FINAL REPORT
After 36 months follow-up
APRIL 2019

Durability Monitoring of LLINs in **Myanmar**

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1 Executive Summary

This report details results from the 36-month follow-up of durability monitoring in Myanmar, a study funded by the President's Malaria Initiative (PMI) and the U.S. Agency for International Development (USAID). The prospective three-year study monitored the physical and insecticidal durability and mean survival of two brands of s, distributed by the National Malaria Control Programme (NMCP) Myanmar. The primary objectives of the study were to assess and compare the physical and insecticidal durability of the two LLIN brands and to identify the major determinants of field performance.

Two LLIN brands (PermaNet 2.0 and DawaPlus 2.0) were distributed during a mass campaign in 32 villages of Tamu Township in December 2015. A baseline durability monitoring assessment was conducted in June 2016, the 12-month assessment was carried out in December 2016, the 24-month assessment in December 2017, and this 36-month assessment in December 2018. Out of 290 households enrolled at baseline, 242 households could be reassessed after 36 months, 13 households were lost to follow-up, and 35 households lost their cohort nets.

At this 36-month assessment, 25.2% of households in the PermaNet 2.0 site and 33.1% in DawaPlus 2.0 site reported ever storing food in the sleeping room. More or less equal numbers of households in both sites mentioned always cooking in the sleeping room (i.e., 12.2% in the PermaNet 2.0 site and 9.7% in the DawaPlus 2.0 site). Rodents were observed during the last six months, which were 79.1% and 65.3% of households in the PermaNet 2.0 site and the DawaPlus 2.0 site, respectively.

Across both sites, 83.2% of cohort nets were used on a mat or ground. The number of cohort nets observed hanging loose was similar at both the PermaNet 2.0 site (67.6%) and the DawaPlus site (63.9%). The proportion of cohort nets that had ever been washed was almost the same in both the PermaNet 2.0 site (85.1%) and DawaPlus 2.0 site (88.0%). The PermaNet 2.0 site had 10.5% of cohort nets and the DawaPlus 2.0 site had 8.3% of cohort nets that were dried on the fence or bush after being washed.

More cohort nets in the PermaNet 2.0 site (48.9%) were used the previous night than those at the DawaPlus 2.0 site (33.5%). Similarly, 47.2% of cohort nets in the PermaNet 2.0 site and 31.9% of those in the DawaPlus 2.0 site were reportedly used every night in the past week.

No significant difference was noted in the overall attrition between PermaNet 2.0 site (33.4%) and DawaPlus 2.0 site (35.2%). The main cause of attrition were nets were given away for 24.4% of PermaNet 2.0 nets and 24.6% of DawaPlus 2.0 nets. Only 7.8% of PermaNet 2.0 and 8.5% of DawaPlus 2.0 nets were discarded due to wear and tear.

The survival estimate of the cohort nets was slightly lower in the DawaPlus 2.0 site (78.2%) than in the PermaNet 2.0 site (84.6%), but the difference was not statistically significant. In cone bio-assays, the proportion of DawaPlus 2.0 nets that met World Health Organization (WHO) optimal effectiveness criteria was lower than those of PermaNet 2.0 nets (3.3% versus 10%). Furthermore, 86.7% of PermaNet 2.0 nets met minimal effectiveness criteria, while 76.7% of DawaPlus 2.0 nets met this criteria.

Chemical residue analysis from the 36-month data collection indicates that a mean of 1.10 g/kg deltamethrin was found on the DawaPlus 2.0 samples (loading dose 2.0 g/kg), compared to 0.97 g/kg for the PermaNet 2.0 (loading dose 1.4g/kg) samples. These results are similar to the chemical residue analysis performed after 24 months, when DawaPlus 2.0 samples had a mean of 1.17 g/kg and PermaNet 2.0 had a mean of 0.99 g/kg.

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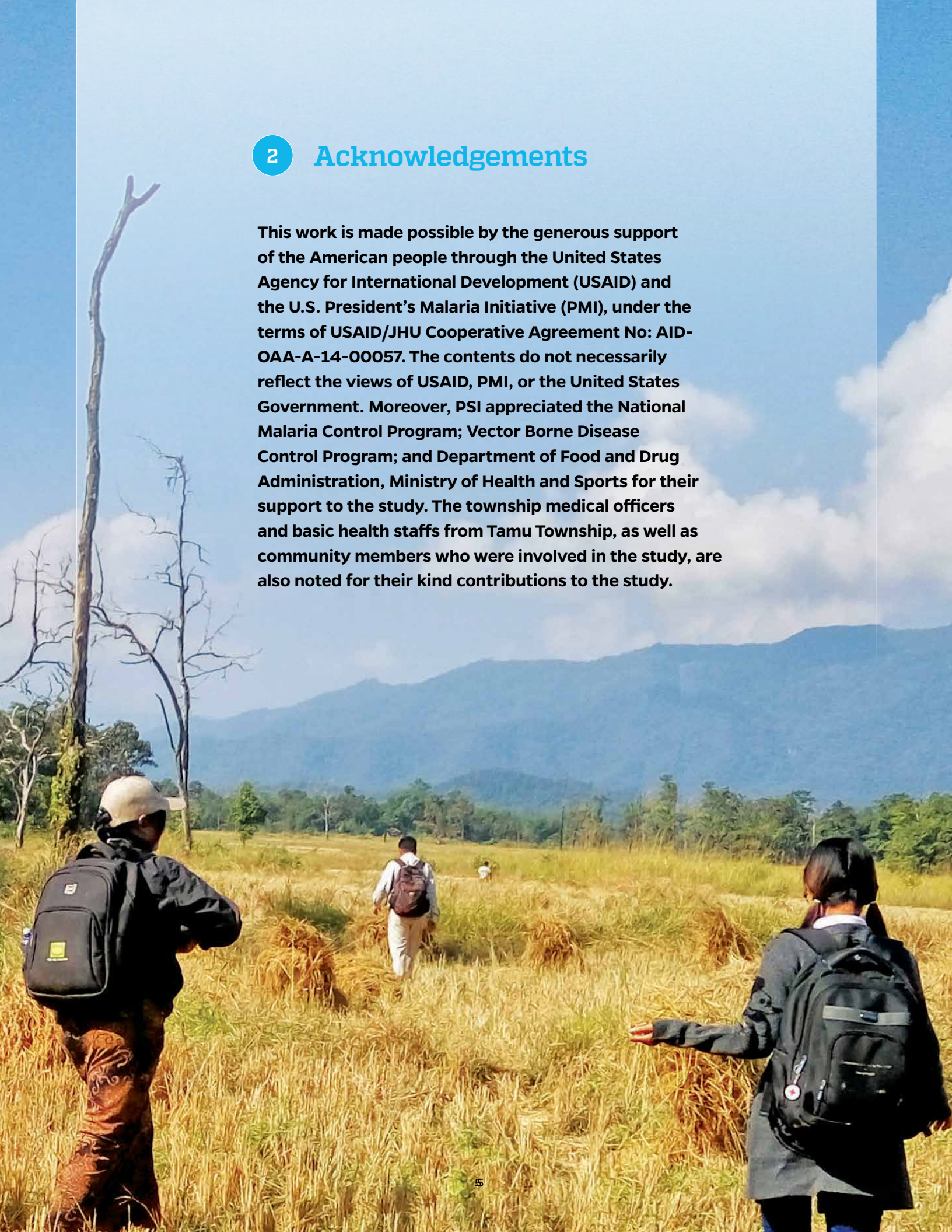

2 Acknowledgements

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3 Background

The use of long-lasting insecticidal nets (LLINs) is an effective malaria prevention measure in Myanmar that provides personal protection and reduces malaria transmission. The Myanmar National Malaria Control Programme (NMCP) aims to achieve universal coverage with LLINs for populations in malaria transmission areas. LLINs are free for targeted populations through mass campaigns and continuous distribution channels with locally appropriate social and behavior change communication/information, education, and communication approaches to promote the correct and effective usage of LLINs. The NMCP and malaria implementing partners are distributing LLINs to cover the entire population residing at the established settlements, such as villages, internally displaced persons camps, and prisons. While the mobile migrant population has also been provided with LLINs, coverage with LLINs for this population is still limited[1].

The target rate for a large sized LLIN is 1.8 persons per net, in line with World Health Organization (WHO) standards, while one single net is distributed per migrant person. According to the malaria micro-stratification plan, the distribution of LLINs will be prioritized for static and mobile populations, based on risk stratification areas, and labeled as strata 3a, 3b, and 3c. In 2015, 100% LLIN scale-up was achieved for the target population in stratum 3a areas; the Global Fund-New Funding Model, and the Regional Artemisinin-resistance Initiative, President's Malaria Initiative-U.S. Agency for International Development (PMI-USAID), and Millennium Development Goal 3 provided support. In 2017, LLINs were distributed to farming communities, forest workers, gem/gold miners, pregnant women, development project employees, agriculture and plantation site workers, and employees from camps associated with commercial projects within the malaria risk stratum 3b and 3c[1].

Continuous distribution focuses on making LLINs accessible to high-risk individuals and groups in malaria endemic areas to maintain coverage between mass distributions in targeted communities. The frequency of these LLIN distributions depends on the expected lifespan of LLINs procured. The effective LLIN lifespan is three to five years, depending on the type of LLIN distributed and how it is handled. The factors determining LLIN durability need to be considered to achieve universal coverage of LLIN for effective protection from malaria. Factors, including washing frequency, detergent usage during washing, cooking location, type of cooking fuel, and net care behaviors are associated with LLIN durability and the insecticidal integrity of LLINs[2].

In this context, the importance of net durability and the "average useful life" of a net is increasingly recognized as one of the critical factors a malaria program needs to know as it determines how often the nets need to be replaced and what type of net to procure. This is reflected in the WHO guidelines for monitoring LLINs in the field, which recommends that countries routinely monitor net durability[3].

In 2013, WHO released additional technical guidance outlining how to estimate the actual physical survival and the median survival time calculated from multiple data points. This has facilitated a number of studies that apply this new methodology of measuring performance of different LLINs in different locations. The results suggest that the physical durability of similar products may vary significantly, and differences are largely driven by environmental and behavioral factors. Similarly, this study aims to provide evidence for the NMCP and stakeholders to help in future LLIN distribution in Myanmar.

[1]National Plan for Malaria Elimination in Myanmar 2016-2030, Ministry of Health and Sports, Myanmar

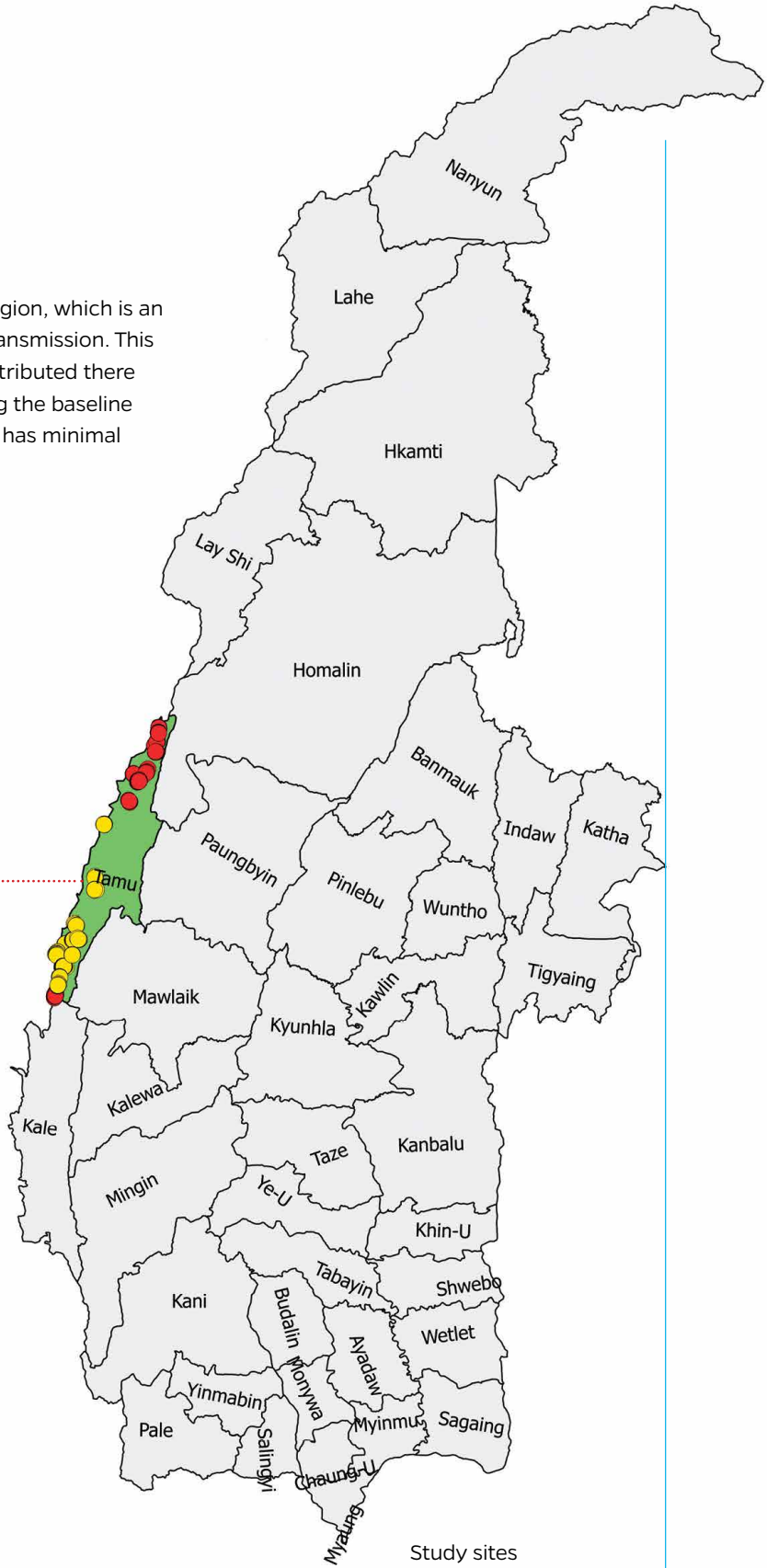
[2]WHO policy and practice Monitoring the durability of LLIN http://www.searo.who.int/publications/journals/seajph/seajphv3n1p81.pdf

[3]WHO: Guidelines for monitoring the durability of long-lasting insecticidal mosquito nets under operational conditions http://apps.who.int/iris/bitstream/10665/44610/1/9789241501705_eng.pdf

4 Methods

4.1 Site

PSI conducted the study in Tamu Township, Sagaing region, which is an area of Myanmar with the potential for high malaria transmission. This site was selected because two brands of LLIN were distributed there during the mass campaign of December 2015, allowing the baseline assessment to be carried out within six months, and it has minimal difficulties with logistics, security, and accessibility.



[4]Annual parasite incidence (API) of Tamu Township in 2015 was 1.66 and 1.19 in 2016 according to NMCP.

4.2 Brands monitored

Two LLIN brands were included in the study (DawaPlus 2.0 and PermaNet 2.0). Both are 100-denier polyester LLINs treated with deltamethrin. The only difference between the sites was the brand of LLIN distributed. The local team from the NMCP ensured that only designated LLIN brands were distributed to the respective sites.

4.2.1 Pre-shipment testing

All LLINs procured with donors' funds are subject to pre-shipment quality control, examining all the parameters determined by WHO Pesticide Evaluation Scheme. Two LLIN brands were included in the study (DawaPlus 2.0 and PermaNet 2.0). Pre-shipment testing from the manufacturers and conformance testing from the USAID|DELIVER PROJECT confirmed the compliance of both LLIN brands on all physical and chemical product quality parameters (mesh size, dimensional stability on washing, netting burst strength, and total deltamethrin content).

4.3 Design summary

This study follows guidance from PMI for LLIN durability monitoring (www.durabilitymonitoring.com); this prospective study follows a cohort of LLINs distributed through a mass campaign in December 2015. During the campaign, 7,000 DawaPlus 2.0 and 7,000 PermaNet 2.0 were distributed in 32 villages of Tamu Township in December 2015. Within six months after the mass campaign, a representative sample of campaign nets from the study location was identified through a cluster household survey, which included all campaign nets from consenting households forming the study cohort. Households were selected using simple random sampling from household lists established on the day of the survey. The sample included 15 clusters for each brand of LLIN. A cluster referred to a village or a section of village with 50–200 households. From each cluster, 10 households were selected, resulting in a total sample of 300 households (150 households per brand). The sample size was targeted at detecting a deviation of 10%–11% points from the expected 50% survival, after three years of comparing the brands.

All campaign nets in each study household were labeled with a unique identifier at the baseline and

their presence and physical condition were assessed at baseline and 12-, 24-, and 36-month follow-up. Net use and attitude were also assessed at each follow-up visit.

At the 12-month and 24-month assessments, sub-samples of campaign nets were selected for insecticide effectiveness testing (bio-assays). In addition, chemical residue testing was conducted at the 24-month assessment. At the 36-month assessment, sub-samples of cohort LLINs were randomly selected for both bio-assays and chemical residue testing.

4.4 Field work

The PSI Myanmar research department conducted a refresher field team training from November 27 to December 3, 2018, prior to the field data collection. The training covered the study design and protocol, sampling procedures, previous results, questionnaires, and hole assessments.

The data collection team comprised one field monitoring supervisor and four field teams deployed from PSI Myanmar; each team comprised a team leader and two data collectors. The field teams were supported by local staff from NMCP and the Ministry of Health and Sports. Data collection lasted for 14 days.

For insecticidal assessment, field teams collected two cohort nets per cluster using systematic random sampling from the list of remaining cohort nets at the 24-month assessment, for a total of 60. If the household refused or a selected net was not found, they selected and collected another random cohort net.

The bio assay assessment was conducted at the VBDC laboratory in Yangon, in accordance with WHO guidelines. Chemical residue testing on the same nets was carried out at the laboratory of Department of Food and Drug Administration in Nay Pyi Taw.

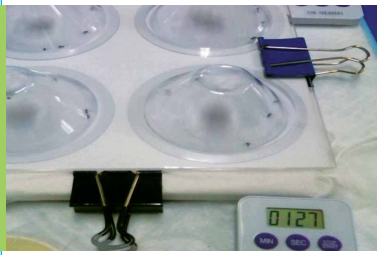
4.5 Data management

Data collection was done on Android tablets using Open Data Kit (ODK) software, offline version. Every household was visited by three interviewers for questionnaire and hole measurement. One interviewer conducted the questionnaire with the tablet and used a notebook to record the answers, especially for open-ended questions. At the same time, the other two team members performed hole measurement for the cohort LLINs. Then, they checked the entered data in the tablet before leaving the household. The data sets were then exported to Stata format. Stata version 14.2 was used for all data cleaning and analysis.

4.6 Analysis

All analyses followed the guidelines on data preparation, cleaning, and management, which were developed by VectorWorks and Tropical Health. Slight adjustments and modifications were made to the syntax files to reflect the study design in Myanmar, and all the changes were documented. For continuous variables, arithmetic means were used to describe the central tendency and the t-test for comparison of groups for normally distributed data. Otherwise, median and non-parametric tests were used. Proportions were compared by contingency tables and the Chi-squared test was used to test for differences in proportions. Wealth index was computed at the household level using principal component analysis (PCA). The variables for household amenities, assets, livestock, and other characteristics related to a household's socio-economic status, were used for the computation.

Household attitudes toward care and repair were measured using Likert score questions; these are summarized by recoding the four-level Likert scale for a value of -2 for "strongly disagree," -1 for "disagree," +1 for "agree," and +2 for "strongly agree." These attitude scores for each respondent were then summed and divided by the number of statements to calculate an overall attitude score; zero (0) represents a neutral result and positive values a positive result. Respondents were asked various questions about their action on net supply and use, and about net care and repair. For calculation of confidence intervals around estimates, the intra- and between-cluster correlation was taken into account.



Bio-assay assessments of 60 collected nets were conducted in the Vector Borne Disease Control (VBDC) laboratory, Yangon. From each collected net, a piece of 30 x 30 cm was cut from the five sites (roof, four sides). The cone assay test was used. For the tests, insectary-raised, two- to five-day-old, unfed females of a pyrethroid sensitive strain were used (Aedes aegypti [Rockefeller] strain). They did not use wild-caught mosquitoes. Five mosquitoes at a time were introduced into the WHO cones. Four cones were applied simultaneously onto the net sample, with a three-minute exposure of the vectors. After exposure, females were grouped into batches of 20 in 200 mL plastic cups and maintained at 28°C ± 2°C and 50% ± 10% relative humidity, with honey solution provided. For each series, a control was run with no exposure and results were used if control mortality was less than 5%. Numbers of mosquitoes knocked down were recorded at 30 and 60 minutes and the knockdown rate at 60 minutes (KD60)was calculated. Percentage mortalities were recorded after 24 hours using immediate and delayed mortality, as defined by WHO guidelines. For each collected net, the percentage of mosquitoes knocked down at 60 minutes after exposure, and percentage mortality after 24 hours, were calculated.

Chemical residue testing of deltamethrin for 60 collected nets (30 each for PermaNet 2.0 and DawaPlus 2.0) were conducted in pharmaceutical chemical laboratory, Department of Food and Drug Administration (DFDA), Nay Pyi Taw, Myanmar (ISO/IEC 17025: 2017 accredited laboratory). From each collected net, a piece of 30 x 30 cm was cut from the five sites (roof, four sides) for chemical residue testing. The testing was performed according to the reference method: determination of deltamethrin content by high-performance liquid chromatography (HPLC) (CIPAC/LN/(M)/3). It was carried out using the calibrated Agilent Infinity 1260 HPLC system and the deltamethrin British Pharmacopoeia (BP) reference standards. A total of 300 tests (five pieces per net) were conducted, and the average remaining concentration for each net was calculated in a g/kg unit. Then, the average remaining percentage of deltamethrin was calculated against the factory reference values: 1.4 g/kg for PermaNet 2.0 and 2.0 g/kg for DawaPlus 2.0.

4.7 Ethical Clearance

Ethical clearance was obtained from the Institutional Review Board (IRB) of Johns Hopkins University (JHU), Baltimore, USA (IRB No. 6970), and Ethical Review Committee of Department of Medical Research, Ministry of Health and Sports, Myanmar (Ethics/DMR/2016/046A). The extension of local ethical approval was applied to the Ethical Review Committee of Department of Medical Research yearly, and approval for this round was received on December 2018 (Ethics/DMR/2016/046E/2018). A respective extension from JHU IRB was also obtained.

4 Results

In this 36-month assessment, nine households were lost to follow-up, out of 272 households still active after 24 months. Out of 263 interviewed households, only 242 households still had cohort nets (Figure 1a). The knowledge and attitude scores on net handling were similar in all four rounds of assessment. The overall attrition rate increased to 34.2% from 19.9% in the baseline, mostly due to nets being given away (24.5%). Regarding physical integrity, 93.2% of cohort nets present for 36-month follow-up were still in serviceable condition. The proportion of nets surviving in serviceable condition, including nets discarded due to wear and tear, dropped to 81.7% in this assessment.

5.1 Sample

All 272 active households from the previous 24-month assessment were revisited. In this assessment, 13 households moved away and were lost to follow-up (Figure 1a and 1b). Of the 582 cohort nets recruited at the baseline, 426 nets (73.2%) were still present at the households, 18 nets (3.1%) were used by family members elsewhere, and 16 nets (2.75%) were not found for unknown reasons. Moreover, 56 (9.6%) nets were discarded, 38 (6.5%) nets were given away, 12 (2.1%) nets were lost for unknown reasons, and 16 (2.7%) nets were lost from 13 households that moved away (Figures 5 and 6).

Figure 1a: Follow-up status of households recruited at baseline at PermaNet 2.0 Site

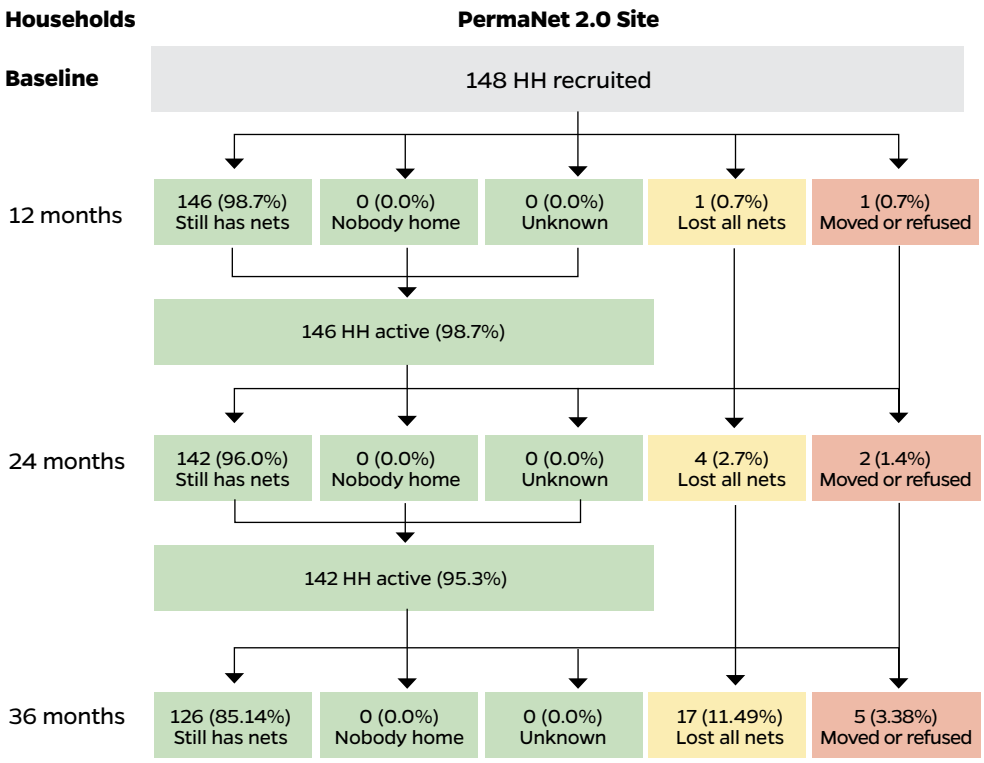
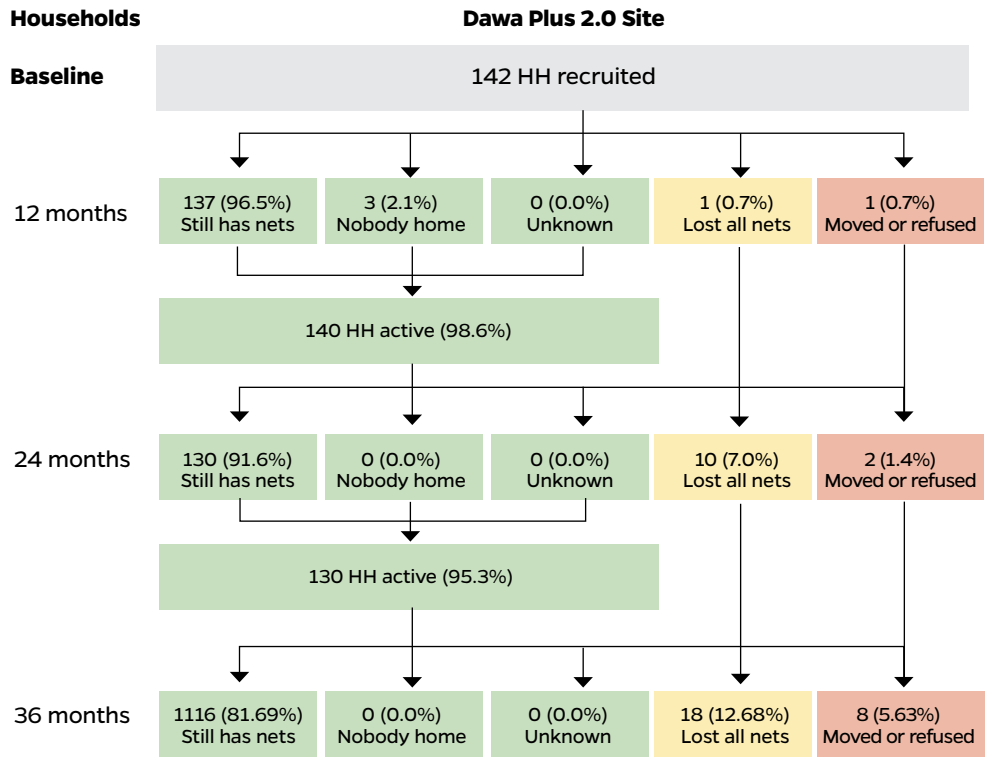


Figure 1b: Follow-up status of households recruited at baseline at Dawa Plus 2.0 Site



5.2 Socio-Demographic characteristics

Comparing the households that participated in the baseline and 36-month surveys (N=263), the data were explored for any demographic or socio-economic changes during the three years of the study.

The average number of household members remained constant in Tamu, with 5.6 in the baseline and 5.4 in the 36-month survey. The proportion of households headed by females increased slightly—from 11.8% to 16.7% in the 36-month survey. As expected, the mean age of the heads of household increased about three years during the study. At the time of the 36-month survey, the mean age was 51 years in PermaNet 2.0 site and 50.2 years in DawaPlus 2.0 site. Population structure, as measured by the proportion of children less than 5-years-old, also did not change much over time; it was 10.4% in the baseline and 9.0% in the 36-month survey.

The educational status of the head of household also did not change, over time. However, it was significantly lower for females than males in both sites ($p<0.001$). The two sites had a few differences, with slightly higher educational status of female household heads in the DawaPlus 2.0 site (Figure 2a).

For socio-economic indicators there was no remarkable change in the three years of the durability monitoring for households that were included in the baseline, as well as 36-month survey for both sites. The only significant change was an increase in access to safe water in the PermaNet 2.0 site, from 3.0% in the baseline to 49.6% in the 36-month assessment (Table 1).

Between the two sites, all indicators on socio-economic status of the households in the PermaNet 2.0 and DawaPlus 2.0 sites were similar. This situation was best shown by the ownership of livestock and access to land for horticulture or agriculture (Figure 2b).

Figure 2a: Educational status of heads of household by gender and site

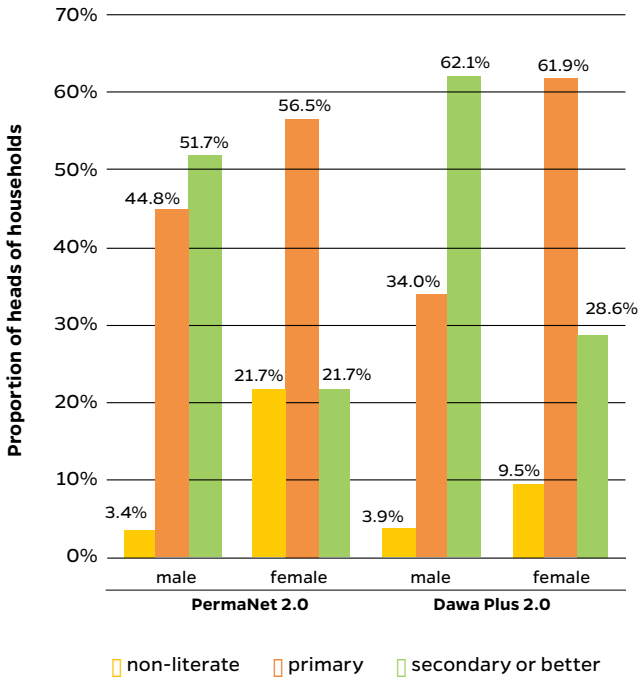


Figure 2b: Economic resources of households by site at 36 months survey

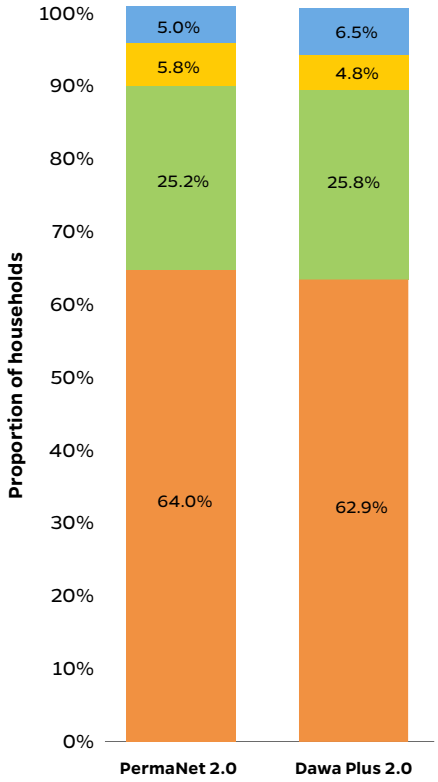


Table 1: Household characteristics and assets (N=263)

Variable and site	Baseline	36 months
PermaNet 2.0		
Roof (sheets/tile)	58.3%	68.4%
Cooking fuel (firewood)	74.1%	91.4%
Access to safe water	23.0%	49.6%
Access to latrine	99.3%	99.3%
Radio	27.3%	19.4%
Mobile phone	82.7%	87.8%
Any transport	71.2%	78.4%
Animal husbandry	91.4%	89.2%
Dawa Plus 2.0		
Roof (sheets/tile)	60.5%	71.0%
Cooking fuel (firewood)	83.1%	82.3%
Access to safe water	43.6%	40.3%
Access to latrine	98.4%	99.2%
Radio	32.3%	22.6%
Mobile phone	77.4%	82.3%
Any transport	78.2%	80.7%
Animal husbandry	90.3%	88.7%
Total		
Roof (sheets/tile)	59.3%	69.2%
Cooking fuel (firewood)	78.3%	87.1%
Access to safe water	32.7%	45.3%
Access to latrine	98.9%	99.2%
Radio	29.7%	20.9%
Mobile phone	80.2%	85.2%
Any transport	74.5%	79.5%
Animal husbandry	90.9%	89.0%

5.3 Determinants of Durability

Factors that were previously shown to be associated with net durability were explored; they can be divided into those involving environmental factors, net handling and knowledge, and attitude toward nets and net care and repair. Table 2 shows factors immediately involved with the sleeping place environment, compared to the baseline, 12-month, 24-month, and 36-month assessments. Food storage in the sleeping room, always cooking in the sleeping room, and rodents observed in last six months decreased in this assessment from 24-month assessment (Table 2).

Table 2: Household risk factors

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0	**N=148**	**N=147**	**N=146**	**N=139**
Ever store food in sleeping room	56.8%	55.1%	37.0%	25.2%
Cook in sleeping room · never · sometimes · always	 73.7% 1.4% 25.0%	 84.4% 1.4% 14.3%	 87.7% 2.1% 10.3%	 83.5% 4.3% 12.2%
Rodents observed (last 6 m)	69.6%	77.6%	82.2%	79.1%
Dawa Plus 2.0	**N=142**	**N=138**	**N=140**	**N=124**
Ever store food in sleeping room	62.0%	61.6%	49.3%	33.1%
Cook in sleeping room · never · sometimes · always	 82.4% 2.1% 15.5%	 81.9% 2.2% 15.9%	 85.0% 2.9% 12.1%	 87.1% 3.2% 9.7%
Rodents observed (last 6 m)	62.7%	79.0%	80.0%	65.3%
Total	**N=290**	**N=285**	**N=286**	**N=263**
Ever store food in sleeping room	59.3%	58.3%	43.0%	28.9%
Cook in sleeping room · never · sometimes · always	 77.9% 1.7% 20.3%	 83.2% 1.8% 15.1%	 86.4% 2.5% 11.2%	 85.2% 3.8% 11.0%
Rodents observed (last 6 m)	66.2%	78.3%	81.1%	72.6%

SiSimilar to the baseline, 12-month, and 24-month assessment, most campaign nets were hung over a mat or placed on the ground (Figure 3). See Table 3 for the durability risk factors connected to handling the nets. Letting cohort nets hang loose without folding or tying up was as high as 83.1% in baseline and decreased to 52.4% in the 12-month assessment and 39.4% in the 24-month assessment, but increased again to 66.3% in the 36-month assessment. The proportion of cohort nets ever washed increased from 13.6% in the baseline to 56.7% at 12 months, 79.7% at 24 months, and 86.4% at 36 months. Median wash frequency within the past six months of data collection, and using a detergent, were similar in all three assessments. Drying of washed nets on the bush/fence can cause damage. Compared with the 24-month assessment, the proportion of households that practiced this behavior increased in this assessment (10.3% in baseline, 16.6% at 12 months, 6.6% at 24 months, and 9.5% at 36 months), but it was similar to earlier data collection rounds.

Figure 3: Main type of sleeping place for campaign nets if used

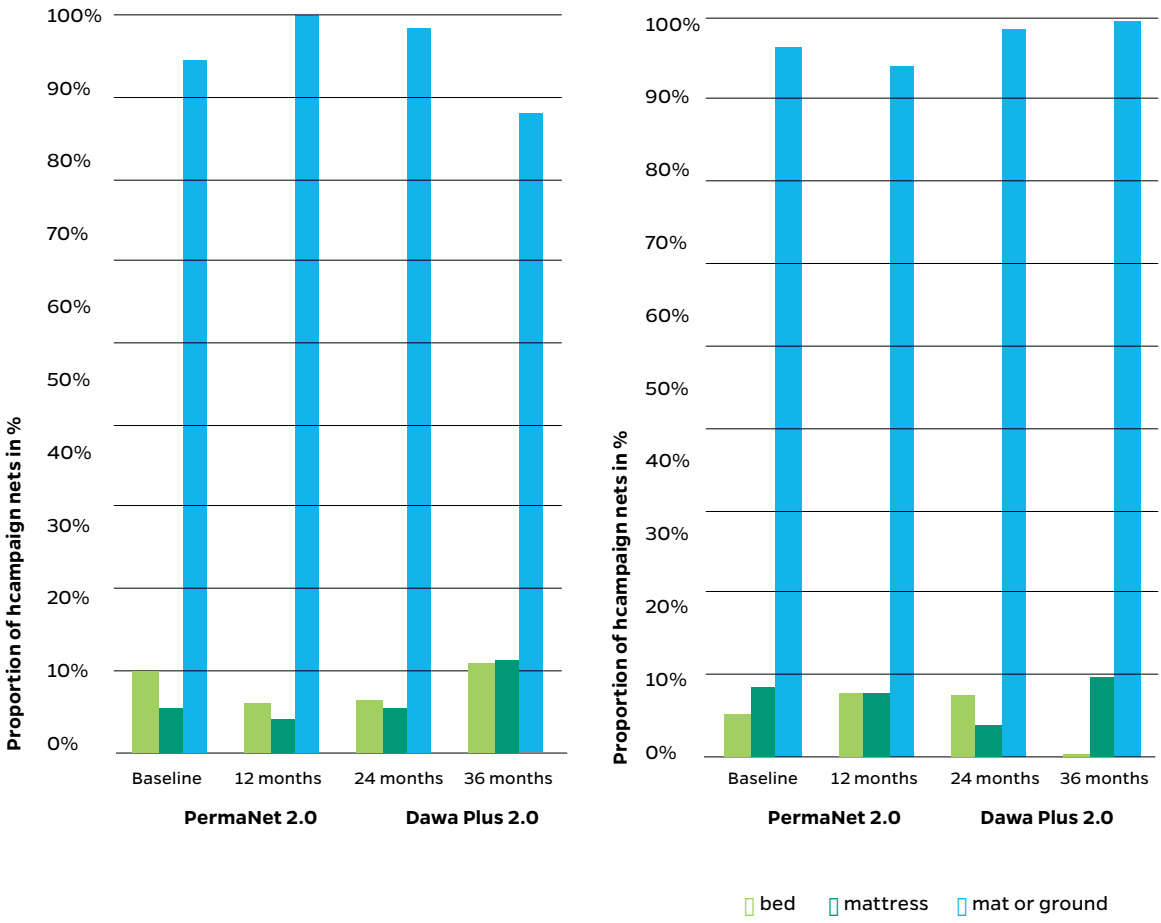


Table 3: Handling of campaign nets

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0				
Hanging nets folded or tied*	12.2%	43.1%	56.0%	32.4%
Hanging nets NOT folded or tied*	87.8%	56.9%	44.0%	67.6%
Net ever washed**	10.5%	56.6%	78.5%	85.1%
Net dried on fence or bush***	9.1%	9.9%	7.4%	10.5%
Median washed last 6 m***	1	1	1	1
Used detergent/bleach for wash***	90.9%	93.2%	93.0%	93.5%
Dawa Plus 2.0				
Hanging nets folded or tied*	22.4%	53.1%	67.8%	36.1%
Hanging nets NOT folded or tied*	77.6%	46.9%	32.2%	63.9%
Net ever washed**	17.2%	56.8%	81.3%	88.0%
Net dried on fence or bush***	11.1%	24.6%	5.6%	8.3%
Median washed last 6 m***	1	1	1	1
Used detergent/bleach for wash***	95.6%	95.5%	98.3%	97.0%
Total				
Hanging nets folded or tied*	16.9%	47.4%	60.6%	33.7%
Hanging nets NOT folded or tied*	83.1%	52.6%	39.4%	66.3%
Net ever washed**	13.6%	56.7%	79.7%	86.4%
Net dried on fence or bush***	10.3%	16.6%	6.6%	9.5%
Median washed last 6 m***	1	1	1	1
Used detergent/bleach for wash***	93.6%	94.3%	95.4%	95.1%

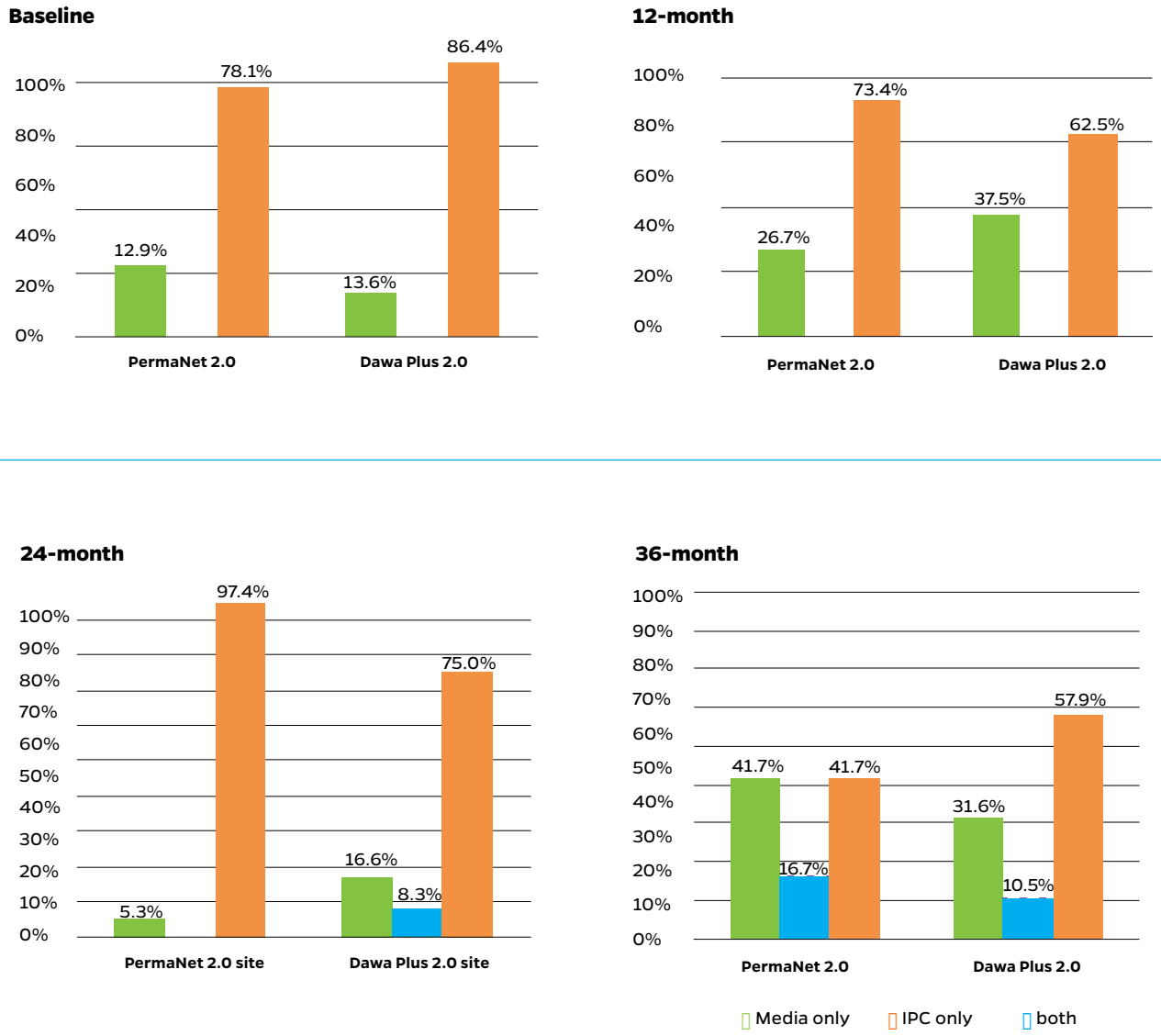
Baseline: *N=307 (only hanging): **N=582 (all campaign nets): *** N=78 (only ever washed)
12 Months: *N=264 (only hanging): **N=522 (all campaign nets): *** N=296 (only ever washed)
24 Months: *N=231 (only hanging): **N=493 (all campaign nets): *** N=393 (only ever washed)
36 Months: *N=172 (only hanging): **N=426 (all campaign nets): *** N=368 (only ever washed)

Overall exposure to net-related messages within the past six months decreased slightly from 18.6% in the baseline to 16.4%, but increased in this round compared with the 24-month (10.8%) (Table 4). Among those who reported exposure to messages, the source of information came mainly from interpersonal communicators (IPC) (48.8%), from the media (37.2%), and from both IPC and media (14.0%). The proportion of households that received messages from IPC fluctuated across four assessments in both sites (Figure 4).

Table 4: Exposure to messages on nets in the last six months

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0	N=148	N=147	N=146	N=139
Any exposure last 6m	21.6%	10.9%	13.0%	17.3%
Mean information sources (if exposed)	1	1	1	1
Type of media · media only · both · IPC only	 21.9% 0.0% 78.1%	 26.7% 0.0% 73.3%	 5.3% 0.0% 94.7%	 41.7% 16.7% 41.7%
Exposure by wealth tertile · Highest · Middle · Lowest	 32.7% 10.4% 10.4%	 15.4% 6.4% 10.4%	 13.2% 11.1% 14.6%	 20.0% 18.4% 13.3%
Dawa Plus 2.0	N=142	N=138	N=140	N=124
Any exposure last 6m	15.5%	12.3%	8.6%	15.3%
Mean information sources (if exposed)	1	1	1	1
Type of media · media only · both · IPC only	 13.6% 0.0% 86.4%	 37.5% 0.0% 62.5%	 16.7% 8.3% 75.0%	 31.6% 10.5% 57.9%
Exposure by wealth tertile · Highest · Middle · Lowest	 15.0% 13.5% 18.0%	 15.0% 13.5% 8.7%	 6.8% 2.0% 17.4%	 23.3% 12.8% 9.5%
Total	N=290	N=285	N=286	N=263
Any exposure last 6m	18.6%	11.6%	10.8%	16.4%
Mean information sources (if exposed)	1	1	1	1
Type of media · media only · both · IPC only	 18.5% 0.0% 81.5%	 32.3% 0.0% 67.7%	 9.7% 3.2% 87.1%	 37.2% 37.2% 48.8%
Exposure by wealth tertile · Highest · Middle · Lowest	 25.0% 12.0% 19.4%	 15.2% 10.1% 9.6%	 10.3% 6.3% 16.0%	 21.6% 15.9% 11.5%

Figure 4. Types of information sources if any exposure in the previous six months



Respondents were asked what messages they could recall pertaining to net care and use. Recall of the message "used net (every) night" and "net prevents malaria" increased in this fourth assessment, compared with the previous ones. The message, "repair net," showed an increasing trend overall. However, "care for net" decreased, compared to the baseline, 12-month, and 24-month assessments. Overall, attitude scores on nets and net care/repair were still highly positive for more than half the respondents in both sites (Table 5).

Table 5: Attitudes towards nets and care & repair

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0				
Recalled "use net (every) night"	59.4%	56.3%	47.4%	70.8%
Recalled "nets prevent malaria"	12.5%	25.0%	5.3%	25.0%
Recalled "care for net"	28.1%	56.3%	52.6%	25.0%
Recalled "repair net"	3.1%	6.3%	10.5%	12.5%
Attitude score nets · mean · %with score >1	 1.3 69.6%	 1.26 65.3%	 1.33 71.9%	 1 51.8%
Attitude score care & repair · mean · %with score >1	 1 50.0%	 0.93 49.0%	 1.02 53.4%	 1.35 71.9%
Dawa Plus 2.0				
Recalled "use net (every) night"	72.7%	64.7%	75.0%	63.2%
Recalled "nets prevent malaria"	22.7%	11.8%	8.3%	26.3%
Recalled "care for net"	22.7%	52.9%	41.7%	42.1%
Recalled "repair net"	4.5%	11.8%	8.3%	10.5%
Attitude score nets · mean · %with score >1	 1.3 68.3%	 1.23 61.6%	 1.41 74.3%	 1.04 54.0%
Attitude score care & repair · mean · %with score >1	 1.08 61.3%	 0.96 47.8%	 1.05 53.6%	 1.49 75.8%
Total				
Recalled "use net (every) night"	64.8%	60.6%	58.1%	67.4%
Recalled "nets prevent malaria"	16.7%	18.2%	6.5%	25.6%
Recalled "care for net"	25.9%	54.6%	48.4%	32.6%
Recalled "repair net"	3.7%	9.1%	9.7%	11.6%
Attitude score nets · mean · %with score >1	 1.3 69.0%	 1.25 63.5%	 1.37 73.1%	 1.02 52.9%
Attitude score care & repair · mean · %with score >1	 1.04 55.5%	 0.95 48.4%	 1.04 53.5%	 1.42 73.8%

There was a steady increase in the proportion of households that reportedly ever had holes in their nets, with the exception of a non-significant drop in the 12-month assessment to 68.9% and 74.1% in both in 24-month and 36-month assessment, respectively (Table 6). The proportion of households that reported they had ever discussed care and repair of nets doubled from the baseline in the 12-month, 24-month, and 36-month assessments: baseline=21%, 12 months=44.2%, 24 months=50.7%, and 36 months=39.5%. Among the households with reported prior experience of holes in their nets, proportions of households that had ever repaired the holes rose slightly in this assessment.

Similar to the previous assessments, stitching was the main method of net repair (95.4%); holes were repaired by one of the household members. Major reported reasons for not repairing holes (N=108) were not having time (51.9%), and holes being too small (20.4%).

Among all observed cohort nets with any holes, the proportion of nets with repairs increased to 32.2%, from 25.5% at the 24-month assessment.

Table 6: Household experience with care and repair of any nets and actual repairs made in damaged campaign nets

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0				
Ever experienced holes in net	54.1%	49.7%	67.8%	76.3%
Ever discussed care and repair	18.9%	39.5%	49.3%	33.1%
Ever repaired (if had holes)*	53.8%	54.8%	37.4%	49.1%
Damaged campaign nets repaired (if had holes in hole assessment)**	15.9%	37.1%	25.2%	32.2%
Dawa Plus 2.0				
Ever experienced holes in net	58.5%	48.6%	70.0%	71.8%
Ever discussed care and repair	23.2%	49.3%	52.1%	46.8%
Ever repaired (if had holes)*	43.4%	61.2%	40.8%	39.3%
Damaged campaign nets repaired (if had holes in hole assessment)**	18.2%	27.9%	25.9%	27.8%
Total				
Ever experienced holes in net	56.2%	49.1%	68.9%	74.1%
Ever discussed care and repair	21.0%	44.2%	50.7%	39.5%
Ever repaired (if had holes)*	48.5%	57.9%	39.1%	44.6%
Damaged campaign nets repaired (if had holes in hole assessment)**	17.1%	32.8%	25.5%	30.1%

Baseline: *N=168 (If had holes): **N=88 (if had holes in hole assessment)
12 months: *N=140 (If had holes): **N=235 (if had holes in hole assessment)
24 months: *N=197 (If had holes): **N=314 (if had holes in hole assessment)
36 months: *N=195 (If had holes): **N=339 (if had holes in hole assessment)

5.4 Nets and Net Use

Across the four assessments, the proportion of cohort nets found hanging was slightly higher in the PermaNet site than the DawaPlus site. No nets were sealed in the package at either site in this assessment. The proportion of cohort nets that were used last night, and every night in the last week, decreased slightly, particularly at the DawaPlus site (Table 7).

Table 7: Hanging and use of campaign nets from cohort

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0				
Hanging	52.1%	52.8%	51.5%	47.2%
Taken down or stored	10.5%	44.8%	46.0%	52.8%
Still in package	37.5%	2.5%	2.6%	0.0%
Used last night	56.5%	52.5%	52.6%	48.9%
Used every night (last week)	52.4%	50.7%	51.8%	47.2%
Dawa Plus 2.0				
Hanging	53.6%	47.9%	41.1%	31.9%
Taken down or stored	11.6%	51.3%	58.9%	68.1%
Still in package	34.8%	0.9%	0.0%	0.0%
Used last night	55.8%	48.3%	45.7%	33.5%
Used every night (last week)	51.7%	48.3%	44.8%	31.9%
Total				
Hanging	52.8%	50.6%	46.9%	40.4%
Taken down or stored	11.0%	47.7%	51.7%	59.6%
Still in package	36.3%	1.7%	1.4%	0.0%
Used last night	56.2%	50.6%	49.5%	42.0%
Used every night (last week)	52.1%	49.6%	48.7%	40.4%

The proportion of non-cohort nets found hanging was similar to the 24-month assessment in the PermaNet site, but it dropped slightly in the DawaPlus site. The proportion of non-cohort nets usage also decreased in this assessment (Table 8).

Table 8: Hanging and use of non-cohort nets

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0				
Hanging	46.8%	36.2%	42.8%	41.2%
Taken down or stored	39.8%	44.6%.	40.9%	45.8%
Still in package	3.2%	8.1%	15.3%	9.5%
Used last night	49.2%	38.2%	42.3%	37.9%
Used every night (last week)	46.0%	36.2%	40.6%	36.7%
Dawa Plus 2.0				
Hanging	28.1%	34.6%	44.7%	38.2%
Taken down or stored	53.5%	46.4%	43.2%	39.3%
Still in package	7.5%	5.7%	10.1%	13.2%
Used last night	31.3%	36.5%	47.1%	41.0%
Used every night (last week)	30.2%	34.8%	44.0%	38.4%
Total				
Hanging	36.7%	35.4%	43.8%	39.6%
Taken down or stored	47.2%	45.5%	42.1%	42.4%
Still in package	5.5%	6.9%	12.7%	11.4%
Used last night	39.5%	37.4%	44.7%	39.5%
Used every night (last week)	37.4%	35.5%	42.3%	37.6%

The proportion of households that reportedly owned non-campaign nets was similar to the previous assessments. Moreover, almost one-third of households (27%), similar to the 12-month and 24-month assessments, reported that they received the non-campaign nets from the public sector, a marked increase from 9.7% at baseline. Other sources, such as private sector or family, friends, or nongovernmental organizations (NGOs) were mentioned in more than half the households (Table 9).

Table 9: Ownership of non-campaign nets and where households obtained them

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0				
Household has any other nets	100.0%	93.2%	93.2%	94.2%
Source public sector	8.8%	30.6%	33.6%	21.6%
Source private sector	77.7%	74.8%	69.2%	74.1%
Source family , friends, NGO	41.9%	42.2%	41.8%	54.7%
Dawa Plus 2.0				
Household has any other nets	100.0%	92.8%	94.3%	100.0%
Source public sector	10.6%	37.0%	34.3%	33.1%
Source private sector	81.0%	81.2%	80.0%	87.9%
Source family, friends, NGO	52.8%	37.0%	50.7%	55.7%
Total	N=290	N=285	N=286	N=263
Household has any other nets	100.0%	93.0%	93.7%	97.0%
Source public sector	9.7%	33.7%	33.9%	27.0%
Source private sector	79.3%	77.9%	74.5%	80.6%
Source family, friends, NGO	47.2%	39.7%	46.2%	55.1%

There was an increase in the proportion of cohort nets used only by adults, from 50.8% in baseline to 55.3% at 12 months, 60.7% at 24 months, and 68.2% at 36 months. Consequently, the proportion of cohort nets used only by children, or children and adults, decreased from the previous assessments (Table 10). There was a slight increase in the use of non-cohort nets by children only or by children and adults (Table 11).

Table 10: Net users of Campaign net cohort

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0				
Children only*	2.2%	1.3%	0.6%	1.2%
Children + adults**	25.6%	29.8%	32.8%	32.5%
Adults only**	72.2%	68.9%	66.7%	66.3%
Dawa Plus 2.0				
Children only*	3.1%	4.7%	1.0%	1.1%
Children + adults**	31.0%	32.4%	35.9%	38.4%
Adults only**	65.9%	62.8%	63.1%	60.5%
Total	N=322	N=299	N=369	N=353
Children only*	2.6%	3.0%	0.8%	1.1%
Children + adults**	27.8%	31.1%	34.4%	35.7%
Adults only**	69.6%	65.9%	64.8%	63.2%

* age 0-9 years; ** includes adolescents 10-19

Table 11: Net users of non-cohort nets

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0				
Children only*	2.2%	1.3%	0.6%	1.2%
Children + adults**	25.6%	29.8%	32.8%	32.5%
Adults only**	72.2%	68.9%	66.7%	66.3%
Dawa Plus 2.0				
Children only*	3.1%	4.7%	1.0%	1.1%
Children + adults**	31.0%	32.4%	35.9%	38.4%
Adults only**	65.9%	62.8%	63.1%	60.5%
Total	N=322	N=299	N=369	N=353
Children only*	2.6%	3.0%	0.8%	1.1%
Children + adults**	27.8%	31.1%	34.4%	35.7%
Adults only**	69.6%	65.9%	64.8%	63.2%

* age 0-9 years; ** includes adolescents 10-19

5.5 Durability of campaign nets

See Figures 5 and 6 for the status of cohort nets recruited at baseline in each site.

Figure 5: Status of cohort nets recruited at baseline [PermaNet 2.0 Sites]

PermaNet 2.0 Site

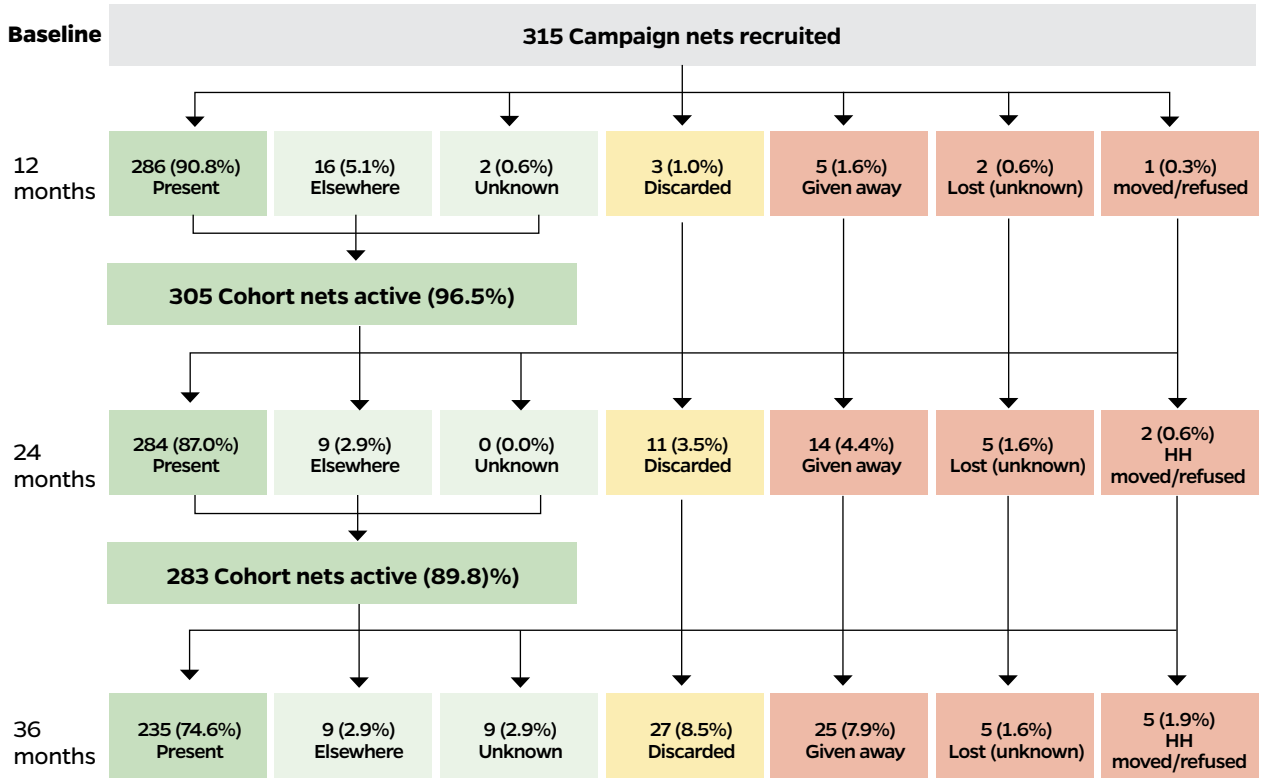
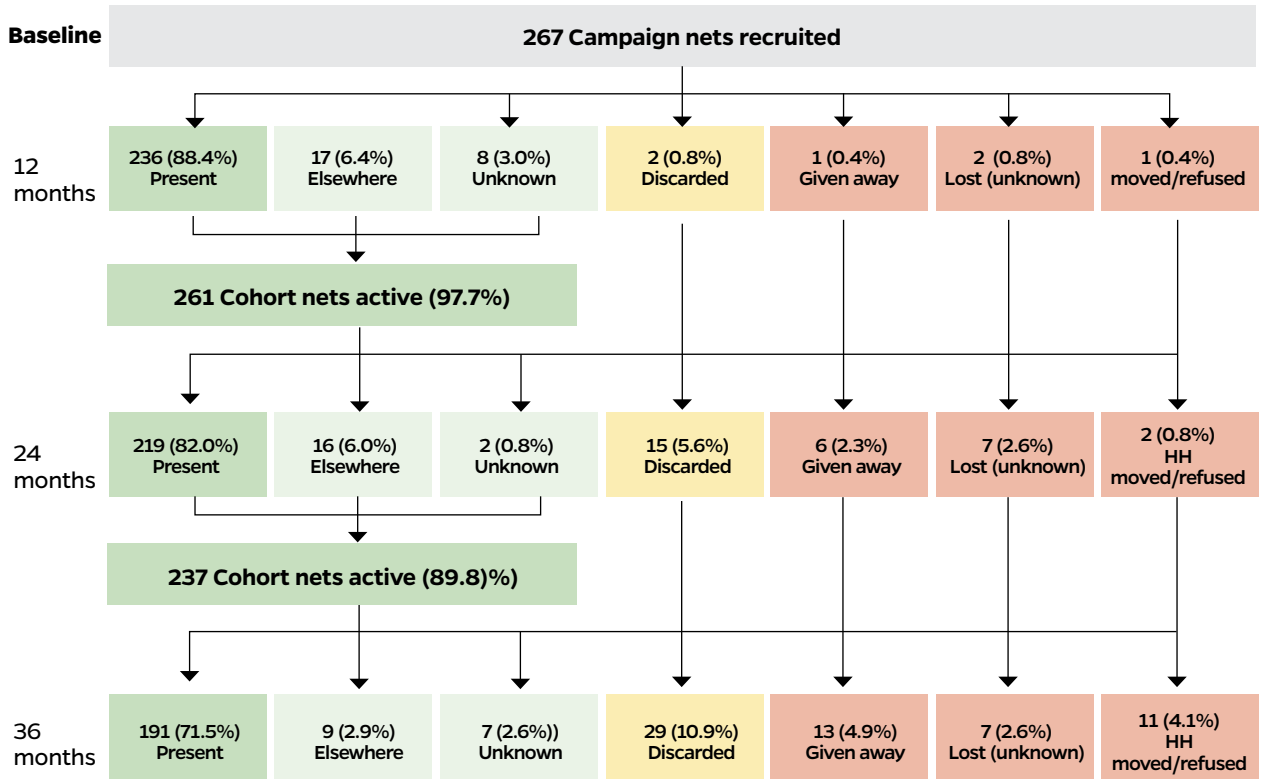


Figure 6: Status of cohort nets recruited at baseline in [Dawa Plus 2.0 Site]

Dawa Plus 2.0 Site



Out of 739 nets distributed to the selected households during the campaign, a total of 582 cohort nets were recruited at the baseline assessment, and 426 were successfully followed up at the 36-month assessment.

Overall attrition increased to 34.2% from 27.8% in the 24_ month assessment, 21.9% in the 12-month assessment, and 19.9% in the baseline. The major cause of attrition was because the nets were given away (24.5%). Attrition due to wear and tear also increased to 8.1% from 4.1% at 24 months, 1.2% at 12 months, and 0.5% at baseline (Table 12). There was no significant difference observed in both sites in terms of attrition and its causes.

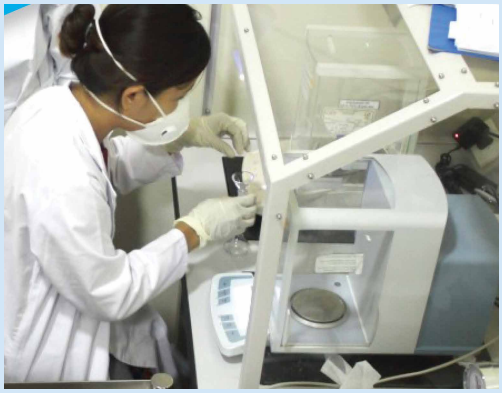
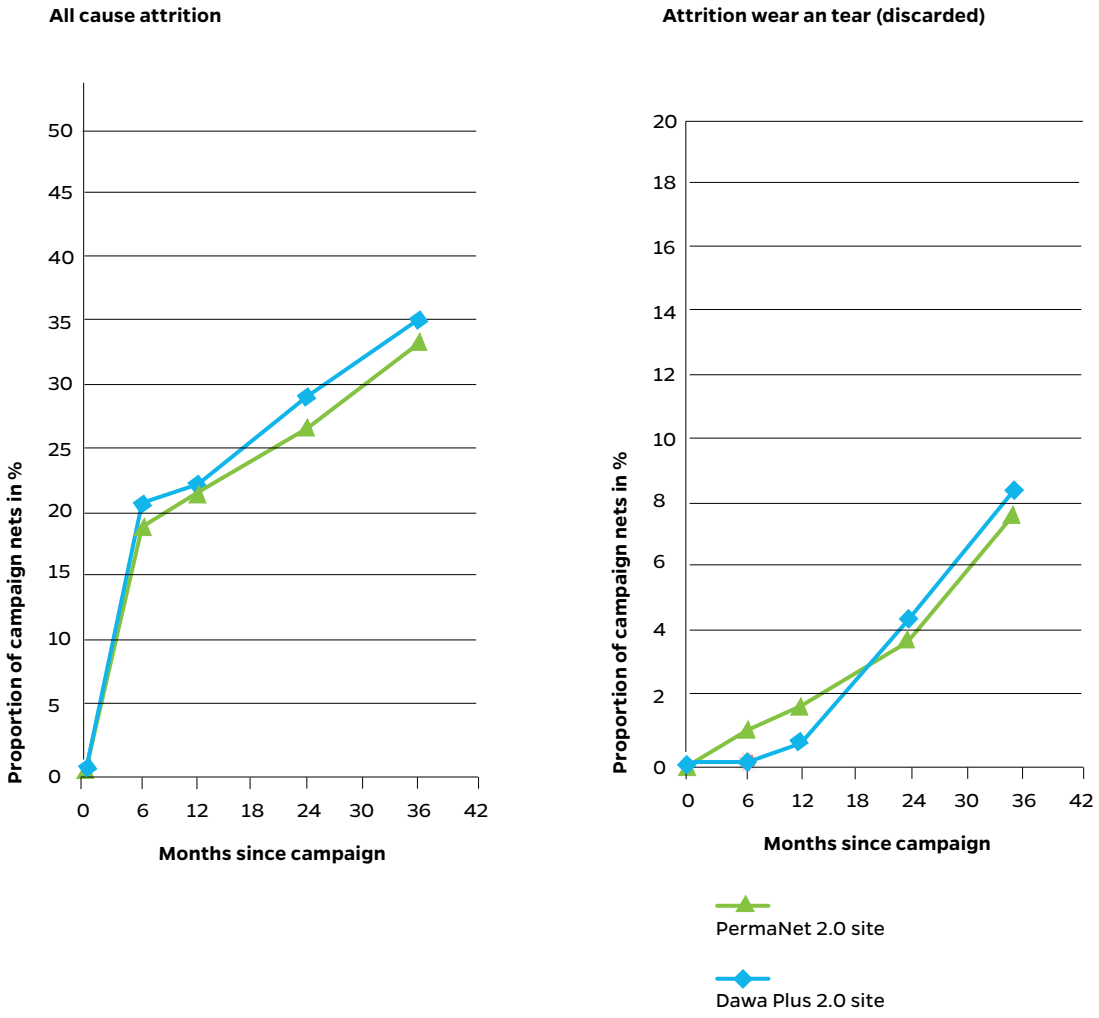


Table 12: Attrition (including nets lost between campaign and baseline)

Variable	Campaign – baseline (N=739)	Campaign – 12 months (N=739)	Campaign – 24 months (N=739)	Campaign – 36 months (N=739)
PermaNet 2.0				
Given away	18.1%	19.4%	21.6%	24.4%
Discarded (wear & tear)	1.0%	1.8%	3.8%	7.8%
Unknown*	0.0%	0.5%	1.3%	1.3%
Total	**19.1%**	**21.7%**	**26.7%**	**33.4%**
Dawa Plus 2.0				
Given away	20.8%	21.1%	22.6%	24.6%
Discarded (wear & tear)	0.0%	0.6%	4.4%	8.5%
Unknown*	0.0%	0.6%	2.1%	2.1%
Total	**20.8%**	**22.3%**	**29.1%**	**35.2%**
Total				
Given away	19.4%	20.2%	22.1%	24.5%
Discarded (wear & tear)	0.5%	1.2%	4.1%	8.1%
Unknown*	0.0%	0.5%	1.6%	1.6 %
Total	**19.9%**	**21.9%**	**27.8%**	**34.2%**

**Lost (unknown reason)*

Figure 7: Trends in all cause attrition and wear and tear (discarded nets) since distribution



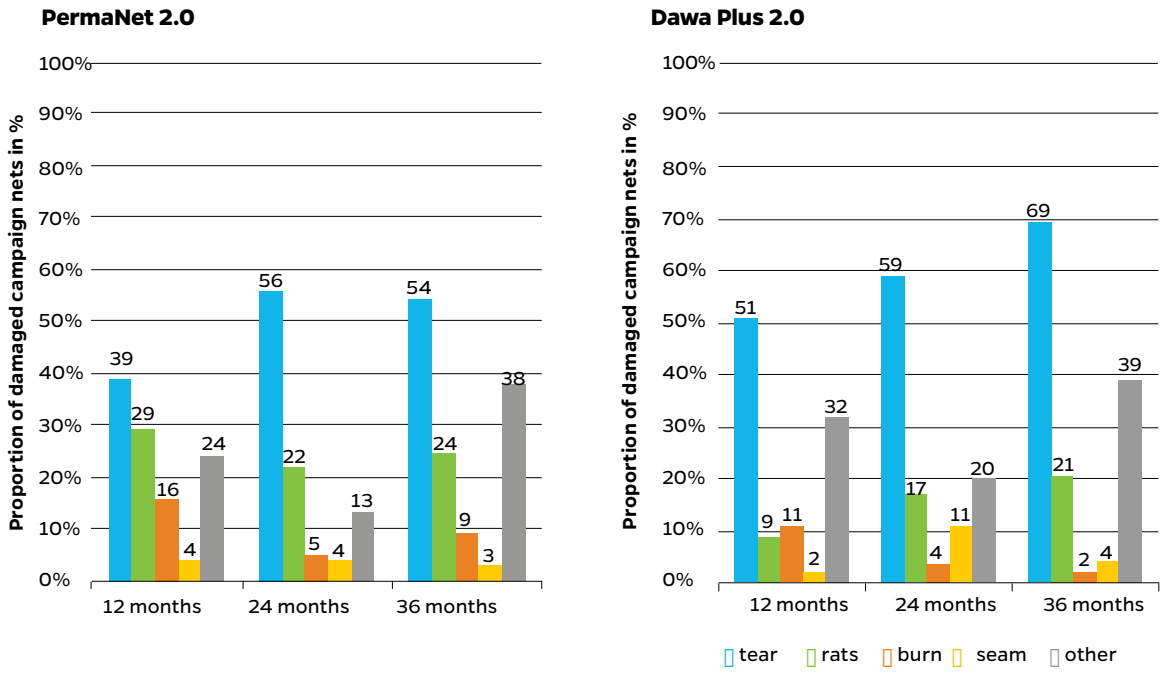
In this assessment, 426 labeled cohort nets were observed. Among these nets, 79.6% had holes at the time of the survey, which is a marked increase from 15.1% at baseline, 45% at 12 months, and 63.7% at 24 months (Table 13). Overall, 66.7% of cohort nets were in good condition, which decreased from 96.9% in the baseline, 88.7% at 12 months, and 77.3% at the 24-month assessment. The drop was more pronounced in the DawaPlus site (baseline=94.4%, 12 months=84.3%, 24 months=68%, 36 months=57.1%). Similarly, the increase in the number of nets that were too torn, and the consequent decrease in the number of nets in serviceable condition, was more prominent in the DawaPlus site (Table 13).

Table 13: Physical condition (integrity) of surviving cohort nets (pHI=proportionate Hole Index)

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0	N=315	N=286	N=274	N=235
Any holes	14.0%	43.4%	61.0%	76.6%
Median PHI (if any hole)	3.5	4	26	30.5
Good (pHI<64)	99.1%	92.3%	84.7%	74.5%
Too torn (pHI>642)	0.0%	1.1%	2.9%	4.3%
Serviceable (pHI≤642)	100.0%	98.9%	97.1%	95.7%
Dawa Plus 2.0	N=267	N=236	N=219	N=191
Any holes	16.5%	47.0%	67.1%	83.3%
Median pHI (if any hole)	24.5	25	54	67
Good (pHI<64)	94.4%	84.3%	68.0%	57.1%
Too torn (pHI>642)	0.4%	3.0%	6.9%	9.9%
Serviceable (pHI≤642)	99.6%	97.0%	93.2%	90.1%
Total	N=582	N=522	N=493	N=426
Any holes	15.1%	45.0%	63.7%	79.6%
Median pHI (if any hole)	23	19	33.5	43
Good (pHI<64)	96.9%	88.7%	77.3%	66.7%
Too torn (pHI>642)	0.2%	1.9%	4.7%	6.8%
Serviceable (pHI≤642)	99.8%	98.1%	95.3%	93.2%

The reported causes of damage were categorized into damage mechanisms (see Figure 8), stratified by site. The highest reported damage mechanism was a “tear” across both sites and both assessments, followed by “rats,” “burn,” and “seam.” Other reported damage mechanisms included insects, such as cockroaches.

Figure 8: Type of damage mechanisms reported for damaged campaign nets (multiple responses)

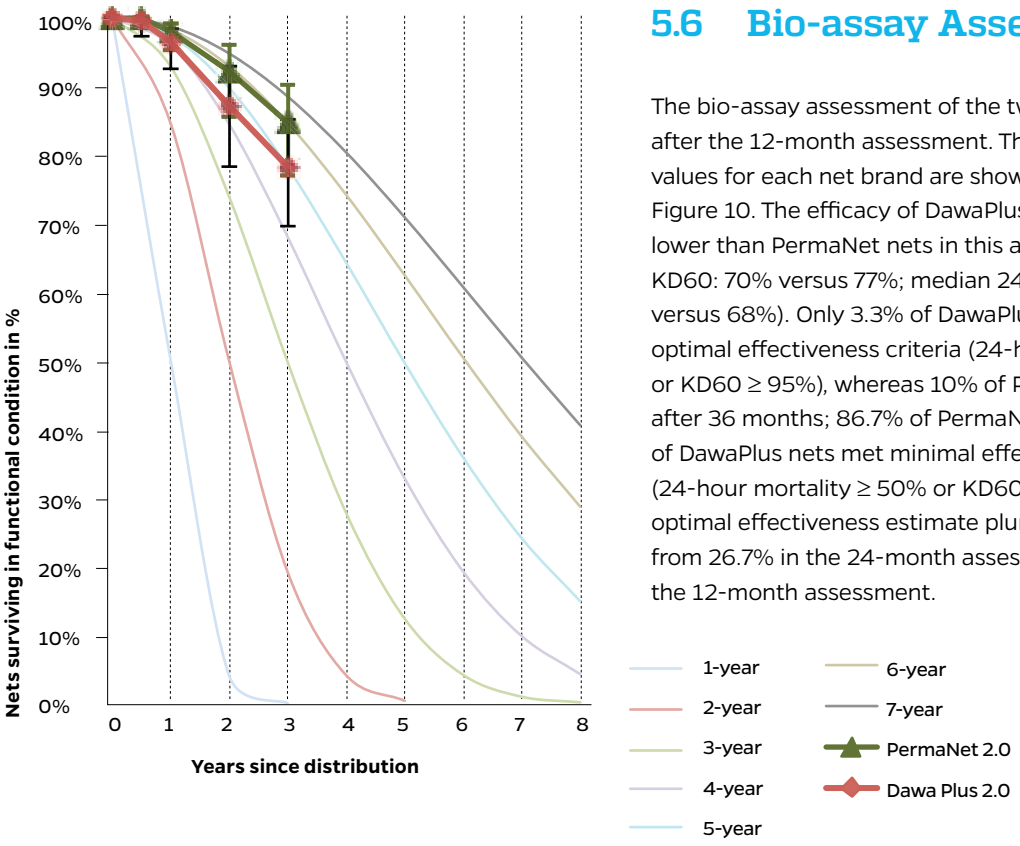


The estimate of campaign nets surviving in serviceable condition was calculated as a combination of attrition and integrity (Table 14). The proportion of nets surviving in serviceable condition showed a gradual decrease across four rounds (baseline=99.8%, 12 months= 97.2%, 24 months=89.9%, 36 months=81.7%). The estimated survival of cohort nets was slightly lower in the DawaPlus site than the PermaNet site (Table 14 and Figure 9).

Table 14: Nets surviving in serviceable condition (including nets discarded before baseline)

Variable and site	Baseline	12 months	24 months	36 months
PermaNet 2.0				
Survival estimate	100.0%	97.9%	92.0%	84.6%
95% CI	-	95.1%-99.1%	85.3%-95.9%	76.9%-90.1%
Only nets ever used				
Survival estimate	100.0%	97.6%	91.4%	84.8%
95% CI	-	94.4%-99.0%	83.3%-95.8%	77.0%-90.3%
Dawa Plus 2.0				
Survival estimate	99.6%	96.2%	87.2%	78.2%
95% CI	97.2% -99.9%	92.4%-98.2%	78.2%-92.8%	69.5%-84.9%
Only nets ever used				
Survival estimate	99.4%	95.5%	87.4%	77.6%
95% CI	95.7% -99.9%	91.4%-97.7%	77.7%-93.2%	68.4%-84.7%
Total				
Survival estimate	99.8%	97.2%	89.9%	81.7%
95% CI	98.7%-99.9%	95.0%-98.4%	84.8%-93.4%	76.1%-86.2%
Only nets ever used				
Survival estimate	99.7%	96.7%	89.6%	81.5%
95% CI	97.9%-99.9%	94.3%-98.1%	83.8%-93.4%	75.8%-86.2%

Figure 9: Estimated net survival in serviceable condition with 95% confidence intervals



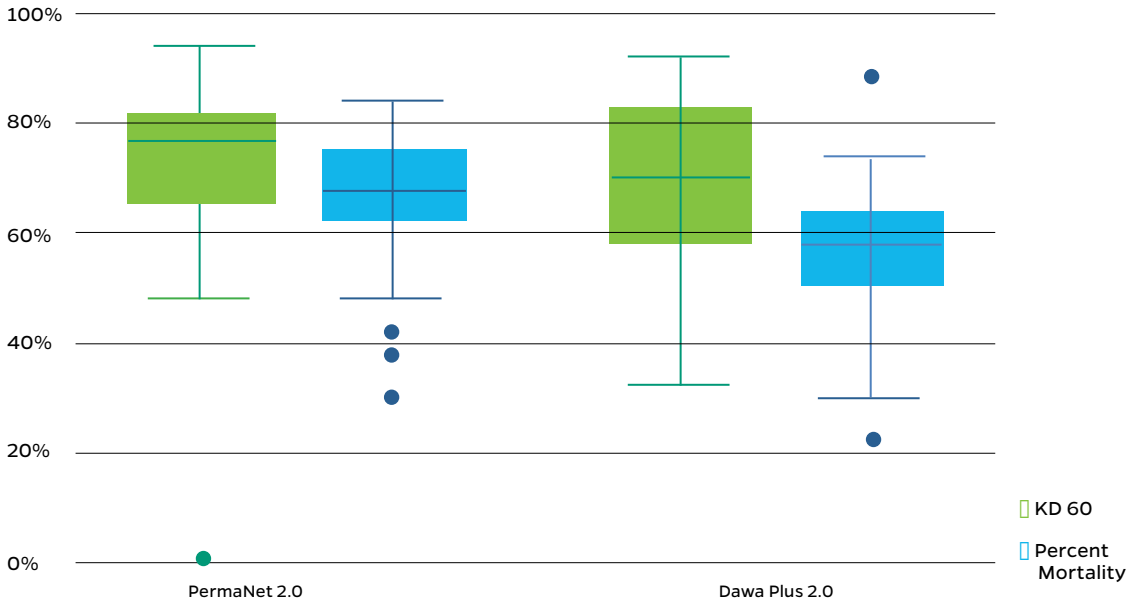
5.6 Bio-assay Assessment

The bio-assay assessment of the two brands was done after the 12-month assessment. The mean and median values for each net brand are shown in Table 15 and Figure 10. The efficacy of DawaPlus nets was slightly lower than PermaNet nets in this assessment (median KD60: 70% versus 77%; median 24-hour mortality: 58% versus 68%). Only 3.3% of DawaPlus 2.0 nets met WHO optimal effectiveness criteria (24-hour mortality ≥ 80% or KD60 ≥ 95%), whereas 10% of PermaNet nets did so after 36 months; 86.7% of PermaNet nets and 76.7% of DawaPlus nets met minimal effectiveness criteria (24-hour mortality ≥ 50% or KD60 ≥ 75%). Overall, the optimal effectiveness estimate plummeted to 6.7% from 26.7% in the 24-month assessment and 61.7% in the 12-month assessment.

Table 15: Results from bio-assays

Variable	12 months	24 months	36 months
PermaNet 2.0	**N=30**	**N=30**	**N=30**
Knock down 60 minutes · Mean (95% CI) · Median (IQR)	 80.8% (76.5-85.1%) 82% (74.0-88.0%)	 75.4% (70.2-80.6%) 76% (70.0-82.0%)	 72.3% (65.5-79.0%) 77.0% (66.0-82.0%)
Mortality 24 hours · Mean (95% CI) · Median (IQR)	 84.2% (80.1-88.3%) 87.5% (79.0-91.0%)	 76.7% (71.7-81.8%) 74% (68.0-86.0%)	 66.2% (60.8-71.6%) 68.0% (62.0-75.0%)
Optimal effectiveness · Estimate (95% CI)	73.3% (54.1-86.5%)	40% (20.8-62.9%)	10% (3.3-26.8%)
Minimal effectiveness · Estimate (95% CI)	100.0%	100.0%	86.7% (69.9-94.8%)
Dawa Plus 2.0	**N=30**	**N=30**	**N=30**
Knock down 60 minutes · Mean (95% CI) · Median (IQR)	 78% (73.1-82.9%) 78% (68-86%)	 56.7% (52.8-60.6%) 58%(52-66%)	 67.8% (60.7-74.8%) 70.0% (58.0-82.0%)
Mortality 24 hours · Mean (95% CI) · Median (IQR)	 75.8% (67.3-84.3%) 79.5% (62-90%)	 66.6% (62.9-70.3%) 70%(60-76%)	 57.0% (51.6-62.4%) 58.0% (50.0-64.0%)
Optimal effectiveness · Estimate (95% CI)	50% (29.4-70.6%)	13.3% (5.2-30.1%)	3.3% (0.4-21.6%)
Minimal effectiveness · Estimate (95% CI)	90% (64.1-97.8%)	83.3% (66.8-92.6%)	76.7% (56.5-89.3%)
Total	**N=60**	**N=60**	**N=60**
Knock down 60 minutes · Mean (95% CI) · Median (IQR)	 79.4% (76.3-82.5%) 81.0% (72-87.5%)	 66.1% (61.3-70.9%) 68% (56-76%)	 70.0% (65.0-75.0%) 73.0% (61.0-82.0%)
Mortality 24 hours · Mean (95% CI) · Median (IQR)	 80.0% (75.3-84.7%) 84.0% (72.5-91.0%)	 71.7% (68-75.3%) 72% (66-80%)	 61.6% (57.4-65.8%) 64.0% (53.0-72.0%)
Optimal effectiveness · Estimate (95% CI)	61.7% (46.6-74.8%)	26.7% (15.3-42.2%)	6.7% (2.5-16.8%)
Minimal effectiveness · Estimate (95% CI)	95% (79.6-98.9%)	91.7% (81.3-96.5%)	81.7% (69.0-89.9%)

Figure 10: Results from WHO cone bio-assays: the box plot shows the median (horizontal line), Inter-Quartile-Range (box), adjacent values[5] (whiskers) and outliers (circles)



At the 36-month assessment, using bio-assays and chemical residue testing, sub-samples of the cohort nets were randomly selected for insecticidal effectiveness testing. Almost equal proportions of nets from both sites were hung, folded, or tied. However, the sleeping place for most of the nets in the DawaPlus site was over a mat or on the ground, while half in the PermaNet site were so. For the net users, all DawaPlus nets were used by adults only, whereas PermaNet LLINs were used by adults only, or adolescents, or young children and adults (Table 16).

[5]Adjacent values: +/- 1.5 * Inter-Quartile-Range

Table 16: Variables related to handling of bio-assay test nets

Variable	12 months	24 months	36 months
PermaNet 2.0	**N=30**	**N=30**	**N=30**
Location found			
· hanging loose	46.7%	46.7%	30.0%
· hanging folded/tied	13.3%	16.7%	16.7%
· Hanging folded/tied if hanged	22.2%	26.3%	35.7%
Type of sleeping place			
· bed	13.3%	3.3%	13.3%
· mattress	0.0%	3.3%	23.3%
· mat/ground	73.3%	93.3%	50.0%
Net users*			
· young child only	11.8%	17.9%	0.0%
· young child + adult	52.9%	32.1%	6.3%
· older child, adolescent	5.9%	10.7%	37.5%
· adult only	29.4%	39.3%	56.3%
Dawa Plus 2.0	**N=30**	**N=30**	**N=30**
Location found			
· hanging loose	40.0%	23.3%	16.7%
· hanging folded/tied	33.3%	46.7%	10.0%
· Hanging folded/tied if hanged	45.5%	66.7%	37.5%
Type of sleeping place			
· bed	6.7%	3.3%	0.0%
· mattress	3.3%	0.0%	13.3%
· mat/ground	80.0%	96.7%	80.0%
Net users*			
· young child only	4.6%	8.0%	0.0%
· young child + adult	54.6%	32.0%	0.0%
· older child, adolescent	4.6%	8.0%	0.0%
· adult only	36.4%	52.0%	100.0%
Total	**N=60**	**N=60**	**N=60**
Location found			
· hanging loose	43.3%	35.0%	23.3%
· hanging folded/tied	23.3%	31.7%	13.3%
Hanging folded/tied if hanged	35.0%	47.5%	36.4%
Type of sleeping place			
· bed	10.0%	3.3%	6.7%
· mattress	1.7%	1.7%	18.3%
· mat/ground/grass	76.7%	95.0%	65.0%
Net users*			
· young child only	7.7%	13.2%	0.0%
· young child + adult	53.9%	32.1%	4.0%
· older child, adolescent	5.3%	9.4%	24.0%
· adult only	33.3%	45.3%	72.0%

*In 24 month: PermaNet 2.0 = 28, Dawa Plus 2.0 = 25, Total = 53

*In 36 month: PermaNet 2.0 = 16, Dawa Plus 2.0 = 9, Total = 25

Variables related to net use are shown in Table 17. Net usage was lower for DawaPlus LLINs than for PermaNet LLINs. Overall usage was similar to all cohort nets in the study. In both sites, about 25% of households reported seasonal use of LLINs (use mainly/only in rainy season).

Table 17: Variables related to use of bio-assay test nets

Variable	12 months	24 months	36 months
PermaNet 2.0	**N=30**	**N=30**	**N=30**
Used last night	56.7%	66.7%	53.3%
Use last week			
· every night	56.7%	63.3%	56.7%
· most nights (5-6)	0.0%	0.0%	0.0%
· some nights (1-4)	3.3%	6.7%	3.3%
· not used	40.0%	30.0%	26.7%
· Never Used	-	-	13.3%
Seasonal use			
· equally rain and dry	53.3%	66.7%	60.0%
· mainly rain	33.3%	20.0%	26.7%
· rain only	0.0%	13.3%	0.0%
· Not used at all	-	-	13.0%
· Not used at rainy season	-	-	0.0%
Dawa Plus 2.0	**N=30**	**N=30**	**N=30**
Used last night	73.3%	63.3%	30.0%
Use last week			
· every night	70.0%	63.3%	30.0%
· most nights (5-6)	3.3%	0.0%	3.3%
· some nights (1-4)	6.7%	3.3%	3.3%
· not used	20.0%	33.3%	53.3%
· Never used	-	-	10.0%
Seasonal use			
· equally rain and dry	66.7%	83.3%	53.3%
· mainly rain	20.0%	3.3%	20.0%
· rain only	3.3%	13.3%	6.7%
· Not used at all	-	-	16.7%
· Not used at rainy season	-	-	3.3%
Total	**N=60**	**N=60**	**N=60**
Used last night	65.0%	65.0%	41.7%
Use last week			
· every night	63.3%	63.3%	43.3%
· most nights(5-6)	1.7%	0.0%	1.7%
· some nights (1-4)	5.0%	5.0%	3.3%
· not used	30.0%	31.7%	40.0%
· Never used	-	-	11.7%
Seasonal use			
· equally rain and dry	66.7%	75.0%	56.7%
· mainly rain	26.7%	11.7%	23.3%
· rain only	1.7%	13.3%	3.3%
· Not used at all	-	-	15.0%
· Not used at rainy season	-	-	1.7%

For the variables related to net washing, the proportion of bio-assay nets ever washed, and the number of washes, were the same as those of cohort nets; there was no difference between the sites. More than 90% of bio-assay nets were washed with detergents at the 36-month assessment (Table 18).

Table 18: Variables related to washing of bio-assay test nets

Variable	12 months	24 months	36 months
PermaNet 2.0	**N=30**	**N=30**	**N=30**
Ever washed	60.0%	93.3%	83.3%
Washes last 6 month (all) · Mean · Median	 1.2 1	 1.6 1.5	 1.1 1
Washes last 6 month (if washed) · Mean · Median	 12.9 2	 1.8 2	 1.1 1
Soap used · country soap bar · detergent or bleach · mix	 0.0% 100.0% 0.0%	 3.6% 96.4% 0.0%	 12.0% 88.0% 0.0%
Dawa Plus 2.0	**N=30**	**N=30**	**N=30**
Ever washed	66.7%	90%	83.3%
Washes last 6 month (all) · Mean · Median	 1.1 1	 1.5 1	 1.0 1
Washes last 6 month (if washed) · Mean · Median	 6.7 1	 1.6 1	 1.0 1
Soap used · country soap bar · detergent or bleach · mix	 0.0% 100.0% 0.0%	 3.7% 96.3% 0.0%	 0.0% 96.0% 4.0%
Total	**N=60**	**N=60**	**N=60**
Ever washed	63.3%	91.7%	83.3%
Washes last 6 month (all) · Mean · Median	 1.15 1	 1.6 1	 1.02 1
Washes last 6 month (if washed) · Mean · Median	 9.6 2	 1.7 1	 1.02 1
Soap used · country soap bar · detergent or bleach · mix	 0.0% 100.0% 0.0%	 3.7% 96.4% 0.0%	 0.0% 92.0% 2.0%

5.7 Chemical Residue Analysis

The LLINs collected 36 months after the 2015 mass campaign were submitted for chemical residue analysis at the DFDA lab in Naypyidaw, Myanmar. The mean deltamethrin content found in DawaPlus 2.0 nets was 1.10 g/kg from an initial loading dose of 2.0 g/kg, or 55.0% of the original loading dose. For the PermaNet 2.0 samples, the mean deltamethrin content was 0.97 g/kg from an initial loading dose of 1.4 g/kg. This represents 69.3% of the loading dose.

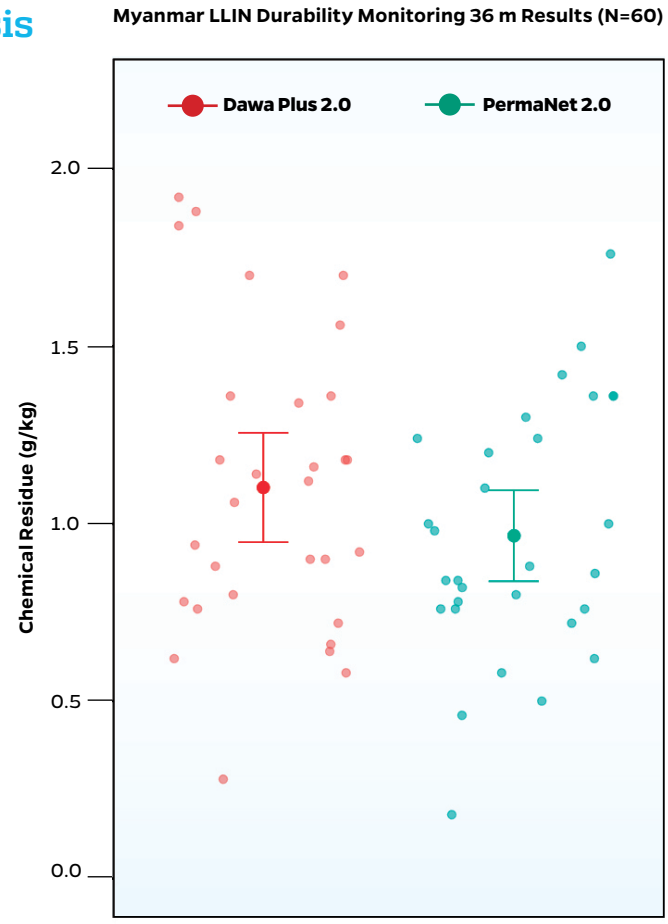


Figure 11: Results from chemical residue analysis: the graph shows the mean chemical residue content of each net as a proportion of the loading dose (2.0 g/kg for Dawa Plus 2.0 and 1.4 g/kg for PermaNet 2.0).

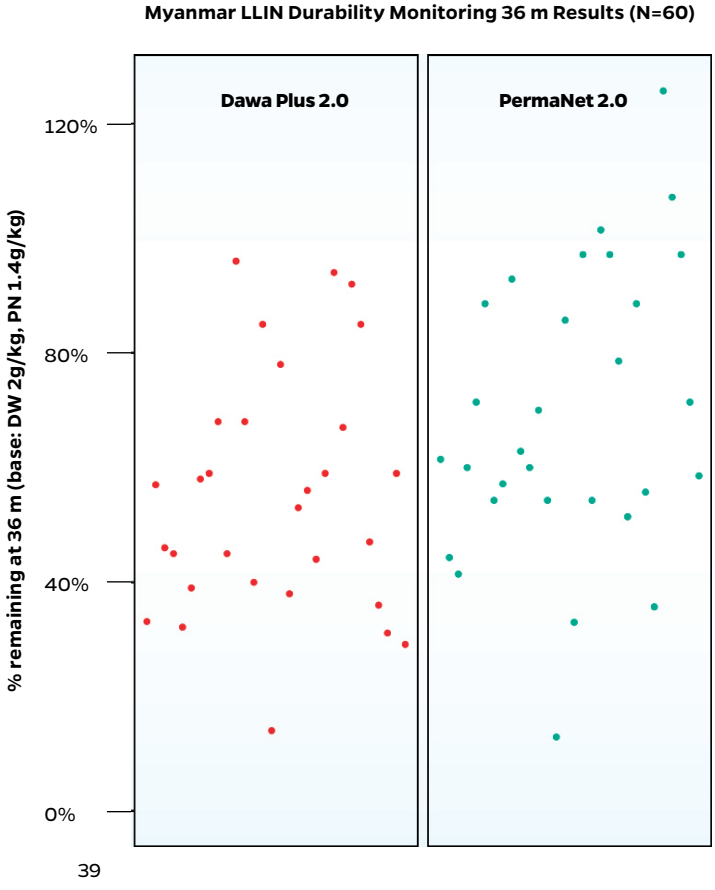


Figure 12: Results from chemical residue analysis: the plot shows chemical residue (g/kg) for individual pieces of 30 Dawa Plus 2.0 and 30 PermaNet 2.0 LLIN collected 36 months after distribution in Myanmar

Summary and Conclusion

This report describes the 36-month assessment results of the LLIN durability study. In this round of follow-up assessments, 263 households out of 290 households enrolled at the baseline were interviewed. Among them, 242 households still had cohort nets in their household. Overall, 35 (12.1%) households lost all their cohort nets and 13 (4.5%) households moved away from the study sites. For the nets, out of 582 nets recruited at the baseline, 426 (73.2%) could be observed in this assessment. Among the original recruited cohort nets, 18 (3.1%) nets were taken elsewhere by family members, 16 (2.7%) were not available for follow-up due to unknown reasons, 56 (9.6%) were discarded, 38 (6.5%) were given away, 12 (2.1%) were lost according to the respondent, and 16 (2.7%) nets were loss to follow-up due to household movement.

Food storage in the sleeping rooms, always cooking in a sleeping room, and rodents observed in the last six months reportedly decreased in this assessment. Similar to the previous assessments, the majority of campaign nets were used over a mat or the ground.

The proportion of cohort nets ever washed increased from 13.6% in the baseline, to 56.7% at the 12-month assessments, 79.7% at the 24-month assessments, and 86.4% at the 36-month assessments. In all assessments, median wash frequency within the past six months of data collection was the same. The use of detergent to wash nets was consistently very high. The proportion of households that dried washed nets on a bush or fence slightly increased in this assessment compared to the 24-month assessment (10.3% in baseline, 16.6% in 12 months, 6.6% in 24 months, and 9.5% in 36 months).

The proportion of households that reportedly ever had holes in their nets increased to 74.1% in this assessment from 56.2% in the baseline, 49.1% at 12 months, and 68.9% at 24 months. Among the households that reportedly ever had holes in their nets, the proportion of households that had ever repaired the holes rose again slightly in this assessment. Similar to the previous assessments, stitching was the main method of net repair (95.4%). The main reported reasons for not repairing holes (N=108) were not having time (51.9%) and holes being too small (20.4%). Among all observed cohort nets with any holes, the proportion of nets with repairs increased to 30.1% from 25.5% at the 24-month assessment.

Among the observed cohort nets, 79.6% had holes at the time of the survey, which was a marked increase from 15.1% in the baseline, 45.0% in the 12-month assessment, and 63.7% in the 24-month assessment. Overall, 66.7% of cohort nets were in good condition, which decreased from 96.9% at baseline, 88.7% at the 12-month assessment, and 77.3% at the 24-month assessment. The drop was more pronounced in the DawaPlus site (baseline=94.4%, 12-month=84.3%, 24-month=68%, 36-month=57.1%). Similarly, the increase in the number of nets that were too torn—and the consequent decrease in the number of nets in serviceable conditions—were more prominent in the DawaPlus site (95.7% of PermaNet versus 90.1% of DawaPlus). The major reported reasons for damage on nets were "tear," "rats," and "burn." When discarded nets were included in the analysis, 84.6% of PermaNet nets were still serviceable compared to 78.2% for DawaPlus. However, this difference was not statistically significant.

Across data collection rounds, the proportion of cohort nets found hanging was similar in the PermaNet site and it fluctuated in the DawaPlus site. The proportions of cohort nets that were used last night or every night in the last week decreased slightly in this assessment. The proportion of cohort nets used only by adults increased from 50.8% in baseline to 55.3% in the 12-month, 60.7% in the 24-month, and 68.2% in the 36-month. Consequently, the proportion of cohort nets used only by children, or children and adults, decreased.

Overall attrition of cohort nets increased to 34.2% from 27.8% in the 24-month assessment, 21.9% in the 12-month assessment, and 19.9% at baseline. The major cause of attrition was due to nets being given away (24.5%). Attrition due to wear and tear also increased to 8.1% from 4.1% at the 24-month, 1.2% at the 12-month, and 0.5% at baseline. The estimated survival of cohort nets in serviceable condition, which was a function of attrition and physical integrity, dropped to 81.7%: from 89.9% at the 24-month, 97.2% at the 12-month, and 99.8% at baseline.

The bio-assays were conducted for 12-, 24-, and 36-month assessments. The bio-efficacy measures of DawaPlus nets were lower than PermaNet nets in this assessment (median KD60: 70% versus 77%; median 24-hour mortality: 58% versus 68%). Only 3.3% of DawaPlus 2.0 nets met WHO optimal effectiveness

criteria, whereas 10% of PermaNet nets did so; 86.7% of PermaNet nets and 76.7% of DawaPlus nets met the minimal effectiveness criteria. Overall, the optimal effectiveness estimate dropped to 6.7% from 26.7% and 61.7% in the previous assessments.

For handling of bio-assay nets, the proportion of bio-assay nets ever washed, and the number of washes, were similar to those of other cohort nets in the study; the sites did not show any notable differences. At the 36-month assessment, more than 90% of bio-assay nets were washed with detergents.

The chemical residue analysis from 36-month data collection indicates that a mean of 1.10 g/kg deltamethrin was found on the DawaPlus 2.0 samples (loading dose 2.0 g/kg) compared to 0.97 g/kg for the PermaNet 2.0 (loading dose 1.4g/kg) samples. These results are very similar to chemical residue analysis performed after 24 months, where DawaPlus 2.0 samples had a mean of 1.17 g/kg and Dawa Plus 2.0 samples had a mean of 0.99 g/kg.

In summary, the 36-month assessment of cohort nets was successful, with only 13 households lost to follow-up. Most of the cohort LLINs (81.7%) were still surviving in physically functioning condition up to this point. However, insecticidal effectiveness, according to the bio-assays, was less than optimal.