WHOPES and Its Impact on Long-lasting Insecticidal Net Availability

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Executive Summary

The World Health Organization Pesticide Evaluation Scheme (WHOPES) reviews and makes recommendations on new pesticide technologies for public health programs, such as long-lasting insecticidal nets (LNs). Used correctly and consistently, LNs protect against malaria-carrying mosquitoes longer than conventionally treated nets. The Roll Back Malaria Partnership (RBM)[1] has made LN distribution a top priority for malaria control and called on the private sector to develop and produce more LNs. Between 2001 and 2006, WHOPES recommended two products that constitute 98 percent of currently available LNs. WHOPES data collection and review could take six months, but due to systemic delays it will have taken recent applicants two years on average to receive the recommendation. During this time, these products are barred from most public tenders for lack of WHO imprimatur. This has restricted competition, kept prices high and limited production capacity for LNs. WHOPES is a valuable international public health resource but needs reform. RBM should immediately revise its policy of procuring WHOPES-recommended LNs to the near exclusion of other qualified LNs.

Introduction

Insecticide-treated nets (ITNs) emerged as a personal protection tool against malaria in the 1980s. They worked better than untreated mosquito nets, but had to be re-treated with insecticide every year to remain effective. WHOPES recommended Sumitomo Chemical's Olyset Net® (hereafter Sumitomo and Olyset®) as an LN for malaria control in 2001[2] as an LN, and granted "interim recommendation" to Vestergaard-Frandsen's PermaNet® 2.0 (hereafter Vestergaard and PermaNet®) in January 2004[3]. In September 2004, RBM convened a meeting of over a hundred companies in Johannesburg to urge them to increase the production of LNs[4]. It was not until December 2006 that a third LN, BASF's Interceptor®, was given WHOPES interim recommendation. Four other ITNs currently are under WHOPES review, and are not expected to receive interim recommendation before January 2008[5].

WHOPES Review

The WHOPES Working Group meets once a year to review test results and make recommendations on pesticide technologies. Review meetings involve around 11 participants, mostly scientists from the WHO and collaborating testing centers[6]. The WHOPES testing process is divided into three phases to test wash resistance, effectiveness under simulated field conditions and then effectiveness under actual field conditions.

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Phase I testing measures insecticidal efficacy in a lab by washing the nets and measuring mosquito responses by several methods. One is the cone test, where mosquitoes are held under a cone for three minutes with the opening covered by the washed and dried net. Another is the tunnel test, which punctures the washed and dried net with holes, then places it between mosquitoes and live animal bait for 15 hours. Nets washed at least 20 times that kill 80 percent of the mosquitoes in either test, paralyze 95 percent in the cone test or inhibit biting for 90 percent in the tunnel test can undergo Phase II testing[7].

Phase II testing measures insecticidal efficacy in experimental field huts. Simulating field conditions, some of the nets are punctured[8] and hung over participants' beds inside the huts. Wild mosquitoes enter the huts overnight. The next day mosquito bites are counted along with the number of mosquitoes found dead or paralyzed and how many rapidly exited the hut (caught in special traps). The number of mosquitoes the net deterred from entering the hut is inferred. Nets that pass both of these tests are given "interim recommendation" as LNs that remain effective for at least three years, and informally begin Phase III.

Phase III is a minimum three-year review of overall performance in the field, measuring insecticide efficacy, net longevity, fabric integrity, community acceptance and safety. Though not mandatory, studies associating LN use with malaria rate reductions are taken into account. Thus far only Olyset® has undergone this review and received "full recommendation".

WHOPES requires products to pass Phase I before starting Phase II and then pass Phase II before granting interim recommendation. Phase II is prone to bottlenecks. Testing sites must undergo rigorous evaluation by WHO before qualifying for official review. Experimental huts are available in Benin, Tanzania, Kenya, Burkina Faso, and Côte D'Ivoire and elsewhere. The latter two are not employed for WHOPES review due to wild mosquito resistance to pyrethroids (used with all the aforementioned ITNs) in Burkina Faso and conflict in Côte D'Ivoire. Though hut testing is done in Kenya, WHOPES has not officially validated this site and its data are not reviewed. Phase II testing must be done during the rainy season[9], making the process sensitive to administrative delays and climatic variability.

The Gold Standard Effect

Between 2004 and 2006, Sumitomo produced and sold approximately 30 million Olysets® and Vestergaard approximately 108 million PermaNets®[10]. Their marketing departments elevated WHOPES recommendation to a "gold standard"[11], and public sector contracts increasingly specified "WHOPES recommendation" as a requirement. In 2006, 93 percent of ITNs purchased by UNICEF and 100 percent of ITNs purchased by the World Bank and the US President's Malaria Initiative (PMI) were WHOPES-recommended LNs[12,13,14]. The Global Fund to Fight AIDS, TB and Malaria changed its policy to procuring only WHOPES-recommended LNs[15], and the International Federation of Red Cross and Red Crescent Societies (IFRC) signed a two-year exclusive agreement with Vestergaard for PermaNets®[16].

By insisting on WHOPES recommendation, RBM and Health Ministries have restricted competition and limited LN availability. (See Table 1)

Table 1: WHOPES Interim Recommendation, 2004-2007[a]

	Interceptor®	DuraNet®	Dawa Plus®	NetProtect®	Iconet®	
Product Description	Polyester net	Polyethylene net	Polyester net	Polyethylene net	Polyester net	
Manufacturer	BASF AG	Clarke Mosquito Control Prod. Inc.	Tana Netting Co., Ltd.	Bestnet Europe, Ltd.	Syngenta AG	
Active Ingredient[b]	Alpha-cypermethrin	Alpha-cypermethrin	Deltamethrin	Deltamethrin	Lambda-cyhalothrin	
Phase I Started	Oct 2004	Dec 2005	Jan 2006	Dec 2005	July 2006	Average Time Elapsed
Phase I Passed	Feb 2005	Nov 2006	Sept 2006	Sep 2006	Dec 2006	
Phase II Started	Sep 2005	Dec 2006	Jan 2007	Oct 2006	April 2007	
Interim Recommendation	Jan 2007	Jan 2008[c]	Jan 2008[c]	Jan 2008[c]	Jan 2008[c]	
Time Elapsed	27 months	25 months	24 months	25 months	18 months	**24 months**
Production Started	Sep 2005	Aug 2006	Dec 2005	Jan 2006	NA	Total
Nets produced	1 million	250,000	1.3 million	350,000	NA	**2.9 million**
Nets sold in markets	500,000	0	50,000	50,000	NA	**0.6 million**
Nets sold to donors	0	0	1.05 million	300,000	NA	**1.35 million**
Nets in stock	500,000	250,000	200,000	0	NA	**0.95 million**
Estimated Potential Production Capacity Through December 2007	1.6 million	1 million	4 million	2.4 million	1 million	**10 million**

a. All data in this table was provided by the product manufacturers. b. All products use a WHOPES-approved insecticide and have completed generic risk assessments for use with LN technology. c. This is the date that the expected results of the December 2007 WHOPES Working Group Meeting will be published.

Clarke Mosquito Control received Phase I approval for DuraNet® in November 2006. Limited testing facilities required Phase II to be done in Benin, where the rainy season will run through to July. DuraNet® will have to wait until January 2008 for interim recommendation[17]. Phase II delays weigh on small companies. Netting samples can be used in Phase I, but Phase II requires factory production of ITNs. After capital investments and WHOPES testing fees, companies must keep factory production, employees and distributors in limbo while waiting to compete for RBM donor contracts that specify WHOPES recommendation.

Of the five products listed in Table 1, each uses a WHOPES-approved insecticide for which a generic risk assessment has been completed. Only Interceptor® has received WHOPES interim recommendation. The others are undergoing WHOPES Phase II review. Based on Phase I results and independent evaluations[18], these products are likely to receive interim recommendation. However, this will not be until January 2008 at the earliest, as WHOPES only publishes LN recommendations following its annual Working Group Meeting in December. Despite BASF's recommendation and UNICEF signing supply agreements in August 2006 with all listed companies except Syngenta[19], a third of nets produced to date remain in stock. Given the preference for existing suppliers and WHOPES recommendation requirements, at least another 10 million nets risk the same fate between now and January 2008[20].

Limited competition has kept LN prices and distribution costs high, prompting the PMI to break with conventional RBM donor policy and choose a product currently under WHOPES Phase II review. According to USAID, the US agency that runs the PMI, "With the consent of the Ugandan host government, the Dawa Plus LNs® were procured using PMI funds through an open and competitive process that ensured that the nets met or exceeded WHOPES standards and used WHO-approved independent laboratories for testing."[21] USAID/NetMark contracted Tana Netting Company to deliver 132,000 Dawa Plus® nets to Uganda in January 2007, with an average delivery cost of $4.93[22]. Only 7 percent of the total cost was spent on logistics[23]. In

comparison, USAID contracted UNICEF to deliver 350,000 PermaNets® and 70,000 Olysets® to Angola in October 2005[24]. The delivery cost per net averaged $6.93, with 31 percent of the total cost spent on logistics[25].

This may seem an unfair comparison; Angola's transportation infrastructure is far less developed than Uganda's despite the latter being landlocked. Yet according to UNICEF's Supply Services Division, the average operational cost of delivering a net is $7.50[26] – even higher. This figure is consistent with UNICEF and its partners' fundraising campaigns for LNs, which cite $10 as the purchase ($5), delivery ($2), education ($2) and administrative ($1) cost for one LN[27]. $3 for logistics amounts to 30 percent of the total cost, $10. Factoring education out of the equation, this figure increases to 38 percent.

What WHOPES Recommended

Sumitomo is a chemical company that manufactures polyethylene nets made from a mix of plastic (polyethylene) and insecticide. Vestergaard is a textile company that impregnates fabric (polyester) nets with insecticide. After being washed, Olyset® technology enables insecticide to migrate from inside the polyethylene net material to the surface of the net. PermaNet® polyester fabric coating technology prevents the surface insecticide from being washed off all at once. Various studies have demonstrated the comparative advantages of each product and localized impact on malaria rates[28]. With few alternatives, RBM donors and malaria control programs have come become dependent on these products and paid less attention to their drawbacks.

The WHOPES review process for LNs was formalized only in the course of reviewing Olysets® and PermaNet®. Based on lab and field studies, WHOPES "recommended" Olyset® in 2001 for malaria control and encouraged the development of new LN technologies. Vestergaard subsequently submitted multiple versions of its product for WHOPES review in December 2003: PermaNet® 1.0 and PermaNet® 2.0, with "improved manufacturing quality control and wash resistance."[29] PermaNet® 1.0 failed wash resistance tests and was not recommended, but PermaNet® 2.0 passed and was given open-ended "interim recommendation" for malaria control. The review stated:

> "In response to the urgent needs of control programmes, when a WHO-recommended insecticide has been used in the manufacture of long-lasting insecticidal mosquito nets, interim recommendations may be given after specific requirements of laboratory and small-scale field studies (experimental huts) have been met...WHO should support and facilitate large-scale field studies of PermaNet 2.0 to confirm its long-lasting efficacy in the prevention and control of malaria and other vector-borne diseases in different settings."[30]

Official WHOPES testing guidelines for LNs based on these reviews were published two years later in 2005[31], specifying a Phase III review of field studies to occur at least three years after interim recommendation is given.

Over three years have elapsed and field reports show at least some PermaNets® 2.0 lack "improved manufacturing quality and wash resistance". Vestergaard's website currently states, "The active ingredient in PermaNet® 2.0 is targeted at 55 mg/m^2, which guarantees a minimum loading of 45 mg/m^2."[32] Yet Graham et al. reported in March 2005 that deltamethrin content on

unwashed PermaNet® 2.0s ranged from 27 to 142 mg/m^2 [33]. The upper range value far exceeds the oral daily acceptable exposure level of 0.01 mg/kg bodyweight for deltamethrin in the WHOPES generic risk assessment[34], which could be harmful to a newborn baby sucking on the net at night. Vestergaard cites the 2005 study elsewhere to validate PermaNet® 2.0's effectiveness without mentioning the variable insecticide load or the potential health hazards for newborns[35].

The lower value for the range quoted above, 27 mg/m^2, might explain other field reports of PermaNet® 2.0 failing after just six months. According to Dr. Pierre Guillet, WHO's Global Malaria Program Coordinator for Vector Control and Prevention:

> "We do not have yet a precise understanding of the duration of coating technologies in real life situations (PermaNet, Interceptor, K-Otab 123). Although PermaNet has been recommended in December 2003, the Phase III has never been completed which leaves us in a vacuum. **We recently received reports from Benin and Angola showing that after no more than 6 months, insecticidal efficacy of PermaNet was exhausted confirming earlier Uganda observations made by A. Kilian with PermaNet 1.0).** [emphasis added] We do not know to which extent washing conditions in Benin and Angola are representative or particularly harsh, but in the absence of a proper Phase III testing and based on limited available evidence, we cannot expect a coating technology to last very long in a wide range of field situation (needless to say that harsh washing condition will "burn" conventional treatment in 1 single wash...)."[36]

The informal nature of Phase III makes it unclear whether this issue will be addressed prior to the WHOPES Working Group Meeting scheduled for December 2007.

Olysets® were originally labeled by the manufacturer as requiring heat after washing to help replenish its surface insecticide. Although Sumitomo stopped using this label, subsequent lab tests have shown that Olyset® may still require heating to replenish surface insecticide[37,38]. The company's scientists dispute these studies and point to field data showing that Olysets® retain insecticidal effectiveness after seven years of use[39,40]. They do not dispute the fact that with or without heat, Olysets® require up to 15 days to replenish surface insecticide[41]. The wide mesh of Olysets® (~4mm x 4mm) improves airflow under the net but also allows sufficient space for the malaria-carrying *Anopheles* mosquito to squeeze through. Users may be vulnerable to attack when insecticide activity is low or non-existent.

BASF's Interceptor® is a polyester fabric net impregnated with 200 mg/m^2 of alpha-cypermethrin, five to ten times higher than the WHOPES recommended range for a conventionally treated net with this chemical[42]. Interceptor® received interim recommendation in January 2007. Field reports are scarce as few have been sold to date. It should be noted that Interceptor® is the only risk assessment to have been published, and with the following comment:

> "The WHO assessment of the compliance of the manufacturer's assessment of exposure to and risks of washing and sleeping under Interceptor nets was in line with the WHO generic risk assessment model and, although procedurally somewhat different, their conclusions were in agreement."[43]

BASF calculates that only a small portion of the insecticide is available on the net surface. The rest is bound up deep within the fabric, so the dose potentially ingested by a newborn sucking on

the net falls below the daily acceptable exposure level. Whether this is the case in practice remains to be seen.

Ultimately, WHOPES recommends new technologies based on limited data with good intentions but without any legal responsibility for consequences[44]. There is no formal time-limit or restrictions on interim recommendations. Companies can freely market their products as LNs that "last 20 washes"[45] irrespective of local water quality and washing techniques[46]. WHOPES Phase I and II do not test net durability. This is a key determinant of net life, as torn nets are less effective and may be discarded. Manufacturers publish product bursting strength, or the force that causes new nets to tear. Despite there being no standardized method to determine how easily nets with holes are torn, Sumitomo guarantees Olyset® for five years on its website[47] and Vestergaard guarantees PermaNet® for four years on its packaging. They sidestep this issue by conditioning these guarantees on "practical" or "recommended" use.

Though it does make regulatory recommendations, regulatory functions like quality control are considered outside WHOPES' mandate. Phase III is suitably passive and amorphous. UNICEF has conducted factory inspections and post-production quality control tests for several ITNs under WHOPES review, which it subsequently procured. These data are treated independently of the WHOPES process and, after years of RBM promoting WHOPES recommendation, have persuaded few Health Ministries to adopt new products.

Why Competition Matters

ITNs are a public health intervention that can reduce malaria rates. They are easily integrated into malaria control programs in a variety of settings, but being a personal protection tool, they rely upon individual compliance. A recent NetMark survey in Uganda shows that ITN use is increasing but still trails ownership: only about 13 percent of children under age five and pregnant women slept under an ITN the night prior to the survey[48]. Taking national data into account, these figures drop to about 10 percent, with about 22 percent in urban districts and 8 percent in rural districts[49].

Net preference can be the difference between using an ITN and dying of malaria. For example, polyester nets with thin mesh might restrict airflow and build up heat, causing a person to take it down in the summer heat and humidity. Preference might be as simple as color or size. Increasing competition means increasing consumer choice and available market data. If coupled with rigorous monitoring and evaluation, these data can help RBM and Health Ministries to anticipate which nets are likely to be accepted by target groups. Increasing competition will also drive prices and logistics costs down as new suppliers compete for business. Since so many LNs are bought by RBM donors, lower costs will translate into more nets distributed and presumably more lives saved with limited public funds.

Conclusion

After years of calling for increased production capacity and competition, RBM has unwittingly created a situation where one company, Vestergaard, manufactures 75 percent of LNs and maintains 60 percent of global production capacity. Large sums of public[50] and private

investment have yielded competitive products that are simply not allowed to compete. For all its commendable efforts, WHOPES has been inconsistent and has unintentionally acted as a barrier to market entry. Its reviews and recommendations are valuable, but they should incorporate a wider body of data and fast-track promising technologies. No new products will receive interim recommendation before January 2008, so RBM donors should decide now which ones qualify based on available data and let them compete for public contracts. UNICEF supply agreements should be a guide. Its factory and product evaluations could serve a formal regulatory role for new and existing LNs in countries lacking regulatory capacity. Donors must make outcomes as much a priority as inputs. For years they have invested public funds on nets without rigorously monitoring results or measuring the impact on malaria cases and related deaths. Strengthening epidemiological surveillance will help all concerned to understand which nets work best.

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[1] A list of current RBM Board Members is available on its website. These organizations are referred to collectively throughout this paper as "RBM". http://www.rollbackmalaria.org/index.html [Accessed April 22, 2007]
[2] Report of the Fifth WHOPES Working Group Meeting, WHO/HQ Geneva, 30-31 October 2001. Available: http://whqlibdoc.who.int/hq/2001/WHO_CDS_WHOPES_2001.4.pdf [Accessed April 19, 2007]
[3] Report of the Seventh WHOPES Working Group Meeting, WHO/HQ, Geneva, 2-4 December, 2003. Available: http://whqlibdoc.who.int/hq/2004/WHO_CDS_WHOPES_2004.8.pdf [Accessed April 19, 2007]
[4] RBM and UNICEF, "Call for increased production of long lasting insecticidal nets for malaria control," Press Release, September 23, 2004. A copy is on file with the author.
[5] The next WHOPES Working Group Meeting is scheduled for December 2007, but the results will not be published and thereby validated until January 2008.
[6] Phase I testing is done by the Institut de Recherche pour le Développement/Laboratoire des Insectes Nuisibles (IRD/LIN), France. Phase II testing is also done by this institution in Benin, and by the London School of Hygiene and Tropical Medicine in Tanzania. The Centers for Disease Control and Prevention, USA provides supplementary and field data. A full list of WHOPES Collaborating Centers is available at: http://www.who.int/whopes/en/WHO_coll_centres_sept05.pdf [Accessed April 16, 2007]
[7] Guidelines for Field-Testing of Long-Lasting Insecticidal Mosquito Nets, WHOPES, WHO, 2005. Available: http://whqlibdoc.who.int/hq/2005/WHO_CDS_WHOPES_GCDPP_2005.11.pdf [Accessed April 19, 2007]
[8] Soaping and beating nets on rocks is a common and typically abrasive washing practice in rural Africa.
[9] Mosquito breeding and malaria transmission peak during the rainy season, which occurs once or twice a year and varies within a range of a few months. Benin's rainy seasons usually occur between March and July, and September and November. Tanzania's usually occur between March and May, and October and January.
[10] These estimates are aggregated from various company publications available on the worldwide web.
[11] Though the term "gold standard" appears infrequently in print, it is used synonymously with "WHOPES approval" at technical meetings and informal discussions with manufacturers and RBM.
[12] Personal communication, Melanie Renshaw, Senior Malaria Advisor, UNICEF, April 16, 2007.
[13] Personal communication, Suprotik Basu, Public Health Specialist, World Bank, April 17, 2007.
[14] 2006 PMI contracts are available at: http://fightingmalaria.gov/funding/index.html [Accessed: April 17, 2007]
[15] Email correspondence from Mark Grabowsky, Malaria Program Manager, Global Fund to Fight AIDS, TB and Malaria, August 22, 2006. A copy is on file with the author.
[16] Personal communication, Selma Bernard, Senior Procurement Officer, IFRC, April 16, 2007.
[17] Personal communication, Rod Flinn, Director of International Business Development, Clarke Mosquito Control, April 15, 2007.
[18] See for example test results of Dawa Plus http://tananetting.com/products/documentation.htm and NetProtect http://www.intection.com/Test-Results.aspx. [Accessed April 21, 2007]
[19] UNICEF has carried out factory and product inspections for all the products listed and signed 12-month supply agreements: http://www.unicef.org/videoaudio/PDFs/contract_awards_october_2006.pdf [Accessed April 21, 2007]
[20] Production capacity is a function of demand. Clarke, Tana Netting and Bestnet Europe are all capable of producing more nets, but the strong preference for WHOPES recommended LNs has limited demand for their products as well as revenue that could be used to scale up production.

[21] Personal communication, Richard Greene, Director, Office of Health, Infectious Diseases and Nutrition, Bureau for Global Health, USAID, April 19, 2007.
[22] A copy of the contract is on file with the author.
[23] Logistics refers to the cost of delivering the nets. Of the total contract cost ($650,420), 93 percent ($605,880), represents the cost of purchasing nets. The rest ($44,540) was for shipping and insurance and district distribution.
[24] This contract was previously available at http://www.fightingmalaria.gov/, but has since been removed. A copy is on file with the author.
[25] Of the total contract cost ($2,908,632), 69 percent ($1,996,225), represents the cost of purchasing nets. The rest ($912,407), was for containers, freight and insurance, in-country logistics and UNICEF Programme Recovery Cost.
[26] Personal communication, Steve Jarrett, Deputy Director of Supply Services, UNICEF, January 9, 2007.
[27] Malaria No More is the only organization that breaks the $10 down: http://www.malarianomore.org/faq.php#faq08 Among many others, its partners are UNICEF/Spread The Net http://www.spreadthenet.org/whatisabednet.html, the UN Foundation/Nothing But Nets http://www.nothingbutnets.net/partners/, and Millenniums Promise http://www.millenniumpromise.org/site/PageServer?pagename=malaria_main. [Accessed April 18, 2007]
[28] Olyset: http://www.sumivector.com/content/view/41/88/ and PermaNet: http://www.permanet.com/content/pdf/test_result_en.pdf?sid=cf8539c8d5f11ef6a00bd18a2ba4134a&slg=en&sbw=l [Accessed April 22, 2007]
[29] Report of the Seventh WHOPES Working Group Meeting, WHO/HQ, Geneva, 2-4 December, 2003. Available: http://whqlibdoc.who.int/hq/2004/WHO_CDS_WHOPES_2004.8.pdf [Accessed April 19, 2007]
[30] Ibid.
[31] Guidelines for Field-Testing of Long-Lasting Insecticidal Mosquito Nets, WHOPES, WHO, 2005. Available: http://whqlibdoc.who.int/hq/2005/WHO_CDS_WHOPES_GCDPP_2005.11.pdf [Accessed April 19, 2007]
[32] http://www.PermaNet.com/site/inner.php?pg=c3&sid=8b7bbbb442128a2c89eeec6b1d5be1d8&slg=en&sbw=l
[33] Graham, K. et al., "Multi-country field trials comparing wash-resistance of PermaNet™ and conventional insecticide-treated nets against anopheline and culicine mosquitoes," Medical and Veterinary Entomology, 2005(19), 72-83. Available with subscription: http://www.blackwell-synergy.com/links/doi/10.1111/j.0269-283X.2005.00543.x/abs/ [Accessed April 22, 2007]
[34] Calculated according to WHOPES formula for newborn oral exposure to deltamethrin $0.544 \times 10^{-3} \times 142 = 0.077$ mg/kg bodyweight per day. "A Generic Risk Assessment Model for Insecticide Treatment and Subsequent Use of Mosquito Nets" WHO, 2004. Available: http://whqlibdoc.who.int/hq/2004/WHO_PCS_04.1.pdf [Accessed April 22, 2007]
[35] See page nine, study overview point nine: http://www.permanet.com/content/pdf/test_result_en.pdf?sid=cf8539c8d5f11ef6a00bd18a2ba4134a&slg=en&sbw=l [Accessed April 22, 2007]
[36] Email to the RBM Working Group for Scalable Malaria Vector Control, Pierre Guillet, WHO, Global Malaria Program Coordinator for Vector Control and Prevention, March 5, 2007. Copy on file with author.
[37] Gimnig, J. et al. Laboratory wash resistance of long-lasting insecticidal nets, Tropical Medicine and International Health, Volume 10(10), 1022-1029, October 2005.
[38] Lindblade, K. et al., Evaluation of long-lasting insecticidal nets after 2 years of household use, Tropical Medicine and International Health, 10(11), 1141-1150, November 2005.
[39] Tami, A. et al., Evaluation of Olyset™ insecticide-treated nets distributed seven years previously in Tanzania, Malaria Journal 2004, 3:19.
[40] Itoh, T., Letters to the editors, Tropical Medicine and International Health, 10(12), 1321-1326, December 2005.
[41] In its recommendation for Olyset®, WHOPES states, "However, a major advantage of Olyset Net is that its biological efficacy is resumed by diffusion of the insecticide from the inside of the yarn to the surface. This "regeneration" occurs naturally but is accelerated when nets are exposed to heat. However, under tropical conditions, Olyset Net washed 10 times recovered its efficacy in less than 15 days." Report of the Fifth WHOPES Working Group Meeting, WHO/HQ Geneva, 30-31 October 2001. Available: http://whqlibdoc.who.int/hq/2001/WHO_CDS_WHOPES_2001.4.pdf [Accessed April 22, 2007]
[42] Report of the Tenth WHOPES Working Group Meeting, WHO/HQ Geneva, 11-14 December 2006. WHO, 2007. Available: http://whqlibdoc.who.int/hq/2007/WHO_CDS_NTD_WHOPES_2007_1_eng.pdf [Accessed April 22, 2007]
[43] Ibid.

[44] Ibid. Like most WHO documents, the Report of the Tenth WHOPES Working Group Meeting states clearly in the pretext, "The responsibility for the interpretation and use of the material lies with the reader. In no event shall the World Health Organization be liable for damages arising from its use."
[45] For example, BASF's website reads, "In contrast, INTERCEPTOR™ nets protect sleepers even after 20 washes, and study results indicate that they provide 100% knockdown at one-hour post exposure meaning all mosquitos are paralyzed after contact with the net and unable to transmit malaria." Available: http://www.basfpublichealth.com/products/interceptor.html [Accessed April 16, 2007]
[46] WHOPES wash resistance testing uses de-ionized water and a non-abrasive washing technique, while much of rural Africa uses hard or mineral-rich water to manually and vigorously wash nets. Hard water requires more soap and rubbing to work up lather, which increase the likelihood of abrasion.
[47] Available: http://www.sumivector.com/content/view/18/37/ [Accessed April 19, 2007]
[48] Netmark 2006 Survey on Insecticide-Treated Nets in Uganda – Key Findings. A copy is on file with the author.
[49] 2006 Uganda Demographic and Health Survey Preliminary Report. Available: http://www.ubos.org/UDHS2006Preliminaryreport.pdf. [Accessed April 9, 2007]
[50] According to NetMark, a USAID-funded partnership investing in commercial development of ITNs, for example, the organization spent approximately $350,000 on testing and technical expertise to develop Dawa Plus technology and production facility.