

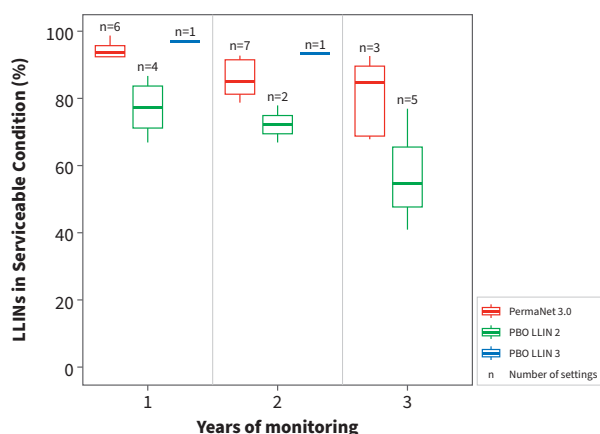
Maximising Impact and Value for Money: considering the cost of functional life of PBO LLINs

There is an assumption that all PBO nets prequalified by WHO provide the same level of protection. However, the durability of PBO LLINs is questioned because laboratory and semi-field studies do not adequately simulate their **actual durability in the community**.

PBO LLINs, seemingly comparable (non-inferior) in **experimental hut studies**, display **substantial differences** when evaluated in **real world field settings**, such as **varying fabric integrity (Figure 1a)**, **net survivorship, or insecticidal activity (Figure 1b)**.

Fabric integrity varies over time amongst PBO LLINs

Figure 1a



Insecticidal activity varies over time amongst PBO LLINs

Figure 1b

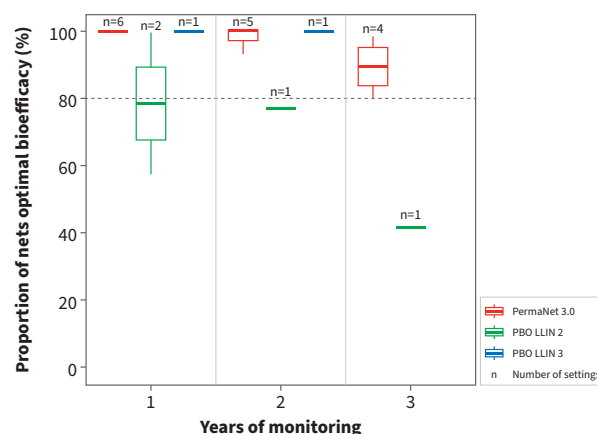


Figure 1. Fabric integrity of PBO LLINs (a), and insecticidal activity of PBO LLINs (b), in long-term field studies based on WHO 2013 guidelines from the publicly available literature.¹⁻⁹ Long-term (3 years) field data across at least three diverse settings are needed to measure the actual durability of PBO LLINs.¹⁰ Today, only two PBO LLIN brands have presented these data, and PermaNet 3.0 is one of them.

The key aspects of durability are **insecticidal activity** (efficacy) and **estimation of functional survival**. Functional survival considers the time in years since distribution when a pyrethroid-PBO LLIN is available for use in the community and the proportion of holes formed during that time.¹¹ Weighing the price of an LLIN against its Functional Survival is the **Cost of Functional Survival**.¹²

Net survivorship varies over time amongst PBO products:

The World Malaria Report 2022 presented net retention estimates by country,^{13,14} (Figure 2) PermaNet 3.0 and another PBO LLIN have data points in more than one country representing different socio-cultural and eco-epidemiological settings. This is required to measure the consistency of functional survival relative to country median LLIN retention estimates. The WHO 2013 long-term (3-year) field study guidelines recommend at least three settings.¹⁰ More studies are required to make a conclusion on the third PBO LLIN.

The Cost of Functional Survival allows for estimating the cost benefits of using a longer-lasting pyrethroid-PBO net relative to a more short-lived pyrethroid-PBO net.

With insufficient funding for malaria relative to what is required to achieve the WHO Global Technical Strategy for Malaria of a 90% reduction in incidence and mortality by 2030, the cost of functional life should be a key consideration in procurement decisions to maximise impact and value for money.

Not all PBO bed nets are the same

PermaNet 3.0: A durable PBO LLIN with proven best value for money

Among PBO LLINs with long-term data from at least three settings, PermaNet 3.0 has been shown to have a lower cost of functional life, offering higher value for each PermaNet 3.0 distributed.

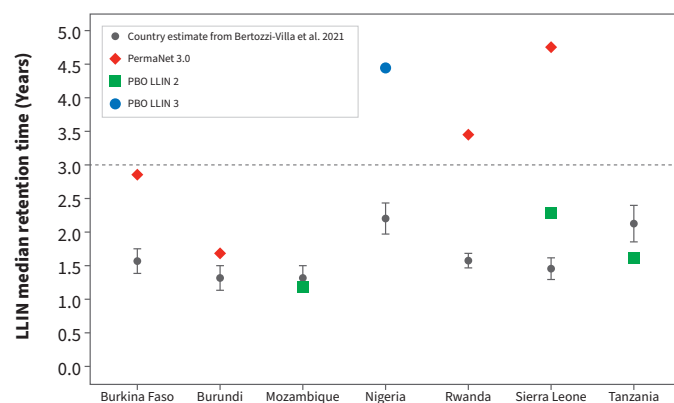


Figure 2. Median retention time of LLINs as estimated by Bertozzi-Villa et al. 2021 and the functional survival of PBO LLINs in years for countries where PBO LLIN data is publicly available. The grey dotted line represents the targeted 3-year net retention in the at-risk population.

PermaNet 3.0 outperforms on durability



The only PBO net with long-term field performance

PermaNet 3.0 consistently shows a higher proportion of LLINs in serviceable condition across settings after three years of monitoring, indicating better **fabric integrity**.

More durable bed nets lead to higher retention rates and reduce the rate of loss and the operational costs of malaria control programmes.

Four metrics of durability:

- Across countries, users continue to sleep under PermaNet 3.0 for longer than the approximative time (**median survival**) nets are **retained** in a country.
- **Better median survival rates lead to improved cost-effectiveness.**
- Based on publicly available data, PermaNet 3.0 is the only brand consistently passing WHO **bioefficacy** criteria up to 36 months of use.
- PermaNet 3.0 is one of only two pyrethroid-PBO LLINs brands with long-term field data (3 years) on durability in multiple settings.

PermaNet 3.0 is the pyrethroid-PBO LLIN with the lowest cost of functional life

Current results of pyrethroid-PBO LLINs suggest that LLIN functional survival differs substantially between products, and these differences strongly influence LLIN **value for money**. PermaNet 3.0 outperforms its competitors (products with diverse long-term durability data) in **every metric of durability**.

Compared to other pyrethroid-PBO LLIN brands, PermaNet 3.0 offers the **lowest cost per year of functional life**.

Retention rates of PermaNet 3.0 are significantly higher than the average retention rates in countries where studies were conducted¹⁴

PermaNet 3.0 consistently shows a high proportion of LLIN in serviceable condition after 3 years of monitoring

The median survival of PermaNet 3.0 is consistently higher than the estimated median survivorship of LLINs in multiple countries

Functional survival differs significantly between pyrethroid-PBO products, and these differences greatly impact the LLIN value for money

Calculating the cost of functional life

	Median Survival (Years)								
	1	1.2	1.5	1.9	2.2	2.5	3	3.2	
1.90	1.90	1.58	1.27	1.00	0.86	0.76	0.63	0.59	
2.00	2.00	1.67	1.33	1.05	0.91	0.80	0.67	0.63	
2.10	2.10	1.75	1.40	1.11	0.95	0.84	0.70	0.66	
2.20	2.20	1.83	1.47	1.16	1.00	0.88	0.73	0.69	
2.30	2.30	1.92	1.53	1.21	1.05	0.92	0.77	0.72	
2.40	2.40	2.00	1.60	1.26	1.09	0.96	0.80	0.75	
2.50	2.50	2.08	1.67	1.32	1.14	1.00	0.83	0.78	
2.60	2.60	2.17	1.73	1.37	1.18	1.04	0.87	0.81	
2.70	2.70	2.25	1.80	1.42	1.23	1.08	0.90	0.84	
2.80	2.80	2.33	1.87	1.47	1.27	1.12	0.93	0.88	

- Median Survival represents the point, in years, at which approximately half of the nets have reached the end of their functional life
- Functional life is the average time a bed net remains useful before it needs to be replaced
- This table provides a simple calculation of cost of functional life for a given price and a given median survival
- Modelled cost of functional life has to be calculated with the help of health economists
- PermaNet 3.0's median survival is 3.2 years (across all published data)
- **Nets with a lower median survival and/or a higher unit price may have a higher cost per functional life**

$$\text{Cost of functional life (simple)} = \frac{\text{Unit Price}}{\text{Median Survival}}$$

0.00 PermaNet 3.0 cost of functional life*

0.00 Combinations of Unit Price and Median survival giving a lower cost of functional life than PermaNet3.0

0.00 Cost of functional life for different price points and for global median survival of LLINs (1.9 years) estimated by the WHO

With the widening funding gap, there is increased pressure on customers to maximise the impact per \$ spent, particularly for HBHI countries; there is a crucial need to optimise the impact of LLINs and ensure the best value-driven purchasing decisions are made.

1. Regulatory and procurement agencies should ensure manufacturers generate and provide long-term field data in diverse settings.
2. There should be a consensus on the approach to estimating the cost of functional life in the malaria Vector Control community.
3. Procurement agencies should include the cost of the functional life of an LLIN (when available) in addition to the unit price in their procurement decision criteria.
4. The global malaria community has a responsibility to make data-driven and evidence-oriented decisions when purchasing Vector Control tools.

References

* Based on average median survival from studies where median survival was calculated for PermaNet 3.0 1. PMI Evolve. Durability Monitoring Report. In: *ASTMH 2023*; 2023. <https://www.pmi.gov/resources/> 2. PATH. *New Nets Project: Evidence of Effectiveness and Cost-Effectiveness of Dual-AI ITNs from the Observational Pilot Studies*; 2023. <https://www.path.org/our-impact/resources/new-nets-project-evidence-of-effectiveness-and-cost-effectiveness-of-dual-ai-itns-from-the-observational-pilot-studies-final-report/> 3. Gichuki PM, Kamau L, Njagi K, et al. Bioefficacy and durability of Olyset® Plus, a permethrin and piperonyl butoxide-treated insecticidal net in a 3-year long trial in Kenya. *Infect Dis poverty*. 2021;10(1):1-11. <https://doi.org/10.1186/s40249-021-00916-2> 4. Mechan F, Katurabee A, Tuhaise V, et al. LLIN Evaluation in Uganda Project (LLINEUP): The fabric integrity, chemical content and bioefficacy of long-lasting insecticidal nets treated with and without piperonyl butoxide across two years of operational use in Uganda. *Curr Res Parasitol Vector-Borne Dis*. Published online 2022:100092. <https://doi.org/10.1016/j.crvbd.2022.100092> 5. Moshia JF, Kulkarni MA, Lukole E, et al. Effectiveness and cost-effectiveness against malaria of three types of dual-active-ingredient long-lasting insecticidal nets (LLINs) compared with pyrethroid-only LLINs in Tanzania: a four-arm, cluster-randomised trial. *Lancet*. 2022;399(10331):1227-1241. [https://doi.org/10.1016/S0140-6736\(21\)02499-5](https://doi.org/10.1016/S0140-6736(21)02499-5) 6. Lukole E, Cook J, Moshia JF, et al. Protective efficacy of holed and aging PBO-pyrethroid synergist-treated nets on malaria infection prevalence in north-western Tanzania. *PLOS Glob Public Heal*. 2022;2(10):1-17. <https://doi.org/10.1371/journal.pgph.0000453> 7. Raghavendra K, Pant S c, Valecha N. *Large-Scale (Phase III) Evaluation of Efficacy, Fabric Integrity and Community Acceptability of PermaNet® 3.0 Long-Lasting Insecticidal Nets Compared with PermaNet® 2.0 in Western Kenya*; 2018. <https://vestergaard.com/products/public-health/permanet-3-0/> 8. Vulule JM, Bayoh NM, Atieli F, Ombok M, Olang G, Gimnig JE. *Large-Scale (Phase III) Evaluation of the Efficacy, Fabric Integrity and Community Acceptability of the PermaNet® 3.0 Long-Lasting Insecticidal Nets Compared with PermaNet® 2.0 in India*; 2017. <https://vestergaard.com/products/public-health/permanet-3-0-9> 9. Dadzie SK, Boakye DA, Appawu M, et al. *Phase III Evaluation to Compare Insecticidal Efficacy, Longevity, Fabric Integrity and Community Acceptance of Long-Lasting Insecticidal Net PermaNet® 3.0 with PermaNet® 2.0 in Ghana*; 2018. <https://vestergaard.com/products/public-health/permanet-3-0/> 10. WHO. *Guidelines for Laboratory and Field-Testing of Long-Lasting Insecticidal Nets*. World Health Organization; 2013. Note: Updated guidelines for field-testing of LLINs are under development by WHO PQ 11. WHO. *WHO Guidance Note for Estimating the Longevity of Long-Lasting Insecticidal Nets in Malaria Control*. World Health Organization; 2013. <https://apps.who.int/iris/bitstream/handle/10665/338345/WHO-HTM-GMP-2013.03-eng.pdf> 12. Lorenz LM, Bradley J, Yukich J, et al. Comparative functional survival and equivalent annual cost of 3 long-lasting insecticidal net (LLIN) products in Tanzania: a randomised trial with 3-year follow up. *PLoS Med*. 2020;17(9):e1003248. <https://doi.org/10.1371/journal.pmed.1003248> 13. WHO. *World Malaria Report 2022*. World Health Organization; 2022 14. Bertozzi-Villa A, Bever, C.A., Koenker, H. et al. Maps and metrics of insecticide-treated net access, use, and nets-per-capita in Africa from 2000-2020. *Nature Communications*. 2012;12(3589). <https://doi.org/10.1038/s41467-021-23707-7>

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