undergo bioassay tests and evaluate insecticidal effectiveness. At 36-months, nets collected for bioassay testing were withdrawn from the main cohort. At 24-months, three clusters in Banfora district could not be visited due to security concerns, therefore, only 24 nets were collected for laboratory testing. Again at 36-months, these three clusters could not be visited secondary to local insecurity, however, in anticipation of this challenge, six additional nets were collected in Banfora to ensure a total of 30 nets were available for testing. Participating households received a new replacement ITN of the same type or another brand net. in exchange for the one withdrawn for the study. Bioassays for this study were conducted by IRSS in Bobo-Dioulasso, in accordance with standard WHO guidelines for cone and tunnel tests for pyrethroid ITNs and standard operating procedures produced by the London School of Hygiene and Tropical Medicine (LSHTM) for testing new ITN products.[6] Chemical content analysis was conducted by Walloon Agricultural Research Centre (CRA-W) in Belgium.

2.4 TRAINING AND FIELDWORK

Fieldwork was conducted by an implementation team of nine people per district. Each district team comprised one coordinator and two field teams of one supervisor and three interviewers. Staff were carefully selected based on their knowledge of the local language and experience conducting household surveys. All fieldwork staff for the 36-month survey had participated in the 24-month round.

Online training of trainers for staff from the IRSS, NMCP, and VectorLink took place between June 21-22, 2022, with two days of remote instruction led by VectorLink research staff experienced in durability monitoring. In-person training of twelve data collectors took place in Bobo-Dioulasso between June 28 – July 1, 2022, and consisted of four days of classroom-based training and one field practice day in a local community with support from IRSS and NMCP staff. The training covered the following topics: the study design and sampling procedures, ethical considerations (such as consent), COVID-19 adaptations, a detailed review of the questionnaire with role play, the use of tablets and the SurveyCTO software, and the physical assessment of holes and net repairs with practical exercises.

In each study village, the field team sought approval to conduct the 36-month study round from village chiefs, re-sharing information on the study objectives and processes. Communities were then sensitized and mobilized to obtain maximum cooperation. A local community guide supported field teams in locating study households.

Data for the main household survey was collected using the Open Data Kit (ODK)-based SurveyCTO software (version 2.70) on Android tablets. Each evening during fieldwork, team coordinators reviewed all data collected that day and gave feedback to the team on their performance, strengths, and weaknesses. Daily progress reports were shared with the study coordinator and any problems that arose were reported to the Regional Research

[6] World Health Organization: WHO Guidelines for Laboratory and Field Testing of Long-Lasting Insecticidal Nets. Geneva 2013, WHO/HTM/NTD/WHOPES/2013.3

Manager or principal investigator via WhatsApp for resolution. The Regional Research Manager remotely downloaded and examined data each day and provided feedback to the field teams via WhatsApp.

2.5 DATA MANAGEMENT

The questionnaire was thoroughly tested prior to deployment. Skip patterns and filters, internal consistency checks, range checks, and logical checks were programmed to support high quality data collection. Depending on the local conditions in each cluster, interviewer data was uploaded to a web-based database daily or stored on tablets until it could be transferred. A one-page paper questionnaire was completed for each ITN taken for bioassay analysis. The questionnaire was stored with the ITN for transfer to the laboratory. At the end of the survey, the web-based database was downloaded and converted into a Stata data file for analysis. Data values were checked for internal consistency and logic, and coding was applied for non-response or missing values. All operations were documented in Stata ".do" files.

2.6 ANALYSIS

The household sample is considered approximately self-weighting, so no weights were applied during analysis. Estimates of sampling errors accounted for the clustered survey design.

Attitudes towards nets, net care, and repair were captured using Likert score questions, through which respondents stated the extent to which they agreed or disagreed with a standard set of statements. Data from the Likert score questions were summarized into two summary scores (nets and net care/repair) by first recoding the four-level Likert scale to have a value of -2 for "strongly disagree", -1 for "disagree", +1 for "agree" and +2 for "strongly agree". The values for each response were then summed and divided by the number of statements to calculate an overall attitude score. An average score greater than one is interpreted as a household respondent with favorable attitudes to a given topic.

The physical integrity of campaign ITNs was assessed in accordance with WHO guidelines[7], with the number of holes of sizes 0.5 – 2 cm diameter (size 1), 2 – 10 cm diameter (size 2), 10 – 25 cm diameter (size 3), and >25 cm diameter (size 4) recorded for each net, following examination by the team in a well-lit location. Data from the ITN hole assessment were transformed into the proportionate Hole Index (pHI) for each ITN using the following standard equation:

$$pHI = Number\ of\ size\ 1\ holes + (No.\ of\ size\ 2\ holes \times 23) + (No.\ of\ size\ 3\ holes \times 196) + (No.\ of\ size\ 4\ holes \times 576)$$

Based on the pHI value, ITNs were categorized as "good", "serviceable", or "torn" as defined below. Note that "good" is a subset of all "serviceable" ITNs.

Good:	pHI $\leq$ 64 (corresponding to a total hole surface area $\leq$ 0.01m^2)
Serviceable:	pHI $\leq$ 642 (total hole surface area $\leq$ 0.1 m^2)
Torn:	pHI > 642 (total hole surface area > 0.1m^2)

Two approaches were used to estimate median survival. At each time point, the proportion surviving in serviceable condition was plotted against the hypothetical survival curves with defined median survival and the median survival was taken as the relative position of the data point on a horizontal line between the two adjacent median survival curves.

At the end of the 36-month round, the median net survival was calculated, using the following formula:

[7] World Health Organization: WHO Guidance Note for Estimating the Longevity of Long-Lasting Insecticidal Nets in Malaria Control. Geneva: 2013

$$tm = t1 + \frac{(t2 - t1) * (p1 - 50)}{(p1 - p2)}$$

Where tm is the median survival time, t1 and t2 are the first and second time points in years (typically the 24- and 36-month rounds), and p1 and p2 are the proportion of nets (as percentages) surviving to the first and second time points. Confidence intervals for this estimate were calculated by projecting the 95% CI from the survival estimates, as described above.

Data were also set up for a survival analysis to estimate survival in a Kaplan-Meier plot. Survival analysis was done using an intention to treat approach, i.e., risk of failure was considered to start at the day of distribution irrespective of whether or when the net was hung and used. Failure was defined as a net being lost due to wear and tear or classified as "too torn" based on physical assessment. Nets that were given away or that had an unknown outcome were censored. The time of failure was directly calculated from the report of time of loss by the respondent or taken as the mid-point between the last two surveys if unknown.

The following protocols were used for baseline, 12-, and 24-month bioassay and chemical content testing. The 36-month survey bioassay and chemical content tests used the same protocols.

For the pyrethroid only net, the 60-minute knock-down (KD60) and the 24-hour mortality rate were measured. The two variables from these tests were combined into the following outcome measures:

Optimal effectiveness: KD60 ≥ 95% or mortality ≥ 80%
Minimal effectiveness: KD60 ≥ 75% or mortality ≥ 50%

For cone tests on PBO-synergist ITNs, KD60 and mortality results were considered separately as combined measures have not been defined for this type of ITN. For tunnel tests, insecticidal effectiveness was measured by estimating 24- and 72-hour mortality, net penetration, level of blood feeding, and blood feeding inhibition (BFI). Results are presented for susceptible and resistant mosquito strains separately.

Standard WHO cone and tunnel tests were used with an insectary-reared pyrethroid susceptible strain (*An. gambiae* Kisumu) and a pyrethroid resistant strain (*An. coluzzii* VKPER). Both strains were characterized prior to performing the bioassays using WHO susceptibility test kits with 0.05% deltamethrin (the pyrethroid in PermaNet® 3.0), and 0.05% alpha-cypermethrin (the pyrethroid in Interceptor® and Interceptor® G2). Tests were also carried out with deltamethrin 0.05% after pre-exposure to PBO 4% (deltamethrin + PBO combination in PermaNet® 3.0). Results of the characterization are presented in the section of insecticidal effectiveness and content of campaign nets below (cf. 3.5).

Samples taken from ITNs selected for bioassays were packaged following standard procedures and shipped to CRA-W in Belgium on samples taken from the bioassay ITNs for chemical content testing. Samples from the roof and sides will be tested separately for the PermaNet® 3.0 brand. Outcome measures from these tests present the mean and median level of AI across the net brand samples in g/kg and mg/m2 and compare these averages with manufacturer specifications for the insecticides used on the netting.

2.7 COVID-19 ADAPTATIONS

To ensure the safety of study participants, trainers, and fieldwork staff, COVID-19 mitigation measures were implemented throughout the survey round. In the field and during training, staff were required to always wear a mask, maintain frequent handwashing, and to use a new pair of gloves when examining nets at each new study household. Personal protective equipment (PPE) including hand sanitizer, gloves, and disinfectant wipes were provided. A set of COVID-19 pre-screening questions were applied in the field to determine whether respondents were at risk from the study team (e.g., if anyone in the household had a pre-existing medical

condition that would require shielding from COVID-19) and whether the study team was at risk from household members (e.g., if the household included member(s) with COVID-19 symptoms).

2.8 ETHICAL CLEARANCE

This study has been determined to be research with human subjects and received written approval from the Institutional Ethics Committee for Health Science Research / Comité d'Ethique Institutionnel pour la Recherche en Science de la Santé (CEIRES) on November 8, 2019, under reference number 2019-012/MESRI/SG/CNRST/IRSS/CEIRES for the duration of the study. The Population Services International (PSI) Research Ethics Board (REB) granted authorization on June 22, 2021, to resume in-person data collection for the 24 –month round of the study. Staff implementing this study complied with all policies and procedures of both PSI REB and the local ethics board. Informed oral consent was sought for all participants in this study prior to conducting interviews.

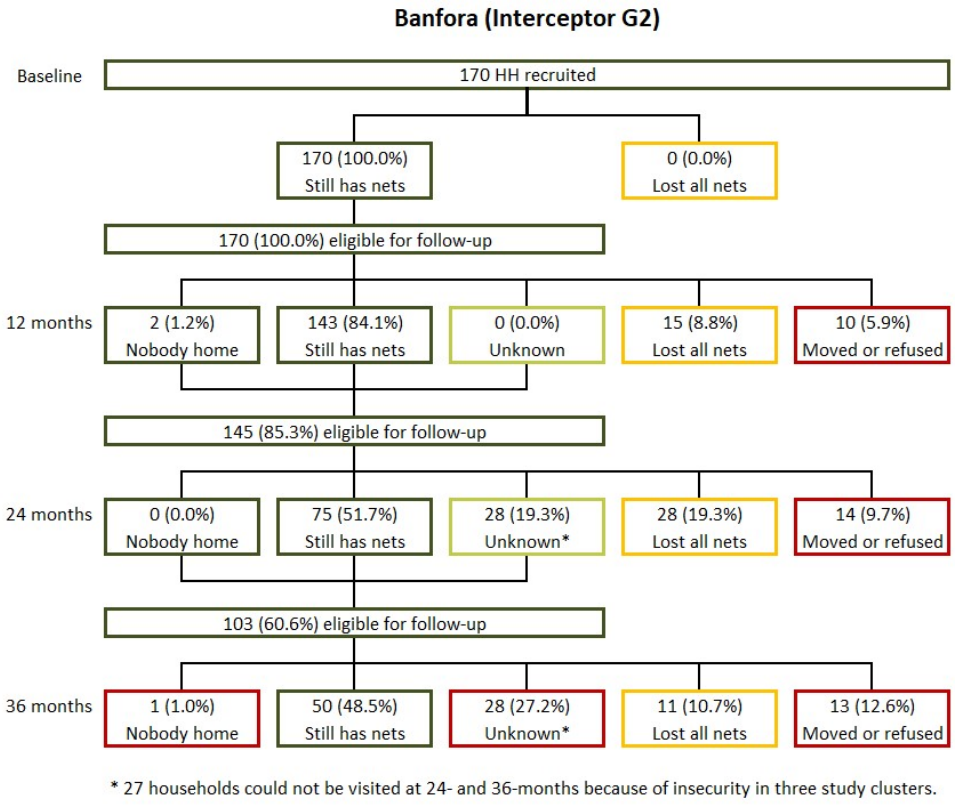
3. RESULTS

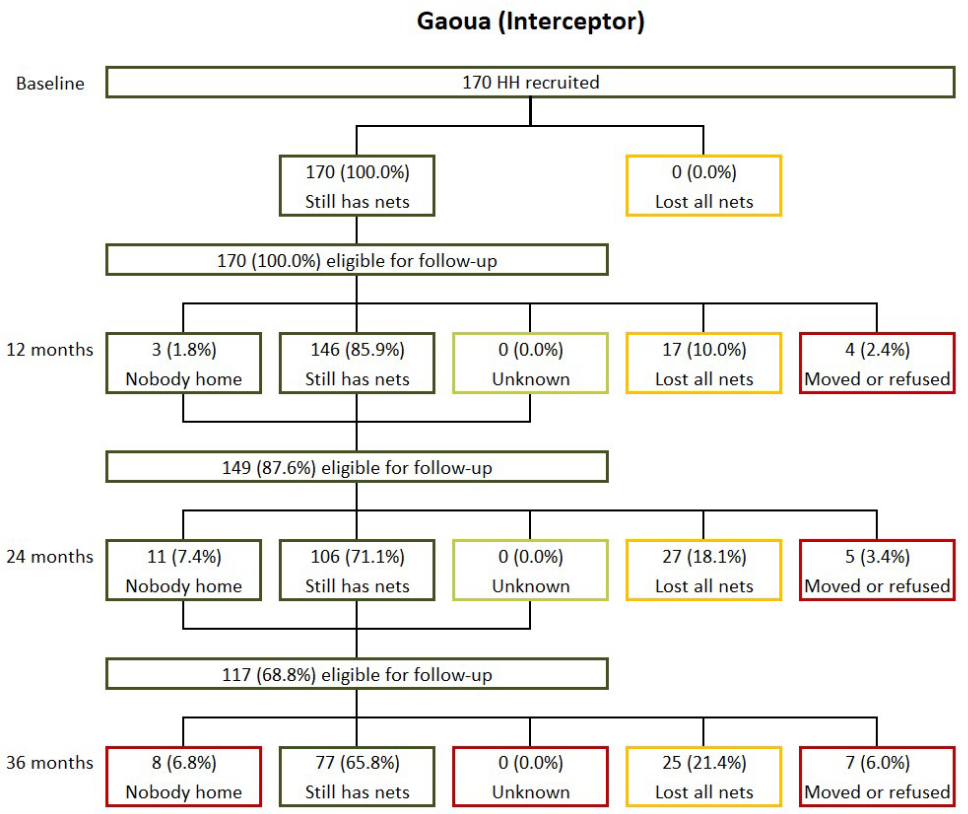
3.1 SAMPLE

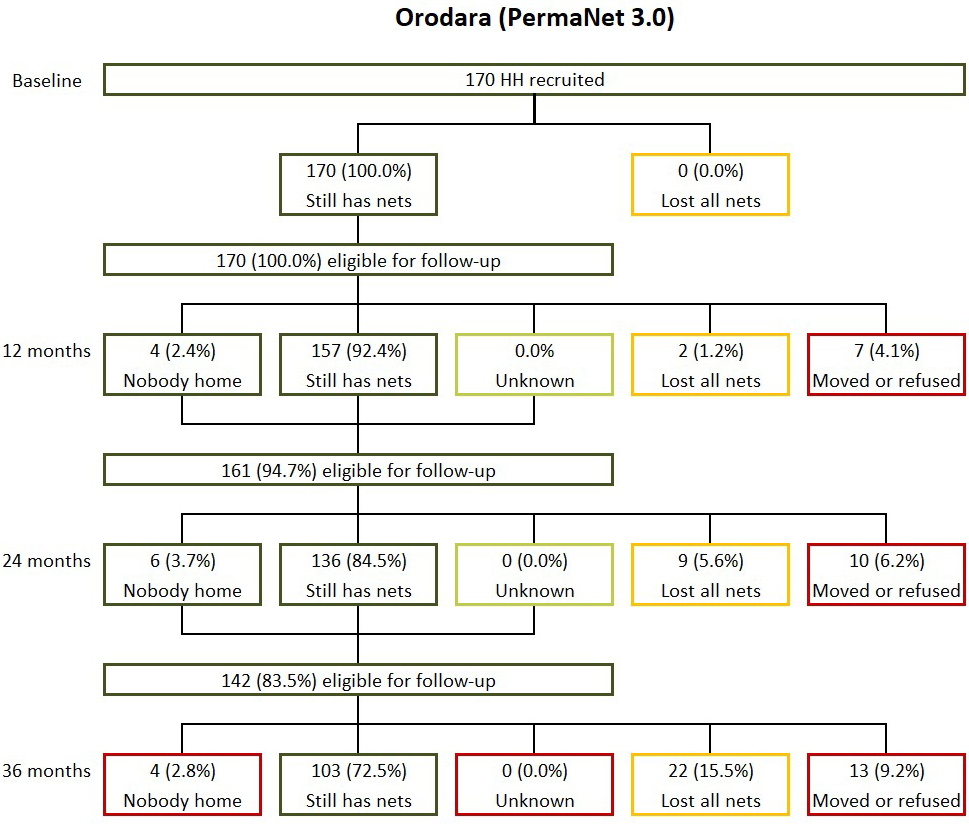
At baseline, a total of 510 households were recruited for durability monitoring (170 in Banfora, 170 in Gaoua, 170 in Orodara) of which 362 (71%) (103 in Banfora, 117 in Gaoua, 142 in Orodara) were eligible for follow-up at 36-months (Figure 3).

At 36 months, of the 103 eligible households in Banfora, 50 (49%) households still had at least one cohort net present, 11 (11%) households no longer had any cohort nets, 13 (13%) households moved out of the study site or refused the interview (11 (11%) moved, two (2%) refused), one (1%) household had nobody home, and 28 (27%) households had an unknown status. There were 27 (26%) households with unknown status because they were located in study clusters that could not be visited due to security concerns (Nadrifa, Kankounadeni II, Ouangolodougou). In Gaoua, 77 (66%) of the 117 eligible households still had cohort nets, 25 (21%) no longer had any cohort nets, seven (6%) moved out of the study site, and eight (7%) households had nobody home. In Orodara, 103 (73%) of the 142 eligible households still had cohort nets, 22 (15%) no longer had any cohort nets, 13 (9%) households moved out of the study site, and four (3%) households had nobody home.

FIGURE 3: 36-MONTH FOLLOW-UP STATUS OF HOUSEHOLDS RECRUITED AT BASELINE




Gaoua (Interceptor)
Baseline
170 HH recruited
170 (100.0%) Still has nets
0 (0.0%) Lost all nets
170 (100.0%) eligible for follow-up
12 months
3 (1.8%) Nobody home
146 (85.9%) Still has nets
0 (0.0%) Unknown
17 (10.0%) Lost all nets
4 (2.4%) Moved or refused
149 (87.6%) eligible for follow-up
24 months
11 (7.4%) Nobody home
106 (71.1%) Still has nets
0 (0.0%) Unknown
27 (18.1%) Lost all nets
5 (3.4%) Moved or refused
117 (68.8%) eligible for follow-up
36 months
8 (6.8%) Nobody home
77 (65.8%) Still has nets
0 (0.0%) Unknown
25 (21.4%) Lost all nets
7 (6.0%) Moved or refused


Orodara (PermaNet 3.0)
Baseline
170 HH recruited
170 (100.0%) Still has nets
0 (0.0%) Lost all nets
170 (100.0%) eligible for follow-up
12 months
4 (2.4%) Nobody home
157 (92.4%) Still has nets
0.0% Unknown
2 (1.2%) Lost all nets
7 (4.1%) Moved or refused
161 (94.7%) eligible for follow-up
24 months
6 (3.7%) Nobody home
136 (84.5%) Still has nets
0 (0.0%) Unknown
9 (5.6%) Lost all nets
10 (6.2%) Moved or refused
142 (83.5%) eligible for follow-up
36 months
4 (2.8%) Nobody home
103 (72.5%) Still has nets
0 (0.0%) Unknown
22 (15.5%) Lost all nets
13 (9.2%) Moved or refused

The 510 households visited at baseline reported receiving a total of 959 campaign nets (307 in Banfora, 293 in Gaoua, and 359 in Orodara; Figure 4). Of these nets, 923 (96%) (294 in Banfora, 282 in Gaoua, and 347 in Orodara) were present in the household and were tagged for study follow-up.

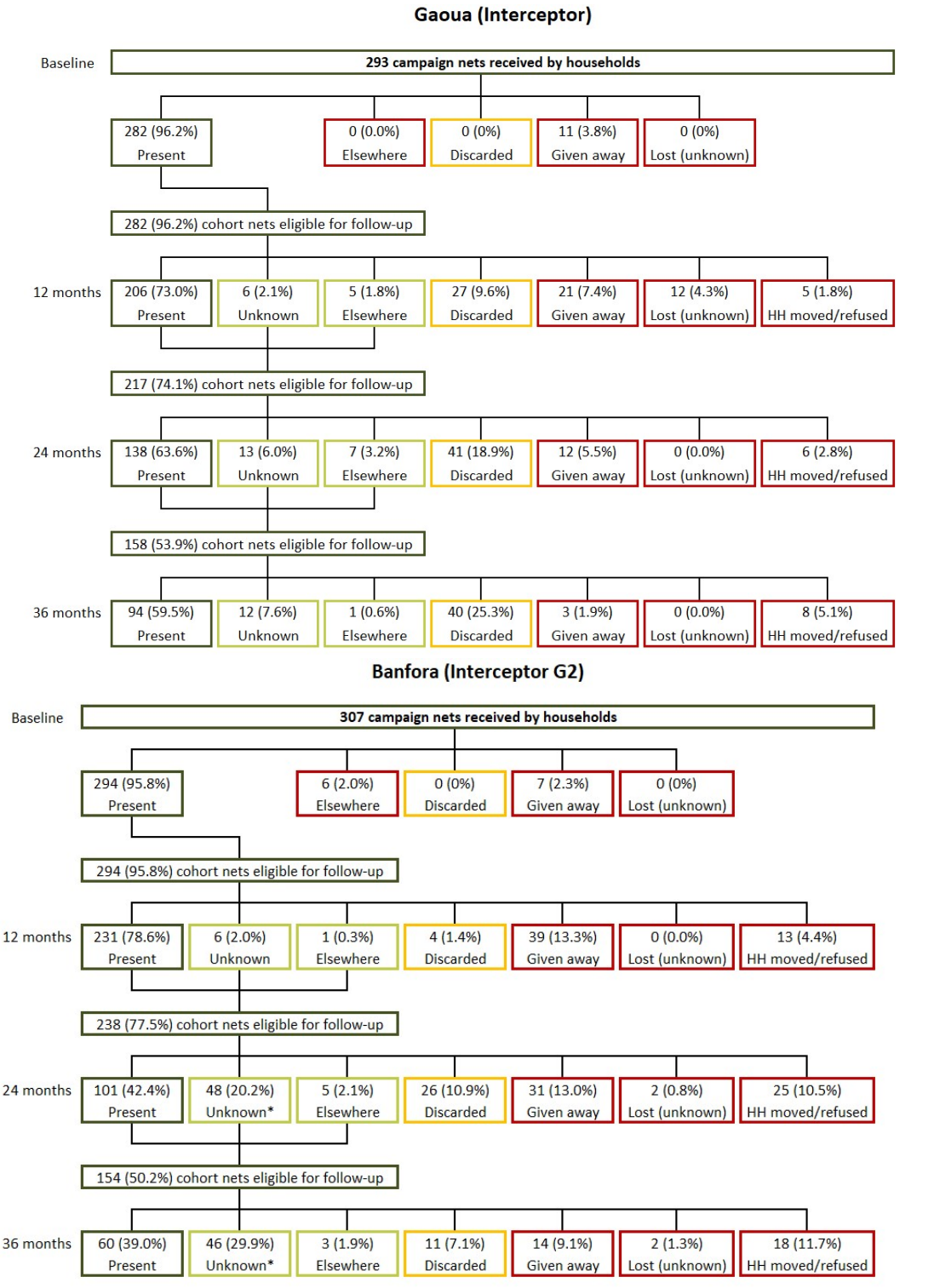
Of the 307 nets received at baseline in Banfora, at 12-months, 238 (78%) cohort nets were still in the households, had an unknown status (either due to nobody being home or lack of more precise respondent recall), or were elsewhere with family members and thus eligible for follow-up. At 24-months, 154 (33%) of the 307 cohort nets received at baseline were eligible for follow-up at 36-months. At 36-months, of the 154 cohort nets still being followed, 60 (39%) were present in households, 46 (30%) had an unknown status (43 or 28% were in clusters that couldn't be accessed because of insecurity), three (2%) were with family members elsewhere, 11 (7%) were discarded, 14 (9%) were given away, two (1%) were lost, and 18 (12%) were in households that moved away or refused the interview. Among cohort nets reported as present, all nets were available for assessment at 12-, 24-, and 36-months.

Of the 293 nets received at baseline in Gaoua, at 12-months, 217 (74%) cohort nets were still in the households, had an unknown status (either due to nobody being home or lack of more precise respondent recall), or were elsewhere with family members and thus eligible for follow-up. At 24-months 158 (54%) of the 293 cohort nets received at baseline were eligible for follow-up at 36-months. At 36-months of the 158 cohort nets still being followed, 94 (60%) were present in households, 12 (8%) had an unknown status, one (1%) was with family members elsewhere, 40 (25%) were discarded, 3 (2%) were given away, and 8 (5%) were in households that moved away or refused the interview. Among cohort nets reported as present, all nets were available for assessment at 12-, 24-, and 36-months.

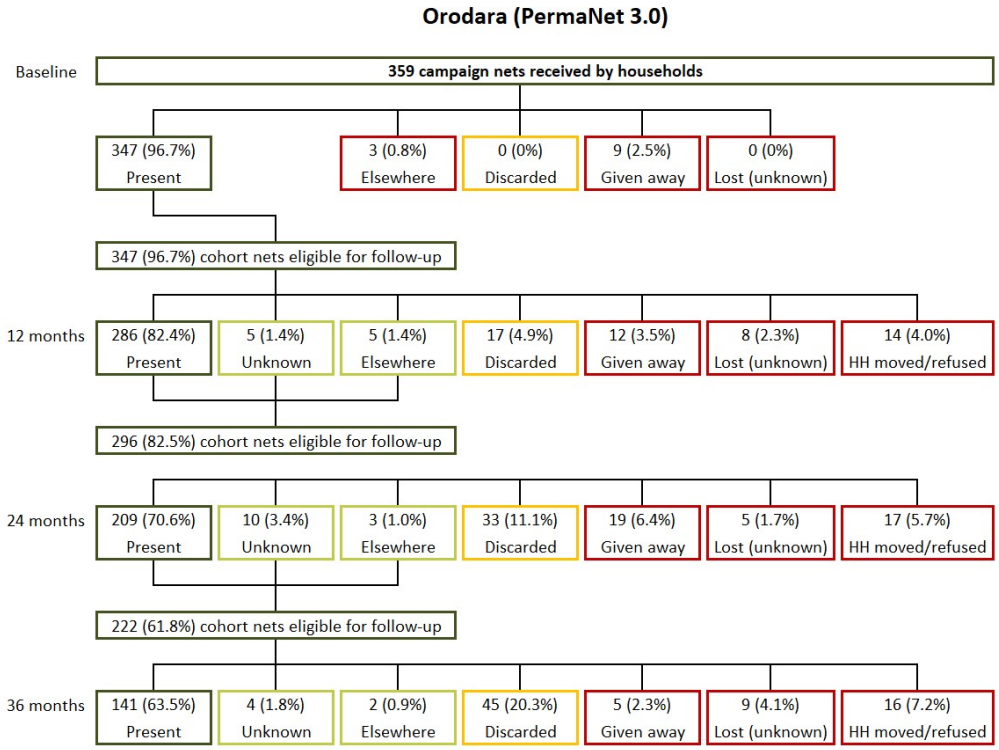
Of the 359 nets received at baseline in Orodara, at 12-months, 296 (82%) cohort nets were still in the households, had an unknown status (either due to nobody being home or lack of more precise respondent recall), or were elsewhere with family members and were eligible for follow-up. At 24-months 222 (62%) of the 359 cohort nets received at baseline were eligible for follow-up at 36-months. At 36-months, of the 222 cohort nets still being followed, 141 (64%) were present in households, four (2%) had an unknown status, three (1%) was with family members elsewhere, 45 (20%) were discarded, five (2%) were given away, eight (4%) were lost, and 16 (7%) were in households that moved away or refused the interview. Among cohort nets reported as present, six nets were unavailable for assessment at 12-months, due to being temporarily taken away for washing or stored in locked rooms, while all nets at 24- and 36-months were available for assessment.

.

FIGURE 4: FOLLOW-UP STATUS OF COHORT ITNS RECRUITED AT BASELINE



* 43 cohort nets belonged to households that could not be visited at 24- and 36-months because of insecurity in three study clusters.



3.2 DETERMINANTS OF DURABILITY

The study assessed household risk factors for net durability and attitudes and behaviors related to net care and repair. Factors that have previously been shown to be associated with net durability can be divided into household factors, handling factors, and net care and repair attitudes and behaviors. Household assets can contribute indirectly to the durability of the nets as household factors (Table 4). Household assets were relatively stable within districts from the baseline to 36-month survey, however, most household characteristics differed between districts at both time points. Overall, a lower proportion of households in Gaoua district presented with preferred household assets (e.g. access to latrines and transportation, ownership of radios and smart phones).

At 36-months, the majority of households lived in a house with roof sheets or tiles (93% in Banfora, 86% in Gaoua, 98% in Orodara). The proportion of households using firewood as an energy source for cooking differed across districts and was lowest in Banfora (77% in Banfora, 93% in Gaoua, 99% in Orodara; p=0.009). Nearly all households had access to safe water (100% in Banfora, 99% in Gaoua, 98% in Orodara). The majority of households had access to latrines in Banfora (89%) and Orodara (90%), however few households in Gaoua had latrine access (18%; p<0.001). Ownership of radios (89% in Banfora, 47% in Gaoua, 66% in Orodara; p=0.001) and mobile phones (82% in Banfora, 70% in Gaoua, 92% in Orodara; p=0.001) was lowest in Gaoua district. Households in Gaoua were also least likely to have access to any means of transportation (92% in Banfora, 61% in Gaoua, 98% in Orodara; p<0.001). The proportion of households reporting animal husbandry did not differ between districts (57% in Banfora, in 64% Gaoua, 82% in Orodara); however differences were detected with agricultural land ownership, with the lowest proportion in Banfora (41% in Banfora, 90% in Gaoua, 78% in Orodara; p<0.001).

TABLE 4: HOUSEHOLD CHARACTERISTICS AND ASSETS

	Baseline	36-month
Banfora	**N=170**	**N=61**
Roof (sheets/ tile)	91.8%	93.4%
Cooking fuel (firewood)	81.8%	77.0%
Access to safe water	90.6%	100.0%
Access to latrine	75.3%	88.5%
Radio	70.0%	88.5%
Mobile phone	84.1%	82.0%
Any transport	84.7%	91.8%
Animal husbandry	62.9%	57.4%
Owning land for farming	20.6%	41.0%
Gaoua	**N=170**	**N=102**
Roof (sheets/ tile)	79.4%	86.3%
Cooking fuel (firewood)	90.6%	93.1%
Access to safe water	90.6%	99.0%
Access to latrine	31.8%	17.6%
Radio	38.8%	47.1%
Mobile phone	64.1%	69.6%
Any transport	65.9%	60.8%
Animal husbandry	73.5%	63.7%
Owning land for farming	84.7%	90.2%
Orodara	**N=170**	**N=125**
Roof (sheets/ tile)	95.9%	97.6%
Cooking fuel (firewood)	98.2%	99.2%
Access to safe water	98.8%	98.4%
Access to latrine	93.5%	89.6%
Radio	76.5%	66.4%
Mobile phone	92.9%	92.0%
Any transport	95.3%	97.6%
Animal husbandry	59.4%	82.4%
Owning land for farming	50.6%	77.6%

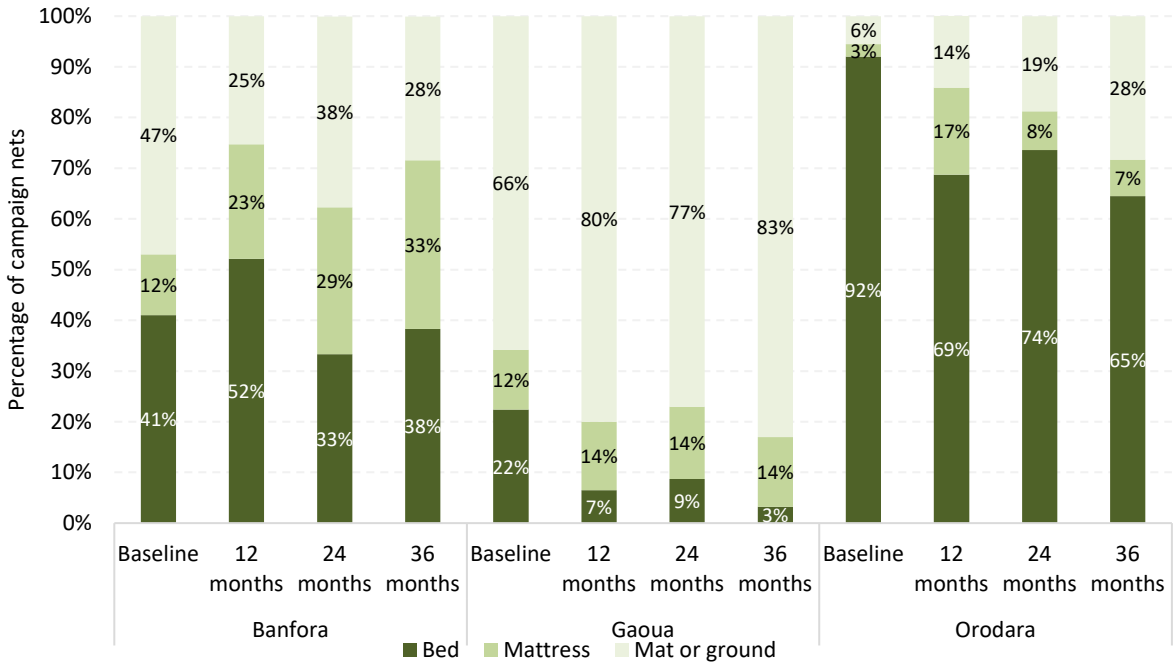
The presence of rodents in the house and the presence of food and practice of cooking near sleeping areas are risk factors for net durability. Table 5 presents the prevalence of these risk factors at 36-months. Food storage in a room used for sleeping was most common among households in Gaoua (64% in Banfora, 100% in Gaoua, 50% in Orodara; $p<0.001$) as was cooking in the same room used for sleeping (26% in Banfora, 45% in Gaoua, 4% in Orodara; $p<0.001$). The proportion of households observing rodents in the last six months was similar between study sites (59% in Banfora, 75% in Gaoua, 67% in Orodara).

TABLE 5: PREVALENCE OF HOUSEHOLD RISK FACTORS FOR DAMAGE

	Baseline	12-month	24-month	36-month
Banfora	**N=170**	**N=158**	**N=103**	**N=61**
Ever store food in room used for sleeping	24.7%	27.2%	56.3%	63.9%
Cook in sleeping room				
Never	97.6%	93.7%	87.4%	73.8%
Sometimes	1.8%	6.3%	11.7%	26.2%
Always	0.6%	0.0%	0.0%	0.0%
Don't know	0.0%	0.0%	1.0%	0.0%
Observed rodents in last 6 months	49.4%	55.1%	55.3%	59.0%
Gaoua	**N=170**	**N=163**	**N=133**	**N=102**
Ever store food in room used for sleeping	65.9%	74.8%	100.0%	100.0%
Cook in sleeping room				
Never	81.2%	70.6%	59.4%	54.9%
Sometimes	15.9%	23.9%	39.1%	45.1%
Always	1.8%	5.5%	1.5%	0.0%
Don't know	1.2%	0.0%	0.0%	0.0%
Observed rodents in last 6 months	78.8%	86.5%	82.0%	74.5%
Orodara	**N=170**	**N=159**	**N=145**	**N=125**
Ever store food in room used for sleeping	38.2%	40.9%	37.9%	49.6%
Cook in sleeping room				
Never	92.4%	91.2%	92.4%	96.0%
Sometimes	6.5%	8.8%	7.6%	4.0%
Always	0.6%	0.0%	0.0%	0.0%
Don't know	0.6%	0.0%	0.0%	0.0%
Observed rodents in last 6 months	76.5%	85.5%	76.6%	67.2%

The type of sleeping place may also affect net durability. Generally, nets used when sleeping on mats or the ground are more prone to wear and tear than those used over mattresses and bed frames. Figure 5 shows the types of sleeping spaces over which cohort ITNs were used by site and study period. Overall, across all study rounds, the highest proportion of cohort nets hung over a mat, or the ground was in Gaoua, a lower proportion in Banfora, and the lowest proportion in Orodara where the majority of nets were hung over beds. During the 36-month study, 83% of cohort nets were hung over a mat or the ground in Gaoua, compared to 28% in Banfora and 28% in Orodara ($p<0.001$).

FIGURE 5: TYPE OF SLEEPING PLACE FOR CAMPAIGN ITNS WHEN USED



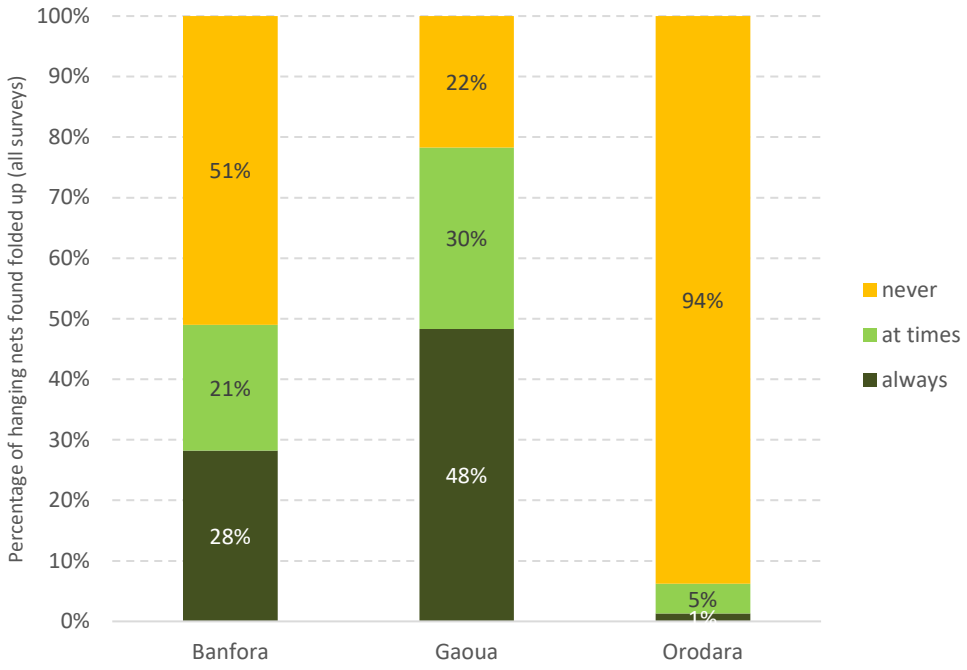
In addition to food storage and cooking practices, excessive net handling is a risk factor for durability (Table 6). Excessive washing, particularly with cleaning products like detergent or bleach, can diminish insecticide effectiveness. At 36-months, nearly all cohort nets in all sites had ever been washed (97% in each district). The highest proportion of cohort nets last washed with detergent or bleach was in Banfora (50%), with a lower proportion in Gaoua (31%), and the lowest proportion in Orodara (13%) ($p=0.015$). The proportion of nets last dried on a bush or fence was low and did not differ between districts (7% in Banfora, 6% in Gaoua, 2% in Orodara). Among nets reported as hanging, the proportion of nets not folded or tied up during the 36-month survey differed between sites, being highest in Orodara (93%) and lower in Banfora (44%), and Gaoua (44%) ($p<0.001$).

TABLE 6: PREVALENCE OF HANDLING RISK FACTORS FOR CAMPAIGN ITNS

	Baseline	12-month	24-month	36-month
Banfora	**N=294**	**N=231**	**N=101**	**N=60**
ITNs ever washed	2.4%	32.5%	82.2%	96.7%
Among ITNs ever washed:	N=7	N=75	N=83	N=58
Median number of washes in last 6 months Interquartile range [IQR]	1.0 [1.0-2.0]	2.0 [1.0-2.0]	2.0 [2.0-3.0]	2.0 [1.0-2.0]
Used detergent or bleach for last wash	42.9%	21.3%	34.9%	50.0%
ITNs dried on bush or fence for last wash	0.0%	9.3%	1.2%	6.9%
Among hanging ITNs:	N=85	N=146	N=69	N=52
Hanging ITNs are not folded or tied up	63.5%	69.2%	50.7%	44.2%
Gaoua	**N=282**	**N=206**	**N=138**	**N=94**
ITNs ever washed	39.4%	78.2%	89.1%	96.8%
Among ITNs ever washed:	N=111	N=161	N=123	N=91
Median number of washes in last 6 months [IQR]	2.0 [1.0-2.0]	2.0 [2.0-3.0]	2.0 [2.0-6.0]	3.0 [2.0-3.5]
Used detergent or bleach for last wash	47.7%	57.8%	38.2%	30.8%
ITNs dried on bush or fence for last wash	19.8%	21.1%	22.0%	5.5%
Among hanging ITNs:	N=149	N=155	N=104	N=82
Hanging ITNs are not folded or tied up	51.7%	38.7%	5.8%	43.9%
Orodara	**N=347**	**N=286**	**N=209**	**N=141**
ITNs ever washed	36.3%	74.8%	91.9%	96.5%
Among ITNs ever washed:	N=126	N=214	N=192	N=136
Median number of washes in last 6 months [IQR]	2.0 [1.0-2.5]	1.0 [1.0-2.0]	1.0 [1.0-2.0]	5.0 [1.0-12.0]
Used detergent or bleach for last wash	20.6%	22.0%	14.1%	13.2%
ITNs dried on bush or fence for last wash	10.3%	9.8%	2.1%	1.5%
Among hanging ITNs:	N=253	N=233	N=177	N=127
Hanging ITNs are not folded or tied up	98.0%	98.7%	98.9%	92.9%

When considering cohort nets that were ever found hanging across all rounds of the survey, results differed between districts with the highest proportion of cohort nets always found folded was in Gaoua (48%), a lower proportion of nets always folded in Banfora (28%) and almost no nets always folded in Orodara (1%) ($p<0.001$) (Figure 6).

FIGURE 6: FOLDING UP OF HANGING NETS ACROSS ALL SURVEYS



Respondent exposure to information on use and care and/or repair of nets is shown in Table 7. At 36-months, exposure to net messaging in the six months before the survey was lowest in Gaoua where no respondents reported exposure (0%) and higher in Banfora (39%) and Orodara (47%) ($p<0.001$). In Gaoua, exposure to net messaging decreased from 32% at baseline to 0% at 36-months. Among exposed households (no exposed households in Gaoua), households in Banfora were exposed to messaging from a mix of interpersonal communication and media sources (71%), whereas households in Orodara were most commonly exposed to messaging from interpersonal communication only sources (85%). At 36-months, the three most commonly recalled message by exposed households in Banfora were "use net every night" (100%), "care for net" (83%), and "hang net" (75%). In Orodara, the most commonly recalled messages were "care for net" (100%), "use net every night" (98%), and "hang net" (98%). A higher proportion of respondents in Orodara recalled "hang net" and "care for net" (98% and 100%) compared to respondents in Banfora (75%, $p<0.001$; 83%, $p=0.005$). Further interpretation or comparison between the study districts should be treated with caution due to the low level of message exposure (Banfora N=24, Gaoua N=0, Orodara N=59) in the six months prior to the 36-month round.

TABLE 7: RESPONDENT EXPOSURE TO MESSAGES ABOUT NETS IN LAST SIX MONTHS

	Baseline	12-month	24-month	36-month
Banfora	**N=170**	**N=158**	**N=103**	**N=61**
Any exposure in last six months	40.0%	48.7%	18.4%	39.3%
Among those exposed:	N=68	N=77	N=19	N=24
Mean number of sources among exposed*	1.3	2.1	2.4	3.0
Type of media source among exposed				
Media only	0.0%	1.3%	15.8%	0.0%
Interpersonal communication only	82.4%	50.6%	42.1%	29.2%
Both	17.6%	48.1%	42.1%	70.8%
Messages recalled among exposed				
"Use net (every) night"	100.0%	100.0%	100.0%	100.0%
"Hang net"	94.1%	93.5%	63.2%	75.0%
"Care for net"	95.6%	97.4%	78.9%	83.3%
"Repair net"	23.5%	93.5%	21.1%	62.5%
"Nets prevent malaria"	94.1%	97.4%	57.9%	70.8%
Gaoua	**N=170**	**N=163**	**N=133**	**N=102**
Any exposure in last 6 months	31.8%	6.1%	17.3%	0.0%
Among those exposed:	N=54	N=10	N=23	N=0
Mean number of sources among exposed*	1.1	1.8	1.1	N/A
Type of media source among exposed				
Media only	0.0%	20.0%	0.0%	N/A
Interpersonal communication only	96.3%	50.0%	91.3%	N/A
Both	3.7%	30.0%	8.7%	N/A
Messages recalled among exposed				
"Use net (every) night"	98.1%	100.0%	100.0%	N/A
"Hang net"	85.2%	80.0%	78.3%	N/A
"Care for net"	100.0%	100.0%	100.0%	N/A
"Repair net"	20.4%	0.0%	43.5%	N/A
"Nets prevent malaria"	64.8%	60.0%	39.1%	N/A
Orodara	**N=170**	**N=159**	**N=145**	**N=125**
Any exposure in last 6 months	42.9%	59.1%	63.4%	47.2%
Among those exposed:	N=73	N=94	N=92	N=59
Mean number of sources among exposed*	2.0	2.2	2.1	2.5
Type of media source among exposed				
Media only	0.0%	1.1%	0.0%	0.0%
Interpersonal communication only	95.9%	85.1%	97.8%	84.7%
Both	4.1%	13.8%	2.2%	15.3%
Messages recalled among exposed				
"Use net (every) night"	100.0%	100.0%	100.0%	98.3%
"Hang net"	98.6%	91.5%	97.8%	98.3%
"Care for net"	97.3%	96.8%	95.7%	100.0%
"Repair net"	57.5%	68.1%	81.5%	39.0%
"Nets prevent malaria"	95.9%	84.0%	97.8%	78.0%

* During the 36-month survey, the maximum number of sources was eight and included: community health agent; radio message/show; health worker; community leader; town announcer; family/friends; church/mosque.

N/A = not applicable

Data on household attitudes towards nets and net care and repair were captured in the form of Likert score questions (i.e., respondents were asked the extent to which they agreed with certain statements) (Table 8). Net use questions were used to understand the extent to which respondents believed they could obtain enough nets for their household, hang nets, use nets consistently, and get children in the household to use nets consistently. Questions on attitudes to net care and repair were used to understand respondent beliefs about the value of nets and their capacity to keep nets in a good condition and repair net damage. These questions were converted into two summary scores by first recoding the four-level Likert scale to have a value of -2 for "strongly disagree", -1 for "disagree", +1 for "agree" and +2 for "strongly agree". The values for each response were then summed and divided by the number of statements to calculate an overall attitude score. An average score greater than one is interpreted as a household respondent with a favorable attitude towards a given topic.

At 36-months, the mean attitude scores in all districts were well below one, indicating an overall negative attitude towards nets and net care and repair. The mean attitude scores for nets and net care and repair fluctuated between survey rounds, however, scores were lowest for all attitude scores in all districts at 36-months, except for the net care and repair score in Gaoua. The proportion of respondents with favorable attitudes towards nets differed between districts and was lowest in Gaoua (36% in Banfora, 7% in Gaoua, 26% in Orodara; $p<0.001$). Less than 10% of respondents in Gaoua and Orodara reported favorable attitudes toward net car and repair (18% in Banfora, 6% in Gaoua, 3% in Orodara; $p=0.014$).

TABLE 8: RESPONDENT ATTITUDES TOWARDS NETS AND NET CARE & REPAIR

	Baseline	12-month	24-month	36-month
Banfora	**N=170**	**N=158**	**N=103**	**N=61**
Attitude score: Nets				
Mean	1.14	0.77	0.96	0.75
(95% CI)	(0.96-1.31)	(0.49-1.04)	(0.76-1.16)	(0.51-1.00)
Percentage of respondents with score > 1.0	61.8%	38.6%	50.5%	36.1%
Attitude score: Net care and repair				
Mean	0.68	0.79	0.69	0.59
(95% CI)	(0.49-0.86)	(0.58-1.01)	(0.50-0.88)	(0.37-0.82)
Percentage of respondents with score > 1.0	22.4%	38.6%	24.3%	18.0%
Gaoua	**N=170**	**N=163**	**N=133**	**N=102**
Attitude score: Nets				
Mean	0.61	0.37	0.29	0.20
(95% CI)	(0.44-0.77)	(0.25-0.49)	(0.06-0.53)	(-0.10-0.49)
Percentage of respondents with score > 1.0	22.9%	6.7%	9.8%	6.9%
Attitude score: Net care and repair				
Mean (95% CI)	0.64 (0.58-0.70)	0.48 (0.37-0.59)	0.66 (0.56-0.76)	0.66 (0.54-0.77)
Percentage of respondents with score > 1.0	5.9%	4.9%	7.5%	5.9%
Orodara	**N=170**	**N=159**	**N=145**	**N=125**
Attitude score: Nets				
Mean	1.17	1.10	0.93	0.80
(95% CI)	(1.02-1.32)	(1.03-1.18)	(0.83-1.03)	(0.66-0.95)
Percentage of respondents with score > 1.0	62.9%	65.4%	41.4%	25.6%
Attitude score: Net care and repair				
Mean	0.86	0.91	0.86	0.46
(95% CI)	(0.78-0.94)	(0.84-0.99)	(0.77-0.94)	(0.35-0.58)
Percentage of respondents with score > 1.0	21.2%	40.3%	31.0%	3.2%

Experience with repairing holes in nets is displayed in Table 9. From baseline to 36-months, a progressively increasing proportion of respondents reported having ever experienced holes, and at 36-months the proportion of respondents experiencing holes did not differ significantly between sites (69% in Banfora, 65% in Gaoua, 82% in Orodara). The proportion of respondents who reported discussing net care and repair was higher in Orodara (30%) compared to in Banfora (3%, $p<0.001$) and Gaoua (0%, $p=0.001$). Although discussion of net care and repair was more common in Orodara, the proportion of households who ever repaired a net was similar between study sites (24% in Banfora, 30% in Gaoua, 23% in Orodara).

TABLE 9: HOUSEHOLD NET CARE AND REPAIR EXPERIENCE

	Baseline	12-month	24-month	36-month
Banfora	**N=170**	**N=158**	**N=103**	**N=61**
Ever experienced holes in a net	15.3%	24.7%	56.3%	68.9%
Discussed net care and repair in last six months	6.5%	21.5%	7.8%	3.3%
Among households experiencing holes:	N=26	N=39	N=58	N=42
Ever repaired net	11.5%	10.3%	24.1%	23.8%
Gaoua	**N=170**	**N=163**	**N=133**	**N=102**
Ever experienced holes in a net	13.5%	27.0%	62.4%	64.7%
Discussed net care and repair in last six months	12.4%	4.9%	9.0%	0.0%
Among households experiencing holes:	N=23	N=44	N=83	N=66
Ever repaired net	13.0%	27.3%	22.9%	30.3%
Orodara	**N=170**	**N=159**	**N=145**	**N=125**
Ever experienced holes in a net	22.4%	45.3%	59.3%	82.4%
Discussed net care and repair in last six months	45.9%	50.9%	51.7%	29.6%
Among households experiencing holes:	N=38	N=72	N=86	N=103
Ever repaired net	50.0%	41.7%	27.9%	23.3%

3.3 NET OWNERSHIP AND NET USE

The status and reported recent use of campaign cohort nets was recorded to understand net use patterns (Table 10). At 36-months, cohort nets were commonly found hanging in all sites (87% in Banfora and Gaoua, 90% in Orodara), however, the proportion of nets found hanging and tied up, versus untied, differed between sites. The majority of nets in Banfora and Gaoua were found hanging and tied (48% in Banfora, 49% in Gaoua) while most nets in Orodara were found hanging untied (84%). Of cohort nets not found hanging, the next most common location was not hanging and not stored away (10% in Banfora and Gaoua, 8% in Orodara).

The use of cohort nets progressively increased during the study period. From baseline to 36-months, the use of cohort nets used the night before the survey increased from 29% to 90% in Banfora, 50% to 88% in Gaoua, and from 72% to 87% in Orodara. Use patterns did not differ between sites except for higher net use every night last week which was highest in Orodara (79%), lower in Banfora (62%) and lowest in Gaoua (47%) ($p=0.031$).

TABLE 10: STATUS AND REPORTED USE OF COHORT NETS IN THE HOUSEHOLD

	Baseline	12-month	24-month	36-month
Banfora	**N=294**	**N=231**	**N=101**	**N=60**
Cohort net status				
Found hanging and tied up	10.5%	19.5%	33.7%	48.3%
Found hanging, untied	18.4%	43.7%	34.7%	38.3%
Not hanging and not stored away	0.7%	3.0%	16.8%	10.0%
Stored away unpacked	68.7%	32.9%	14.9%	3.3%
Stored away in a package	1.7%	0.9%	0.0%	0.0%
Temporarily unavailable during visit	0.0%	0.0%	0.0%	0.0%
Net ever used	30.3%	68.4%	92.1%	100.0%
Net used last night	28.6%	61.9%	70.3%	90.0%
Net used every night last week	26.9%	58.9%	61.4%	61.7%
Gaoua	**N=282**	**N=206**	**N=138**	**N=94**
Cohort net status				
Found hanging and tied up	25.5%	46.1%	71.0%	48.9%
Found hanging, untied	27.3%	29.1%	4.3%	38.3%
Not hanging and not stored away	1.1%	1.0%	7.2%	9.6%
Stored away unpacked	45.4%	23.8%	17.4%	3.2%
Stored away in a package	0.7%	0.0%	0.0%	0.0%
Temporarily unavailable during visit	0.0%	0.0%	0.0%	0.0%
Net ever used	54.3%	78.2%	91.3%	93.6%
Net used last night	50.4%	73.3%	73.9%	88.3%
Net used every night last week	38.7%	49.0%	68.1%	46.8%
Orodara	**N=347**	**N=286**	**N=209**	**N=141**
Cohort net status				
Found hanging and tied up	1.4%	1.0%	1.0%	6.4%
Found hanging, untied	71.5%	80.4%	83.7%	83.7%
Not hanging and not stored away	0.9%	6.3%	8.6%	7.8%
Stored away unpacked	8.4%	8.4%	2.4%	2.1%
Stored away in a package	17.6%	1.7%	4.3%	0.0%
Temporarily unavailable during visit	0.0%	2.1%	0.0%	0.0%
Net ever used	74.4%	86.0%	94.3%	97.9%
Net used last night	72.0%	79.7%	82.8%	86.5%
Net used every night last week	71.2%	77.6%	82.3%	78.7%

Each survey round documents all mosquito nets in selected households, including nets from sources other than the 2019 mass distribution campaign (referred to as non-cohort nets). Household ownership of non-cohort nets and sources of these nets are presented in Table 11.

At 36-months, in all study sites, the proportion of households owning non-cohort nets was the lowest of all time points and did not differ between districts (36% in Banfora, 31% in Gaoua, 29% in Orodara). The most common source of non-cohort nets was ANC visits in Orodara (34%) and other (for which all cases were family/friends) in Banfora (50%) and Gaoua (54%).

TABLE 11: OWNERSHIP AND SOURCE OF NON-COHORT NETS

	Baseline	12-month	24-month	36-month
Banfora	**N=170**	**N=158**	**N=103**	**N=61**
Households with any non-cohort nets	67.1%	52.5%	49.5%	36.1%
Non-cohort net sources	**Net N=166**	**Net N=114**	**Net N=67**	**Net N=28**
ANC visit	12.0%	12.3%	20.9%	25.0%
Previous mass campaign	76.5%	61.4%	29.9%	0.0%
School	0.0%	0.9%	0.0%	0.0%
Other public source*	2.4%	2.6%	4.5%	25.0%
Private sector	3.0%	0.9%	3.0%	0.0%
Other/doesn't recall**	6.0%	21.9%	41.8%	50.0%
Gaoua	**N=170**	**N=163**	**N=133**	**N=102**
Households with any non-cohort nets	32.9%	41.7%	39.1%	31.4%
Non-cohort net sources	**Net N=73**	**Net N=89**	**Net N=67**	**Net N=37**
ANC visit	16.4%	4.5%	14.9%	29.7%
Previous mass campaign	68.5%	44.9%	34.3%	0.0%
School	0.0%	0.0%	0.0%	0.0%
Other public source*	2.7%	20.2%	4.5%	16.2%
Private sector	5.5%	1.1%	3.0%	0.0%
Other/doesn't recall**	6.8%	29.2%	43.3%	54.1%
Orodara	**N=170**	**N=159**	**N=145**	**N=125**
Households with any non-cohort nets	50.0%	54.1%	57.2%	28.8%
Non-cohort net sources	**Net N=111**	**Net N=131**	**Net N=123**	**Net N=53**
ANC visit	17.1%	23.7%	29.3%	34.0%
Previous mass campaign	66.7%	32.1%	4.9%	9.4%
School	0.0%	0.0%	0.0%	0.0%
Other public source*	7.2%	27.5%	35.0%	11.3%
Private sector	3.6%	1.5%	9.8%	22.6%
Other/doesn't recall**	5.4%	15.3%	21.1%	22.6%

* Includes other (non-ANC) public health facility visits, community-based workers and immunization campaigns.

** Includes family/friends, NGO and faith-based organizations.

During the 36-month survey, a total of 118 non-cohort nets (28 in Banfora, 37 in Gaoua, 53 in Orodara) were audited in study households (Table 12). Of these, 31% were PermaNet® 3.0, 16% were Interceptor® G2, 15% were Interceptor®, and 10% were PermaNet® 2.0 brand nets. Similar to cohort nets, most non-cohort nets were found hanging, untied, in Orodara (81%) and hanging tied in Banfora (50%) and Gaoua (73%).

Non-cohort net ever use was highest in Banfora and Orodara (96% in both districts) and lowest in Gaoua (84%) (p=0.016). The relative pattern of non-cohort net use every night last week was similar to that of cohort nets where use was highest in Orodara (79%), lower in Banfora (62%), and lowest in Gaoua (47%) (p=0.031). Non-cohort net use the night prior to the survey did not differ statistically between study sites (90% in Banfora, 88% in Gaoua, 87% in Orodara).

TABLE 12: STATUS AND REPORTED USE OF NON-COHORT NETS IN THE HOUSEHOLD

	Baseline	12-month	24-month	36-month
Banfora	**N=166**	**N=114**	**N=67**	**N=28**
Non-cohort net status				
Found hanging and tied up	31.9%	27.2%	29.9%	50.0%
Found hanging, untied	50.0%	54.4%	58.2%	39.3%
Not hanging and not stored away	6.6%	4.4%	1.5%	7.1%
Stored away unpacked	9.6%	11.4%	9.0%	3.6%
Stored away in a package	0.6%	2.6%	1.5%	0.0%
Temporarily unavailable during visit	1.2%	0.0%	0.0%	0.0%
Net ever used	92.8%	85.1%	94.0%	96.4%
Net used last night	80.1%	78.1%	88.1%	85.7%
Net used every night last week	66.9%	67.5%	83.6%	60.7%
Gaoua	**N=73**	**N=89**	**N=67**	**N=37**
Non-cohort net status				
Found hanging and tied up	45.2%	53.9%	76.1%	73.0%
Found hanging, untied	39.7%	27.0%	6.0%	8.1%
Not hanging and not stored away	8.2%	1.1%	3.0%	2.7%
Stored away unpacked	6.8%	16.9%	14.9%	13.5%
Stored away in a package	0.0%	0.0%	0.0%	2.7%
Temporarily unavailable during visit	0.0%	1.1%	0.0%	0.0%
Net ever used	89.0%	89.9%	94.0%	83.8%
Net used last night	79.5%	80.9%	79.1%	81.1%
Net used every night last week	49.3%	47.2%	71.6%	21.6%
Orodara	**N=111**	**N=131**	**N=123**	**N=53**
Non-cohort net status				
Found hanging and tied up	1.8%	3.1%	3.3%	9.4%
Found hanging, untied	61.3%	69.5%	79.7%	81.1%
Not hanging and not stored away	0.0%	6.1%	12.2%	5.7%
Stored away unpacked	35.1%	19.1%	1.6%	1.9%
Stored away in a package	0.9%	2.3%	2.4%	1.9%
Temporarily unavailable during visit	0.9%	0.0%	0.8%	0.0%
Net ever used	98.2%	84.7%	87.0%	96.2%
Net used last night	63.1%	71.0%	82.9%	90.6%
Net used every night last week	55.9%	59.5%	81.3%	81.1%

The study captured data on the age categories of household members using cohort (Table3) and non-cohort nets (Table 14) the night before the interview as another potential factor for durability. At 36-months, approximately half of cohort and non-cohort nets were used by adults only in all districts (cohort nets: 50% in Banfora, 60% in Gaoua, 66% in Orodara; non-cohort nets: 58% in Banfora, 53% in Gaoua, 44% in Orodara). The proportion of nets used by users of different age groups was not statistically different between sites for cohort or non-cohort nets.

TABLE 13: USE OF COHORT NETS BY HOUSEHOLD MEMBERS AMONG NETS USED THE PREVIOUS NIGHT

	Baseline	12-month	24-month	36-month
Banfora	**N=84**	**N=143**	**N=71**	**N=54**
Cohort nets				
Used by child(ren) only	6.0%	5.6%	9.9%	18.5%
Used by child(ren) sharing with adult(s)	41.7%	35.7%	38.0%	31.5%
Used by adult(s) only	52.4%	58.7%	52.1%	50.0%
Gaoua	**N=142**	**N=151**	**N=102**	**N=83**
Cohort nets				
Used by child(ren) only	4.9%	3.3%	1.0%	6.0%
Used by child(ren) sharing with adult(s)	35.9%	31.1%	41.2%	33.7%
Used by adult(s) only	59.2%	65.6%	57.8%	60.2%
Orodara	**N=250**	**N=228**	**N=173**	**N=122**
Cohort nets				
Used by child(ren) only	9.2%	8.3%	6.4%	5.7%
Used by child(ren) sharing with adult(s)	35.2%	44.3%	46.8%	28.7%
Used by adult(s) only	55.6%	47.4%	46.8%	65.6%

Children aged 0-9 years; Adults include adolescents aged 10-19 years.

TABLE 14: USE OF NON-COHORT NETS BY HOUSEHOLD MEMBERS AMONG NETS USED THE PREVIOUS NIGHT

	Baseline	12-month	24-month	36-month
Banfora	**N=133**	**N=89**	**N=59**	**N=24**
Non-cohort nets				
Used by child(ren) only	7.5%	10.1%	3.4%	12.5%
Used by child(ren) sharing with adult(s)	35.3%	40.4%	39.0%	29.2%
Used by adult(s) only	57.1%	49.4%	57.6%	58.3%
Gaoua	**N=58**	**N=72**	**N=53**	**N=30**
Non-cohort nets				
Used by child(ren) only	6.9%	11.1%	0.0%	3.3%
Used by child(ren) sharing with adult(s)	39.7%	27.8%	26.4%	43.3%
Used by adult(s) only	53.4%	61.1%	73.6%	53.3%
Orodara	**N=70**	**N=93**	**N=102**	**N=48**
Non-cohort nets				
Used by child(ren) only	18.6%	25.8%	13.7%	20.8%
Used by child(ren) sharing with adult(s)	25.7%	28.0%	45.1%	35.4%
Used by adult(s) only	55.7%	46.2%	41.2%	43.8%

Children aged 0-9 years; Adults include adolescents aged 10-19 years.

Access to ITNs is a critical determinant of ITN use (Table 15). Access can be measured at the household and population levels. Household access is defined as the proportion of households with one ITN for every two

people in the household; population access is defined as the proportion of people that could sleep under an ITN, assuming each ITN in a household is used by two people.

From baseline to 36-months, household and population access to all ITNs decreased in Banfora (34 and 11 percentage point), Gaoua (24 and 5 percentage points) and Orodara (35 and 18 percentage points). At 36-months household and population access to all ITNs and to campaign cohort ITNs did not differ between districts. Cohort ITN household and population access were generally three to four times that of other ITN household and population access in all study sites. Population use differed significantly between districts, with population use of any ITN and campaign cohort ITNs being highest in Banfora (67% and 51%), lower in Orodara (62% and 46%) and lowest in Gaoua (45% and 34%) (p=0.034 for any ITN, p=0.046 for campaign cohort ITN).

TABLE 15: HOUSEHOLD AND POPULATION ITN ACCESS AND USE

	Baseline	12-month	24-month	36-month
Banfora				
Household access	**N=168**	**N=158**	**N=102**	**N=61**
All ITNs	82.7%	65.2%	49.0%	49.2%
Campaign cohort ITNs (Interceptor® G2)	70.2%	55.1%	36.3%	32.8%
Other ITNs	22.6%	4.4%	8.8%	8.2%
Population access	**N=576**	**N=567**	**N=350**	**N=208**
All ITNs	79.3%	79.4%	62.3%	68.8%
Campaign cohort ITNs (Interceptor® G2)	66.1%	71.1%	53.4%	53.8%
Other ITNs	25.7%	18.5%	13.4%	18.8%
Population use	**N=576**	**N=567**	**N=350**	**N=208**
All ITNs	60.6%	64.6%	50.3%	67.3%
Campaign cohort ITNs (Interceptor® G2)	30.7%	51.3%	38.6%	51.0%
Other ITNs	31.2%	13.6%	12.6%	16.8%
Gaoua				
Household access	**N=170**	**N=163**	**N=133**	**N=102**
All ITNs	55.9%	56.4%	45.1%	32.4%
Campaign cohort ITNs (Interceptor®)	43.5%	36.8%	28.6%	23.5%
Other ITNs	7.1%	6.1%	12.8%	0.0%
Population access	**N=725**	**N=652**	**N=518**	**N=407**
All ITNs	62.2%	70.9%	67.8%	57.7%
Campaign cohort ITNs (Interceptor®)	51.2%	56.9%	50.6%	43.7%
Other ITNs	10.9%	21.2%	23.6%	15.2%
Population use	**N=725**	**N=652**	**N=518**	**N=407**
All ITNs	52.1%	54.3%	51.2%	44.5%
Campaign cohort ITNs (Interceptor®)	38.1%	40.5%	36.9%	33.7%
Other ITNs	14.9%	14.0%	14.5%	11.1%
Orodara				
Household access	**N=170**	**N=159**	**N=144**	**N=123**
All ITNs	77.6%	62.9%	52.1%	43.1%
Campaign cohort ITNs (PermaNet® 3.0)	57.6%	37.7%	25.7%	25.2%
Other ITNs	12.9%	10.7%	6.2%	4.1%
Population access	**N=752**	**N=801**	**N=731**	**N=552**
All ITNs	80.5%	81.9%	77.3%	62.7%
Campaign cohort ITNs (PermaNet® 3.0)	65.7%	67.7%	54.7%	46.6%
Other ITNs	15.8%	27.2%	29.3%	17.6%
Population use	**N=752**	**N=801**	**N=731**	**N=552**
All ITNs	81.8%	81.6%	82.1%	62.3%

Campaign cohort ITNs (PermaNet® 3.0)	67.7%	64.7%	54.9%	45.5%
Other ITNs	15.2%	18.5%	27.6%	17.2%

3.4 DURABILITY OF CAMPAIGN ITNS

The durability of ITNs can be conceptualized as two components: attrition, or nets that are no longer present in the household, and physical integrity of nets that are available for use in the household. Table 15 presents results for the attrition of cohort nets at baseline, 12-, 24-, and 36-month rounds. Of the 307 cohort nets in Banfora, 293 nets in Gaoua, and 359 nets in Orodara enrolled at baseline, 202, 261, and 306 nets, respectively, were included in the attrition calculation at 36-months. Excluded nets either belonged to households that were not interviewed (nobody was home, household refused, household omitted due to security concerns in Banfora), were not assessed due to inaccessibility within the house, or were said to be with family elsewhere during this round and thus their actual status could not be ascertained. Tagged nets that were reported as with family elsewhere were kept in the study cohort until the 36-month endline survey in case they reappeared in the household.

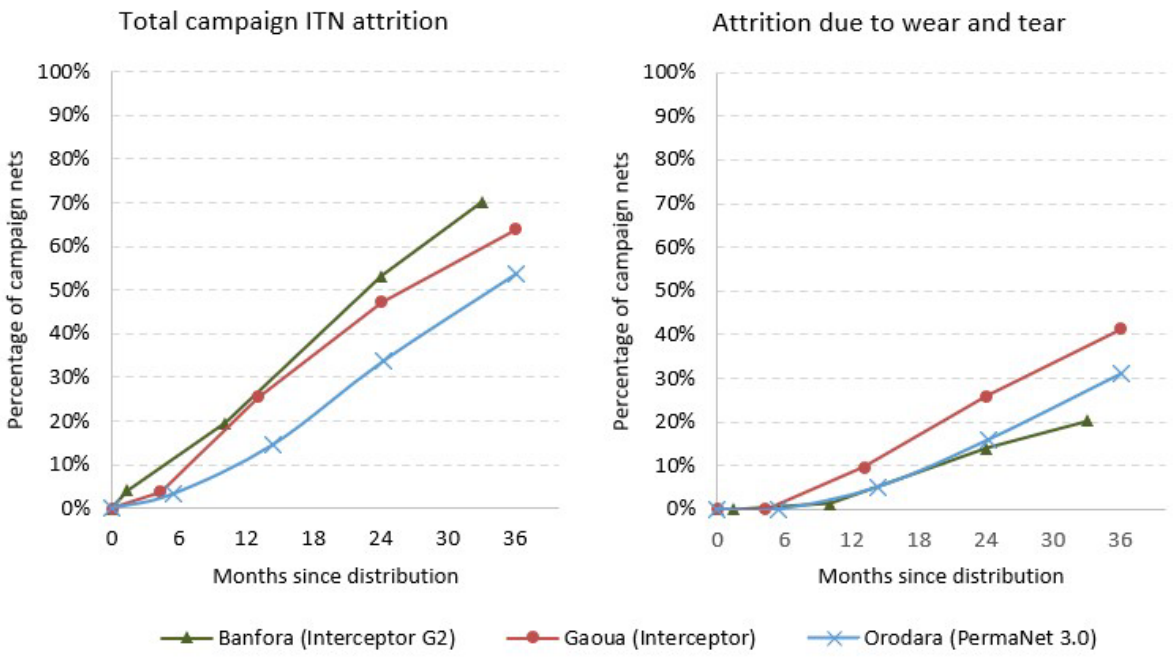
Total cohort ITN attrition increased from 4% at baseline to 70% at 36-months in Banfora, from 4% to 64% in Gaoua, and from 3% to 54% in Orodara (Table 16, Figure 7). At 36-months, total cohort ITN attrition did not differ significantly between study sites (p=0.066). In Gaoua and Orodara, the most common reason for attrition was ITNs being discarded (41% and 31% respectively), while ITNs were most commonly given away to others in Banfora (48%). The second most common reason for attrition was nets given away to others in Gaoua and Orodara (18% and 16% respectively) and discarded in Banfora (20%). Attrition from ITNs being given away to others was higher in Banfora (48%) compared to in Gaoua (18%, p<0.001) and Orodara (16%, p<0.001), while attrition from ITN being discarded was higher in Gaoua (41%) compared to in Banfora (20%, p=0.002). Attrition from ITNs lost for other/unknown reasons was relatively low in all three study sites (2% in Banfora, 5% in Gaoua, and 7% in Orodara).

TABLE 16: CAMPAIGN COHORT ITN ATTRITION

	Baseline	12-month	24-month	36-month
Banfora	**N=307**	**N=287**	**N=216**	**N=202**
Total campaign ITN attrition	4.2%	19.5%	53.2%	70.3%
ITNs given away to others	4.2%	18.1%	38.4%	48.0%
ITNs discarded	0.0%	1.4%	13.9%	20.3%
ITNs lost for other/unknown reason	0.0%	0.0%	0.9%	2.0%
Gaoua	**N=293**	**N=277**	**N=262**	**N=261**
Total campaign ITN attrition	3.8%	25.6%	47.3%	64.0%
ITNs given away to others	3.8%	11.6%	16.8%	18.0%
ITNs discarded	0.0%	9.7%	26.0%	41.4%
ITNs lost for other/unknown reason	0.0%	4.3%	4.6%	4.6%
Orodara	**N=359**	**N=335**	**N=315**	**N=306**
Total campaign ITN attrition	3.3%	14.6%	33.7%	53.9%
ITNs given away to others	3.3%	7.2%	13.7%	15.7%
ITNs discarded	0.0%	5.1%	15.9%	31.0%
ITNs lost for other/unknown reason	0.0%	2.4%	4.1%	7.2%

Given away to others includes nets that were stolen, given to non-household members and nets that were recorded as being with family members elsewhere at baseline (e.g., at school).
Discarded (also known as attrition due to wear and tear) includes nets that were destroyed, thrown away, or used for other purposes

FIGURE 7: TRENDS IN TOTAL ATTRITION AND ATTRITION DUE TO WEAR AND TEAR (DISCARDED NETS)



Measuring the second component of ITN durability, physical integrity, is a primary study objective. Data from the ITN hole assessment was transformed into the pHI for each ITN using standard weights defined by WHO:

pHI = Number of size 1holes + (No. of size 2 holes x 23) + (No. of size 3 holes x 196) + (No. of size 4 holes x 576)

Good:	pHI ≤ 64 (corresponding to a total hole surface area ≤ 0.01m²)
Serviceable:	pHI ≤ 642 (total hole surface area ≤ 0.1 m²)
Torn:	pHI > 642 (total hole surface area > 0.1m²)

Table 17 reports the physical integrity results of nets that were in the household from baseline to 36-months. Nets that were in the household but were temporarily unavailable due to being washed or were locked away were not included in the assessment.

The proportion of cohort nets with any holes increased from 3% at baseline to 83% at 36-months in Banfora, from 25% to 80% in Gaoua, and from 30% to 90% in Orodara. At 36-months, the proportion of cohort nets with any holes differed between districts and was highest in Orodara (90%), lower in Banfora (83%), and lowest in Gaoua (80%) (p=0.027). The proportion of cohort nets classified as "good" (52% in Banfora, 54% in Gaoua, 52% in Orodara), "too torn" (20% in Banfora, 20% in Gaoua, 10% in Orodara), and "serviceable" (80% in Banfora, 80% in Gaoua, 90% in Orodara) was similar across study sites at 36-months.

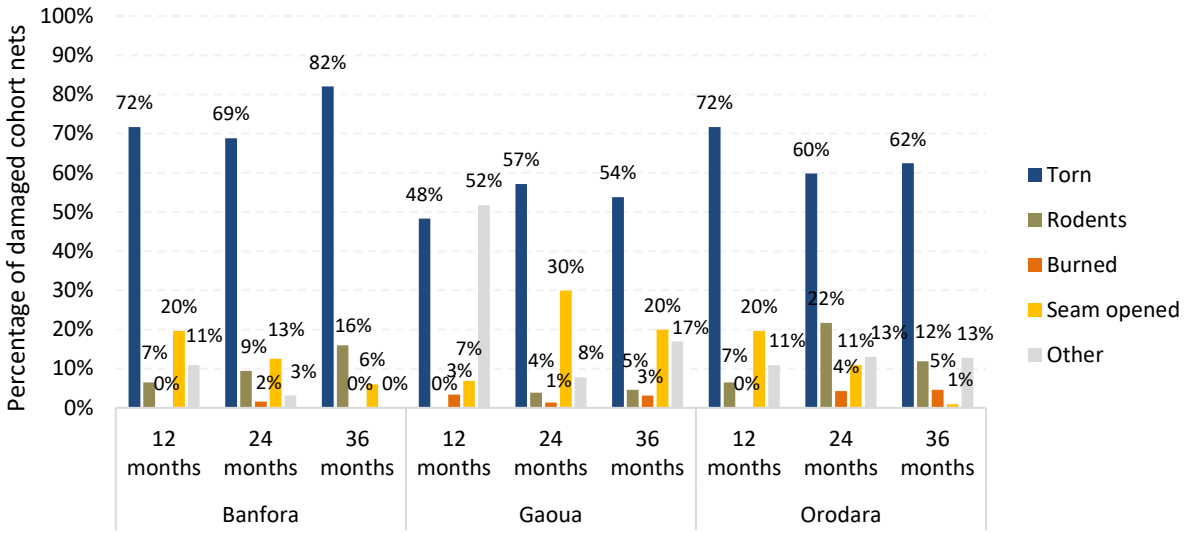
TABLE 17: PHYSICAL INTEGRITY OF OBSERVED CAMPAIGN COHORT ITNS

	Baseline	12-month	24-month	36-month
Banfora	**N=294**	**N=231**	**N=101**	**N=60**
Cohort ITN with any holes	3.1%	27.7%	69.3%	83.3%
ITNs classified as "Good"	100.0%	91.8%	68.3%	51.7%
ITNs classified as "Too torn"	0.0%	3.5%	15.8%	20.0%
ITNs classified as "Serviceable"	100.0%	96.5%	84.2%	80.0%
Among ITNs with any holes:	N=9	N=64	N=70	N=50
Median pHI for ITNs with any holes	24.0	25.0	51.5	143.5
Gaoua	**N=282**	**N=206**	**N=138**	**N=94**
Cohort ITN with any holes	24.5%	46.1%	70.3%	79.8%
ITNs classified as "Good"	94.0%	90.3%	63.8%	54.3%
ITNs classified as "Too torn"	1.1%	2.9%	11.6%	20.2%
ITNs classified as "Serviceable"	98.9%	97.1%	88.4%	79.8%
Among ITNs with any holes:	N=69	N=95	N=97	N=75
Median pHI for ITNs with any holes	24.0	16.0	69.0	99.0
Orodara	**N=346**	**N=280**	**N=209**	**N=141**
Cohort ITN with any holes	29.5%	65.4%	81.8%	90.1%
ITNs classified as "Good"	94.5%	81.8%	64.6%	51.8%
ITNs classified as "Too torn"	2.3%	4.3%	9.6%	9.9%
ITNs classified as "Serviceable"	97.4%	95.7%	90.4%	90.1%
Among ITNs with any holes:	N=102	N=183	N=171	N=127
Median pHI for ITNs with any holes	11.5	26.0	51.0	77.0

To understand the ways in which nets were damaged in real-life conditions, prior to the hole assessment respondents were asked what causes the holes in their nets. The responses are captured in Figure 8. Baseline figures are not presented because the low number of nets with any holes are not directly comparable to those during subsequent study rounds.

The most commonly reported damage mechanism across study sites and survey rounds was tears. At 36-months, the most common cause of holes was tears (82% in Banfora, 54% in Gaoua, and 62% in Orodara). The second most common cause was damage by rodents in Banfora (16%), seams opening in Gaoua (20%), and other causes in Orodara (13%, the majority of which were reported to be general net deterioration). At 36-months, damage mechanisms did not differ significantly between sites except for seams opening which was highest in Gaoua (6% in Banfora, 20% in Gaoua, 1% in Orodara; $p<0.001$).

FIGURE 8: TYPES OF DAMAGE MECHANISMS REPORTED FOR DAMAGED CAMPAIGN ITNS



*Other includes tear, net is old, net is not resistant, cut into smaller pieces for general use

ITN survivorship combines the two aspects of durability, attrition, and physical integrity, and is defined as the proportion of campaign ITNs originally received that are still in the possession of the household and in serviceable condition. As with attrition and physical integrity, cohort nets that were said to be used by family elsewhere (e.g., taken to school) were not included in these calculations. Additionally, nets ever given away or lost for other or unknown reasons are not included.

Table 18 reports the proportion of cohort ITNs surviving and in serviceable condition from baseline to 36-months. All cohort net survival decreased from 100% at baseline to 48% at 36-months in Banfora, from 99% to 37% in Gaoua, and from 98% to 54% in Orodara. At 36-months, survival of all cohort nets, and cohort nets ever-used and present, was highest in Orodara (54% and 90%), lower in Banfora (48% and 80%) and lowest in Gaoua (37% and 80%), however, differences in survival between study sites were not statistically significant (p=0.077 and p=0.058).

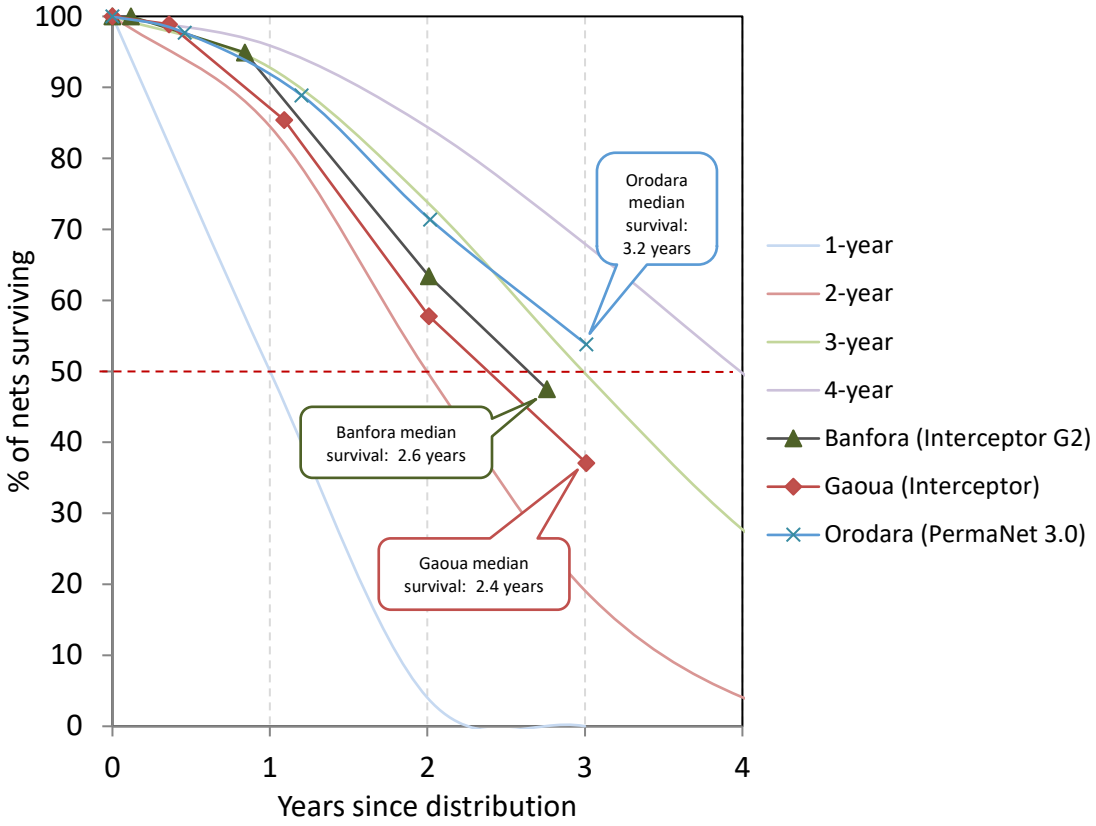
TABLE 18: CAMPAIGN COHORT ITNS SURVIVING IN SERVICEABLE CONDITION

	Baseline	12-month	24-month	36-month
Banfora				
All cohort nets*	N=294	N=235	N=131	N=101
Survival estimate	100.0%	94.9%	63.4%	47.5%
95% CI	--	91.8%-96.9%	48.2%-76.3%	35.7%-59.6%
Cohort nets ever used and present	N=89	N=158	N=93	N=60
Survival estimate	100.0%	94.9%	80.6%	80.0%
95% CI	--	89.7%-97.6%	65.7%-90.1%	68.5%-88.0%
Gaoua				
All cohort nets*	N=282	N=233	N=206	N=202
Survival estimate	98.9%	85.4%	57.8%	37.1%
95% CI	96.9%-99.6%	75.7%-91.7%	48.3%-66.7%	27.9%-47.4%
Cohort nets ever used and present	N=153	N=161	N=126	N=88
Survival estimate	98.0%	96.3%	84.9%	79.5%
95% CI	94.2%-99.4%	91.8%-98.4%	77.2%-90.4%	67.6%-87.9%
Orodara				
All cohort nets*	N=346	N=298	N=259	N=236
Survival estimate	97.7%	88.9%	71.4%	53.8%
95% CI	95.2%-98.9%	82.1%-93.4%	58.2%-81.8%	41.4%-65.7%
Cohort nets ever used and present	N=258	N=240	N=197	N=138
Survival estimate	96.9%	93.8%	87.8%	89.9%
95% CI	93.7%-98.5%	90.3%-96.0%	79.5%-93.1%	85.0%-93.3%

*Among ITNs that are still in the possession of the household or discarded due to wear and tear in a previous survey round.

Figure 9 plots the proportion of nets surviving in serviceable condition against hypothetical survival curves for nets lasting one to four years using the survival data from baseline 12-, 24-, and 36-month study rounds. The median survival can be estimated as the relative position of the data point on a horizontal line between the two adjacent median survival curves. Using this method at 36-month, the estimated median useful life for Interceptor® G2 nets in Banfora was 2.6 years, Interceptor® nets in Gaoua was 2.4 years, and for PermaNet® 3.0 nets in Orodara was 3.2 years.

FIGURE 9: ESTIMATED ITN SURVIVAL



*Error bars show 95% confidence intervals.

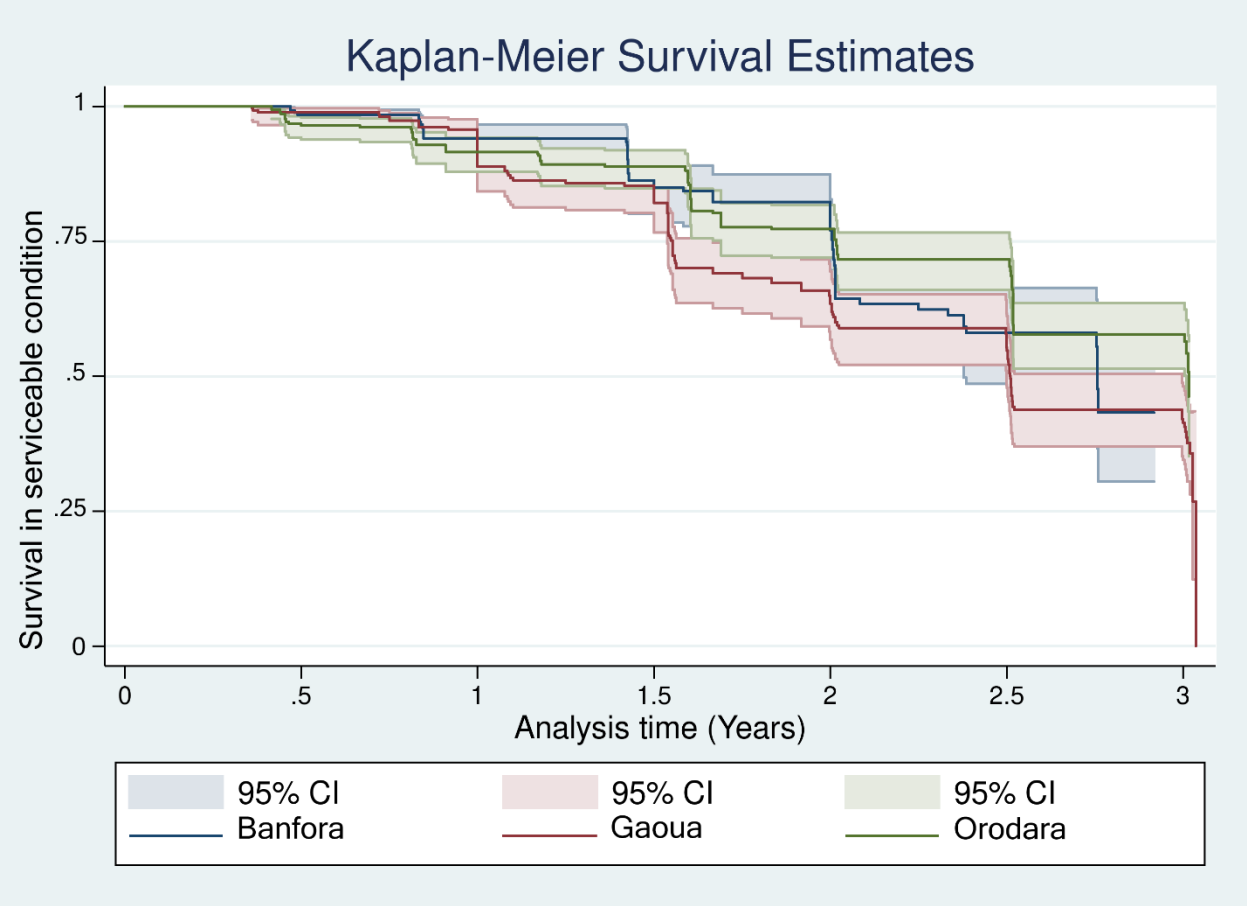
Table 19 displays estimated median survival times using the most recent two data points as another method to calculate the survival estimate. Using this method, the estimated median useful life (with 95% CIs) is 2.6 (1.9-3.2) years for Interceptor® G2 nets in Banfora, 2.4 (1.9-2.9) years for Interceptor® nets in Gaoua, and 3.2 (2.5-4.0) years for PermaNet® 3.0 nets in Orodara.

TABLE 19: ESTIMATED MEDIAN SURVIVAL OF ITNS IN YEARS USING DIFFERENT METHODS

	12-month	24-month	36-month
Banfora (Interceptor® G2)	**N=235**	**N=131**	**N=100**
Estimated from figure 9	3.0	2.4	2.7
Calculated from last two data points (95% CI)	-	-	2.6 (1.9-3.2)
Gaoua (Interceptor®)	**N=233**	**N=206**	**N=202**
Estimated from figure 9	2.3	2.2	2.6
Calculated from last two data points (95% CI)	-	-	2.4 (1.9-2.9)
Orodara (PermaNet® 3.0)	**N=298**	**N=259**	**N=236**
Estimated from figure 9	2.9	2.9	3.2
Calculated from last two data points (95% CI)	-	-	3.2 (2.5-4.0)

When data were analyzed as survival analysis in a Kaplan-Meier plot (Figure 10), Interceptor® ITNs in Gaoua, showed a slight trend of lower survival compared to Interceptor® G2 nets in Banfora and PermaNet® 3.0 nets in Orodara.

FIGURE 10: KAPLAN-MEIER CURVES OF PHYSICAL SURVIVAL WITH 95% CONFIDENCE INTERVALS



3.5 INSECTICIDAL EFFECTIVENESS AND CONTENT OF CAMPAIGN NETS

At baseline, bioassays were performed against Interceptor®, Interceptor® G2 and PermaNet® 3.0 field samples to test for bioefficacy. The results of the characterization of the mosquito strains used in the bioassay analysis revealed that the Kisumu strain was susceptible to deltamethrin and alpha-cypermethrin and polymerase chain reaction (PCR) confirmed the species as *An. gambiae* with no kdr mutations present (Table 20). Testing confirmed the presence of deltamethrin and alpha-cypermethrin resistance in the VKPER strain (Table 21). PBO synergist tests with deltamethrin showed a greater than 60% increase in mortality compared to deltamethrin alone. Chlorfenapyr testing was added to the characterization from the second round. The results from the 12-, 24-, and 36-month rounds showed that 72-hour mortality remained above 95% with an interim diagnostic dose of 100µg/bottle and 100% with 200 µg/bottle. PCR confirmed the strain as *An. coluzzii* with a high (although not fixed) frequency of the kdr west (L1014F) mutation and no presence of the kdr east (L1014S) mutation.

TABLE 20: CHARACTERISTICS OF *AN. GAMBIAE* KISUMU MOSQUITOES USED TO TEST PERMANET® 3.0, INTERCEPTOR® AND INTERCEPTOR® G2 NETS

	Baseline	12-month	24-month	36-month
Pyrethroid resistant mosquito strain (*An. gambiae* Kisumu)				
% Mortality (24h) in deltamethrin (0.05%) susceptibility tests	100% (n=90)	100% (n=89)	100% (n=96)	100% (n=90)
% Mortality (24h) in alpha-cypermethrin susceptibility tests	100% (n=95)	100% (n=96)	100% (n=95)	100% (n=90)
% Mortality (24h) in deltamethrin (0.05%) + PBO (4%) synergist tests	n/a	100% (n=89)	100% (n=96)	100% (n=96)
% Mortality (24h) in chlorfenapyr in CDC bottle bioassays at 100ug/bottle.	n/a	100% (n=98)	100% (n=95)	100% (n=90)
Species composition of strain (PCR)	100% *An. gambiae* (n=90)	100% *An. gambiae* (n=92)	100% *An. gambiae* (n=96)	100% *An. gambiae* (n=90)
Kdr west (L1014F) frequency	f=0.0 (90 SS) (n=90)	f=0.0 (92 SS) (n=90)	f=0.0 (n=96)	f=0.0 (n=90)
Kdr east (L1014S) frequency	f=0.0 (90 SS) (n=90)	f=0.0 (92 SS) (n=90)	f=0.0 (n=96)	f=0.0 (n=90)

TABLE 21: CHARACTERISTICS OF *AN. COLUZZII* VKPER MOSQUITOES USED TO TEST PERMANET® 3.0, INTERCEPTOR® AND INTERCEPTOR® G2 NETS

	Baseline	12-month	24-month	36-month
Pyrethroid resistant mosquito strain (*An. coluzzii* VKPER)				
% Mortality (24h) in deltamethrin (0.05%) susceptibility tests	Test 1 33.0% (n=94) Test 2 42.3% (n=104)	39.4% (n=99)	34.4% (n=90))	28.5% (n=90)
% Mortality (24h) in deltamethrin (0.05%) + PBO (4%) synergist tests	Test 1 89.6% (n=96) Test 2 93.2% (n= 148)	88.4% (n=105)	91.8% (n=95)	89.8% (n=90)
% Mortality (24h) in deltamethrin resistance intensity tests, 5X (0.25%)	62.8% (n=94)	-	-	-
% Mortality (24h) in deltamethrin resistance intensity tests, 10X (0.50%)	84.9% (n=106)	-	-	-
% Mortality (24h) in alpha-cypermethrin susceptibility tests	13.3% (n=143)	1.9% (n=107)	6.4% (n=96)	4.08% (n=90)
% Mortality (24h) in tunnel tests with new Interceptor® net (alpha-cypermethrin)	Test 1 12.0% (n=100) Test 2 22.0% (n=91)	-	-	-
% Mortality (72h) in chlorfenapyr in CDC bottle bioassays at 100ug/bottle.	n/a	95.7% (n=94)	96.1% (n=98)	94.8% (n=90)
% Mortality (72h) in chlorfenapyr in CDC bottle bioassays at 200ug/bottle.	n/a	100% (n=99)	100% (n=96)	100% (n=90)
Species composition of strain (PCR)	100% *An. coluzzii* (n=89)	100% *An. coluzzii* (n=88)	100% *An. coluzzii*	100% *An. coluzzii*
Kdr west (L1014F) frequency	f=0.82 (58 RR, 30 RS, 1 SS) (n=89)	f=0.90 (69 RR, 16 RS) (n=85)	f=0.91 (71 RR, 14 RS) (n=85)	f=0.95 (81 RR, 9RS) (n=90)
Kdr east (L1014S) frequency	f=0.0 (89 SS) (n=89)	f=0.0 (85 SS) (n=85)	f=0.0 (85 SS) (n=85)	f=0.0 (90 SS) (n=90)

3.5.1 GAOUA / INTERCEPTOR® (ALPHA-CYPERMETHRIN)

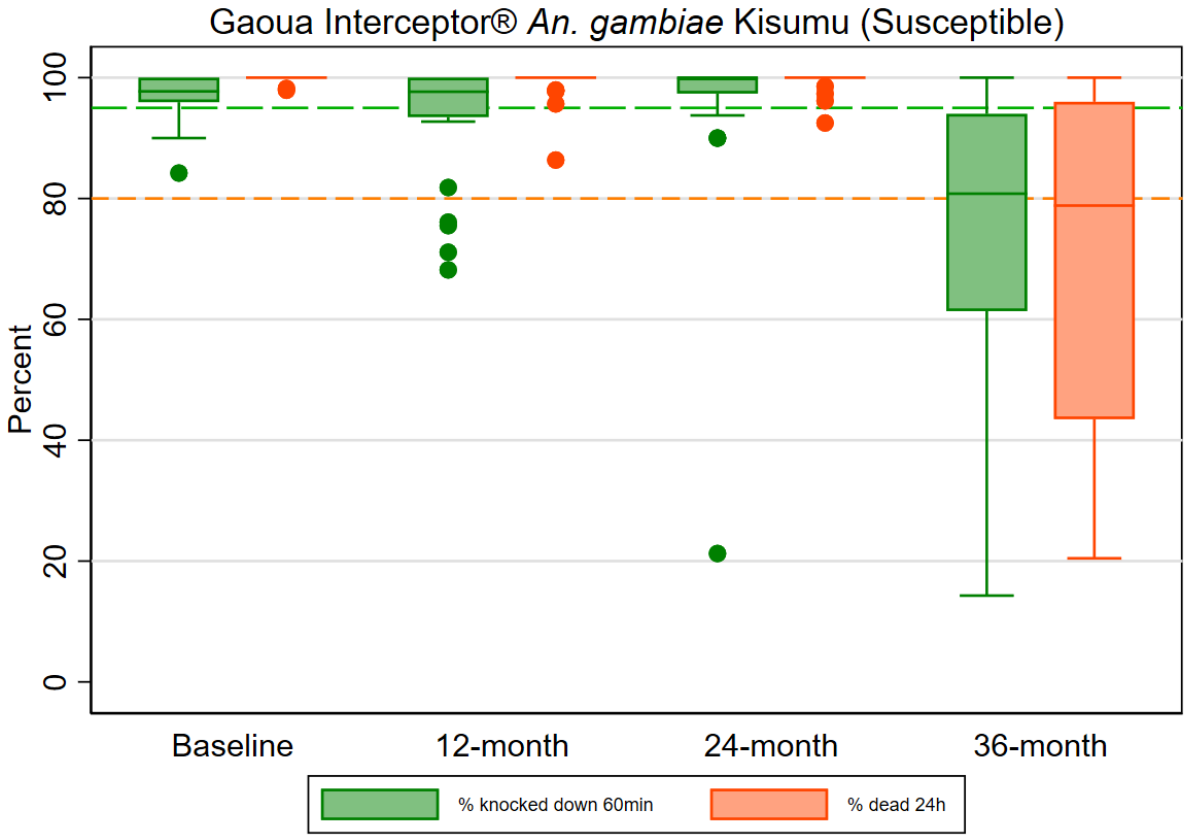
The Interceptor® brand is a pyrethroid-only ITN with the AI alpha-cypermethrin. Interceptor® samples withdrawn this survey round had been in the field for 36 months. Insecticidal effectiveness outcomes for Interceptor® were based on standard WHO cone test results, where KD60 and 24-hour mortality was measured. These variables were combined to measure optimal effectiveness and minimal effectiveness.

During the previous three rounds of data collection, KD60 exceeded 94% and 24-hour mortality was higher than 99%. However, at 36 months, these indicators fell to 76% and 71%, respectively (Table 22). As a result, the proportion of nets classified as optimally effective declined from 100% to 60%. Similarly, the proportion of nets with minimal effectiveness dropped from 100% to 87% at 36 months. For the first time in this study, mean 24-hour mortality dropped below the WHO threshold of 80% (Figure 11).

TABLE 22: INTERCEPTOR® CONE BIOASSAY RESULTS FOR RESIDUAL EFFICACY OF PYRETHROID

Gaoua / Interceptor®	Baseline	12-month	24-month	36-month
Susceptible mosquito strain (*An. gambiae* Kisumu)	**Mean (95% CI)**	**Mean (95% CI)**	**Mean (95% CI)**	**Mean (95% CI)**
	N=30	**N=30**	**N=24**	**N=30**
Knock down 60 minutes	96.9 (95.9-98.0)	94.0 (89.5-98.6)	95.8 (90.3-100.0)	75.8 (65.6-86.1)
Mortality 24 hours	99.9 (99.7-100.0)	99.2 (98.2-100.0)	99.5 (98.8-100.0)	70.8 (58.0-83.7)
Optimal effectiveness	100.0 (--)	100.0 (--)	100.0 (--)	60.0 (37.2-82.8)
Minimal effectiveness	100.0 (--)	100.0 (--)	100.0 (--)	86.7 (70.4-100.0)

FIGURE 11: BOX PLOT OF INTERCEPTOR® CONE BIOASSAY RESULTS FOR RESIDUAL EFFICACY OF PYRETHOID



Results from WHO cone bioassays: the box plot shows the median (horizontal line), interquartile range (box), adjacent values (whiskers) and outliers (circles), lines represent WHO optimal effectiveness thresholds for knock-down (green, 95%) and mortality (orange, 80%).

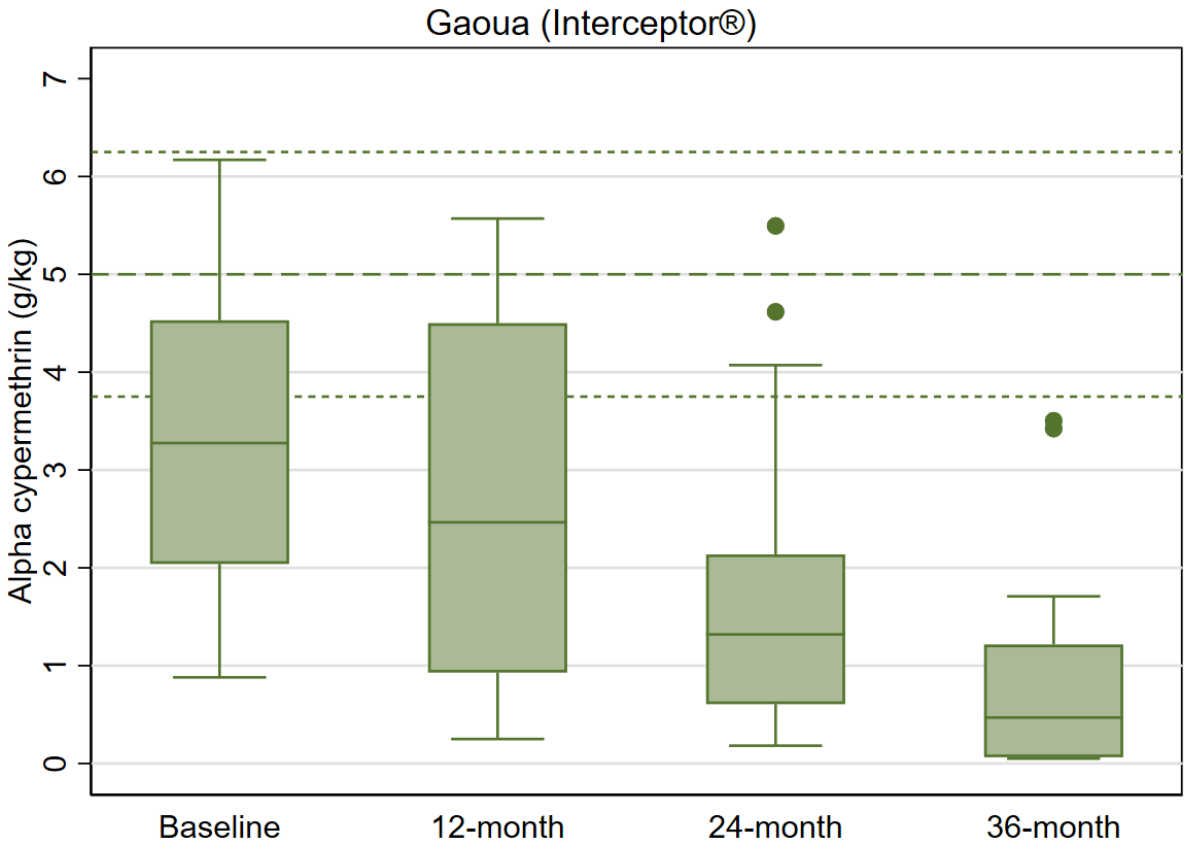
In addition to testing for insecticidal effectiveness, net samples were sent to CRA-W in Belgium for chemical content testing. Interceptor® ITNs are manufactured with 5 g/kg of alpha-cypermethrin (for 75 denier nets). After 36 months of use in the field, the mean alpha-cypermethrin content was 0.8g/kg, corresponded to a 84% loss compared to the original target dose (Table 23). At 36 months, the alpha-cypermethrin content in individual samples ranged from 0.05 g/kg to 3.50 g/kg (Figure 12), below the lower tolerance limit for alpha-cypermethrin content. This decrease in chemical content concentration likely contributed to the decline in insecticidal efficacy demonstrated above.

TABLE 23: CHEMICAL CONTENT RESULTS FOR INTERCEPTOR® ITNS

Gaoua / Interceptor®*	Baseline	12-month	24-month	36-month
Alpha-cypermethrin 5.0 g/kg	**N=30**	**N=30**	**N=30**	**N=30**
Mean (95% CI)	3.33 (2.66-4.00)	2.73 (1.89-3.58)	1.70 (1.16-2.24)	0.8 (0.3-1.3)
Median [IQR]	3.3 [2.0-4.5]	2.5 [0.9-4.5]	1.3 [0.6-2.1]	0.5 [0.1-1.2]

* Interceptor® ITNs are polyester nets manufactured with 5.0 g/kg of alpha-cypermethrin for 75 denier nets.

FIGURE 12: BOX PLOT OF ITN CHEMICAL CONTENT RESULTS FOR INTERCEPTOR® ITNS



Box plot shows the median (horizontal line), interquartile range (box), adjacent values (whiskers), and for each legend, bolder line dishes specify manufacturer threshold (with fine line dishes indicate acceptable range).

3.5.2 ORODARA / PERMANET® 3.0 (DELTAMETHRIN AND PBO SYNERGIST)

The PermaNet® 3.0 brand is a pyrethroid + PBO synergist ITN with AI deltamethrin-only on the net sides and deltamethrin + PBO on the roof. Samples withdrawn this round had been in the field for 36 months. Cone bioassays were performed with an insectary-reared pyrethroid susceptible strain (*An. gambiae* Kisumu) and a pyrethroid resistant strain (*An. coluzzii* VKPER). Field ITNs were tested alongside new PermaNet® 3.0 and new PermaNet® 2.0 net samples as positive controls, and against untreated netting as a negative control. KD60 and 24-hour mortality results are presented for susceptible and resistant mosquito strains separately, and for PermaNet® 3.0 sides and roof pieces separately, within Table 24 and Figures 13 and 14.

PermaNet® 3.0 field side pyrethroid-only samples showed 72% 24-hour mortality against pyrethroid-susceptible mosquitoes 36 months after distribution and mortality in roof panel samples, incorporating a PBO-synergist, achieved 95% 24-hour mortality (Table 24, Figure 13).

Against resistant mosquitos, roof samples, incorporating PBO, had higher mean 24-hour mortality outcomes than pyrethroid-only side samples (26% vs. 11%) (Table 24, Figure 14). Field PermaNet® 3.0 roof samples performed more poorly than new positive control samples, (100% for both KD60 and mortality for new PermaNet® 3.0 samples compared to 45% and 26%, respectively, for field samples). Field PermaNet® 3.0 side samples also performed more poorly than PermaNet® 2.0 controls (17% KD60 and 11% mortality for field PermaNet® 3.0 side samples compared with 43% KD60 and 59% mortality for PermaNet® 2.0 controls).

TABLE 24: PERMANET® 3.0 CONE BIOASSAY RESULTS FOR RESIDUAL EFFICACY OF PYRETHROID AND PBO

Orodara / PermaNet® 3.0	Baseline	12-month	24-month	36-month
Susceptible mosquito strain (*An. gambiae* Kisumu)	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**
Sides (pyrethroid-only)	**N=30**	**N=30**	**N=30**	**N=30**
Knock down 60 minutes	97.2 (95.9-98.5)	98.9 (97.7-100.0)	94.3 (86.4-100.0)	84.9 (78.0-91.9)
Mortality 24 hours	100.0 (100.0-100.0)	99.1 (97.4-100.0)	97.2 (93.8-100.0)	71.9 (61.2-82.6)
Roof (pyrethroid + PBO)	**N=30**	**N=30**	**N=30**	**N=30**
Knock down 60 minutes	100.0 (92.9-100.0)	99.3 (98.9-99.7)	97.2 (92.7-100.0)	95.5 (91.4-99.6)
Mortality 24 hours	100.0 (--)	99.9 (99.7-100.0)	95.4 (88.0-100.0)	95.4 (90.2-100.6)
Untreated control	**N=2***	**N=1***	**N=4***	**N=4***
Knock down 60 minutes	2.1	0	0	0.0 (0.0)
Mortality 24 hours	4.3	0	0.5	0.0 (0.0)
Resistant mosquito strain (*An. coluzzii* VKPER)	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**
Sides (pyrethroid-only)	**N=30**	**N=30**	**N=30**	**N=30**
Knock down 60 minutes	42.4 (33.9-50.8)	42.1 (28.0-56.1)	34.1(23.5-44.7)	17.2 (11.7-22.6)
Mortality 24 hours	23.8 (18.6-29.0)	52.6 (43.4-61.9)	21.1 (9.5-32.7)	10.9 (6.6-15.1)
Roof (pyrethroid + PBO)	**N=30**	**N=30**	**N=30**	**N=30**
Knock down 60 minutes	85.2 (76.8-93.5)	67.9 (57.6-78.2)	69.7 (57.3-82.1)	44.5 (34.5-54.5)
Mortality 24 hours	71.7 (63.9-79.6)	75.1 (69.2-81.1)	51.8 (38.5-64.7)	25.7 (15.7-35.6)
New ITN Sides (pyrethroid-only)	**N=6***	**N=10***	**N=5***	**N=2***
Knock down 60 minutes	26.6 (SD 15.0)	51.0 (SD 24.1)	50.2 (SD 19.9)	43.4 (3.2)
Mortality 24 hours	27.4 (SD 23.1)	52.4 (SD 18.1)	27.0 (SD 12.3)	59.4 (4.9)
New ITN Roof (pyrethroid + PBO)	**N=6***	**N=10***	**N=5***	**N=2***
Knock down 60 minutes	93.9 (SD 6.5)	96.6 (SD 8.3)	92.3 (SD 5.7)	100.0 (0.0)
Mortality 24 hours	100.0 (SD 0.0)	100.0 (SD 0.0)	86.7 (SD 12.3)	100.0 (0.0)
Untreated control	**N=2***	**N=3***	**N=5***	**N=4***
Knock down 60 minutes	0	0	0	0.0 (0.0)
Mortality 24 hours	1	0	0	0.0 (0.0)

* The standard deviation is reported for positive and negative control results due to the low sample sizes for these net types.

FIGURE 13: BOX PLOT OF PERMANET® 3.0 CONE BIOASSAY RESULTS FOR RESIDUAL EFFICACY AGAINST SUSCEPTIBLE *AN. GAMBIAE* KISUMU STRAIN

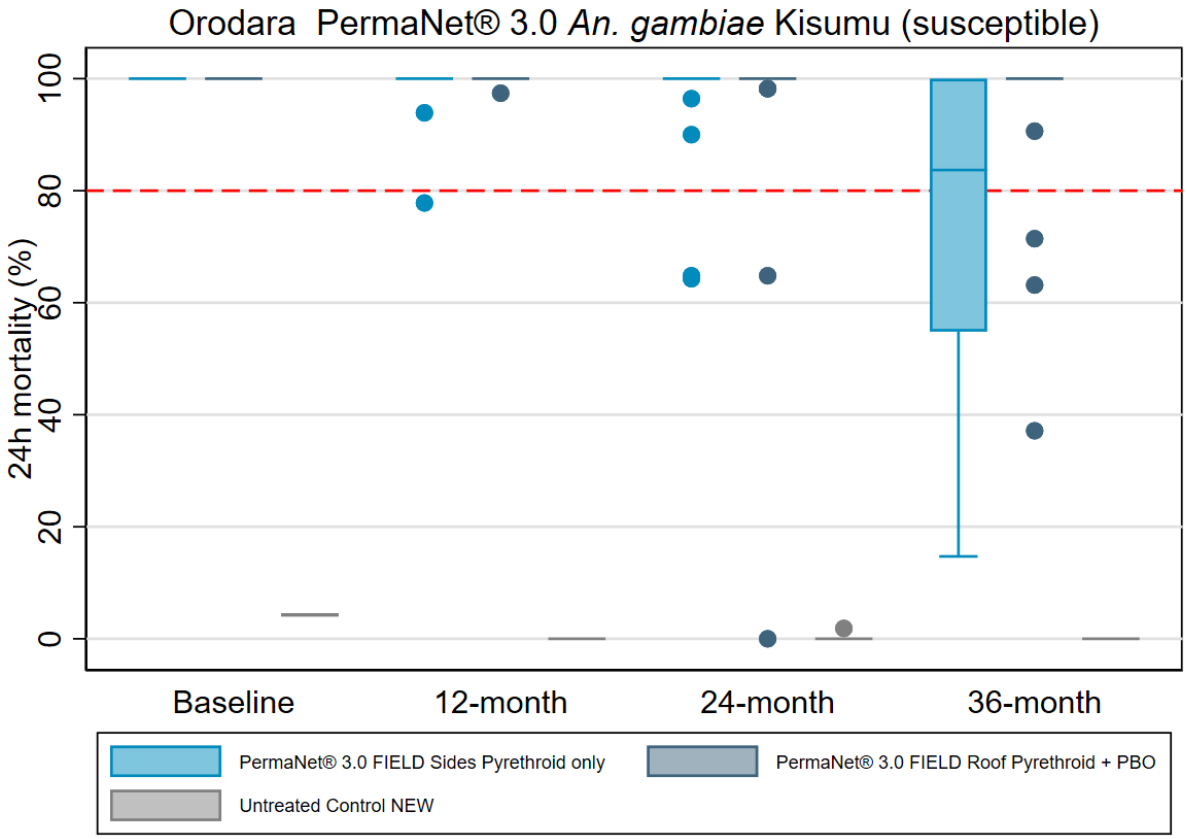
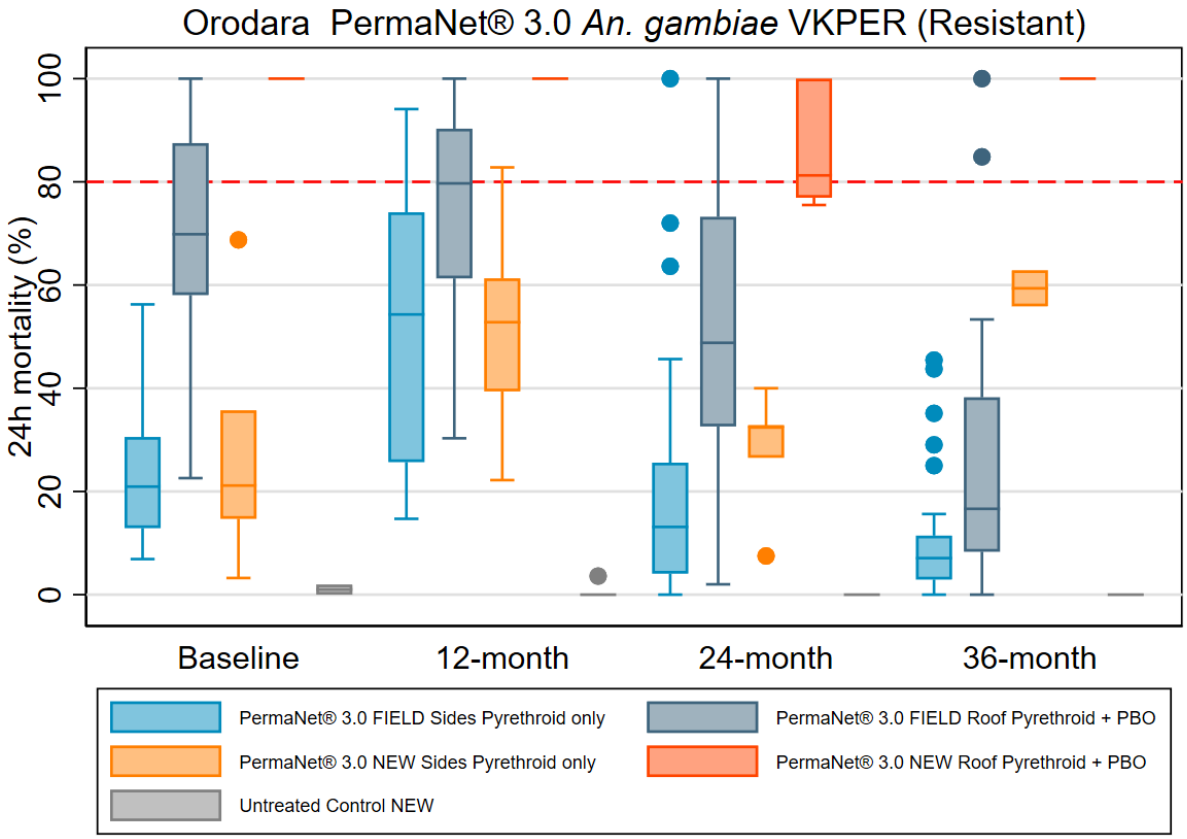


FIGURE 14: BOX PLOT OF PERMANET® 3.0 CONE BIOASSAY RESULTS FOR RESIDUAL EFFICACY AGAINST RESISTANT *AN. COLUZZII* VKPER STRAIN



Results from WHO cone bioassays: the box plot shows the median (horizontal line), interquartile range (box), adjacent values (whiskers) and outliers (circles), line represent WHO optimal effectiveness thresholds for mortality (red, 80%).

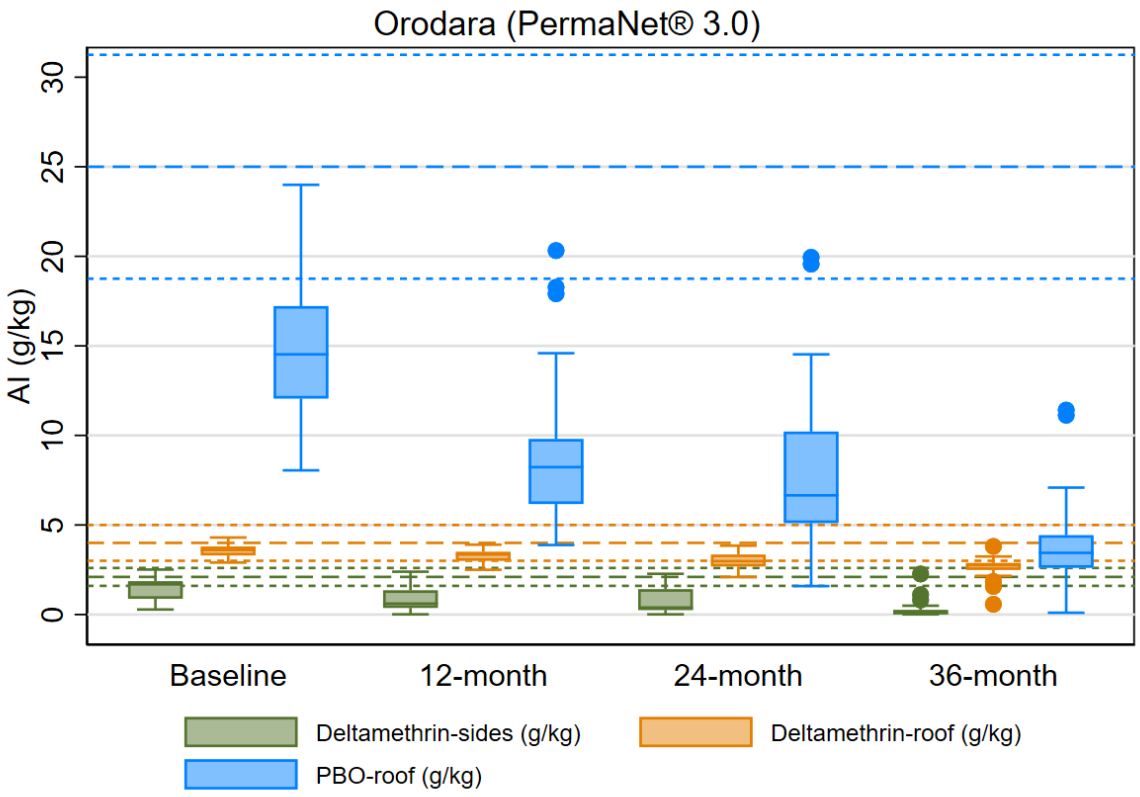
PermaNet® 3.0 ITNs are manufactured with 2.1g/kg of deltamethrin on side panels (for 100 denier nets) and 4 g/kg deltamethrin on the roof panel. PBO is also added to the roof at 25 g/kg. The mean chemical content for each AI and panel was lower than the manufacturer's target across all survey rounds (Table 25). After 36 months of use in the field, the mean deltamethrin content of side panels was 0.3g/kg, corresponding to a loss of 86% compared to the target dose. The mean deltamethrin content on roof samples was 2.6g/kg, corresponding to a loss of 32%. The mean PBO content on roof samples was 3.9g/kg, corresponding to a loss of 84%. At 36 months, PBO content was less than the manufacturer minimum acceptable threshold in all field samples, which may help to explain the 50% reduction in 24-hour mortality in resistant mosquitos between 24- and 36-month survey rounds.

TABLE 25: CHEMICAL CONTENT RESULTS FOR PERMANET® 3.0 ITNS

Orodara / PermaNet® 3.0*	Baseline	12-month	24-month	36-month
Pyrethroid - side panels (deltamethrin 2.1 g/kg)	**N=30**	**N=30**	**N=30**	**N=30**
Mean (95% CI)	1.47 (1.21-1.73)	0.84 (0.61-1.07)	0.78 (0.42-1.13)	0.3 (0.1-0.4)
Median [IQR]	1.7 [0.9-1.9]	0.6 [0.4-1.4]	0.4 [0.3-1.4]	0.1 [0.0-0.3]
Pyrethroid - roof (deltamethrin 4 g/kg)	**N=30**	**N=30**	**N=30**	**N=30**
Mean (95% CI)	3.54 (3.39-3.69)	3.28 (3.11-3.44)	3.02 (2.81-3.23)	2.6 (2.4-2.9)
Median [IQR]	3.6 [3.3-3.8]	3.4 [3.0-3.5]	3.0 [2.7-3.3]	2.8 [2.5-2.9]
PBO - roof (PBO 25g/kg)	**N=30**	**N=30**	**N=30**	**N=30**
Mean (95% CI)	15.20 (1.21-1.73)	9.03 (7.39-10.67)	7.82 (5.86-9.79)	3.9 (2.9-4.8)
Median [IQR]	14.5 [12.1-17.2]	8.2 [6.2-9.8]	6.7 [5.1-10.2]	3.4 [2.6-4.4]

*PermaNet® 3.0 ITNs are manufactured with 2.1g/kg of deltamethrin on side panels (for 100 denier nets) and 4 g/kg deltamethrin on the roof panel.

FIGURE 15: BOX PLOT OF CHEMICAL CONTENT RESULTS FOR FOR PERMANET® 3.0 ITNS



Box plot shows the median (horizontal line), interquartile range (box), adjacent values (whiskers), and for each legend, bolder line dishes specify manufacturer threshold (with fine line dishes indicate acceptable range).

3.5.3 BANFORA / INTERCEPTOR® G2 (ALPHA-CYPERMETHRIN AND CHLORFENAPYR)

The Interceptor® G2 brand is a dual AI ITN with alpha-cypermethrin and chlorfenapyr. Interceptor® G2 samples withdrawn during the 36-month survey round had been in the field for 33 months. Tunnel tests were performed with an insectary-reared pyrethroid-susceptible strain (*An. gambiae* Kisumu) and a pyrethroid-resistant strain (*An. coluzzii* VKPER). Field ITNs were tested alongside new Interceptor® G2 and new Interceptor® net samples as positive controls, and against untreated netting as a negative control. Insecticidal effectiveness was measured by estimating 24- and 72-hour mortality, net penetration, blood feeding, and BFI. Results are presented for susceptible and resistant mosquito strains separately.

While Interceptor® G2 field samples exhibited 99% mean 24-hour mortality against pyrethroid-susceptible mosquitos in the previous three rounds, during the 36-month survey round, 24-hour mortality decreased to 87%. 72-hour mortality remained relatively constant across rounds (99% in previous round compared to 93% in the 36-month round (Table 26, Figure 16). In 36-month field Interceptor® G2 samples, 21% of test mosquitoes were blood-fed, and BFI was 79%% relative to the negative control. Both positive controls (Interceptor® G2 and Interceptor®) showed similar performance in terms of mortality (100%), and lower blood feeding rates (8% and 5%, respectively), translating to 95% BFI in Interceptor® G2 and ~~93~~92% in Interceptor® positive controls.

Interceptor® G2 field samples had a mean 72-hour mortality of 51% against the pyrethroid resistant VKPER strain, down from 81% at baseline. A total of 39% of test mosquitos were blood fed and BFI was 54%. BFI in field samples was similar at 36 months to those recorded at baseline and 12 months but slightly lower than BFI recorded at 24 months (Table 27). New Interceptor® G2 positive control and Interceptor® positive pyrethroid-only control samples had similar 72-hour mortality (63-64%) against the pyrethroid resistant VKPER strain, indicating that chlorfenapyr did not restore mortality at 36 months.

TABLE 26: INTERCEPTOR® G2 TUNNEL TEST BIOASSAY RESULTS FOR ITN RESIDUAL EFFICACY AGAINST SUSCEPTIBLE STRAIN

Banfora / Interceptor® G2	Baseline	12-month	24-month	36-month
Susceptible mosquito strain (*An. gambiae* Kisumu)	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**
Field-sampled ITN (pyrethroid + chlorfenapyr)	**N=30**	**N=30**	**N=24**	**N=30**
Mortality 24 hours	98.8 (97.9-99.7)	99.2 (97.6-100.0)	98.8 (96.8-100.8)	86.9 (80.2-93.6)
Mortality 72 hours	99.1 (98.2-100.0)	99.2 (97.6-100.0)	98.8 (96.8-100.8)	93.3 (90.3-96.2)
Net penetration	32.6 (23.0-42.2)	39.5 (32.1-46.9)	40.5 (31.3-49.7)	41.9 (35.5-48.3)
Blood fed	10.3 (3.2-17.4)	1.3 (0.3-2.3)	23.6 (13.8-33.4)	21.0 (14.5-27.5)
Blood-feeding inhibition	89.2 (81.6-96.8)	97.6 (95.4-99.7)	50.9 (30.4-71.3)	78.8 (72.2-85.4)
New ITN (pyrethroid + chlorfenapyr)	**N=5***	**N=3***	**N=4***	**N=3***
Mortality 24 hours	100.0 (--)	100.0 (--)	99.8 (SD 0.5)	100.0 (--)
Mortality 72 hours	100.0 (--)	100.0 (--)	99.8 (SD 0.5)	100.0 (--)
Net penetration	29.4 (SD 20.1)	16.9 (SD 10.0)	60.9 (SD 6.2)	47.8 (SD 12.8)
Blood fed	4.0 (SD 2.9)	0.0 (--)	30.4 (SD 12.5)	4.8 (SD 2.6)
Blood-feeding inhibition	95.7 (SD 3.1)	100.0 (--)	36.7 (SD 26)	95.2 (SD 2.6)
New ITN (pyrethroid only)	**N=5***	**N=1***	**N=4***	**N=3***
Mortality 24 hours	99.2 (SD 0.9)	100 (--)	100.0 (--)	100.0 (--)
Mortality 72 hours	99.6 (SD 0.6)	100 (--)	100.0 (--)	100.0 (--)
Net penetration	26.7 (SD 5.7)	45.6	44.7 (SD 3.6)	41.0 (SD 3.3)
Blood fed	5.5 (SD 3.0)	0.0 (--)	12.9 (SD 8.2)	7.9 (SD 3.1)
Blood-feeding inhibition	94.1 (SD 3.3)	100.0 (--)	73.2 (SD 17.0)	92.0 (SD 3.4)
Untreated control	**N=5***	**N=5***	**N=4***	**N=3***
Mortality 24 hours	7.2 (SD 4.3)	2.7 (SD 1.8)	1.9 (SD 0.8)	1.7 (SD 0.1)
Mortality 72 hours	9.7 (SD 5.2)	5.0 (SD 1.7)	1.9 (SD 0.8)	2.3 (SD 0.6)
Net penetration	96.0 (SD 4.8)	76.3 (SD 16.3)	75.5 (SD 9.6)	80.5 (SD 5.4)
Blood fed	96.0 (SD 4.8)	66.6 (SD 17.9)	98.9 (SD 1.1)	99.1 (SD 3.2)

* The standard deviation is reported for positive and negative control results due to the low sample sizes for these net types.

TABLE 27: INTERCEPTOR® G2 TUNNEL TEST BIOASSAY RESULTS FOR ITN RESIDUAL EFFICACY AGAINST RESISTANT STRAIN

Banfora / Interceptor® G2	Baseline	12-month	24-month	36-month
Susceptible mosquito strain (*An. gambiae* VKPER)	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**	**Mean (95% CI or SD)**
Field-sampled ITN (pyrethroid + chlorfenapyr)	**N=30**	**N=30**	**N=24**	**N=30**
Mortality 24 hours	71.2 (65.0-77.3)	55.1 (48.1-62.0)	57.3 (43.4-71.2)	44.5 (32.0-57.1)
Mortality 72 hours	84.5 (79.6-89.3)	66.2 (58.6-73.7)	71.8 (57.2-86.3)	50.5 (39.1-61.8)
Net penetration	58.5 (51.8-65.3)	50.6 (44.-2-57.0)	45.1 (37.3-52.7)	43.1 (35.5-50.7)
Blood fed	43.0 (35.2-50.9)	41.7 (34.6-48.8)	35.2 (24.4-46.0)	39.3 (27.3-51.4)
Blood-feeding inhibition	55.2 (47.0-63.4)	55.2 (48.0-62.2)	61.9 (50.3-73.6)	53.6 (37.8-69.4)
New ITN (pyrethroid + chlorfenapyr)	**N=5***	**N=10***	**N=3***	**N=2***
Mortality 24 hours	80.4 (SD 17.8)	73.6 (SD 17.9)	78.3 (SD 10.5)	52.3 (SD 10.9)
Mortality 72 hours	86.9 (SD 13.2)	81.6 (SD 17.7)	94.0 (SD 4.3)	64.0 (SD 24.0)
Net penetration	45.6 (SD 22.0)	38.1 (SD 14.8)	41.1 (SD 18.8)	41.9 (SD 8.1)
Blood fed	36.9 (SD 23.3)	25.2 (SD 19.5)	36.7 (SD 15.4)	65.0 (SD 18.6)
Blood-feeding inhibition	61.3 (SD 23.9)	72.8 (SD 20.9)	60.3 (SD 16.6)	27.3 (SD 9.6)
New ITN (pyrethroid only)	**N=5***	**N=4***	**N=3***	**N=2***
Mortality 24 hours	35.9 (SD 9.6)	59.8 (SD 17.1)	57.9 (SD 9.6)	62.8 (SD 21.9)
Mortality 72 hours	51.3 (SD 6.0)	67.8 (SD 20.5)	47.7 (SD 44.9)	63.3 (SD 21.3)
Net penetration	50.9 (SD 21.3)	72.7 (SD 15.7)	38.2 (SD 85.8)	48.3 (SD 1.2)
Blood fed	38.0 (SD 20.4)	36.8 (SD 29.0)	48.9 (SD 5.9)	53.9 (SD 22.3)
Blood-feeding inhibition	60.8 (SD 19.8)	60.7 (SD 30.5)	47.1 (SD 6.4)	40.3 (SD 15.8)
Untreated control	**N=5***	**N=5***	**N=3***	**N=2***
Mortality 24 hours	3.5 (SD 2.7)	0.8 (SD 0.4)	0.9 (SD 0.9)	1.0 (SD 0.2)
Mortality 72 hours	5.4 (SD 2.3)	1.6 (SD 0.5)	2.3 (SD 0.3)	2.1 (SD 0.4)
Net penetration	100.0 (--)	83.9 (SD 14.5)	81.8 (SD 14.1)	84.2 (SD 9.7)
Blood fed	96.2 (SD 7.0)	92.2 (SD 4.2)	96.5 (SD 6.0)	88.4 (SD 13.9)

* The standard deviation is reported for positive and negative control results due to the low sample sizes for these net types.

FIGURE 16: BOX PLOT OF INTERCEPTOR® G2 TUNNEL TEST BIOASSAY RESULTS FOR RESIDUAL EFFICACY AGAINST SUSCEPTIBLE STRAIN

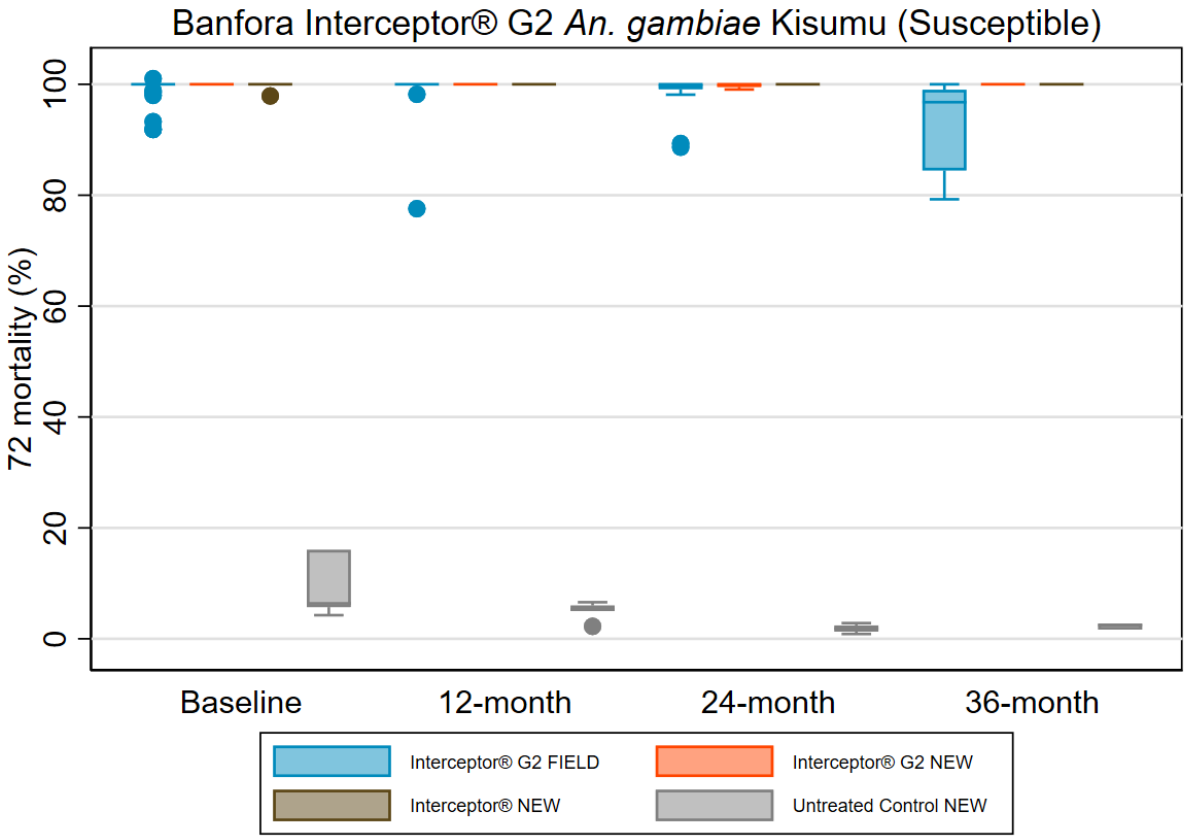
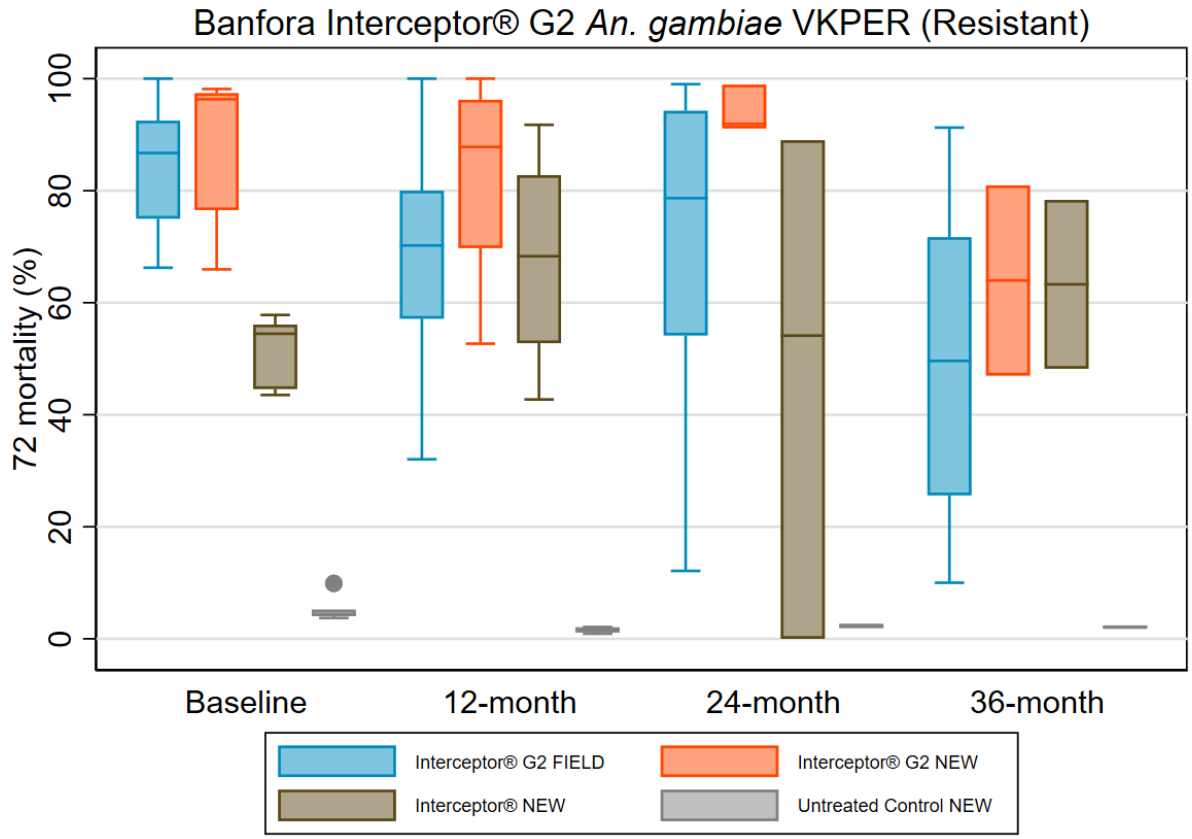


FIGURE 17: BOX PLOT OF INTERCEPTOR® G2 TUNNEL TEST BIOASSAY RESULTS FOR RESIDUAL EFFICACY AGAINST RESISTANT STRAIN



Results from WHO cone bioassays: the box plot shows the median (horizontal line), interquartile range (box), adjacent values (whiskers) and outliers (circles).

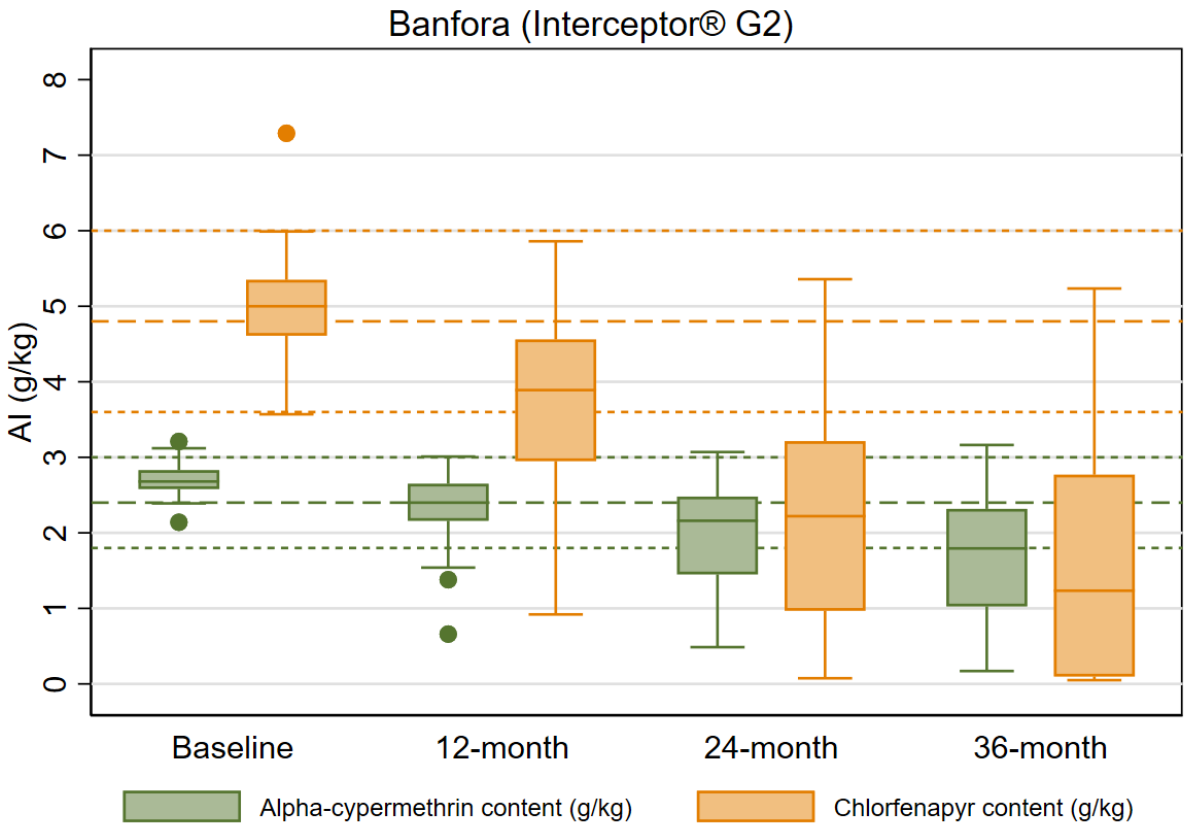
The manufacturer chemical target doses for Interceptor® G2 ITNs is 2.4g/kg of alpha-cypermethrin and 4.8 g/kg of chlorfenapyr. After 36 months, the mean alpha-cypermethrin content was 1.7g/kg, corresponding to a 29% loss in chemical content. The mean chlorfenapyr content was 1.6g/kg, corresponding to a 67% loss in chemical content compared to the manufacturer's target dose (Table 28). The mean chlorfenapyr content decreased by 67% after 36 months of use in the field, from 5.00 g/kg at baseline (1 month) to 1.6 g/kg at the fourth round (36 months). Figure 18 presents the Interceptor® G2 ITN chemical content results for the baseline, 12-, 24-, and 36-month survey rounds. The alpha-cypermethrin content in field samples ranged from 0.17 g/kg to 3.21 g/kg, and the chlorfenapyr content ranged from 0.05 g/kg to 7.29 g/kg. The majority of the samples fell under the manufacturer's minimum acceptable range for chlorfenapyr. This decrease contributed to reduced insecticidal efficacy against resistant mosquitos at 36-months, compared with previous rounds.

TABLE 28: CHEMICAL CONTENT RESULTS FOR INTERCEPTOR® G2 ITNS

Banfora / Interceptor® G2*	Baseline	12-month	24-month	36-month
Alpha-cypermethrin 2.4 g/kg	**N=30**	**N=30**	**N=24**	**N=30**
Mean (95% CI)	2.70 (2.63-2.78)	2.32 (2.15-2.49)	1.95 (1.59-2.31)	1.7 (1.3-2.1)
Median [IQR]	2.7 [2.6-2.8]	2.4 [2.2-2.7]	2.2 [1.5-2.5]	1.8 [1.0-2.3]
Chlorfenapyr 4.8 g/kg	**N=30**	**N=30**	**N=24**	**N=30**
Mean (95% CI)	5.00 (4.70-5.31)	3.54 (3.15-3.92)	2.21 (1.55-2.87)	1.6 (1.0-2.2)
Median [IQR]	5.0 [4.6-5.3]	3.9 [3.0-4.6]	2.2 [1.0-3.2]	1.2 [0.1-2.8]

*Interceptor® G2 ITNs are polyester nets manufactured with 2.4 g/kg of alpha-cypermethrin and 4.8 g/kg of chlorfenapyr on all panels for 100 denier nets.

FIGURE 18: BOX PLOT OF CHEMICAL CONTENT RESULTS FOR INTERCEPTOR® G2 ITNS



Box plot shows the median (horizontal line), interquartile range (box), adjacent values (whiskers), and for each legend, bolder line dishes specify manufacturer threshold (with fine line dishes indicate acceptable range).

3.5.4 HANDLING AND USE OF BIOASSAY NETS

Tables 29-31 present details of reported handling and use for the ITNs undergoing bioassay analysis for each survey period. Overall, nets collected for bioassay were similar to cohort nets not sampled for bioassay. At 36-months, net location (hanging tied or loose, not hanging, stored), sleeping place (bed, mattress, mat/ground), and use (last night, every night) were similar for bioassay and cohort nets. Differences between bioassay and cohort nets included net use by children (21% for bioassay nets, 9% for cohort nets), washing frequency (4.6 for bioassay nets, 3.0 for cohort nets), and use of detergent/bleach (16% for bioassay nets, 26% for cohort nets). Differences in bioassay nets between districts were similar to differences observed in cohort nets between districts.

TABLE 29: HANDLING OF BIOASSAY TEST ITNS

	Baseline	12-month	24-month	36-month
Banfora				
Location found	N=30	N=30	N=24	N=29
Hanging and folded or tied	13.3%	3.3%	33.3%	34.5%
Hanging loose	40.0%	80.0%	62.5%	51.7%
Not hanging	0.0%	0.0%	4.2%	6.9%
Stored unpacked	46.7%	16.7%	0.0%	6.9%
Stored in package	0.0%	0.0%	0.0%	0.0%
Type of sleeping space (if used)	N=16	N=27	N=24	N=29
Bed	56.2%	70.4%	45.8%	48.3%
Mattress	18.8%	22.2%	20.8%	27.6%
mat or ground	25.0%	7.4%	33.3%	24.1%
Net users	N=16	N=27	N=24	N=25
Child(ren) only	12.5%	7.4%	41.7%	8.0%
Child(ren) and adult(s)	37.5%	37.0%	25.0%	36.0%
Adult(s) only	50.0%	55.6%	33.3%	56.0%
Gaoua				
Location found	N=30	N=30	N=30	N=30
Hanging and folded or tied	33.3%	26.7%	63.3%	46.7%
Hanging loose	43.3%	46.7%	23.3%	46.7%
Not hanging	6.7%	6.7%	10.0%	3.3%
Stored unpacked	16.7%	20.0%	3.3%	3.3%
Stored in package	0.0%	0.0%	0.0%	0.0%
Type of sleeping space (if used)	N=27	N=27	N=30	N=30
Bed	11.1%	11.1%	13.3%	0.0%
Mattress	7.4%	22.2%	13.3%	10.0%
mat or ground	81.5%	66.7%	73.3%	90.0%
Net users	N=27	N=27	N=30	N=28
Child(ren) only	11.1%	3.7%	3.3%	7.1%
Child(ren) and adult(s)	44.4%	48.1%	23.3%	32.1%
Adult(s) only	44.4%	48.1%	73.3%	60.7%
Orodara				
Location found	N=30	N=30	N=30	N=30
Hanging and folded or tied	10.0%	3.3%	3.3%	13.3%
Hanging loose	83.3%	96.7%	90.0%	80.0%
Not hanging	3.3%	0.0%	6.7%	6.7%
Stored unpacked	3.3%	0.0%	0.0%	0.0%
Stored in package	0.0%	0.0%	0.0%	0.0%
Type of sleeping space (if used)	N=29	N=30	N=30	N=30
Bed	17.2%	60.0%	63.3%	70.0%
Mattress	20.7%	6.7%	16.7%	13.3%
mat or ground	62.1%	33.3%	20.0%	16.7%
Net users	N=29	N=30	N=30	N=26
Child(ren) only	10.3%	23.3%	23.3%	0.0%
Child(ren) and adult(s)	17.2%	13.3%	40.0%	19.2%
Adult(s) only	72.4%	63.3%	36.7%	80.8%

TABLE 30: REPORTED USE OF BIOASSAY TEST ITNS

	Baseline	12-month	24-month	36-month
Banfora	N=30	N=30	N=24	N=29
Used last night	46.7%	80.0%	95.8%	86.2%
Used last week	N=30	N=30	N=24	N=29
Every night	43.3%	73.3%	91.7%	75.9%
Most nights (5-6 nights)	3.3%	10.0%	4.2%	10.3%
Some nights (1-4 nights)	6.7%	3.3%	0.0%	0.0%
Not used last week	0.0%	3.3%	4.2%	13.8%
Never used	46.7%	10.0%	0.0%	0.0%
Don't know	0.0%	0.0%	0.0%	0.0%
Seasonal use	N=30	N=30	N=24	N=30
Equally in rainy and dry seasons	26.7%	70.0%	75.0%	100.0%
Mainly rainy season	13.3%	20.0%	25.0%	0.0%
Rainy season only	10.0%	0.0%	0.0%	0.0%
Not used	46.7%	10.0%	0.0%	0.0%
Don't know	3.3%	0.0%	0.0%	0.0%
Gaoua	N=30	N=30	N=30	N=30
Used last night	66.7%	63.3%	86.7%	93.3%
Used last week	N=30	N=30	N=30	N=30
Every night	43.3%	60.0%	83.3%	56.7%
Most nights (5-6 nights)	20.0%	6.7%	0.0%	10.0%
Some nights (1-4 nights)	20.0%	10.0%	10.0%	20.0%
Not used last week	6.7%	13.3%	6.7%	6.7%
Never used	10.0%	10.0%	0.0%	0.0%
Don't know	0.0%	0.0%	0.0%	6.7%
Seasonal use	N=30	N=30	N=30	N=30
Equally in rainy and dry seasons	43.3%	46.7%	53.3%	50.0%
Mainly rainy season	43.3%	33.3%	46.7%	26.7%
Rainy season only	3.3%	10.0%	0.0%	23.3%
Not used	10.0%	10.0%	0.0%	0.0%
Don't know	0.0%	0.0%	0.0%	0.0%
Orodara	N=30	N=30	N=30	N=30
Used last night	93.3%	93.3%	90.0%	86.7%
Used last week	N=30	N=30	N=30	N=30
Every night	90.0%	96.7%	86.7%	76.7%
Most nights (5-6 nights)	3.3%	3.3%	3.3%	13.3%
Some nights (1-4 nights)	0.0%	0.0%	3.3%	3.3%
Not used last week	3.3%	0.0%	6.7%	6.7%
Never used	3.3%	0.0%	0.0%	0.0%
Don't know	0.0%	0.0%	0.0%	0.0%
Seasonal use	N=30	N=30	N=30	N=30
Equally in rainy and dry seasons	80.0%	90.0%	66.7%	96.7%
Mainly rainy season	13.3%	10.0%	23.3%	3.3%
Rainy season only	3.3%	0.0%	10.0%	0.0%
Not used	3.3%	0.0%	0.0%	0.0%
Don't know	0.0%	0.0%	0.0%	0.0%

TABLE 31: HANDLING OF BIOASSAY TEST ITNS

	Baseline	12-month	24-month	36-month
Banfora	N=30	N=30	N=24	N=29
Ever washed	6.7%	66.7%	91.7%	93.1%
Washes in the last 6 months among all nets (if known)	N = 30	N = 30	N = 24	N = 27
Mean	0.07	2.03	2.38	1.61
Median	0.0	1.0	2.5	1.5
Washes in the last 6 months among washed nets	N = 2	N = 20	N = 22	N = 26
Mean	1.00	3.05	2.59	1.67
Median	1.0	1.5	3.0	2.0
Soap used for last wash	N=2	N=20	N=22	N=29
Soap bar	100.0%	70.0%	68.2%	62.1%
Detergent or bleach	0.0%	30.0%	27.3%	31.0%
Mix	0.0%	0.0%	4.5%	0.0%
None	0.0%	0.0%	0.0%	0.0%
Don't know	0.0%	0.0%	0.0%	6.9%
Where dried after last wash	N=2	N=20	N=22	N=27
Shade	100.0%	70.0%	54.5%	81.5%
Sun	0.0%	30.0%	45.5%	18.5%
Don't know	0.0%	0.0%	0.0%	0.0%
Gaoua	N=30	N=30	N=30	N=30
Ever washed	73.3%	83.3%	96.7%	96.7%
Washes in the last 6 months among all nets (if known)	N = 30	N = 29	N = 26	N = 25
Mean	2.40	3.24	5.04	3.48
Median	1.5	2.0	3.0	3.0
Washes in the last 6 months among washed nets	N = 22	N = 24	N = 25	N = 24
Mean	3.27	3.92	5.24	3.62
Median	2.0	3.0	3.0	3.0
Soap used for last wash	N=21	N=25	N=29	N=30
Soap bar	66.7%	52.0%	51.7%	66.7%
Detergent or bleach	23.8%	32.0%	24.1%	0.0%
Mix	9.5%	16.0%	24.1%	30.0%
None	0.0%	0.0%	0.0%	0.0%
Don't know	0.0%	0.0%	0.0%	3.3%
Where dried after last wash	N=19	N=25	N=29	N=29
Shade	36.8%	20.0%	13.8%	24.1%
Sun	63.2%	80.0%	86.2%	75.9%
Don't know	0.0%	0.0%	0.0%	0.0%
Orodara	N=30	N=30	N=30	N=30
Ever washed	56.7%	100.0%	90.0%	100.0%
Washes in the last 6 months among all nets (if known)	N = 26	N = 30	N = 23	N = 25
Mean	0.88	3.57	2.78	9.20
Median	1.0	2.0	2.0	10.0
Washes in the last 6 months among washed nets	N = 14	N = 30	N = 20	N = 25
Mean	1.64	3.57	3.20	9.20
Median	1.5	2.0	2.0	10.0
Soap used for last wash	N=18	N=30	N=27	N=30
Soap bar	33.3%	63.3%	77.8%	83.3%
Detergent or bleach	16.7%	36.7%	22.2%	16.7%
Mix	0.0%	0.0%	0.0%	0.0%
None	50.0%	0.0%	0.0%	0.0%
Don't know	0.0%	0.0%	0.0%	0.0%
Where dried after last wash	N=18	N=30	N=27	N=30
Shade	50.0%	46.7%	51.9%	70.0%
Sun	44.4%	53.3%	48.1%	30.0%
Don't know	5.6%	0.0%	0.0%	0.0%

4. CONCLUSIONS

4.1 SUMMARY OF FINDINGS

This is the second durability monitoring study completed under the PMI VectorLink Project to investigate novel ITNs (PermaNet® 3.0 a PBO-synergist, Interceptor® G2 a dual AI ITN). This 36-month round of the Burkina Faso durability monitoring study successfully visited 362 households across three districts, where three different brands of ITNs were distributed during the 2019 mass campaign: Interceptor® G2 in Banfora, Interceptor® in Gaoua and PermaNet® 3.0 in Orodara. At baseline, a total of 959 ITNs were recorded as having been distributed to cohort households (including those lost before the baseline round). At 36-months, 230 (24%) ITNs from the 2019 campaign were still present (59 in Banfora, 77 in Gaoua, 103 in Orodara).

Total cohort ITN attrition at 36-months was lowest in Orodara (54%), higher in Gaoua (64%), and highest in Banfora (70%), however, differences between districts were not statistically significant. In Gaoua and Orodara, the most common reason for attrition was ITNs being discarded (41% and 31% respectively), while ITNs were most commonly given away to others in Banfora (48%). The second most common reason for attrition was given away to others in Gaoua and Orodara (18% and 16% respectively) and discarded in Banfora (20%). Attrition from ITNs being given away to others was higher in Banfora (48%) compared to in Gaoua (18%, $p<0.001$) and Orodara (16%, $p<0.001$), while attrition from ITN being discarded was higher in Gaoua (41%) compared to in Banfora (20%, $p=0.002$).

The combination of durability risk factors and the net's intrinsic physical properties can either facilitate or protect nets from damage. The 36-month study clearly found more prevalent durability risk factors in Gaoua district. This may partially explain why attrition due to wear and tear was highest in Gaoua, and may also, somewhat counterintuitively, explain why measures of physical integrity did not differ between districts. In Gaoua, cohort nets that were in poor physical condition were discarded (41% were discarded at 36-months) and replaced with newer nets in better condition (from baseline to 36-months, 43% of nets were taken out of storage and hung), effectively increasing the overall physical integrity of cohort ITNs remaining in study households. Physical integrity is also affected by sustained cohort net use (use every night the previous week was highest in Orodara) and the physical properties of the different ITNs brands distributed in each district.

At 36-months, 48% of cohort nets in Banfora, 37% in Gaoua, and 54% in Orodara had survived in serviceable condition, corresponding to an estimated median life of 2.6 (95% CI: 1.9-3.2) years in Banfora, 2.4 (95% CI: 1.9-2.9) years in Gaoua, and 3.2 (95% CI: 2.5-4.0) years in Orodara. Although differences in survivorship were not statistically significant between sites at 36-months ($p=0.77$), current findings suggest that lower cohort net attrition, and higher cohort net physical integrity in Orodara resulted in higher survivorship. Net attrition and physical integrity measures also did not differ significantly between districts.

At 36-months, no households in Gaoua reported exposure to net messaging in the past six months. This compares with 39% of households in Banfora and 47% in Orodara. Considering the low proportion of respondents with favorable attitudes towards nets and net care and repair in Gaoua (7% and 6% respectively), it's possible that a lack of net messaging about the benefits of net use, care, and repair, contributed to negative attitudes, and in turn, to the higher observed durability risk factors and the lower survival rates in Gaoua. Exposure to net messaging and respondent attitudes may have negatively affected net use in Gaoua where the discrepancy between all ITN population access and use was relatively large compared to that in Banfora and Orodara (2 percentage point lower in Banfora, 13 percentage points lower in Gaoua, <1 percentage points lower in Orodara). The current data suggests that these causal chains are plausible, however, the degree to which lower cohort net survival and ITN use in Gaoua can be attributed to a lack of net messaging is unclear.

Optimal effectiveness of Interceptor® field samples decreased from 100% at baseline to 60% at 36-month round. This was likely due to a reduction of the alpha-cypermethrin concentration in sampled nets. Mortality in PermaNet® 3.0 ITNs tested against resistant mosquitos was lower than previous rounds. 24-hour mortality in field roof samples containing deltamethrin + PBO, was 26% at 36-months, compared to 72% at baseline. This is likely due to a decrease in PBO over time. At 36 months, a decrease in chlofenapyr in field Interceptor® G2 samples led to reduced 72-hour mortality (87% at baseline compared to 64% at 36 months).

After 36 months, 84% loss of alpha-cypermethrin was measured in Interceptor® ITNs, an 84% loss of PBO was measured in PermaNet® 3.0 ITNs, and a 67% loss of chlorfenapyr was measured in Interceptor® G2 ITNs, compared to the original target doses. These losses help explain reduced insecticidal efficacy of studied nets at the survey's endline round.

4.2 KEY CHALLENGES AND LESSONS LEARNED

Data collection during the 36-month survey was conducted between July 4-21, 2022, in Orodara district and between August 4-20, 2022, in Gaoua and Banfora districts. These data collection dates correspond to 36 months post-campaign in Orodara and Gaoua districts and 33 months post-campaign in Banfora district. Originally, data collection was planned for November 2022 in Banfora district (36 months post-campaign) but was rescheduled to earlier, before the start of the planned 2022 mass distribution campaign. Not doing so would have resulted in a flood of new ITNs in study households.

Only 14 clusters were visited during the 36-month survey in Banfora district because clusters Nadrifa, Kankounadeni II, Ouangolodougou could not be visited due to security concerns in the region. This resulted in missing data for 27 households and 43 cohort nets. In anticipation of the security risk, six additional bioassay nets were collected in Banfora district to ensure a total of 30 nets were available for testing. The lack of data was not significant and should not materially limit the conclusions of the study. Working closely with health and administrative authorities to ensure the safety of data collection staff while in the field will remain a priority for future durability studies.