



**2013**

# **Malaria Vector Control Commodities Landscape**

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## Abbreviations

<b>ALMA</b>	African Leaders Malaria Alliance	<b>OC</b>	organochlorine
<b>C</b>	carbamate	<b>OP</b>	organophosphate
<b>CAGR</b>	compound annual growth rate	<b>PMI</b>	President's Malaria Initiative
<b>CHAI</b>	Clinton Health Access Initiative	<b>PY</b>	pyrethroid
<b>DOD</b>	Department of Defense	<b>RBM</b>	Roll Back Malaria Partnership
<b>GFATM</b>	The Global Fund to Fight AIDS, Tuberculosis and Malaria	<b>R4D</b>	Results for Development Institute
<b>GMAP</b>	Global Malaria Action Plan	<b>R&amp;D</b>	research and development
<b>GPIRM</b>	Global Plan for Insecticide Resistance Management	<b>TFM</b>	Transitional Funding Mechanism
<b>IRM</b>	insecticide resistance management	<b>UN</b>	United Nations
<b>IRS</b>	indoor residual spraying	<b>UNICEF</b>	United Nations Children's Fund
<b>ITN</b>	insecticide-treated net	<b>US</b>	United States
<b>IVCC</b>	Innovative Vector Control Consortium	<b>USAID</b>	United States Agency for International Development
<b>LLIN (LN)</b>	long-lasting insecticide treated net	<b>USD</b>	United States dollar
<b>LLIRS</b>	long-lasting IRS	<b>UTN</b>	untreated nets
<b>LN</b>	long-lasting insecticide treated net	<b>VCAG</b>	Vector Control Advisory Group
<b>NGO</b>	nongovernmental organization	<b>WHA</b>	World Health Assembly
<b>NIH</b>	National Institutes of Health	<b>WHO</b>	World Health Organization
<b>NMCP</b>	national malaria control programme	<b>WHOPES</b>	WHO Pesticide Evaluation Scheme

## 1 Executive summary

### Introduction

This report is part of an ongoing initiative within UNITAID to describe and monitor the landscape for malaria commodities. This report focuses on product, technology and market dynamics around malaria vector control products that impact at-risk populations in endemic countries, specifically insecticide-treated nets (ITNs) and indoor residual spraying (IRS). It includes an overview of the current ITN and IRS technology and market landscape, and a high-level perspective on barriers to delivery and access. Information in this report was collected through a variety of methods, including desk research, literature reviews and expert interviews.

### Public health problem

The World Malaria Report 2012 estimated that there were 219 million cases of malaria in 2010 and 660 000 deaths. Malaria cases have decreased 8% since their peak in the mid-2000s and deaths have decreased 19%. In Africa specifically, 1.1 million malaria-related child deaths have been prevented since 2000 and malaria-specific mortality has fallen 33% during the same period. However, malaria remains a substantial global health problem and the current trajectory is not sufficient to reach the World Health Assembly (WHA) goals of 75% case reduction (to ~56 million cases) and near-zero deaths by 2015. In 2010, Africa had the highest burden with 70% of total cases (153 million) and 86% of deaths (560 000), although 67% of the 3.3 billion worldwide at-risk population occurred in Asia. Malaria mortality primarily impacts children, with 85% of cases in children under 5 years old.

### Technology landscape

Vector control products are mainly used in malaria control; vector control can additionally be used for other vector-borne neglected tropical disease, primarily dengue and leishmaniasis. Vector control for malaria targets *Anopheles* mosquitoes to prevent mosquito bites and, therefore, transmission and overall reduce the vector population. Several interventions for vector control are available. The World Health Organization (WHO) primarily recommends use of the WHO Pesticide Evaluation Scheme (WHOPES)-recommended long-lasting insecticide treated nets (LLINs) and IRS as they are the most effective at reducing the mosquito population and the ability to transmit (through reduced lifespan). There is limited endorsement of larviciding, space spraying and environmental management in specific contexts. Vector control products include:

- Bednets
  - ◆ untreated net (UTN): net material that acts as a physical barrier between a person and mosquitoes, inhibiting blood feeding and, therefore, transmission;
  - ◆ ITN: mosquito net that inhibits blood feeding and kills mosquitoes coming into contact with netting fibres coated with insecticide by dipping the net in a solution of insecticide and water; the insecticide usually lasts 6–12 months depending on washing mode and community practices and thus requires periodic re-treatment;
  - ◆ LLIN (or LN): mosquito net with insecticide incorporated within or bound around the net fabric, WHO defines an LLIN as a factory-treated net expected to retain its biological activity for at least 20 standard washes under laboratory conditions and three years of recommended use under field conditions;
- IRS: application of chemical insecticides on interior walls and roofs of all houses in a given area, killing vectors that rest on those surfaces;
- larviciding: reduces vector population growth by identifying larval habitats and acting on them to reduce mosquito larvae by either chemical insecticides or biological tools—WHO does not recommend this approach except where breeding sites are “few, fixed and findable” and only in conjunction with LLIN or IRS use;

- space spraying: dispersion into the air of a diluted insecticide, effective at killing vectors that come in contact with the insecticide while airborne; has been used for other vector-borne diseases such as dengue, but is recommended only in extreme circumstances for malaria control such as epidemics in urban areas or refugee camps;
- environmental management: modification or manipulation of environmental factors to reduce vector breeding, mainly acting on water accumulation sites; also may include house screening to prevent entry of mosquitoes;
- other products:
  - ◆ consumer products (household insecticides): products primarily available through the private sector market and used for nuisance abatement, e.g. coils, vaporizing mats and aerosols that incorporate an insecticide or repellent; lotions and wipes are also common;
  - ◆ wall linings: treated wall linings are a potential alternative to IRS, e.g. a lining of loosely woven high-density polyethylene panels treated with insecticide could be installed on the walls of a house; – WHO currently does not recommend wall linings;
  - ◆ other new paradigms as they become available such as traps, targets, etc.

The vector control R&D pipeline is focused on new insecticides, incremental improvements to existing products such as longer-lasting products and new paradigm approaches such as biological or genetic tools and consumer-oriented products. Improvements to existing tools are the most advanced, with multiple products in Phase III development. LLINs in Phase III development include products with longer efficacy than existing products and products with synergists (chemicals that block resistance mechanisms in malaria vectors) designed to have increased efficiency against pyrethroid-resistant malaria vectors. Long-lasting IRS is also under development, which could improve the convenience and cost-effectiveness of this approach.

Increased awareness and donor funding in the last 10 years have resulted in substantial scale-up of vector control interventions for prevention. Scale-up of IRS and LLINs has been particularly effective in Africa where half of the households in endemic areas have at least one ITN (compared to only 3% in the early 2000s) and IRS coverage has reached 10% of the population at risk (from 1% in the early 2000s). Globally, ITN and IRS coverage peaked in 2010 with the delivery of 166 million nets and 34 million households sprayed. Outside of Africa, six countries accounted for 70% of the total net use: India 18.4 million; Indonesia 6.5 million; Afghanistan 4.6 million; Myanmar 3.6 million; Philippines 3.0 million; China 2.2 million.

### Market landscape: ITNs and LLINs

A total of 483 million ITNs were delivered from 2009 to 2012. An initial estimate of the global steady-state donor-funded demand is ~225 million nets per year, which would account for 100% coverage of the at-risk population globally, low net coverage in South-East Asia (~5% coverage with donor-provided nets), approximately three years of effective duration, but not accounting for net loss. WHO has estimated that 150 million nets will be needed each year in Africa. An upper limit of theoretical demand based on 100% coverage of the 3.3 billion at-risk population is 1.8 billion nets, or ~610 million per year.

The market for nets is very concentrated in both funding and supply. Donor funding is highly concentrated in two donors—The Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) and the United States Agency for International Development (USAID)/President's Malaria Initiative (PMI). Combined, these two donors funded US\$ 919 million in 2009–2010 to purchase 166 million nets (62% of the estimated total). Historically, >70% of the funds from GFATM and USAID/PMI has been used to procure nets from two large manufacturers: Vestergaard Frandsen (55%) and Sumitomo (18%)<sup>1</sup>. BASF (7%) and Bestnet (6%) also supply nets, with the remaining 14% distributed among other manufacturers. Purchases are typically made via large tenders, which may limit access by smaller manufacturers and introduce long cycle times.

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<sup>1</sup> Since the time this report was prepared, The Global Fund to Fight AIDS, Tuberculosis and Malaria announced it had suspended contracts with Vestergaard Frandsen and Sumitomo after uncovering evidence that they had committed serious financial wrongdoing in Cambodia. The announcement was made on November 14<sup>th</sup>, 2013.



High-level analysis indicates the average cost to deliver a net has reduced by approximately 40% over the past 10 years to US\$ 4.80. However, interviews suggest the fully loaded cost to deliver a net may vary substantially by country or area, particularly due to the social costs—behaviour modification programmes and communication costs, for example. The main driver of cost is the price of the net, averaging US\$ 3.65 in 2012 (70–85% of the total), plus training, overhead and personnel distribution.

Procurement and tender decisions are often made based on price, as a lower price results in higher coverage, rather than on metrics of cost-effectiveness, quality or durability. Reduced prices increase pressure on margins for manufacturers; the cost to manufacture may be above this market value and may disincentivize manufacturers from pursuing innovative products. Globally, delivery channels remain concentrated in mass campaigns. In Africa, distribution is primarily via mass campaigns (78%), and additionally via antenatal care clinics (14%), immunization clinics (6%) and other channels (2%). Outside of Africa, distribution is also mainly via mass campaigns (81%), compared to immunization clinics (6%), antenatal clinics (1%) and other channels (12%).

Insecticides for nets are limited to pyrethroids, increasing the risk for resistance. Insecticide resistance remains a major challenge, particularly for this class of insecticide. New nets (expected by 2015) that are a combination of pyrethroids and another insecticide are in development, and manufacturers are scanning their active ingredient libraries to identify new active principles. WHOPES evaluates products in existing technology categories and is now accepting new product concepts (e.g. combinations of LLINs and new IRS products). The new Vector Control Advisory Group (VCAG) will promote innovation in new tools and paradigms (e.g. insecticide resistance mitigation) and establish evaluation criteria when they become available<sup>2</sup>.

UTNs may represent a substantial portion of the overall market beyond the demand estimated above; however, the UTN segment of the overall preventatives market is not a focus of this landscape.

### **Market landscape: IRS**

Approximately 30 million households were protected by IRS in 2011, representing 5% of the entire at-risk population. Maintaining current coverage levels, an estimated steady-state demand is 40 million households protected (80 million households sprayed, assuming twice-a-year spraying is required). It is important to note that IRS is likely to be used only in areas where there is sufficient government infrastructure and technical capacity to implement and fund the operational expenses.

Cost and logistical capacity are seen as the primary barriers to the adoption of IRS. Cost varies with programme size although the primary driver is spray operations (42–52% of total); other costs are insecticide, labour, shipping and equipment. In one analysis, large programmes averaged approximately US\$ 15 per household sprayed versus small programmes that averaged US\$ 25–30 per household sprayed. In addition, large programmes have seen their costs decrease from 2008 to 2010, while small programme costs have increased.

Historically, the largest financiers of IRS have been country governments (particularly in southern Africa, India and South-East Asia) as well as donors GFATM and USAID/PMI. The private sector also has been a contributor, leveraging IRS to protect employee communities surrounding their mines, sugar operations and other facilities. However, there has been very limited tracking of IRS efforts thus there are minimal data available on coverage, manufacturers and funding of IRS.

With the increasing risk of insecticide resistance, IRS may become an increasingly used tool. IRS can be applied with non-pyrethroid insecticides, making it an essential near-term component of insecticide resistance management (IRM) strategies, particularly in areas with known pyrethroid resistance and until new insecticide resistance-breaking tools are available. However, the increased cost of implementation, lack

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<sup>2</sup> Since the time this report was prepared, the WHO Vector Control Advisory Group (VCAG) on New Tools issued a Call for submissions on innovative vector control tools in which potential manufacturers and academic institutions were invited to submit application dossiers for new product/paradigms for consideration and review by VACG. The call was announced on November 1<sup>st</sup>, 2013.

of long-lasting IRS formulations and the logistical and operational capabilities required may be reducing uptake.

### **Challenges and market shortcomings**

The greatest challenge facing the malaria community is to reduce the risk of backsliding and maintain vector control coverage in 2013 and beyond. From 2009 to 2012, 483 million nets were delivered; 381 million of these are estimated to still be effective, but approximately 165 million are due to be replaced in 2013. In the near term, the primary focus of the malaria community is to maintain the coverage levels already attained such that, at a minimum, the ~165 million nets delivered in 2010 that are nearing the end of their lifecycle will be replaced. To achieve this, the community must overcome challenges in financing, particularly with the cancellation of GFATM Round funding, and in understanding the true demand and ensuring effective delivery.

Several other challenges face the community in the near term:

- insecticide resistance is driven by limited products and insecticides, however, the cost of implementing IRM strategies and the lack of in-country capacity may be limiting the uptake of recommendations even with the existing tools presented in the Global Plan for Insecticide Resistance Management (GPIRM);
- few tools are available to donors and countries to differentiate products and evaluate cost-effectiveness;
- limited resources exist to move beyond just sustaining coverage and to begin filling the historic coverage gap by reaching previously unserved populations.

Looking ahead, sustainable malaria control will require:

- a system for valuing innovation in malaria products and a regulatory/evaluation process that can provide data to differentiate new classes of products and incentivize development of new products;
- exploring a range of delivery channels beyond mass campaigns and reliance on donor funding to promote increased ownership by countries;
- sustained political commitment to reach elimination, particularly as mortality is reduced, to mitigate the risk of resurgence.

### **Market shortcomings and their reasons**

There are several shortcomings in the malaria vector control market for IRS and LLINs that represent potential areas for intervention to address the range of near-term and long-term challenges the malaria community faces (Table 1).

**Table 1: Summary of malaria vector control for IRS and LLINs shortcomings**

Category	Shortcoming	Reason	Section
Quality	Some LLINs may not be meeting minimum durability standards	<ul style="list-style-type: none"> <li>■ While the lifespan of the insecticide (residual efficacy) does not seem to be the issue, the physical durability of the textile to withstand holes from wear and tear seems to be a limiting factor</li> <li>■ Durability and effectiveness of any product vary significantly by region, making it difficult to predict durability</li> <li>■ Manufacturers are pushed to cut costs to remain competitive, which may put the quality of products in jeopardy</li> </ul>	4.2
Availability	Innovative LLIN and IRS products face difficulties reaching the market in a timely fashion	<ul style="list-style-type: none"> <li>■ Improved tools to address resistance and durability challenges will take an additional one to three years in the WHOPEs process after development</li> <li>■ Unclear metrics to differentiate products and measure innovations</li> </ul>	5.2, 5.3
	Manufacturers hesitant to invest in R&D for new paradigms, particularly to address resistance and durability concerns	<ul style="list-style-type: none"> <li>■ Uncertainty around whether or not there will be a willingness to pay for the innovations, as the market is very price sensitive</li> <li>■ Metrics to differentiate innovation in net-based products (e.g. longer efficacy, increased durability, insecticide resistance mitigation) are not in place beyond the WHOPEs minimum quality standards (Note: bursting strength is included in the current standards for LLINs, and standards for IRS include a duration of effective action)</li> <li>■ Economic impact of successful vector control is neither well documented nor understood</li> <li>■ Evidence of the health impact and effectiveness of new paradigms will be difficult and expensive to generate</li> <li>■ R&amp;D costs are difficult to recoup because “me too” equivalent products can undercut reference product prices</li> </ul>	4.4
Delivery	Manufacturers unable to plan ahead for future capacity needs due to uncertainty of funding <sup>1</sup>	<ul style="list-style-type: none"> <li>■ Uncertainty if the funding will be available to support the demand and capacity scale-up demands</li> <li>■ Uncertainty around future demand inhibits manufacturers from planning ahead</li> <li>■ Lack of transparency of global manufacturing capacity to meet spikes in demand, or to design potential steady-state demand</li> </ul>	5.2, 5.3
	Uncertainty about true demand and where the nets are that have to be replaced at the country/district level	<ul style="list-style-type: none"> <li>■ Lack of any cohesive delivery monitoring or demand forecasting to identify areas with highest needs</li> </ul>	5.2
	Current distribution systems may be less efficient and less sustainable than routine distribution channels	<ul style="list-style-type: none"> <li>■ Current scale-up efforts have relied on mass campaigns, which are less suitable for more ongoing, intermittent maintenance</li> <li>■ Routine delivery channels are currently underutilized for keep-up efforts and as a supplement to mass campaigns</li> </ul>	5.2
	Sustained gaps in coverage, particularly within certain population segments (i.e. children over 5, pockets of people in South-East Asia, rural poor population)	<ul style="list-style-type: none"> <li>■ Current donors have not focused scale-up efforts on populations that have the potential to purchase protection products on their own (i.e. population segments in South-East Asia)</li> <li>■ Donors have historically concentrated efforts on certain populations who are at greatest risk (i.e. children under 5 and pregnant women), while focus may need to be expanded to meet targeted universal coverage</li> </ul>	5.2, 5.3

<sup>1</sup> The Global Fund to Fight AIDS, TB and Malaria is currently in the process of operationalizing its new procurement framework (Procurement for Impact, P4i) for LLINs. Key strategies under the framework include joint forecasting with partners and longer-term contracts with suppliers to improve production, capacity planning.

Category	Shortcoming	Reason	Section
Affordability	Lack of predictable funding at historical levels to meet the near-term need of maintaining coverage	<ul style="list-style-type: none"> <li>■ Continued uncertainty around GFATM funding levels</li> <li>■ Concentrated donor landscape</li> </ul>	5.2, 5.3
	Unclear sources of funding to close the coverage gaps	<ul style="list-style-type: none"> <li>■ Concentrated donor landscape</li> <li>■ Minimal contributions from domestic funding sources; domestic funding for malaria control is generally less than US\$ 1 per person at risk (1)</li> </ul>	5.2, 5.3
	Difficulty shifting to a consumer-driven market	<ul style="list-style-type: none"> <li>■ Scale-up of donor funding has created a culture built on the expectation of free nets</li> </ul>	5.2
	Cost-effectiveness data not taken into account in purchasing decisions for both nets and IRS	<ul style="list-style-type: none"> <li>■ Durability metrics have only recently been released</li> <li>■ Methods for translating durability data into procurement decisions to optimize cost and value have not yet been released, preventing countries from making procurement decisions based on cost-effectiveness</li> <li>■ Detailed understanding of comparative application and implementation costs are not available</li> <li>■ Very price-sensitive market since a lower price turns into higher coverage given a fixed pool of funds</li> </ul>	4.2
Acceptability/ adaptability	Limited uptake of IRM products and recommendations	<ul style="list-style-type: none"> <li>■ IRM approaches tend to be more costly than traditional vector control methods</li> <li>■ Countries lack the tools and resources to implement IRM strategies</li> </ul>	5.3
	Limited uptake of IRS in contrast to LLINs	<ul style="list-style-type: none"> <li>■ For many areas, higher cost and lower lifespan of IRS versus LLINs drive the decision to focus on LLINs, though IRS may be more appropriate in some areas</li> <li>■ General feeling of IRS being less convenient than net campaigns or approaches</li> <li>■ IRS needs more teams specifically trained to apply IRS products compared to LLIN delivery</li> </ul>	5.3
	Country purchasing decisions driven by short-term impact	<ul style="list-style-type: none"> <li>■ Metrics and guidance to enable procurement based on cost-effectiveness rather than cost not yet developed</li> <li>■ Limited entomological capacity, knowledge and data to help guide countries as they develop longer-term strategic plans</li> </ul>	5.2

### Potential interventions

A few examples of potential market interventions to improve access to malaria vector control commodities are provided in Figure 1. This list is illustrative and not comprehensive. Examples of the shortcomings that would be addressed by these interventions are provided in Figure 2.

Figure 1: Examples of potential market interventions

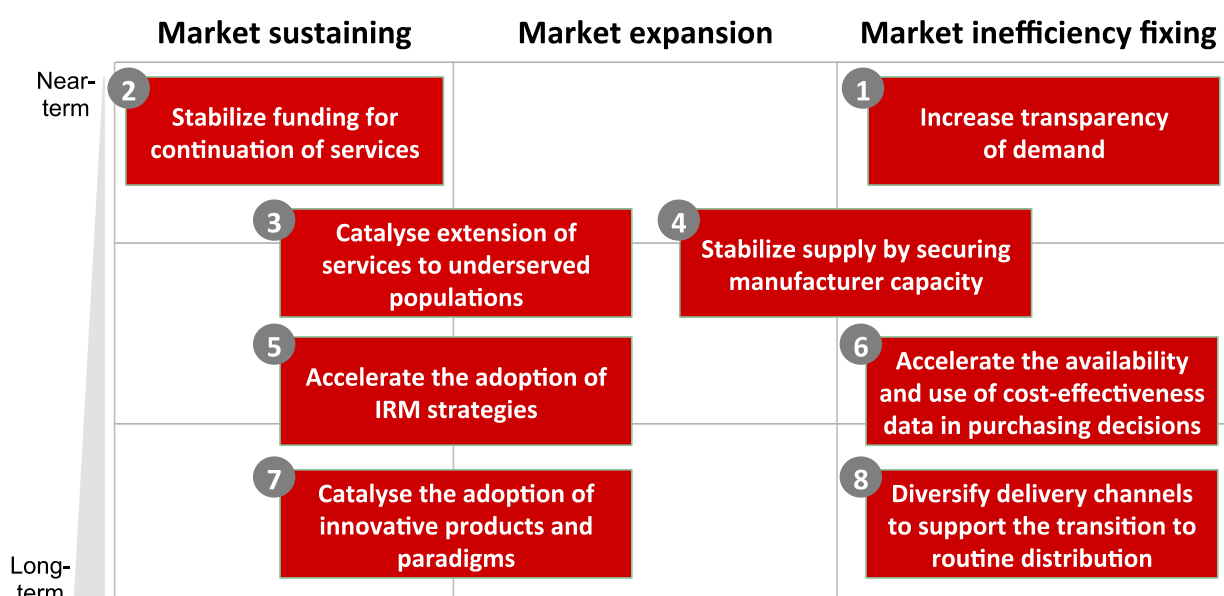


Figure 2: Examples of potential interventions and the shortcomings addressed

Intervention	Shortcomings addressed
1 Increase transparency of demand	<ul style="list-style-type: none"> <li>Delivery: Uncertainty about true demand and where the nets are that have to be replaced at the country/district level</li> <li>Delivery: Sustained gaps in coverage, particularly within certain population segments</li> <li>Delivery: Manufacturers unable to plan ahead for future capacity needs</li> </ul>
2 Stabilize funding for continuation of services	<ul style="list-style-type: none"> <li>Affordability: Lack of predictable funding at historical levels to meet the near-term need of maintaining coverage</li> </ul>
3 Catalyse extension of services to underserved populations	<ul style="list-style-type: none"> <li>Affordability: Sustained gaps in coverage, with limited funding on the horizon for scaling up</li> <li>Affordability: Difficulty shifting to a consumer-driven market</li> </ul>
4 Enable manufacturers to maintain suitable levels of capacity	<ul style="list-style-type: none"> <li>Delivery: Manufacturers unable to plan ahead for future capacity needs</li> </ul>
5 Accelerate the adoption of IRM strategies	<ul style="list-style-type: none"> <li>Acceptability/adaptability: Limited uptake of IRM products and recommendations</li> </ul>
6 Accelerate the availability and use of cost-effectiveness data in purchasing decisions	<ul style="list-style-type: none"> <li>Quality: Lower quality products are being purchased over higher quality ones</li> <li>Acceptability/adaptability: Country purchasing decisions driven by short-term impact</li> </ul>
7 Catalyse the adoption of innovative products and paradigms	<ul style="list-style-type: none"> <li>Availability: Manufacturers hesitant to invest in R&amp;D for new paradigms, particularly to address resistance and durability concerns</li> </ul>
8 Diversify delivery channels to support the transition to routine distribution	<ul style="list-style-type: none"> <li>Delivery: Current scale-up distribution systems are not efficient</li> </ul>

### 2 Introduction

This report is part of an initiative within UNITAID to describe and monitor the landscape for malaria commodities. This report focuses on product, technology and market dynamics around malaria vector control products that impact at-risk populations in endemic countries, specifically insecticide-treated nets (ITNs) and indoor residual spraying (IRS). It includes an overview of the current ITN and IRS technology and market landscape, and a high-level perspective on barriers to delivery and access. Information in this report was collected through a variety of methods, including desk research, literature reviews and expert interviews.

This report (and others) will facilitate informed decision-making by the UNITAID Board, support the Proposal Review Committee should they evaluate any relevant proposals and serve as global public goods for other donors, global health organizations and malaria programmes.

The report is structured as follows:

- Section 3 provides an overview of the vector control approaches and the global trends in coverage and use;
- Section 4 provides an overview of the technology landscapes for the main categories of interventions: insecticides, IRS, ITNs and long-lasting insecticide treated nets (LLINs), discussing the range of products available as well as those products currently in the R&D pipeline;
- Section 5 provides an overview of the market landscape for the main categories of interventions (insecticides, IRS and ITNs/LLINs), discussing supply and demand market characteristics;
- Section 6 summarizes the critical near-term and long-term challenges in the malaria vector control market, and gives an overview of the major market shortcomings and their causes;
- Section 7 discusses the range of possible market interventions and details eight specific examples that could address the market deficiencies and yield health impact.

In addition, a set of annexes provides further detail on specific topics to supplement the landscape:

- Annex 1 provides the full set of references and acknowledgements;
- Annex 2 provides a short summary of insecticide resistance management (IRM) approaches with IRS;
- Annex 3 is a summary of key stakeholders, including R&D funders and drivers, donors and multilateral organizations;
- Annex 4 documents the WHO Pesticide Evaluation Scheme (WHOPES) process in more detail.

### Methodology

In order to gather a comprehensive view of malaria vector control commodity issues, several sources of data were used. Desk research identified public information available on vector control products, specifically insecticides, nets and IRS. Examples include: the World Malaria Report 2010–2012; the Global Plan for Insecticide Resistance Management (GPIRM); and the Global Malaria Action Plan (GMAP).

A number of interviews were conducted with malaria experts from various international stakeholders, including the World Health Organization (WHO), Roll Back Malaria Partnership (RBM), UNITAID, GFATM, the Clinton Health Access Initiative (CHAI) and IVCC. Consultations with manufacturers were limited but will be expanded in future editions of the landscape. This report builds further on prior interviews and workshops conducted as part of GPIRM and the Vector Control Advisory Group (VCAG) development.

Data were primarily collected during the period December 2012 - March 2013, however data were also updated through July 2013. Any developments which have occurred since July 2013 have been noted in footnotes and will be developed further in the biannual update of the landscape scheduled for Spring 2014.

**Caveat:** This document consolidates data from different sources and different periods. Since no information is available on the overall malaria vector control commodities market, we have, therefore, extrapolated from these sources to draw general conclusions about the global market. For this reason, data sets from different analyses might not be immediately comparable with each other. In addition, given the limited amount of robust data available on the malaria vector control market, it is important to note that individual countries may vary from the picture described here.

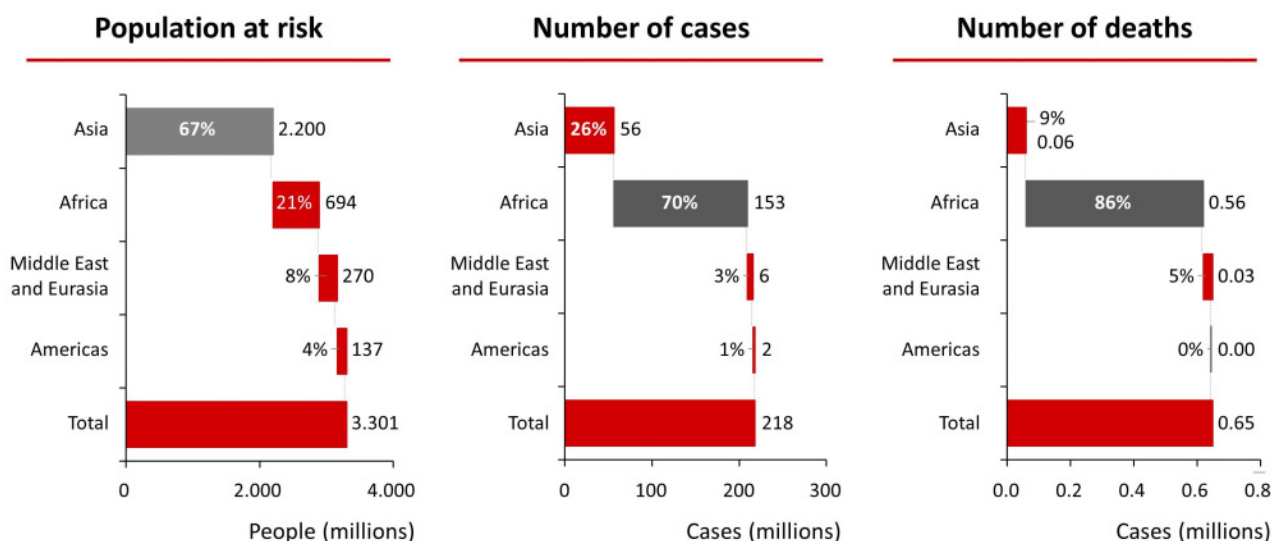
### 3 Malaria today

#### 3.1 Disease overview

Malaria is a vector-borne parasitic disease caused by the parasite *Plasmodium* and spread through the bite of *Anopheles* mosquitoes. Though prevention and drug treatment exist, symptoms of severe chills, headaches and high fever can ultimately progress to coma and death if the disease goes undiagnosed and unaddressed. Malaria mortality primarily impacts children, with 85% of cases in children under 5 years old. (1)

Malaria is a global challenge. In 2010, WHO estimated the global population at risk for malaria to be 3.3 billion people. (2) While 2.2 billion of the at-risk population resided in Asia, Africa represented 70% of the worldwide cases and 86% of the deaths (Figure 3). Since 77% of the at-risk population in Asia lives in areas of low transmission, the region has a low malaria burden given its large size. Africa is often the focus of malaria discussions because of the disproportionately high burden for the 694 million people, or 21% of the global at-risk population, living in the region. In 2010, the Americas, Europe, the Middle East and Eurasia accounted for approximately 12% of the global at-risk population and contributed minimally to global cases and deaths. (2)

**Figure 3: Malaria at-risk population, cases and deaths by region in 2010 (2)**

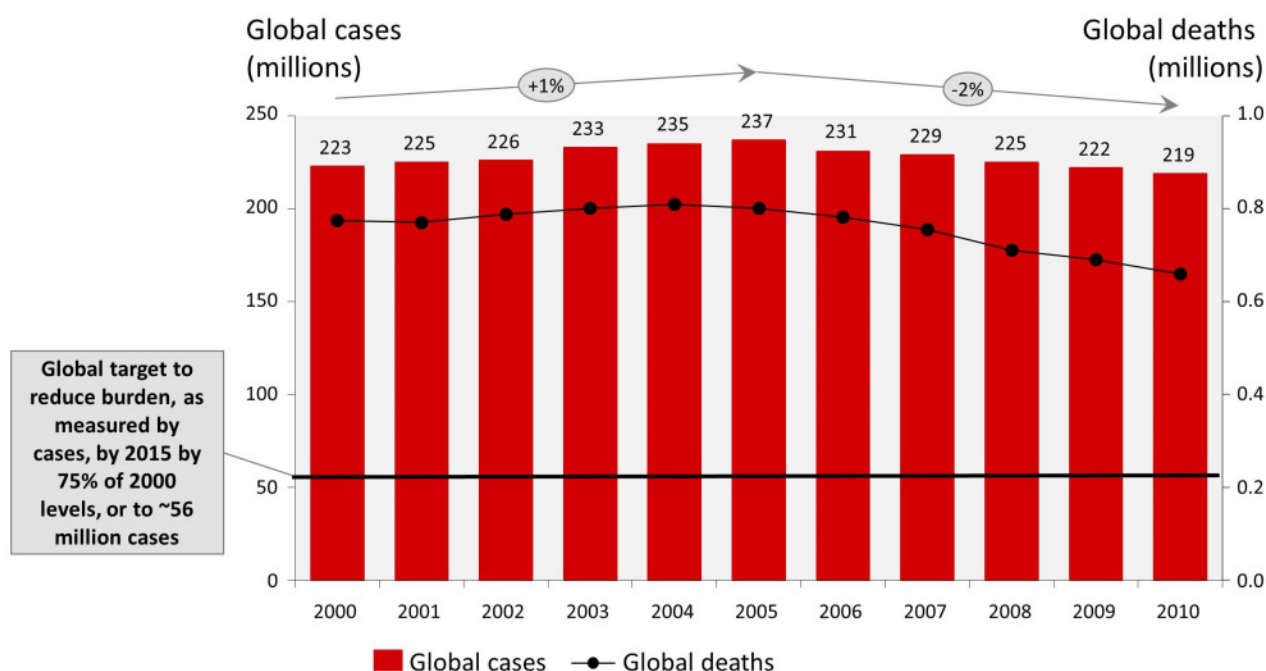


The global health community has set forth various goals for the control and eventual eradication of malaria. In a 2007 resolution (WHA58.2), the World Health Assembly (WHA) targeted a 75% global malaria burden reduction from 2000 levels by 2015, or a reduction of 167 million cases, as part of achieving the United Nations (UN) Millennium Development Goals; similarly, RBM has targeted a goal of near-zero preventable deaths by 2015. (3) In addition, malaria is a key priority on the UN Secretary-General Five-year Action Agenda for 2012–2017.

To date, much progress has been made in addressing malaria in various regions as awareness and funding has increased in efforts to scale up prevention and treatment. Released in 2008, GMAP helped focus the malaria community on the long-term goal of eradication. (4) However, malaria still represents a major global health issue today. The number of cases worldwide has decreased only 3% since 2000 to 219 million cases in 2010, far from the 75% reduction targeted. Similarly, the number of deaths caused by malaria has decreased 13% since 2000 to 655 000 deaths in 2010 (Figure 4). (2) While the overall global gains in malaria control have been modest, the World Malaria Report 2012 stated that 50 of the 99 countries with ongoing malaria transmission are on track to hit the target of reducing malaria case incidence by 75% by 2015. (1)



Figure 4: Global malaria cases and deaths, 2000–2010



### 3.2 Vector control overview

Vector control is one of the primary tools used for preventing malaria as part of broader control and elimination efforts. Vector control also can be used to control additional vector-borne neglected tropical diseases, mainly dengue and leishmaniasis.

#### Vector control goals

The global health community has established specific goals for vector control as part of the broader objectives in controlling malaria, as discussed earlier. In prior years, coverage goals had been targeted primarily at those most at risk for malaria—pregnant women and children under the age of 5. Specifically, the goal previously was to reach 80% coverage of children and pregnant women by 2010, and 100% coverage by 2015. WHO and RBM have expanded these targets to strive for broader, universal (100%) coverage of the global at-risk population by 2015. Beyond 2015, the goal is to sustain universal coverage for all populations at risk until local field research suggests that coverage can gradually be targeted to high-risk areas and seasons only, without the risk of a generalized resurgence. (4)

#### Interventions

There is a range of different vector control approaches (Table 2). WHO primarily recommends use of WHOPES-recommended LLINs and IRS as they are the most effective at reducing the mosquito population and the ability to transmit (through reduced lifespan). There is limited endorsement of larviciding, space spraying and environmental management in specific contexts.

**Table 2: Summary of vector control interventions (5) (6) (7) (8) (9) (10) (11) (12) (13)**

<b>Approach</b>	<b>Description</b>	<b>Insecticides (if applicable)</b>
<b>Bednets</b>	Untreated nets (UTN): A net material that acts as a physical barrier between a person and mosquitoes, inhibiting blood feeding and, therefore, transmission.	Not applicable
	ITN: A mosquito net that also can inhibit blood feeding and kills mosquitoes coming into contact with netting fibres coated with insecticide by dipping the net in a solution of insecticide and water. The insecticide usually lasts from 6–12 months depending on washing mode and community practices and thus requires periodic retreatment.	Pyrethroids <i>only</i>
	LLIN (or LN): Insecticide is incorporated within or bound around the net fabric. WHO defines an LLIN as a factory-treated net expected to retain its biological activity for at least 20 standard washes under laboratory conditions and three years of recommended use under field conditions.	
<b>IRS</b>	Application of chemical insecticides on interior walls and roofs of all houses in a given area, killing vectors that rest on those surfaces. Spraying domestic animal shelters also is done in some countries.	Pyrethroids Organochlorines (DDT) Organophosphates Carbamates
<b>Larviciding</b>	Reduces vector population growth by identifying larval habitats and acting on them to reduce mosquito larvae by means of either chemical insecticides or biological tools. WHO does not recommend this approach except where breeding sites are “few, fixed and findable” and only in conjunction with LLIN or IRS use.	Organophosphates and carbamates as chemicals Bacteria and fish as biological tools
<b>Space spraying</b>	Consists of the dispersion into the air of a diluted insecticide, effective at killing vectors that come in contact with the insecticide while airborne. Space spraying has been used for other vector-borne diseases such as dengue, but is recommended only in extreme circumstances for malaria control such as epidemics in urban areas or refugee camps.	Pyrethroids Organophosphates
<b>Environmental management</b>	Consists of the modification or manipulation of environmental factors to reduce vector breeding, mainly acting on water accumulation sites. May also include house screening to prevent entry of mosquitoes.	Not applicable
<b>Other products</b>	Consumer products (household insecticides): Products primarily available through the private sector market and used for nuisance abatement. Examples: coils, vaporizing mats and aerosols that incorporate an insecticide or repellent; lotions and wipes also are common.	Pyrethroids Carbamates Plants and oils with repellent effect
	Wall linings: Treated wall linings are a potential alternative to IRS. For example, a lining of loosely woven high-density polyethylene panels treated with insecticide could be installed on the walls of a house. Wall linings may also address some issues of consumer acceptance as they may be perceived as enhancing the interior style of walls. Wall linings are not currently recommended by WHO.	Pyrethroids

The most appropriate intervention is based on the specific conditions whereby it is being implemented and, therefore, can vary due to infrastructure, vector ecology and environmental constraints, transmission levels, implementation capacity, cultural habits and acceptance and, ultimately, available funding. Nets followed by IRS are the primary forms of vector control in use due to the ease of scale-up and use and the

clear evidence of impact, particularly on vectorial capacity. As a result, universal coverage has commonly focused on 100% coverage of nets or IRS in a given country or district.

UTNs may represent a substantial portion of the overall market beyond the demand and coverage discussed in this report; however, the UTN segment of overall preventatives market is not a focus of this landscape. In 2005, a study of a small region in Mali showed 98% coverage of bednets (all forms), but 11% coverage of ITNs. Similar levels of coverage were documented in Cambodia during this time. Additional data are needed to understand how education and mass campaign efforts, as well as the introduction of LLINs, have impacted the relative proportion of untreated versus treated nets.

The remainder of this report concentrates on insecticides and the insecticide-based interventions—ITNs, LLINs and IRS.

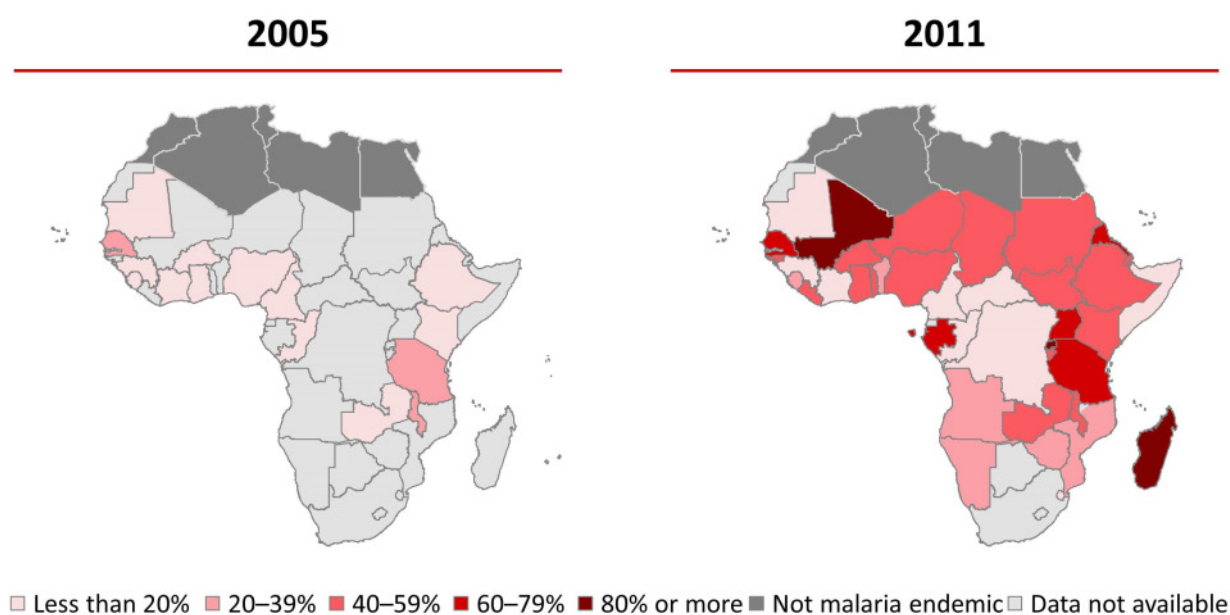
### 3.3 Global trends

In the past five years, there has been significant progress in the scale-up of nets and IRS globally. Today, 381 million ITNs/LLINs are estimated to be in use, protecting 21% of the 3.3 billion people globally at risk, including 153 million people who were protected through IRS in 2011 alone. (1) However, commodity access issues remain and have limited the ability to meet universal coverage targets.

ITN use and IRS coverage have increased substantially over the last five years, driven in part by the decreasing average cost to deliver a bednet, which has fallen over the past decade to US\$ 4.80. (14) ITNs and LLINs are primarily donor funded, with very concentrated donor and supplier markets. Between 2009 and 2012, over 80% of the global LLIN deliveries was concentrated in sub-Saharan Africa. Africa has experienced an increase in ITN coverage between 2005 and 2011 (Figure 5).

Both 2009 and 2010 were years of substantial scale-up of vector control interventions globally, primarily of bednets. In 2013, the malaria community will, therefore, be faced with the challenge of procuring and delivering, at a minimum, the approximately 165 million nets to replace those originally delivered in 2010 that are nearing the end of their three-year lifespan. (1) In addition, while many households have at least one net, the current recommendation is for one net per approximately two people, indicating that many households will require more than one net to cover the entire house.

**Figure 5: Proportion of households with at least one ITN (2)**



Note: Based on latest survey available in the respective years.

Source: World Malaria Report 2011, WHO.

ITNs have proven to be highly effective tools for controlling malaria, especially when used at high coverage rates. When high community coverage is achieved, the overall number of mosquitoes, as well as their individual lifespan, will be reduced. When this happens, all community members are protected regardless whether or not they have a net. In areas with high coverage rates, bednets can reduce malaria cases by 40–60%. (4)

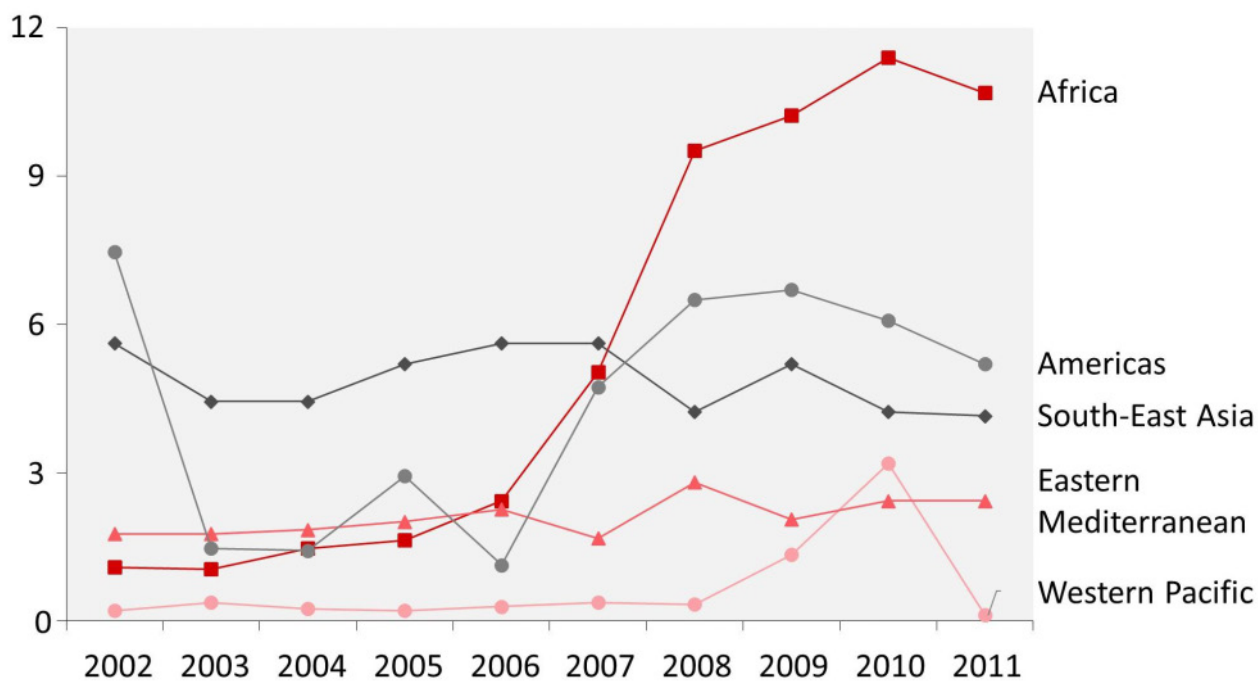
The increasing residual efficacy and access to bednets, coupled with the broadening of coverage targets to include the coverage of all at-risk populations, have led to major scale-up efforts by many countries over the last few years. These various scale-up initiatives led to a spike in the quantity of bednets delivered in 2010. In 2010, 166 million bednets were delivered globally (15), about a 40% increase from 2009. Between 2009 and 2012, 483 million LLINs were delivered globally, 392 million of those in sub-Saharan Africa alone. (15) Outside of Africa, six countries account for 70% of the total 78 million nets in use: India 18.4 million; Indonesia 6.5 million; Afghanistan 4.6 million; Myanmar 3.6 million; Philippines 3.0 million; China 2.2 million.

Current coverage rates vary dramatically by region, country and district. Coverage variations are attributable to many geographical differences such as transmission rates, disease burden, governmental infrastructure and historical coverage targets. For instance, in Africa, with 86% of its at-risk population living in areas of high transmission and having the highest disease burden of all other regions, all countries in the control stage use LLINs. Similarly, in Eurasia and the Middle East, LLINs are the main form of vector control. On the other hand, both the Americas and Asia have significantly different LLIN usage. In the Americas, only six of the countries target the entire at-risk population with LLINs, and although Asia represents 67% of the global at-risk population, coverage with donor-funded LLINs has been historically low. In both the Americas and Asia, IRS has historically been the predominant prevention tool. (4)

IRS coverage also has increased. Historically, global IRS efforts have been poorly monitored and tracked, resulting in minimal and poor data on coverage rates, prices, manufacturers and suppliers. Between 2006 and 2008, two community events prompted major increases in IRS coverage of the at-risk populations in both Africa and the Americas (Figure 6): the global call-to-action to prevent malaria transmission and the establishment of the United States President's Malaria Initiative (PMI), which focused on curbing malaria primarily in Africa through IRS and other interventions. (16) Other regions have seen only slight fluctuations. Although Africa and the Americas have seen great improvements recently, IRS coverage may continue to increase globally, as it is a recommended component for IRM strategies—assuming that cost and resource barriers can be overcome to increase uptake.

**Figure 6: IRS scale-up by region (1)**

Proportion of population at risk protected by IRS (%)



Sources: WHO; NMCP reports.

## 4 Technology landscape

### 4.1 Technology landscape: insecticides

Currently, four classes of insecticides are used and recommended by WHOPES for malaria vector control (Table 3). The limited number of insecticide classes introduces challenges for effective IRM, particularly as the mechanisms of action are similar between pyrethroids and organochlorines and between organophosphates and carbamates.

**Table 3: Characteristics of the four classes of insecticide currently recommended by WHOPES for malaria vector control (13)**

Insecticide type	Molecules available	Advantages	Limitations	Duration of spray effect
<b>Pyrethroids</b>	<ul style="list-style-type: none"> <li>■ Alpha-cypermethrin</li> <li>■ Bifenthrin</li> <li>■ Cyfluthrin</li> <li>■ Deltamethrin</li> <li>■ Lambdacyhalothrin</li> <li>■ Etofenprox</li> <li>■ Bayer LL Deltamethrin</li> </ul>	<ul style="list-style-type: none"> <li>■ Low toxicity to humans</li> <li>■ Rapid knock-down effect<sup>1</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ Resistance developed in many countries</li> </ul>	3–6 months
				9–12 months
<b>Organo-chlorines</b>	<ul style="list-style-type: none"> <li>■ DDT</li> </ul>	<ul style="list-style-type: none"> <li>■ Rapid knock-down effect<sup>1</sup></li> <li>■ Relatively long residual activity</li> <li>■ Historically low cost, although scarcity may be driving cost up</li> </ul>	<ul style="list-style-type: none"> <li>■ Banned in agriculture due to concerns about long-term toxicity effects, except for disease control</li> <li>■ Possible cross-resistance with pyrethroids, due to similar modes of action</li> </ul>	6–12 months
<b>Organo-phosphates</b>	<ul style="list-style-type: none"> <li>■ Fenitrothion</li> <li>■ Malathion</li> <li>■ Pirimiphos-methyl</li> <li>■ Actellic CS</li> </ul>	<ul style="list-style-type: none"> <li>■ Wide range of chemicals in this class</li> <li>■ Considered highly effective, results in neuromuscular overstimulation</li> <li>■ Longer duration of action (8–12 months) for pirimiphos-methyl and actellic CS</li> </ul>	<ul style="list-style-type: none"> <li>■ Short residual activity</li> <li>■ High cost</li> <li>■ Toxicological monitoring recommended, especially for spraying operators</li> <li>■ Mode of action similar to carbamates, with possible cross-resistance</li> </ul>	2–3 months
<b>Carbamates</b>	<ul style="list-style-type: none"> <li>■ Bendiocarb</li> <li>■ Popoxur</li> </ul>	<ul style="list-style-type: none"> <li>■ High effectiveness</li> </ul>	<ul style="list-style-type: none"> <li>■ Short residual activity</li> <li>■ High cost</li> <li>■ Mode of action similar to organophosphates, with possible cross-resistance</li> </ul>	2–6 months

<sup>1</sup> Reference knock-down times are usually the times it takes for 50% and 95% of the mosquitoes to die. There is wide variation, mainly depending on insecticide resistance status, but the lowest times for 50% mortality are 8–10 minutes for DDT.

## 4.2 Technology landscape: ITNs and LLINs

### Description and policy on use

An ITN is a mosquito net that primarily kills mosquitoes coming into contact with the insecticide on the netting material and inhibits blood feeding. Nets are placed inside houses or huts, hung above beds with a hook, and have become one of the major vector control interventions due to their high cost-effectiveness and ease of scale-up.

Bednets can fall into three main categories: nets (untreated), ITNs (treated nets, usually dipped in insecticide mixed with water and require re-treating approximately every six months) and LLINs (insecticide impregnated into the fibres, usually lasting about three years).




Treated nets are effective in three ways: (i) acting as a physical barrier to prevent mosquitoes from biting individuals while sleeping; (ii) repelling mosquitoes; and (iii) killing mosquitoes after coming in direct contact with the insecticides present on the net. In addition, a community effect occurs above a certain level of coverage due to an overall reduction in transmission and, therefore, reduced risk of contact with an infected mosquito, indirectly protecting those not sleeping under the net. ITNs were developed in the 1980s, and LLINs were developed and introduced to the market about a decade later in the mid-1990s. LLINs have a clear advantage over ITNs, with a residual efficacy that is much longer and thus eliminating the need to retreat every six months. While LLINs have replaced ITNs in most countries, ITNs are still available in certain retail markets, particularly in Asia. Donors almost exclusively fund LLINs over ITNs.

As noted earlier, WHO recommends universal coverage of all people at risk for malaria with LLINs, expanding beyond initial recommendations for just children under 5 and pregnant women. Furthermore, WHO recommends use of LLINs at ideally one net per two people. With an average household size of about five members, this would mean two or three nets per household although the metric currently being tracked is at least one net per household. (11)

Pyrethroids are currently the only insecticide class used for LLINs due to safety and toxicity concerns. Next-generation nets that include synergists, or chemicals that block the resistance mechanisms in the malaria vectors, are currently in the WHOPES evaluation process.

As of July 2012, WHOPES has recommended the use of 13 nets from 11 suppliers for (Table 4). Several products, including those with synergists, are still under evaluation. The four additional suppliers with products under evaluation are Kuse Lace Co (Japan, Aka Net), A to Z Textile (Tanzania, MiraNet), Life Ideas Textiles (China, PandaNet 1.0 and 2.0) and Fujian Yamein Industries (China, Yahe LN). For more information on the WHOPES process, see Annex 4.

**Table 4: LLINs recommended for use by WHOPES, July 2012 (17)**

Company	LLINs offered	Status of WHO recommendation	Product type
 (Dubai, United Arab Emirates)	DawaPlus® 2.0	Interim	Deltamethrin coated on polyester
Shobikaa Impex Pvt Ltd (India)	Duranet®	Interim	Alpha-cypermethrin incorporated into polyethylene
 (Switzerland)	Interceptor®	Full	Alpha-cypermethrin coated on polyester
 (South Africa)	LifeNet®	Interim	Deltamethrin incorporated into polypropylene
	MAGNet™	Interim	Alpha-cypermethrin incorporated into polyethylene
 (Denmark)	Netprotect®	Interim	Deltamethrin incorporated into polyethylene
 (Japan)	Olyset®	Full	Permethrin incorporated into polyethylene
 and Net Health Ltd (Tanzania)	OlysetPlus®	Interim	Permethrin and piperonylbutoxide incorporated into polyethylene
 (Switzerland)	PermaNet® 2.0	Full	Deltamethrin coated on polyester
	PermaNet® 2.5	Interim	Deltamethrin coated on polyester with strengthened border
	PermaNet® 3.0	Interim	Combination of deltamethrin coated on polyester with strengthened border (side panels) and deltamethrin and piperonylbutoxide incorporated into polyethylene (roof)
 (India)	Royal Sentry	Interim	Alpha-cypermethrin incorporated into polyethylene
Tinajin Yorkool International (China)	Yorkool LN	Full	Deltamethrin coated on polyester

There are additional ongoing R&D efforts to identify new classes of insecticides for use on nets as well as developing multipanel nets (nets treated with two chemicals) and synergist-treated nets. In the near term, nets continue to have some efficacy even against resistant populations. According to GPIRM, nets maintain their physical barrier effect and pyrethroid resistance may not completely impair pyrethroid effects, as observations suggest that irritancy action is still effective to reduce blood-feeding or to encourage diversion to animals. (13)



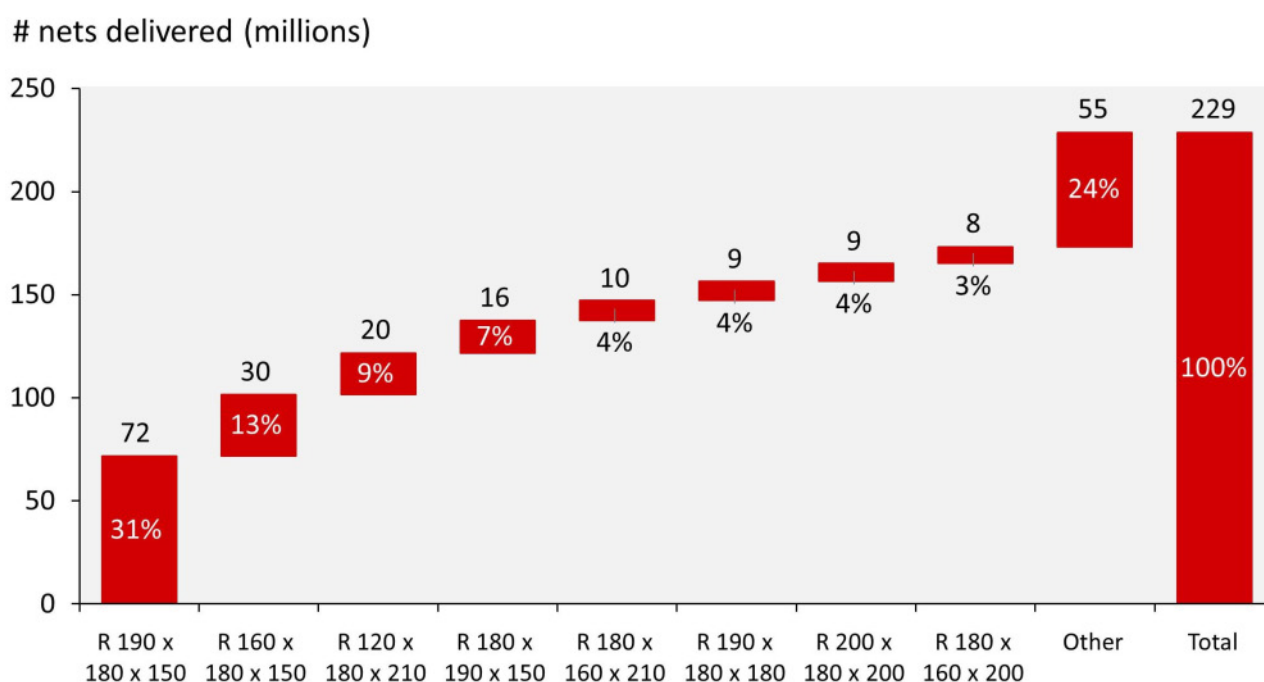
### Product variation

The first variation relates to theoretical residual efficacy. Conventionally treated nets are treated by dipping the net into a WHO-recommended insecticide and must be retreated after three washes, or at least once a year to maintain insecticidal effectiveness.

LLINs, on the other hand, have the insecticide incorporated within or bound around the fibres. They retain the insecticidal effect for at least 20 washes under laboratory standard conditions and three years of recommended use under field conditions. (11) At the time of the design of this metric, it was believed that performance in the 20 washes would be indicative of the three years of recommended use under field conditions.

There also are different shapes (conical and rectangular) and sizes, with more than 100 options, although the rectangular 190x180x150 centimetres is the size most frequently sold (31 % of cumulative orders reported by GFATM in 2003–2012) (Figure 7). (18) A few sizes account for most of the sales (eight rectangular sizes account for 76 % of the cumulative orders). Most manufacturers, however, offer size customization.

**Figure 7: GFATM ITNs delivered according to dimensions (18)**



Different colors also are available, in order to achieve higher cultural acceptability. Bestnet, for instance, offers the possibility to print donors' logos on the nets. They announced a version of their nets for autumn 2012 tailored for the Nigerian public, with stripes of the national colors and footballs, expecting to increase willingness of the people to use them.

There also are different options regarding the fabric used; the choice of fabric might impact net strength or durability under certain conditions. Among those recommended by WHOPES there are five polyester LLINs, six polyethylene LLINs, Vestergaard Frandsen Permanet 3.0 that combines polyester and polyethylene and Bayer LifeNet that uses polypropylene (Table 4).

A 2012 Results for Development (R4D) Institute report, *Expanding Access to LLINs: A Global Market Dynamics Approach*, targeted variation in one of their three key recommendations. The high degree of fragmentation, as well as a few unique outlier products, generate increased costs and lead times in procurement. R4D estimates that reducing variation to the most cost-effective specifications could save up to US\$ 290 million over five years. (19)

### 4.3 Technology landscape: IRS

#### Description and policy on use

IRS consists of the application of long-lasting chemical insecticides on the walls and roofs of all houses and domestic animals shelters in a given area in order to kill the adult vector mosquitoes that land and rest on these surfaces. Governments (e.g. ministries of health) are typically responsible for IRS operations, while nongovernmental organizations (NGOs) and other agents generally participate as implementers and supporters. (20)

There are two main effects achieved through IRS: it reduces the lifespan of vector mosquitoes so that they cannot transmit the parasites from one person to another, and thereby reduces the overall density of vector mosquitoes.

IRS is delivered during campaigns that require careful planning. Based on entomologic studies and bioassays, the insecticide to be used first has to be selected, and then both the insecticide and equipment are procured, usually through open tenders. In order to make IRS an effective vector control measure, it is important to perform it with proficiency. The spray operators, who are often new for each campaign, need training sessions, which often last about one week. In some cases, training of trainers also is needed. Training and appropriate oversight are critical to ensure the quality and, therefore, the effectiveness of spray operations.

IRS is normally done using hand-operated compression sprayers (12), which are manufactured mainly by H.D. Hudson, Semco Co., Golden Agin, Solo, B&G Equipment Company and Micron. The operators also need protective equipment, including at a minimum goggles or an eye mask, a face mask, long-sleeve overalls, boots, rubber gloves and a hat or helmet due to the health and safety risks of concentrated insecticide exposure. Equipment for spraying insecticide is no longer evaluated or approved by WHOPES and the last specification guidelines were published in 2010.

The insecticide can come in liquid form or in the form of soluble sachets, tablets and granules, sachets being the most common. Depending on the form, the insecticide can be poured directly into the sprayer tank or has to be previously mixed in a separate bucket.

The number of houses sprayed per day varies depending on the country and operator; PMI reports on several countries in the 8–15 range. (8) (21) During the actual spraying operations, all household items must be removed and furniture must be removed or covered. The occupants have to wait until the insecticide is dry, which can take up to two hours. The process causes significant inconvenience for the population, which can lead to certain opposition from the recipients. In addition, there are many protocols in order to avoid environmental problems; the remaining insecticide and empty packaging after spraying must be placed in pit latrines, if available, or into pits that have been dug in the ground.

IRS is one of the primary vector control interventions recommended by the WHO Global Malaria Programme (22) because it can be very effective in a wide range of contexts:

- in unstable, epidemic-prone areas, IRS prevents seasonal increase in transmission, prevents and controls epidemics and can be used for the elimination of local transmission of malaria;
- in stable-endemic areas with intense but seasonal transmission, IRS can prevent seasonal transmission increase by focusing the intervention during the transmission periods—it also reduces levels of prevalence and high seasonal morbidity and mortality;

- in stable-hyperendemic areas with intense seasonal or perennial transmission, IRS can reduce the level of transmission, infection prevalence, morbidity and mortality.

There are some places, mainly where there are no structures to spray, in which IRS is not recommended as an effective intervention. This is the case, for instance, of some forested areas in South-East Asia and the Amazon area.

All four WHOPEs-recommended insecticide classes for malaria vector control can be used in IRS, but pyrethroids are most common in terms of area sprayed and DDT in terms of volume used. Pyrethroids require a lower insecticide concentration than DDT to achieve the same effectiveness.

#### 4.4 R&D for vector control products

GMAP originally estimated that 3 novel active ingredient classes, 15 formulations and 3 new paradigms, such as larviciding, consumer products, etc., would be needed in the upcoming years to achieve malaria control and elimination. (4) The development of these new products would require approximately US\$ 670 million in 2008–2020. IVCC has recently revised these costs, estimating that 3 active ingredients, 10 formulations and 3 new paradigms would require a total of US\$ 480 million. The development of a new active ingredient still drives the majority of this cost, as each is estimated to be ~US\$ 120 million and the development time is assumed to be 12 years. In subsequent decades, one active ingredient, five formulations and one new paradigm tool is estimated to be needed to address insecticide resistance and evolving needs closer to elimination at a cost of ~US\$ 170 million per decade (Table 5).

**Table 5: Estimated cost of research and development for vector control**

Time frame	R&D stream	Total cost (US\$ millions)
2008–2020	3 active ingredients	360
2008–2018	10 formulations	60
	3 paradigms	60
Subsequent decades	1 active ingredient	120
	5 formulations	30
	1 paradigm	20

Sources: IVCC; expert interviews.

R&D investment for vector control is essential for a variety of reasons. First, these product innovations are necessary to combat the impending insecticide resistance issues. Additionally, these advancements are necessary for continual adaptations to consumer needs to make the products as user-friendly as possible, increasing the likelihood of usage. And last, product R&D helps address the changing behaviours of the vectors such as targeting outdoor biting mosquitoes.

Current spending on R&D for malaria vector control products was US\$ 28.6 million in 2011, representing only 5.1% of the overall R&D spending on malaria. (23) Even though there has been a slight increase in vector control R&D funding over the past five years, it still fell well short of the recommended funding levels in the 2011 Staying the Course report. Other key areas for malaria R&D spending in order of spending include basic research, drugs, vaccines and diagnostics.

Although funding for vector control R&D trended slightly upwards between 2007 and 2010 (from US\$ 17.6 million to US\$ 28.5 million), it still fell substantially short of the recommended annual increase of around US\$ 10 million per year until at least 2015, in order to reach a peak of around US\$ 90 million in 2016–2017. (23) Funding for vector control R&D is clearly not on track to meet this target.

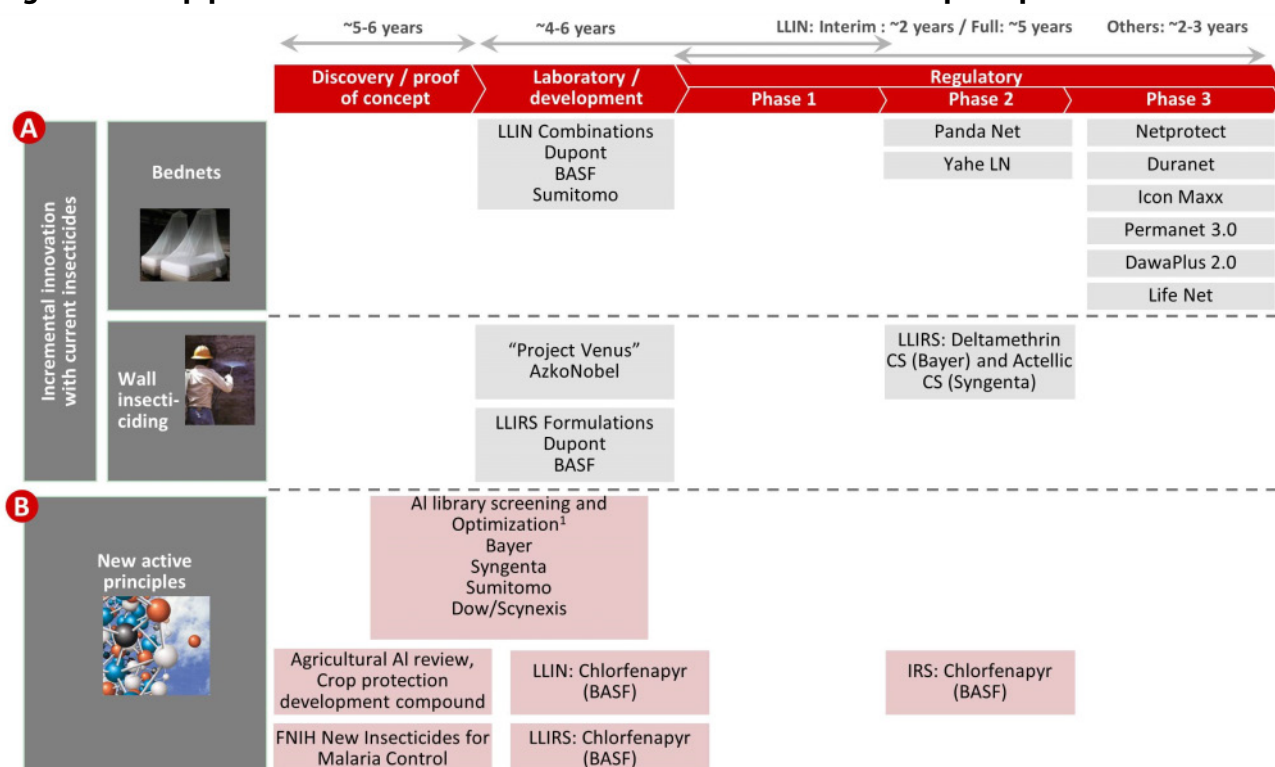
Funding concentration in malaria vector control R&D has remained high, with the top five funders accounting for 97% of the funding in 2011. (23) These top five funding organizations in decreasing order of fund-

ing supplied in 2011 are: the Bill & Melinda Gates Foundation (78%); the United States National Institutes of Health (NIH) (8%); Aggregate Pharmaceutical and Biotechnology Company Respondents (6%); the United States Department of Defense (DOD), including DOD Defense Advanced Research Projects Agency (3%); and the Wellcome Trust (2%). Manufacturers are hesitant to invest in R&D for vector control since R&D costs are difficult to recover in a very price-sensitive market with easy “me too” approval processes and uncertainty around size.

### R&D pipeline

The R&D pipeline can currently be categorized into three main areas of exploration: (i) incremental improvements; (ii) new active ingredients; and (iii) new paradigm tools. Improvements to existing tools, particularly bednets, are the most advanced, with multiple products in Phase III development (Figure 8).

**Figure 8: R&D pipeline overview: incremental innovation and new active principles**



<sup>1</sup> New active principal ingredient screening is focused on bednet use but may be used in other applications.

Sources: IVCC; WHOPEs.

Incremental innovation in current products used for malaria control deal with LLINs and wall insecticiding (i.e. IRS or IRS alternatives), since these are the products that have been proven from a public health standpoint. There are several new LLINs that have already received interim recommendation from WHOPEs and are currently on the market, including Netprotect, Duranet, PermaNet 3.0, DawaPlus 2.0 and LifeNet (Table 4). Some of these newly available nets have advanced technology that may give them an advantage over existing products on the market such as slow releasing insecticides in the yarn, resulting in longer-lasting efficacy and synergists that have a proven increased efficiency against pyrethroid-resistant malaria vectors. Large purchasers, such as GFATM and the United States Agency for International Development (USAID), have already begun purchasing these nets that have received interim recommendations. Two more LLINs from Chinese companies, PandaNet and Yahe LN, could receive interim recommendations in the near future as equivalent products. (17)

R&D stakeholders also are considering innovations within IRS. Long-lasting IRS (LLIRS) is being developed and represents a significant portion of the IVCC public health pesticide portfolio. This new range of formu-

lations would maximize the number of insecticidal classes available, allowing vector control programmes to cost-effectively manage resistance. Both Syngenta and Bayer currently have LLIRS formulations in WHOPES testing phases. (24)

In order to address insecticide resistance, new active ingredients with different modes of action are needed. Several companies, including Syngenta and Bayer, are screening their compounds libraries in order to find new ingredients. (24) The Foundation for the National Institutes of Health has given four grants for target-based discovery of new active ingredients. However, if successful, these products would not arrive on the market until 2020 at the earliest. Even so, chlorfenapyr is a new active ingredient that has already proved successful and could be recommended for IRS in the near term. A longer-lasting formulation of chlorfenapyr is also under development and could be used in LLINs in the future.

In addition to developing new active principles, R&D efforts have been focusing on experimenting with new paradigms and approaches that have not been proven from a public health standpoint. Many new paradigms are still in the discovery and developmental early stages. Traps and targets, however, are more advanced in development. These tools, such as attractive toxic sugar bait, reduce the mosquito population by creating a bait station that attracts and kills mosquitoes looking for a sugar meal. They are particularly useful because they would be able to target outdoor biters and other settings where current tools are not effective, and may be available as early as 2015.

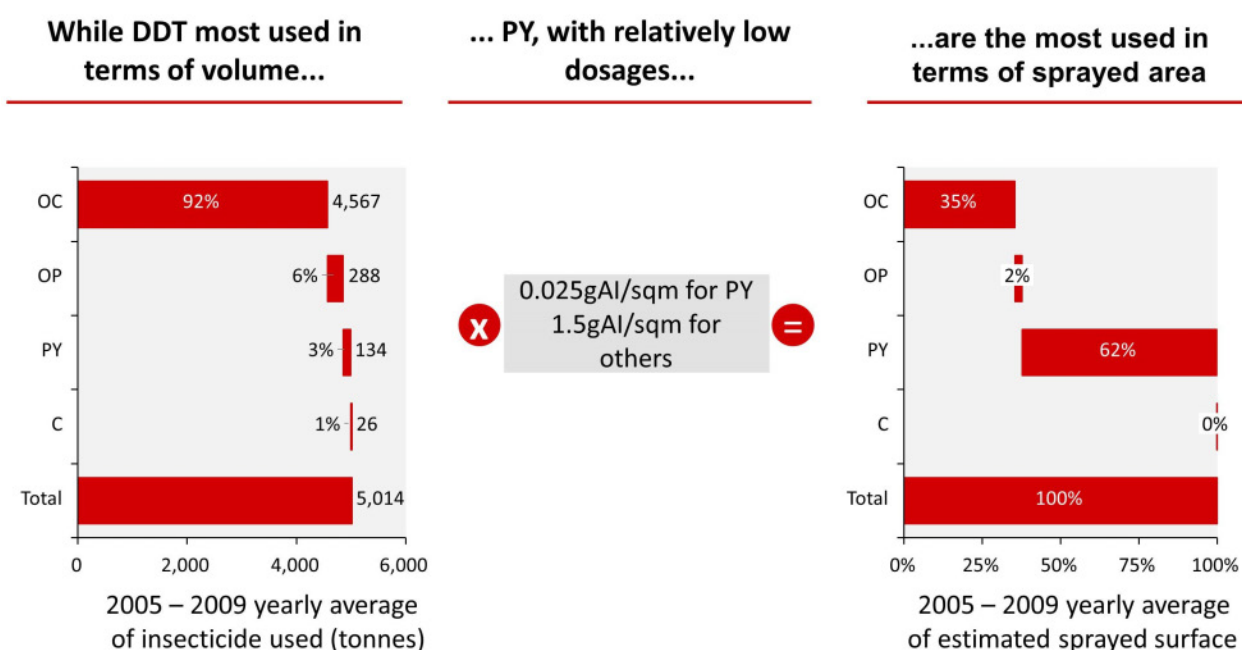
Other areas of research are being pursued, including biologically and genetically modified vectors that have the potential to either suppress a vector population or render a population incompetent for disease transmission. Odorant research is progressing as well; researchers have validated mosquito odorant receptors as targets for the discovery and development of new odorant-based approaches and have identified at least five novel chemical classes. Finally, even though the literature review indicates that topical repellents are effective when correctly used, further testing is needed and currently being planned.

## 5 Market landscape

### 5.1 Market landscape: insecticides

Pyrethroids are the most commonly used insecticide class and are used in comparatively very low dosages, meaning a lower volume is required to be effective. In IRS for instance, 92% of the volume used is DDT (organochlorine) and 6% is organophosphates. However, pyrethroids are used in a proportion of 60 to 1 relative to DDT or organophosphates in terms of active ingredient per unit of sprayed area and, therefore, are the most used insecticides in terms of area sprayed (in contrast to volume) (Figure 9). In addition, pyrethroids is the only insecticide class used on ITNs/LLINs. As a result, the high area coverage for IRS and presence of bednets mean that vectors are most commonly exposed to pyrethroids, putting them at the highest risk for resistance.

**Figure 9: Share of insecticide types in IRS in terms of volume used and area sprayed (16)**



Note: The estimation assumes that the active ingredient percentage of weight in the formulated insecticide is similar for the different insecticides. Relative dosages are measured in grams of active ingredient (AI) per square meter (gAI/sqm)

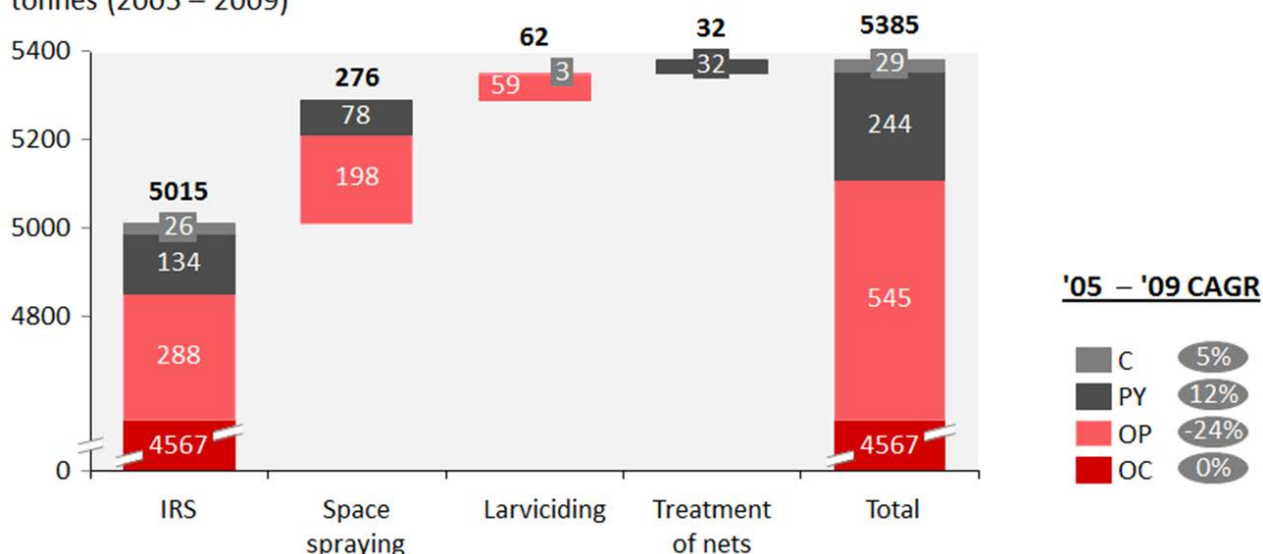
Source: *Global Insecticide Use for Vector-Borne Disease Control, fifth edition, WHO, 2011.*

By volume, 93% of all insecticides used annually (based on the average of 2005–2009) is used in IRS compared to 5% for space spraying and 1% each for larviciding and net treatment (Figure 10). Space spraying is not a recommended intervention for malaria, instead it is used primarily for dengue control, but it could be applied in emergency or extreme situations.

From 2005 to 2009, pyrethroid use grew the most, with a compound annual growth rate (CAGR) of 12%. (16) This scale-up was mainly due to the increase of its use in IRS. Organophosphates, conversely, decreased the most, with a CAGR of -24% during the same period. The use of organophosphates in IRS actually increased, reaching a high peak in 2007, but they have almost disappeared from usage in space spraying, which caused this reduction of total volume used. In general, the trends in the use of the different insecticides have been rather unstable over time, so the picture may have changed substantially during 2010–2012, for which the data are still unavailable, especially in response to insecticide resistance. In particular, interviews have suggested an increase in the use of carbamates and uptake of organophosphates for IRS.

**Figure 10: Insecticide shares by intervention in terms of volume (16)**

Average yearly insecticide tonnes (2005 – 2009)

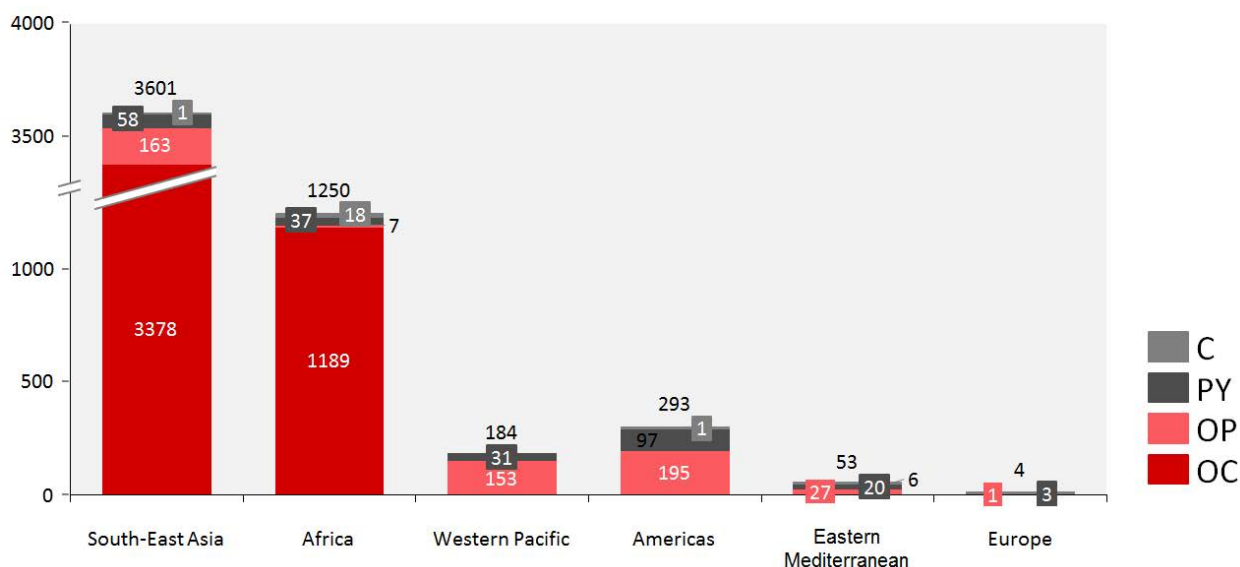


Note: Figure updated following previous printing of this report.

South-East Asia uses the highest volume of insecticide annually with 67% of the total global volume, nearly three times the amount used in Africa. The remaining regions have significantly lower usage levels. The Americas and the Western Pacific, however, do not use DDT (organochlorines/OC), preferring instead organophosphates and pyrethroids (Figure 11).

**Figure 11: Regional split of insecticide use (16)**

Average yearly insecticide, tonnes (2005 – 2009)



Source: Global Insecticide Use for Vector-Borne Disease Control, fifth edition, WHO.

Multiple manufacturers are engaged in insecticide production; however, many are focused on agrochemical applications rather than on public health uses. Sumitomo and Bayer are the only manufacturers that produce insecticides as well as the finished nets.

## 5.2 Market landscape: ITNs and LLINs

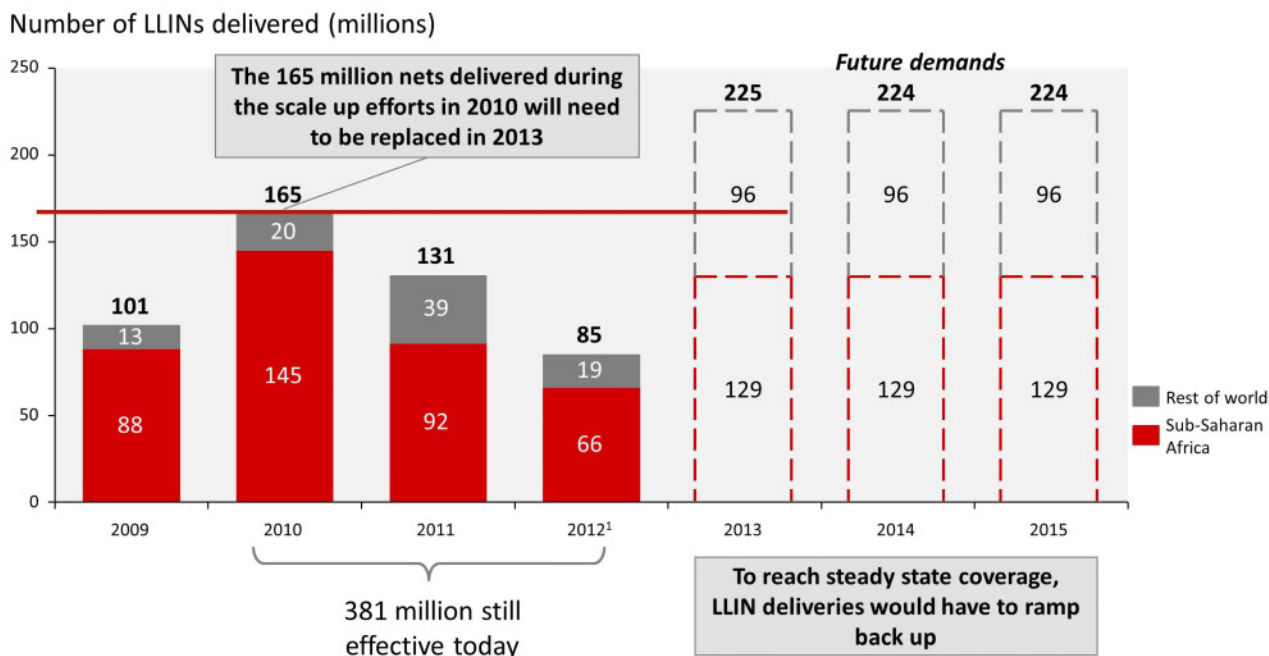
### Market trends

The large scale-up efforts of LLIN deliveries in 2010 have proven to be a major driver of net demand. The future demand of nets will be driven by the need to maintain existing coverage levels and to further bridge the coverage gap to reach universal coverage. For example, assuming that the nets have an effective life of three years, an estimated 381 million of the 483 million nets are still effective, but at least 166 million (40%) are due to be replaced in 2013 alone (Figure 12).

Demand is currently based on mass campaigns approximately every three years, with routine “keep-up” distribution in the interim. With the large delivery in 2010, demand could take two different paths going forward. If there is another large year of coverage to replace those nets that are outdated, then the demand will likely remain “spiky” with peaks approximately every three years. Alternatively, replacement could be scaled up each year until demand is smooth. Thus, bednets would be supplied by more of a “wave” method with approximately one third of the at-risk population receiving a net each year.

The global theoretical demand for nets would be determined by assuming that the entire 3.3 billion at-risk population is covered by bednets, resulting in a theoretical demand of 1.8 billion nets, or an average of 611 million nets per year based on three-year cycles. However, given the varying protection protocols by region, this theoretical demand is significantly higher than the actual demand expected. In particular, South-East Asia has had a historically low net coverage (~ 5% coverage with donor-provided nets) mainly due to the fact that 77% of the at-risk population lives in low transmission areas. Assuming that all regions except for Asia aim for 100% coverage and Asia’s goal is to maintain its current coverage levels, the estimated need to achieve universal coverage will likely be 672 million nets, or approximately 225 million nets per year; 129 million of these nets annually would be targeted at sub-Saharan Africa (Figure 12). WHO has estimated 150 million nets will be needed annually in sub-Saharan Africa. (1)

**Figure 12: Net deliveries 2009–2012 and estimated future needs**



<sup>1</sup> Number of LLINs delivered for 2012 was obtained by multiplying the first three quarters by 4/3.

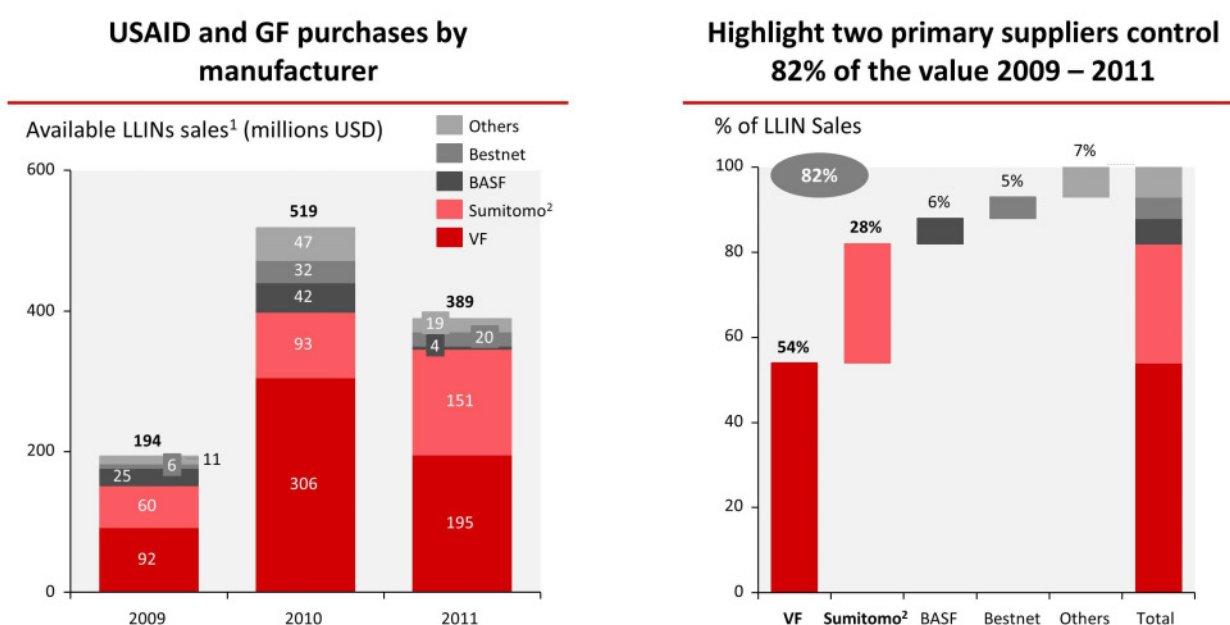
Source: J Milliner, Net Mapping Project, Alliance for Malaria Prevention, March 2009.



## Funding and supply

Currently, the ITN market is very concentrated in both funding and supply. Donor funding is highly concentrated in two donors—GFATM and USAID/PMI. (Additionally, these two donors are the only ones providing detailed data about the nets they deliver.) Combined, they funded US\$ 1102 million in 2009–2011. Since inception in 2006, PMI has procured over 82 million ITNs, including over 21 million ITNs in fiscal year 2012 alone. (25) Historically, of the US\$ 1102 million funded by GFATM and USAID/PMI, over 80% was spent on nets from two manufacturers: 54% on Vestergaard Frandsen and 28% on Sumitomo<sup>3</sup> (including A to Z Textiles). The remaining funds were spent on BASF nets (6%), Bestnet (5%), and the remaining 7% distributed among other manufacturers (Figure 13). (18) It is important to note that PMI net tenders are at the discretion of the national malaria control programmes (NMCPs) and the host country government and, therefore, this concentration is not directly controllable by PMI. Purchasing data have shown that purchases are typically made via large tenders that may limit order access by smaller WHOPE-approved manufacturers and introduce long lead times<sup>4</sup>.

**Figure 13: LLIN sales by manufacturer**



<sup>1</sup> Includes USAID Deliver Project sales (approximately 10% of total LLINs delivered) and GFATM transactions reported to its Price and Quality Reporting Tool.

<sup>2</sup> Sumitomo includes A to Z.

VF = Vestergaard Frandsen

Sources: USAID; GFATM.

The concentrated donor and supply market poses many potential issues. In fact, the community is currently dealing with the fruition of these issues with the recent cancellation of the GFATM Round 11 funding. In November 2011, the GFATM Board made an executive decision to cancel Round 11 of funding,

<sup>3</sup> Since the time this report was prepared, The Global Fund to Fight AIDS, Tuberculosis and Malaria announced it had suspended contracts with Vestergaard Frandsen and Sumitomo after uncovering evidence that they had committed serious financial wrongdoing in Cambodia. (34). This announcement was made on November 14<sup>th</sup>, 2013.

<sup>4</sup> Since the time that this report was prepared, The Global Fund to Fight AIDS, TB and Malaria has operationalized its new procurement framework (Procurement for Impact, P4i) for LLINs as part of a partnership with the UK's Department for International Development, the U.S. President's Malaria Initiative and UNICEF (35). Key strategies under the framework include joint forecasting with partners to improve planning, standardisation of specifications to simplify procurement & production, using large-scale purchasing power to reduce prices for all partners, and longer-term contracts with suppliers to improve visibility, production, capacity planning, and competitive pricing. Following a tender process, the Global Fund announced that it will sign contracts with 7 manufacturers for 90 million LLINs under initial contracts, which will be part of an overall purchase of 190 million nets by partners in 2014. It estimates immediate costs savings to be US\$ 51.2 million, with projected overall savings of US\$140 million over two years. These recent developments in donor procurement processes will be explored in more detail in the next version of the landscape, scheduled for Spring 2014.

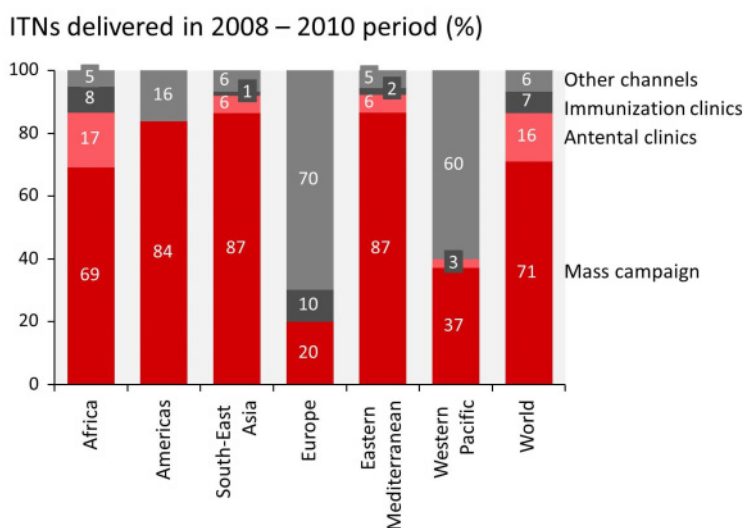
estimating that they will have no funds available for new grants until 2014. In order to protect the gains achieved in malaria control and ensure that essential programmes are maintained, GFATM has established a Transitional Funding Mechanism (TFM), which essentially acts as a replacement for Round 11 to enable the continuation of prevention, treatment and care services for the three diseases funded by GFATM. At the same time, the GFATM Board is focusing on developing a new funding model that is consistent with the GFATM strategy for 2012–2016, with a transition phase that will enable some countries to access funds in 2013 and early 2014, while the rest may access funds from mid–2014. Still, even with the TFM and other efforts by GFATM as well as other donors, resources are still constrained, which will undoubtedly put pressure on endemic countries and manufacturers to procure/supply enough nets for replacement.

**Delivery**

There are multiple channels used for delivery of donor-funded nets. Globally, 71% of ITNs in 2008–2010 was delivered through mass campaigns, with interim replacement efforts coordinated through antenatal and immunization clinics and the private sector, among others (Figure 14). (2) There is, however, an urgent need to devise ways of efficiently targeting delivery towards households in need of nets. Cost restrictions and logistical challenges of conducting a census to identify the precise number of nets can be prohibitive and some programmes, therefore, deliver a fixed number of nets to households instead of providing them according to the number of people. This approach, while logistically easier, may lead to wasted resources and not covering all individuals at risk.

**Figure 14: ITN delivery methods by region, 2008–2010 (2)**

**Mass Campaigns deliver most ITNs except in Europe and Western Pacific**



Sources: WHO; NMCP reports; Alliance for Malaria Prevention.

Communication and advocacy strategies are essential in order to ensure that LLINs are effectively and properly delivered to and used by target populations. (11) Recent data have highlighted that 90% of people with access to a net will regularly sleep under it (1) thus communication campaigns could be aimed at proper use and care of ITNs/LLINs rather than increasing their use. Mass campaigns and interaction with health-care delivery workers are ideal touch points with at-risk populations in order to increase their knowledge and awareness.

### **Role of the private sector**

The private sector currently plays a role in the sale and distribution of ITNs even though there are not many quantitative data available. According to GMAP, overall malaria financing in 2007 was broken down into external assistance—i.e. the World Bank, GFATM (47%) and national government spending (34%)—and private sector spending (19%). (4) However, it is important to realize that this breakdown varies greatly by region. For instance, Asia likely has a much higher retail market than Africa due to high donor concentration in Africa.

From a variety of household surveys in Africa, monthly per capita expenditure on prevention (includes mosquito coils, aerosol sprays, bednets and mosquito repellents) ranged from US\$ 0.24 (rural Malawi) to US\$ 15 (urban Cameroon) (26). A set of studies published since 1999 identified 28 different ITN delivery channels and emphasized that although the private sector is used today for ITN deliveries, it is used far less than other delivery channels. Use of the private sector may be explored as a way to achieve universal coverage, although experts interviewed in this process highlighted the risk this channel poses to address equity in distribution.

Despite the role that the private sector has played in many countries in the fabrication, distribution and sale of ITNs, enormous opportunities still exist for the private sector and there has been considerable recent pressure on it to play a bigger role, especially as the malaria community looks to shift to more routine delivery of vector control commodities.

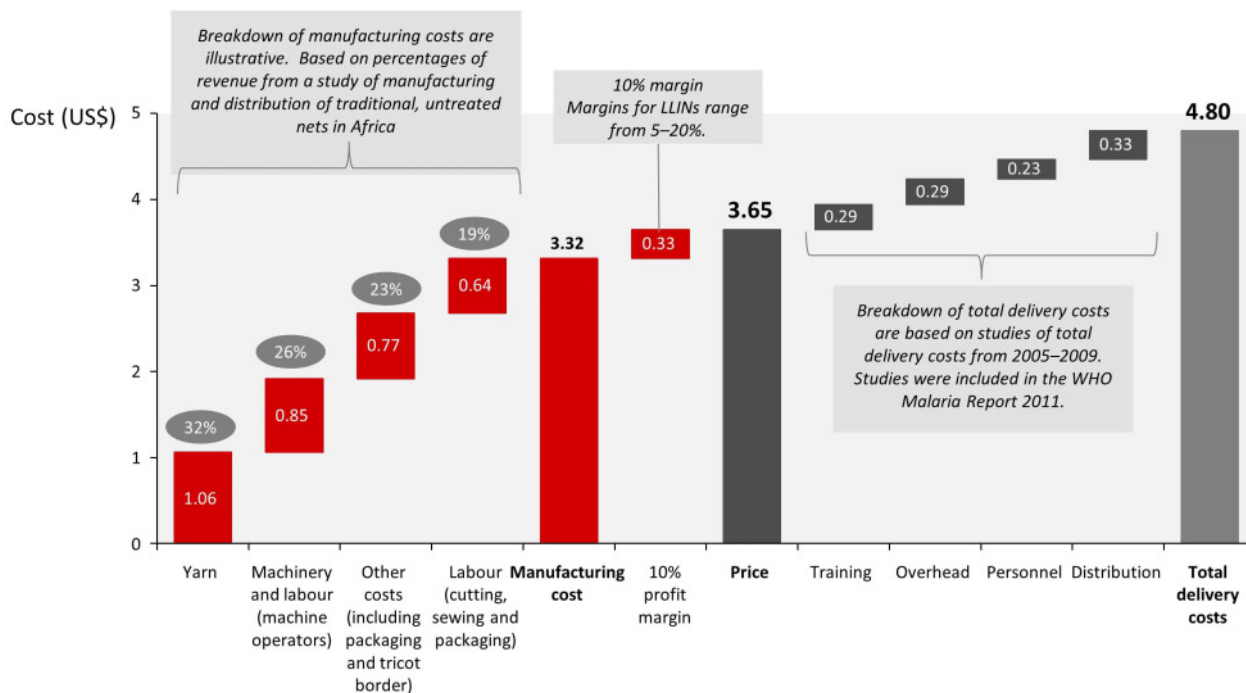
The private sector is particularly well positioned to establish or expand continuous distribution channels because the majority of people living in malaria-affected countries already rely on the commercial market for many of their other household and personal needs. They could utilize their existing infrastructure and even subcontract some of their logistics operations to vector control manufacturers.

Greater participation by the private sector may result in several benefits for the community. A strong, competitive market may lead to higher quality products at lower prices due to the competition in the market, greater variety of product offerings and wider availability. There also is the potential for increased purchasing choices and convenience once enough vendors are involved. Furthermore, the private sector is demand-driven, which will help to both create and sustain demand to increase product uptake and appropriate use. Financially speaking, by increasing availability through the private sector to those who can afford it, public sector delivery may have the opportunity to focus on the most vulnerable population with its limited resources, although some experts expressed concern with the reliance on private sector purchases in the context of the goal of universal coverage. (27)

### **Cost of a delivered bednet**

High-level analysis indicates the average cost to deliver an LLIN via a mass campaign was reduced by approximately 40% between 2002 and 2012, reaching US\$ 4.80 per net in 2012. (14) The main driver of the overall cost to deliver an LLIN is the cost of the net, representing 70–85% of the total. (28) The potential cost structure illustrated in Figure 15 is based on the average price of an LLIN delivered via mass campaigns in 2012 of US\$ 3.65 and uses assumptions for margin and ratios of manufacturing and delivery costs. This illustration is meant to be a starting point for in-depth conversations with manufacturers and implementing agencies on how costs vary from these initial values.

**Figure 15: Illustrative LLIN cost structure delivered through a mass campaign**

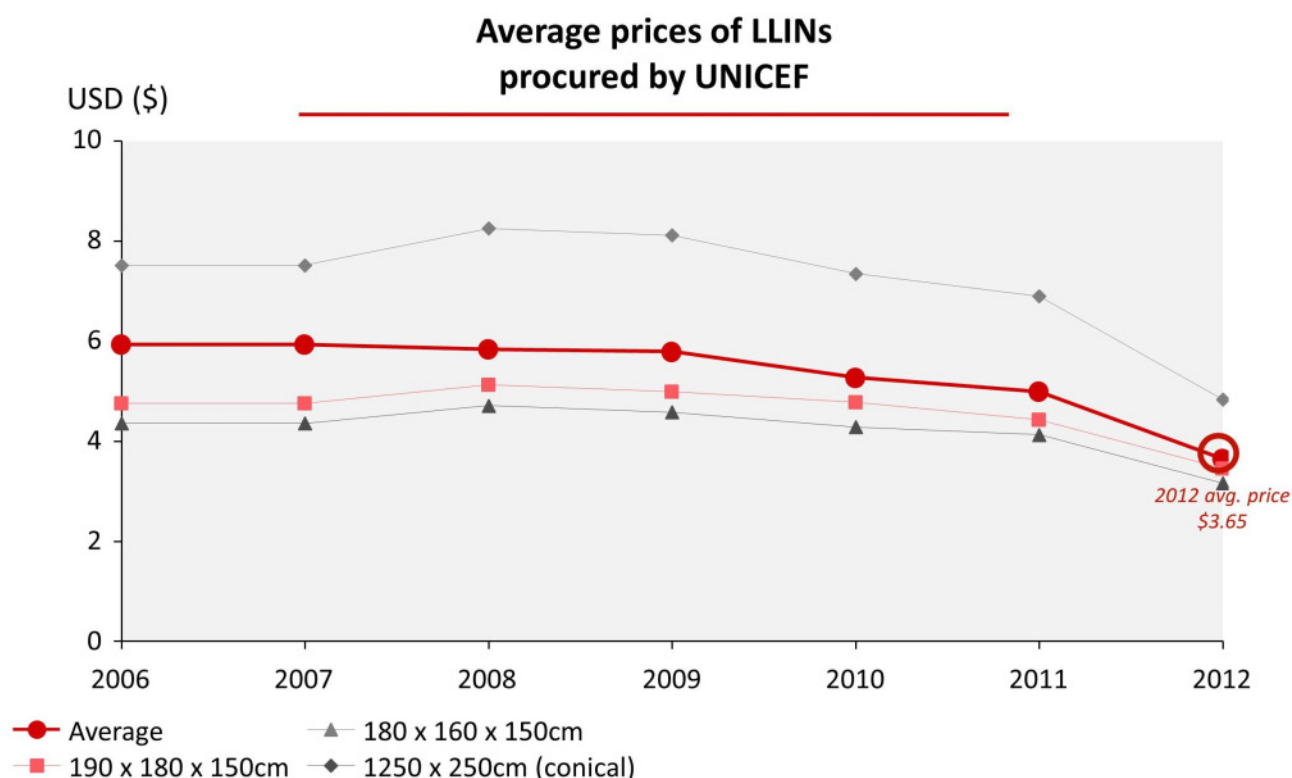


Sources: Strategic Plan for Stimulating the Development, Manufacturing and Widespread Distribution of Long-Lasting Insecticidal Nets, Management Sciences for Health, 2004; World Malaria Report 2011, WHO; LLIN Price Transparency Report, UNICEF, 2012.

### Price

The main driver of the delivery cost of an LLIN, representing 70–85% of the overall costs, is the cost of the LLIN, averaging US\$ 3.65 in 2012 according to the United Children Fund (UNICEF) LLIN Price Transparency Report (Figure 16). (14) (28) UNICEF is one of the leading procurers of LLINs, providing over 25 million LLINs in 2011 alone across 36 countries.

Figure 16: LLIN price trend, 2006–2012 (14) (28)



Notes: Prices indicated above are the suppliers' tendered fixed unit base prices established on long-term agreements: discounts and surcharges are not included in the prices as there are no standard discount/surcharge structures. Individual suppliers offer different discounts (e.g. early payment discounts, staircase pricing, cumulative discounts). UNICEF supplies ~27% of the total bednets annually.

Sources: *World Malaria Report 2011, WHO; LLIN Price Transparency Report, UNICEF, 2012.*

The decreasing overall cost to deliver a net over the past decade is due to this decreasing average LLIN procurement price since 2006. The decreasing price of LLINs is clearly beneficial in terms of allowing greater coverage within a defined resource allocation. However, it puts pressure on the margins for manufacturers, and some manufacturers claim that their production costs may actually be above this market value. Quality assurance will become increasingly important as margins decrease to ensure continued product effectiveness.

LLIN prices have been dropping steadily for six years. The price of LLINs procured by UNICEF has decreased by 39% in 2007–2011 (2) (14), while a GFATM analysis presented in 2013 indicated their prices have dropped 45% since the third quarter (Q3) of 2009 from US\$ 5.56 to 2.90. (29)

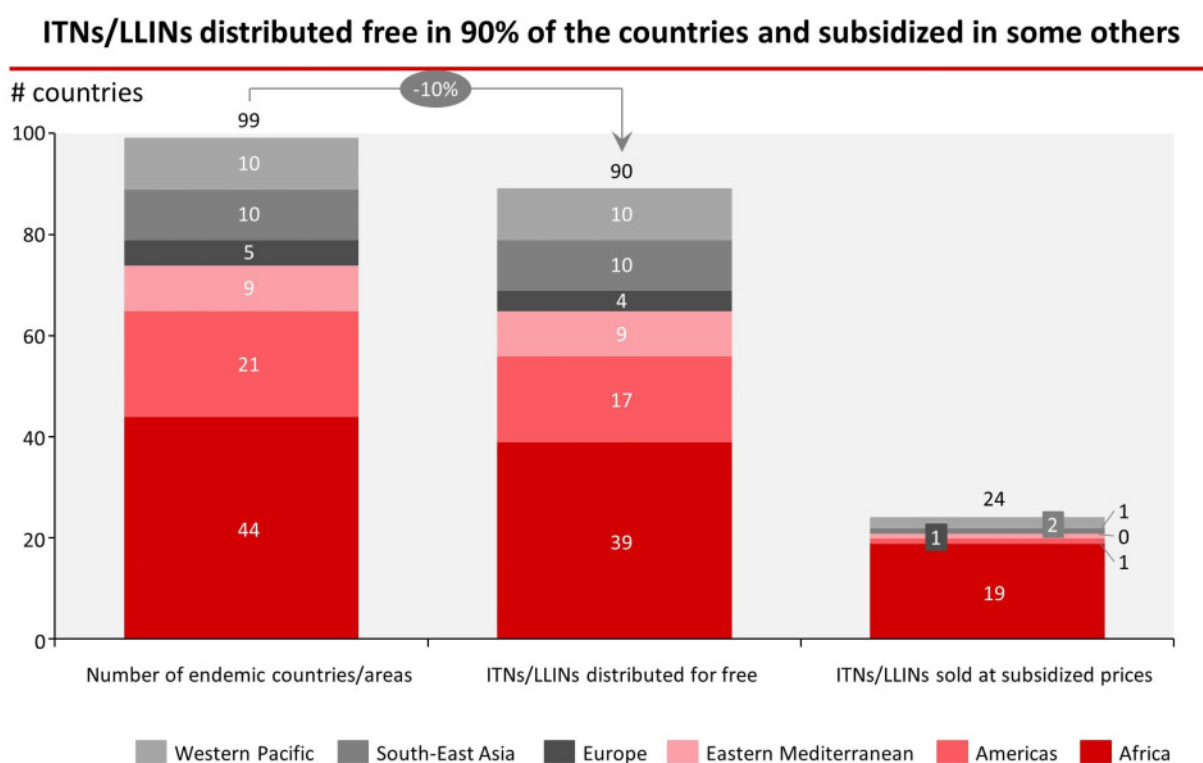
The decreasing price of LLINs is due to a wide variety of factors. In recent years, there has been a dramatic increase in the number of purchases of nets, leading to more of a scale effect. Additionally, there has been increased market competition as the number of WHOPEs-recommended suppliers has increased from 1 in 2002 to 10 in 2012. (17) New, generic suppliers also can benefit from “me too” equivalence test procedures that allow them to reach the market with substantially lower costs. Finally, there has been excess production capacity since the scale-up in 2010 to meet universal coverage targets. This, together with advancing technologies, has helped to drive down prices.

These price trends are all representative of the costs through a mass campaign delivery style. In Africa, the delivery of nets is broken down into mass campaigns (78%), antenatal care clinics (14%), immunization clinics (6%) and other channels (2%). Outside of Africa, the delivery of nets is broken down into mass campaigns (81%), immunization clinics (6%), antenatal care clinics (1%) and other channels (12%). (1) This predominance of mass campaigns poses uncertainty around true demand and the locations of

nets that have to be replaced at the country/district level since there is no cohesive delivery monitoring or demand forecasting. While mass campaigns are appropriate for major scale-up efforts every few years, they need to be complemented with other methods more suitable for ongoing, intermittent keep up.

Irrespective of the distribution method used, 90% of the countries distribute nets free of charge (2) (Figure 17). There has been an ongoing debate as to whether ITNs should be provided free of charge or highly subsidized for a small fee. However, a study in Kenya found that while charging a fee significantly reduced demand for the product, they did not see the corresponding increases in utilization rates that were expected to result from paying for nets. (30) This suggests that there should be a continued push to provide the nets free of charge to populations at risk. However, such a “free net culture” also could act as a barrier to the development of consumer-driven markets in places where a part of the population could afford an ITN.

**Figure 17: LLIN distribution country breakdown in terms of cost to user, 2011 (2)**



**Manufacturer costs**

To provide a starting point for manufacturing cost estimates, a 10% margin was assumed for manufacturers as margins range from 5–20% in this industry (Figure 15). Manufacturing costs were then broken down based on percentages of the current ITN price from a study on the manufacturing and distribution of traditional UTNs in Africa (Figure 15). (28) The study broke the manufacturing costs down into four components: yarn; machinery and related labour (i.e. machine operators); other labour (i.e. cutting, sewing, packaging); and other costs (i.e. packaging and tricot border). Based on this analysis, the manufacturing costs were driven primarily by the yarn, which represented 32% of the total manufacturing costs, but were closely followed by machinery and related labour (26%), other costs (23%) and other labour (19%). (28)

However, it is important to note that the study used to determine the breakdown of the manufacturing costs was conducted prior to LLINs being introduced and focused on UTNs. Actual LLIN manufacturing costs may differ significantly, since the treated yarn may account for an even greater proportion of total costs. Interviews suggest that the likely primary driver of manufacturing costs today is the insecticide. However, data on LLIN manufacturing costs are extremely limited; current manufacturer costs can vary

substantially from this initial view and further analysis will be required to better understand the breakdown, variation by type of product and impact, if any, of scale and/or location.

### Costs of delivery

Various studies throughout Africa, ranging from 2005 to 2009, have reported on the cost of net delivery. (2) Beyond the net itself, there are additional costs of delivery, training, overhead, personnel and distribution. Altogether, these make up less than a quarter of the total cost. It has been suggested that mass campaigns have the lowest median cost per net delivered compared with other delivery channels. (1) The true, fully loaded cost to deliver a bednet will vary substantially by country or area and can be driven by social costs—e.g. behaviour modification and communication costs—as well as the necessary logistical requirements for delivery.

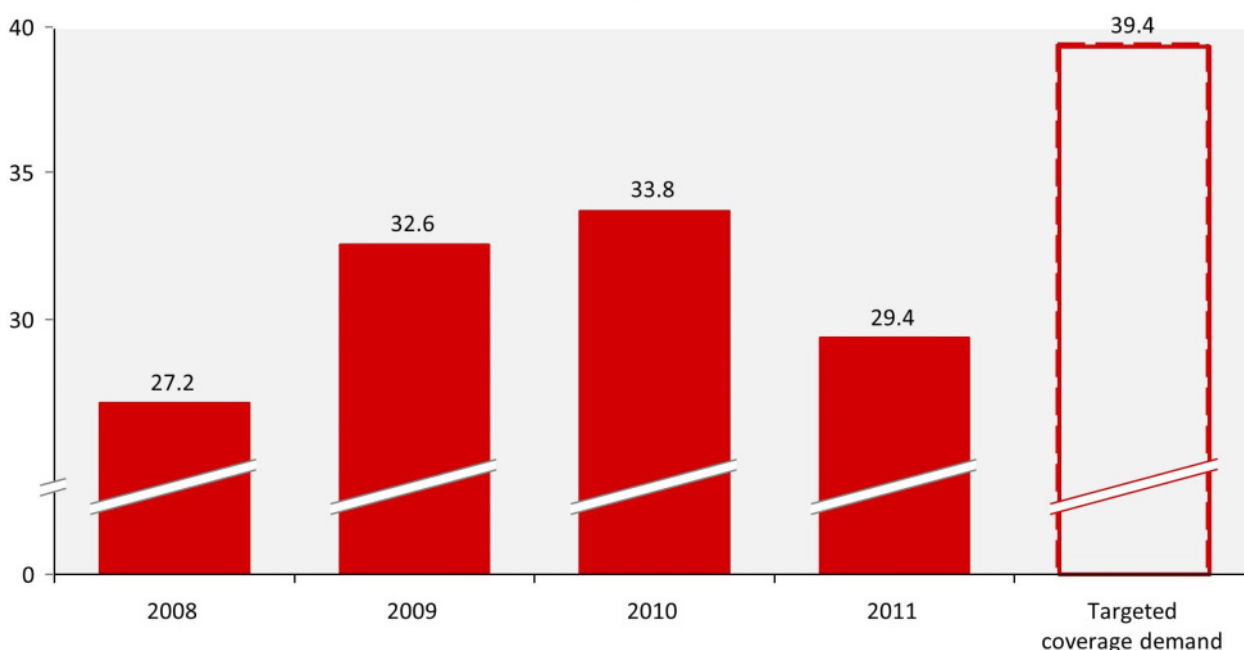
## 5.3 Market landscape: IRS

### Market trends

There were approximately 30 million households protected by IRS in 2011 (153 million people), which represents ~ 5% coverage of the global at-risk population (Figure 18). (1)

**Figure 18: IRS coverage 2008–2011 and future demand (1) (2)**

Number of households protected (millions)



Note: These demand figures represent the number of households protected in a year, not the number sprayed; the number sprayed would be approximately two times these estimates.

Sources: World Malaria Report 2011 (Annex 4) and 2012 (Annex 4), WHO; The Boston Consulting Group analysis.

If the target is for universal coverage of all at-risk populations, then the theoretical demand becomes 635 million households protected, or 1.3 billion households sprayed per year. Maintaining current coverage levels by region, the targeted demand becomes approximately 40 million households protected annually, or 80 million households sprayed annually (Figure 18). (2) IRS is likely to be used only in areas where there is sufficient government infrastructure to coordinate its implementation and fund operational expenses.

There has been very limited tracking of IRS efforts over the years so there are, therefore, minimal data available on manufacturers and funding of IRS. Historically, the largest financiers of IRS have been country

governments, GFATM and USAID/PMI. Since its inception, PMI has been committed to funding IRS, and without it the future of IRS would be in jeopardy. PMI has supported IRS programmes in all of its focus countries, protecting over 28 million people by spraying over 7 million structures in 2011 alone. Despite being one of the major funders of IRS, the GFATM support of malaria has been overwhelmingly directed to ITNs as compared with PMI. Still, by mid-2012, GFATM-supported programmes had provided IRS in 44 million households.

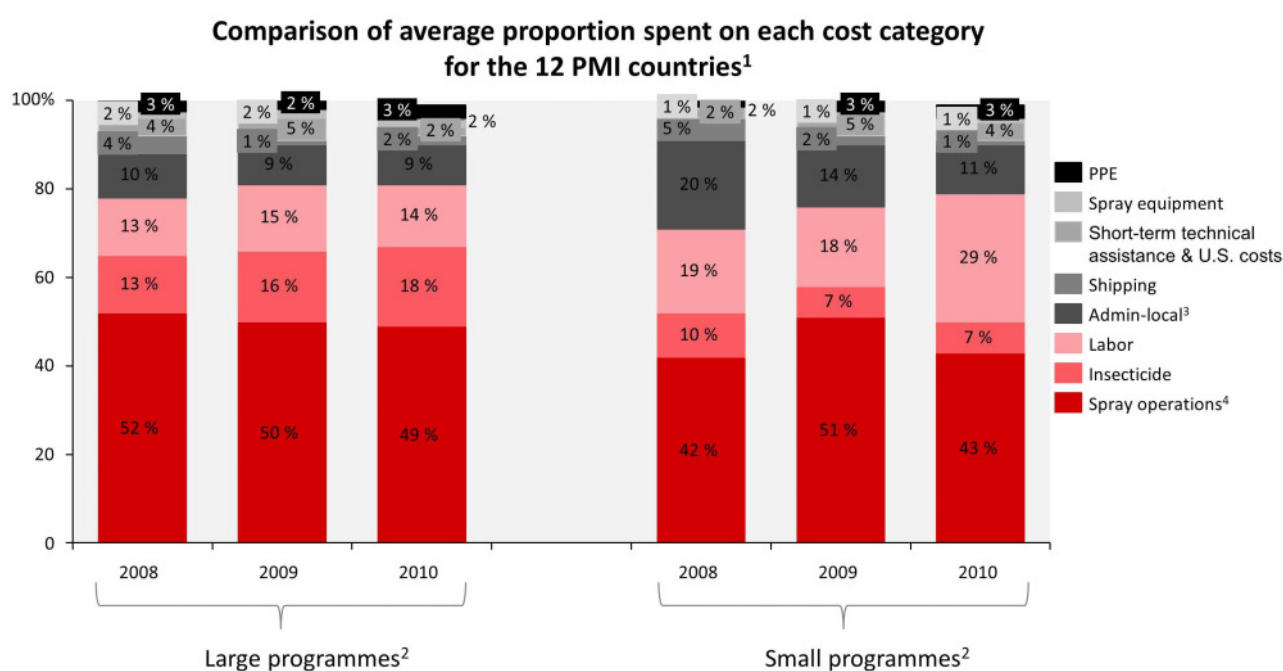
IRS also is used by the private sector to protect communities surrounding their mines, sugar operations and other facilities.

IRS can be applied with non-pyrethroid insecticides, making it an essential component of IRM strategies. However, both the cost barrier and time needed to move through the WHOPES recommendation process have reduced uptake.

### Delivery

Cost and logistical requirements are perceived to be the primary barriers to adoption of IRS. The cost of spraying varies with programme size, type of insecticide used and rounds of application per year. Costs are largely driven by the cost of spray operations, representing 42–52% of the total. Other costs include the cost of the insecticide, labour, shipping and equipment (Figure 19). (31)

**Figure 19: Breakdown of IRS costs for large and small programmes**



<sup>1</sup> Weighted averages based on the number of structures sprayed in each country. The 12 PMI countries are Angola, Benin, Burkina Faso, Ethiopia, Ghana, Liberia, Madagascar, Malawi, Mali, Mozambique, Rwanda, and Senegal.

<sup>2</sup> Large programmes are those that sprayed 150 000 or more structures in 2010 and small programmes are those that sprayed fewer than 150 000 structures in 2010.

<sup>3</sup> Admin-local includes office leases, utilities and maintenance as well as management travel and transportation.

<sup>4</sup> Spray operations include activities such as planning and logistics, training, information, education, communication, warehousing, transportation and monitoring and evaluation.

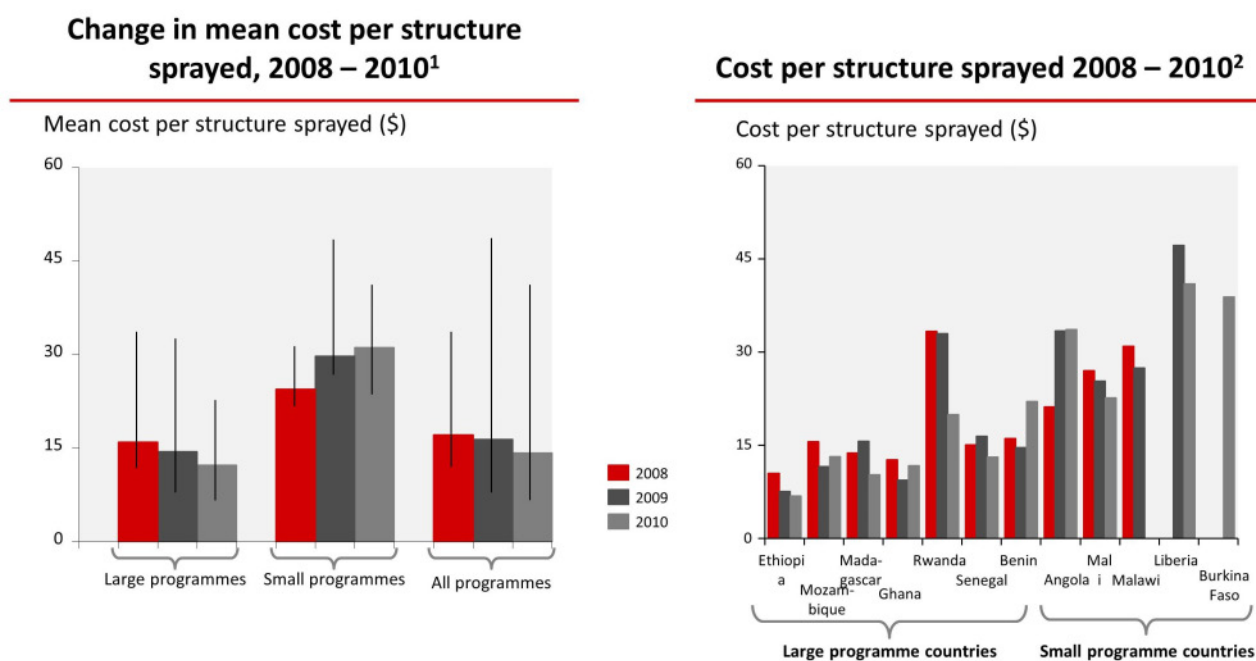
Source: *An economic analysis of the costs of indoor residual spraying in 12 PMI countries, USAID, 2011.*

The cost to spray one house is approximately US\$ 15 for a large programme, compared with US\$ 25–30 for a small programme (Figure 20). (31) Furthermore, while large programmes have seen their costs de-



crease between 2008 and 2010, small programme costs have actually increased. If countries move to more expensive insecticides to address resistance or other needs, the proportion of cost for insecticide (sachets) also may increase. For example, current sachets for pyrethroids are approximately US\$ 4, compared to US\$ 12–13/sachet for carbamates and US\$ 20–25/sachet for organophosphates.

**Figure 20: IRS cost per structure sprayed for large and small programmes in PMI countries**



<sup>1</sup> The vertical line on each bar represents the range of costs for each group.

<sup>2</sup> In all except four cases represented on this graph, structures were sprayed once in the relevant year. In 2009, 65% of all structures sprayed in Rwanda was sprayed twice and 12% of all structures sprayed in Senegal was sprayed twice. In 2010, 21% of structures sprayed in Rwanda was sprayed twice. In 2010, in Benin, all 166 910 structures sprayed in Round 1 were sprayed again in Round 2, and an additional 33 126 structures were sprayed during Round 2. All figures on this graph show costs per unique structure, regardless of whether they were sprayed once or twice.

Source: *World Malaria Report 2011*, WHO.

## 6 Challenges and market shortcomings

### 6.1 Near-term challenges: prevent backsliding and maintain coverage levels

Despite all of the recent scale-up progress, the malaria community faces an imminent challenge of sustaining the progress made to date in coverage and malaria control. An RBM press release in January 2013 following its latest Board meeting called for action, “Africa has made enormous progress in fighting malaria, but we have to ensure, as a continent, that this funding is sustained; we risk backsliding if we don’t act fast. The gaps in funding will have serious consequences if they are not filled; lives will be lost and our battle against poverty derailed”. (7)

An immediate priority in malaria vector control is to replace the nets that were originally delivered in 2010 and which are nearing the end of their three-year lifespan. Interviews with experts in the field have suggested that there are four critical components to ensure delivery of these needed nets: reliable funding; clear demand; sufficient supply; and effective delivery.

- **Reliable funding:** Funding unpredictability is a concern for nearly every stakeholder in the value chain. Current donor funding is concentrated in two primary donors: GFATM and USAID/PMI. New funding and financing sources are needed to increase the stability of the funding landscape. At a minimum, funding is needed at historic, or slightly above historic, levels to replace the nets that are now at the end of their lifecycle and sustain gains. The 2013 RBM press release also highlighted the urgent need to diversify, “We urgently need fresh ideas and new thinking about financing mechanisms that will reap greater resources for malaria” (4).
- **Demand forecasts:** Manufacturers need accurate forecasts of demand to determine if there is sufficient production capacity; and delivery partners need to identify where nets are in need of replacement and in what quantity. The African Leaders Malaria Alliance (ALMA) has begun work in this area to increase transparency of demand by working with individual countries; GFATM, along with other partners, also has engaged in demand estimation to enable better planning.
- **Sufficient supply:** It is unclear what the current industry capacity is for net manufacturing and, therefore, it is unclear whether the current capacity will be sufficient to meet the immediate demand in 2013 as well as the potential steady-state demand.
  - ◆ One estimate of industry capacity is 200 million nets, which is sufficient for meeting 2013 needs but not for meeting steady-state demand. This has assumed that manufacturers have not reduced capacity following the 2008–2010 scale-up efforts.
- **Effective delivery:** Net deliveries (based on the two primary donors) have been trending downward since 2010.
  - ◆ Procurement, funding and ramp-up of delivery systems will take time and should be under way to ensure that nets can be delivered in 2013. Countries need to mobilize distribution systems in partnership with NGOs and other agencies as well as explore the use of multiple channels to reach all at-risk population and further work towards bridging the coverage gap.

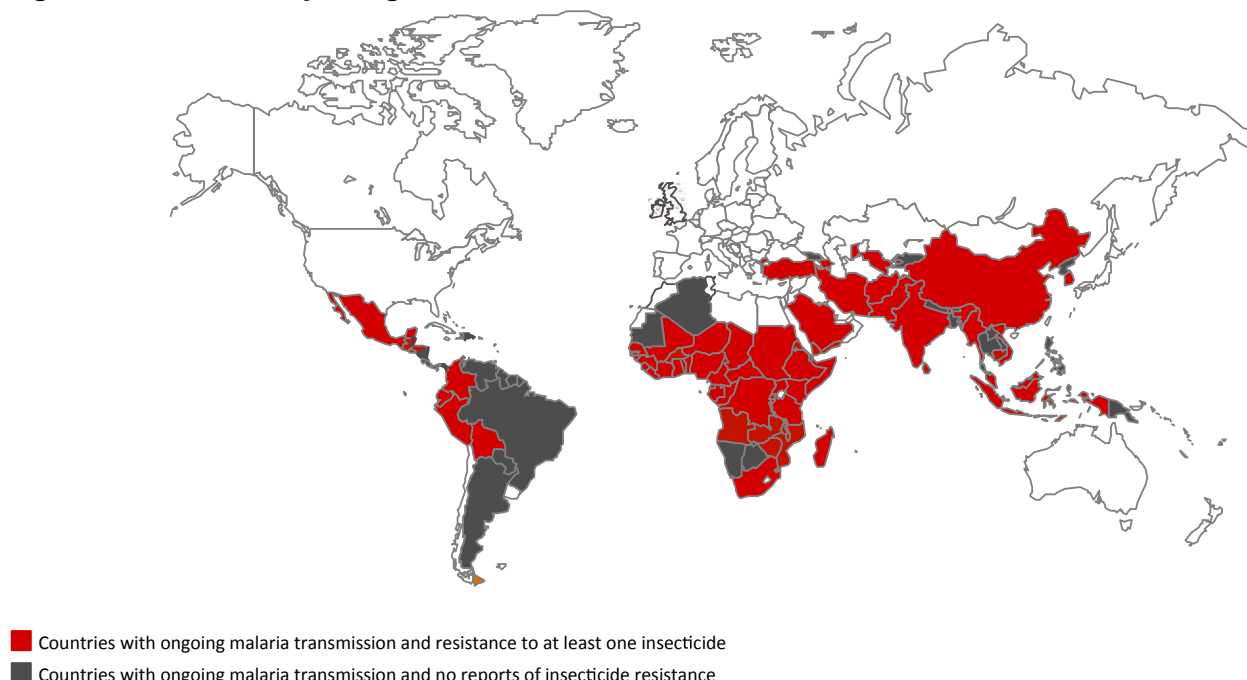
### 6.2 Additional near-term challenges to be addressed

#### Insecticide resistance

Insecticide resistance, identified in 64 countries (1), is a growing concern and could pose a serious risk to the existing tools (Figure 21). *Anopheles* mosquitoes are developing resistance to all insecticide classes and, in particular, to the most widely used insecticides, pyrethroids, which are the only ones currently available for ITNs/LLINs and are used in approximately 60% of IRS operations. The 2012 GPIRM detailed the sources and drivers of resistance as well as approaches for identifying and addressing insecticide resistance. (13) The strategy laid out in GPIRM is a five-pronged approach, including: (i) planning and implementing IRM strategies in endemic countries; (ii) ensuring proper, timely entomological and resistance monitoring and effective data management; (iii) developing new and innovative vector control tools; (iv) filling in gaps in knowledge; and (v) ensuring that enabling mechanisms are in place. (13) Since many of

these strategies represent an increase in cost, ranging from 17% to 96% depending on the approach used and the length of the transmission season, many funders and implementing countries will be faced with short-term tradeoffs in managing resistance versus achieving and sustaining high levels of coverage.

**Figure 21: Countries reporting insecticide resistance (1)**



Note: Includes countries with confirmed susceptibility to all insecticides used and countries where susceptibility testing is not currently conducted or results are not available. The map provides no indication of how widespread resistance is within a country, therefore, a single report of resistance would be sufficient to mark a country as having resistance.

### Product differentiation and cost-effectiveness

A current challenge that limits cost-effective decision-making by donors and countries is the inability to differentiate products based on quality, effectiveness or presence of new innovations. While countries may develop their own quality assurance or testing system, there is a global reliance on WHOPES to identify pesticides that are safe and, in the case of nets, they meet a minimum threshold for durability. The evaluation system only gives approval for meeting minimum qualifications, but does not test any other differentiation metrics. A potential need is to identify metrics that would be most useful in differentiating existing products and future innovations, and then to establish the system that would allow new products and innovations to come to market quickly to incentivize manufacturers to invest<sup>5</sup>.

- WHOPES only identifies whether a product meets the minimal threshold, and there is no broad agreement on a set of metrics that would be effective for distinguishing different products beyond these minimum criteria, although work is ongoing to establish these metrics, particularly for durability.
- The WHOPES process can take from one to three years, which has been perceived as a disincentive for manufacturers to invest in incremental product improvements. This time line needed for WHOPES evaluation may be causing some manufacturers to bypass this regulatory body and go directly to the country NMCPs. It also might be causing donors to consider products they believe demonstrate greater value and cost-effectiveness even though they are not yet recommended by WHOPES. For

<sup>5</sup> The Vector Control Advisory Group (VCAG), a joint establishment between WHO Global Malaria Programme and WHO Neglected Tropical Diseases departments, has been charged with two responsibilities:

- To review and assess the public health value, "proof of principle" (epidemiological impact) of new tools, approaches and technologies; and
- To make recommendations on their use for vector control within the context of integrated vector management in multi-disease settings. (38)

example, in Ghana, IRS activities funded by PMI in 2012 faced a challenge with the signs of early insecticide resistance in 2010–2011 and prompted a change in insecticide for the 2012 Round. A long-acting organophosphate, still under WHOPEs evaluation (pirimiphos-methyl/Actellic 300 CS), was selected. (20)

### **Net durability**

Expert interviews suggest that the limiting factor of a LLIN lifespan is the physical durability of the net textile, rather than the longevity of the insecticide woven into the net. Due to natural wear and tear from everyday use, environmental conditions and the strain that washing puts on the product, the net is vulnerable to tears and holes, and often the actual durability of the net is less than the three-year recommendation<sup>6</sup>.

An emerging challenge is the tension between increasing the number of available manufacturers in order to spur competition and drive prices down and incentivizing innovation. Generic manufacturers are currently able to gain access to innovative products specifications and trial data, enabling them to quickly release new, extremely similar products to those already on the market. A balance between protection for innovative manufacturers and healthy competition must be addressed as new and innovative products are brought to market to address challenges of durability and insecticide resistance.

## **6.3 Long-term challenges: sustain coverage and introduce “game changers”**

### **Reliable funding**

Unpredictable funding remains a challenge beyond the immediate need to replace expiring bednets in 2013. Attention also must shift to garnering additional funding to improve coverage in areas that are below targeted universal levels (e.g. South-East Asia) and bring coverage closer to the universal coverage goal (an estimated 224 million nets per year). Diversification of funding is one key approach, introducing a range of funding sources to mitigate reliance on one large donor, and also increasing private household and endemic country governmental spending to ultimately make malaria control an essential part of the health-care spending. In order to achieve this, malaria will need to remain a top priority for countries, even as the number of deaths is reduced.

### **Expand routine delivery channels**

Looking beyond 2015, sustaining coverage will become the primary focus of the malaria control and elimination efforts. Sustaining coverage will require diverse distribution channels to supplement and support mass campaigns. These channels will further help smooth demand and increase predictability for suppliers of interventions and help ease the burden of mass campaigns for countries.

### **R&D pipeline**

Preparing for insecticide resistance is the major driver behind the R&D pipeline for malaria vector control. The R&D pipeline can currently be categorized into three main areas of exploration: incremental improvements for existing products; new active ingredients (insecticides); and new paradigm tools, including tools to address a wider range of *Anopheles* mosquito behaviours. Improvements to existing tools, particularly to bednets, are the most advanced, with multiple products in Phase III development. New active ingredients are seen as the critical component, however, to preserve the effectiveness of malaria tools in the long term. More detail on the R&D pipeline is described in Section 4.1.

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<sup>6</sup> Since the preparation of this report, WHO has issued guidance on estimating the longevity of long-lasting insecticidal nets in malaria control (September 2013) (36). Aimed at malaria programme staff and researchers who are involved in the collection and analysis of data on LLIN durability in the field, this guidance is intended to allow standardization of procedures and analysis of LLIN durability estimates across countries. Its two main purposes are to provide guidance to countries to track LLIN durability in order to support management of resupply; and to inform at global level procurement decisions in conjunction with urgently needed new, more predictive textile laboratory testing.

### Valuing innovation

There will need to be a means of valuing innovation in order to ensure the availability of new tools. Innovation in improving current paradigms (e.g. net durability and insecticide combinations) will come first, but ultimately new tools such as new adulticides (e.g. chemical treatments targeted at adult mosquitoes to shorten or interrupt their lifespans), non-insecticide-based vector control tools (e.g. genetic-based vector population suppression) and tools adapted to low transmission areas (e.g. attractive sugar baited mosquito traps) could be the game changers. These potential game changers will need a system for evaluation and approval as well as a means for getting introduced into the market at the global level in order to have an impact<sup>7</sup>.

### Sustained political commitment

If the malaria burden continues to decrease and starts heading towards complete elimination, there needs to be a sustained political commitment to continue investing in malaria, particularly as mortality levels are reduced. Historically, as shown with other diseases, success is extremely fragile; the risk is that as soon as efforts are reduced, malaria will resurge. A recent literature review identified 75 resurgence events in 61 countries, occurring from the 1930s through the 2000s, nearly all of which were attributed in part to weakened malaria control programmes and resource constraints. (32) Rwanda, in particular, has been cited as a country that had dramatically decreased its malaria burden, and then experienced a delay in ITN procurement that eventually led to nationwide ITN stock-outs and a resurgence of malaria cases by almost twofold in one year. (33)

## 6.4 Summary of key market shortcomings

Several shortcomings in the malaria vector control market for IRS and LLINs and their reasons for being identified (Table 6). These shortcomings represent potential areas for intervention to address the range of near-term and long-term challenges the malaria community faces.

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<sup>7</sup> Since the preparation of this report, The WHO Vector Control Advisory Group (VCAG) on New Tools issued a Call for submissions on innovative vector control tools in which potential manufacturers and academic institutions were invited to submit application dossiers for new product/paradigms for consideration and review by VACG (37). The call was announced on November 1st, 2013. This development will be explored in more detail in the next version of the landscape, scheduled for Spring 2014.

**Table 6: Summary of vector control shortcomings**

Category	Shortcoming	Reason
<b>Quality</b>	Some LLINs may not be meeting minimum durability standards	<ul style="list-style-type: none"> <li>■ While the lifespan of the insecticide (residual efficacy) does not seem to be the issue, the physical durability of the textile to withstand holes from wear and tear seems to be a limiting factor</li> <li>■ Durability and effectiveness of any product varies significantly by region, making it difficult to predict durability</li> <li>■ Manufacturers are pushed to cut costs to remain competitive, which may put the quality of products in jeopardy</li> </ul>
<b>Availability</b>	Innovative LLIN and IRS products face difficulties reaching the market in a timely fashion	<ul style="list-style-type: none"> <li>■ Improved tools to address resistance and durability challenges will take an additional one to three years in the WHOPEs process</li> <li>■ Unclear metrics to differentiate products and measure innovations</li> </ul>
	Manufacturers hesitant to invest in R&D for new paradigms, particularly to address resistance and durability concerns	<ul style="list-style-type: none"> <li>■ Uncertainty around whether or not there will be a willingness to pay for the innovations, as the market is very price sensitive</li> <li>■ Metrics to differentiate innovation in net-based products (e.g. longer efficacy, increased durability, insecticide resistance mitigation) are not in place beyond the WHOPEs minimum quality standards (Note: bursting strength is included in the current standards for LLINs, and standards for IRS include a duration of effective action)</li> <li>■ R&amp;D costs are difficult to recoup because “me too” equivalent products can undercut reference product prices</li> <li>■ Economic impact of successful vector control is neither well documented nor understood</li> <li>■ Evidence of the health impact and effectiveness of new paradigms will be difficult and expensive to generate</li> </ul>
<b>Delivery</b>	Manufacturers unable to plan ahead for future capacity needs due to uncertainty of funding <sup>1</sup>	<ul style="list-style-type: none"> <li>■ Uncertainty if the funding will be available to support the demand and capacity scale-up demands</li> <li>■ Uncertainty around future demand inhibits manufacturers from planning ahead</li> <li>■ Lack of transparency of global manufacturing capacity to meet spikes in demand, or to design steady-state demand</li> </ul>
	Uncertainty about true demand and where the nets are that have to be replaced at the country/district level	<ul style="list-style-type: none"> <li>■ Lack of any cohesive delivery monitoring or demand forecasting to identify areas with highest needs</li> </ul>
	Current distribution systems may be less efficient and less sustainable than routine distribution channels	<ul style="list-style-type: none"> <li>■ Current scale-up efforts have relied on mass campaigns, which are less suitable for more ongoing, intermittent maintenance</li> <li>■ Routine delivery channels are currently underutilized for keep-up efforts and as a supplement to mass campaigns</li> </ul>
	Sustained gaps in coverage, particularly within certain population segments (i.e. children over 5, pockets of people in South-East Asia, rural poor population)	<ul style="list-style-type: none"> <li>■ Current donors have not focused scale-up efforts on populations that have the potential to purchase protection products on their own (i.e. population segments in South-East Asia)</li> <li>■ Donors have historically concentrated efforts on certain populations who are at greatest risk (i.e. children under 5 and pregnant women), while focus may need to be expanded to meet targeted universal coverage</li> </ul>

<sup>1</sup> The Global Fund to Fight AIDS, TB and Malaria is currently in the process of operationalizing its new procurement framework (Procurement for Impact, P4i) for LLINs. Key strategies under the framework include joint forecasting with partners and longer-term contracts with suppliers to improve production, capacity planning.

Category	Shortcoming	Reason
<b>Affordability</b>	Lack of predictable funding at historical levels to meet the near-term need of maintaining coverage	<ul style="list-style-type: none"> <li>■ Continued uncertainty around GFATM funding levels</li> <li>■ Concentrated donor landscape</li> </ul>
	Unclear sources of funding to close the coverage gaps	<ul style="list-style-type: none"> <li>■ Concentrated donor landscape</li> <li>■ Minimal contributions from domestic funding sources; domestic funding for malaria control is generally less than US\$ 1 per person at risk (1).</li> </ul>
	Difficulty shifting to a consumer-driven market	<ul style="list-style-type: none"> <li>■ Scale-up of donor funding has created a culture built on the expectation of free nets</li> </ul>
	Cost-effectiveness data not taken into account in purchasing decisions for both nets and IRS	<ul style="list-style-type: none"> <li>■ Durability metrics are under development but are not yet available or approved</li> <li>■ Methods for translating durability data into procurement decisions to optimize cost and value have not yet been released, preventing countries from making procurement decisions based on cost-effectiveness</li> <li>■ Detailed understanding of comparative application and implementation costs are not available</li> <li>■ Very price-sensitive market since lower price turns into higher coverage given a fixed pool of funds</li> </ul>
<b>Acceptability/adaptability</b>	Limited uptake of IRM products and recommendations	<ul style="list-style-type: none"> <li>■ IRM approaches tend to be more costly than traditional vector control methods</li> <li>■ Countries lack the tools and resources to implement IRM strategies</li> </ul>
	Limited uptake of IRS in contrast to LLINs	<ul style="list-style-type: none"> <li>■ For many areas, higher cost and lower lifespan of IRS versus LLINs drive the decision to focus on LLINs, though IRS may be more appropriate in some areas</li> <li>■ General feeling of IRS being less convenient than net campaigns or approaches</li> <li>■ IRS needs more teams trained specifically to apply IRS products compared to LLIN delivery</li> </ul>
	Country purchasing decisions driven by short-term impact	<ul style="list-style-type: none"> <li>■ Metrics and guidance to enable procurement based on cost-effectiveness rather than cost not yet developed</li> <li>■ Limited entomological capacity, knowledge and data to help guide countries as they develop longer-term strategic plans</li> </ul>

## 7 Potential market interventions

### 7.1 Summary of potential interventions

As discussed above, there are multiple, interrelated market shortcomings and challenges facing the vector control community. Potential interventions to address these shortcomings can range from investment in R&D to policy guidance and advocacy to direct financing of delivery and may not all be a suitable fit for UNITAID engagement (Table 7).

**Table 7: Examples of potential interventions**

Category	Shortcoming	Potential interventions
Quality	Some LLINs may not be meeting minimum durability standards	<ul style="list-style-type: none"> <li>■ Enable the evaluation process to account for regional differences and be indicative of actual field use</li> <li>■ Develop methods to predict LLIN life according to the local context</li> <li>■ Accelerate the monitoring of quality metrics for LLIN by country</li> <li>■ Accelerate the publication of the methods for using durability data, when developed and accepted, to inform procurement decisions and accelerate their adoption by countries and donors</li> </ul>
	Innovative LLIN and IRS products face difficulties reaching the market in a timely fashion	<ul style="list-style-type: none"> <li>■ Accelerate the WHOPES approval process</li> <li>■ Identify alternative pathways for interventions to come to market</li> </ul>
Availability	Manufacturers hesitant to invest in R&D for new paradigms, particularly to address resistance and durability concerns	<ul style="list-style-type: none"> <li>■ Expand the evaluation process to ensure that “me too” products are as rigorously tested as the original products</li> <li>■ Accelerate the adoption of cost-effectiveness procurement decisions to incentivize innovation</li> <li>■ Support the development of evidence of health impact for new paradigm tools to accelerate uptake</li> </ul>
	Manufacturers unable to plan ahead for future capacity needs	<ul style="list-style-type: none"> <li>■ If smaller manufacturers are confirmed to have difficulty accessing orders, consider:               <ul style="list-style-type: none"> <li>■ splitting, staggering and dispersing orders so that smaller manufacturers can have a portion of larger tenders</li> <li>■ establishing a consortium among smaller manufacturers so that they can apply for larger tenders</li> </ul> </li> <li>■ Increase transparency around overall manufacturing capacity to meet spikes in demand or potential steady-state demand</li> </ul>
Delivery	Uncertainty about true demand and where the nets are that have to be replaced at the country/district level	<ul style="list-style-type: none"> <li>■ Regularly consolidate coverage and delivery data and forecast future demand in detail to help manufacturers plan for the demand or support organizations already engaged in this activity to accelerate use in planning</li> <li>■ Diversify funding landscape, e.g. by engaging the private sector</li> </ul>
	Current scale-up distribution systems are not efficient	<ul style="list-style-type: none"> <li>■ Catalyse the transition from a mass campaign style to more of a routine distribution system</li> </ul>
	Sustained gaps in coverage, particularly within certain population segments (i.e. children over 5, pockets of people in South-East Asia, rural poor population)	<ul style="list-style-type: none"> <li>■ Diversify funding landscape, e.g. engaging the private sector</li> <li>■ Expand funding levels specifically to increase coverage in currently underserved populations</li> </ul>



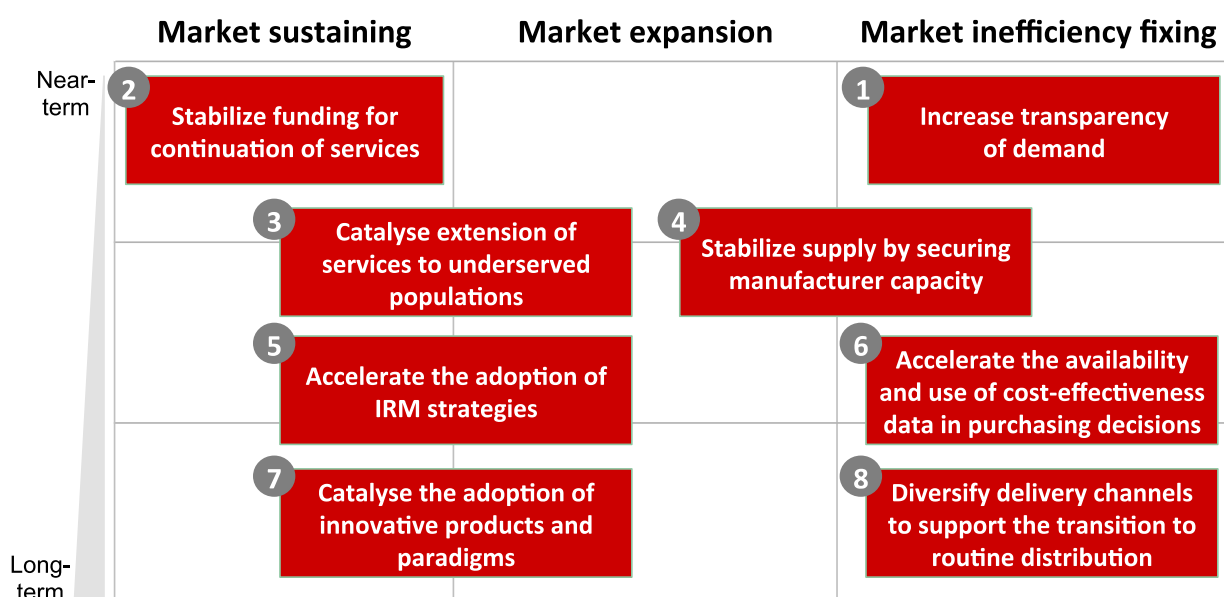
Category	Shortcoming	Potential interventions
Affordability	Lack of predictable funding at historical levels to meet the near-term need of maintaining coverage	■ Supply direct complementary funding
	Unclear sources of funding to close the coverage gaps	■ Supply direct complementary funding
	Difficulty shifting to a consumer-driven market	■ Catalyse the engagement of the private sector in regions where there is enough economic strength
Acceptability/ adaptability	Limited uptake of IRM products and recommendations	■ Provide funding for the extra cost of IRM interventions, at least for countries most in need ■ Build up in-country entomological capabilities
	Limited uptake of IRS in contrast to LLINs	■ Co-fund IRS to lower the cost barrier ■ Reduce the country-level burden of planning and executing IRS by supporting comprehensive spraying services or increasing capacity
	Country purchasing decisions driven by short-term impact	■ Accelerate the uptake and implementation of guidelines and durability data when available

A note on the UNITAID role: A broad range of potential interventions exists; however, not every intervention will be suited to UNITAID goals and capabilities. UNITAID uses time-limited, market-based interventions to improve access to key commodities with a focus on low-income countries. In light of this, UNITAID will need to consider how best to contribute in both the near-term and in the longer-term, in order to address key market shortcomings and ultimately improve access.

## 7.2 Detailed examples

In Figure 22, eight examples of potential market interventions are described, each with a different market impact, which could be: sustaining the existing demand for products; expanding the market to include populations or new approaches (e.g. IRM) and tools; or addressing an existing inefficiency such as lack of transparency in demand or diversity in delivery channels. The timing and size of the health impact burden additionally varies by intervention, ranging from sustaining the coverage and burden reduction gains observed to date to filling the historic coverage gap and looking to elimination.

**Figure 22: Summary of detailed interventions and expected timing of impact**



Details on the specific shortcomings addressed by each of these proposed interventions are provided in Figure 23.

**Figure 23: Summary of interventions and shortcomings addressed**

Intervention	Shortcomings addressed
1 <b>Increase transparency of demand</b>	<p>Delivery: Uncertainty about true demand and where the nets are that have to be replaced at the country/district level</p> <p>Delivery: Sustained gaps in coverage, particularly within certain population segments</p> <p>Delivery: Manufacturers unable to plan ahead for future capacity needs</p>
2 <b>Stabilize funding for continuation of services</b>	<p>Affordability: Lack of predictable funding at historical levels to meet the near-term need of maintaining coverage</p>
3 <b>Catalyse extension of services to underserved populations</b>	<p>Affordability: Sustained gaps in coverage, with limited funding on the horizon for scaling up</p> <p>Affordability: Difficulty shifting to a consumer-driven market</p>
4 <b>Enable manufacturers to maintain suitable levels of capacity</b>	<p>Delivery: Manufacturers unable to plan ahead for future capacity needs</p>
5 <b>Accelerate the adoption of IRM strategies</b>	<p>Acceptability/adaptability: Limited uptake of IRM products and recommendations</p>
6 <b>Accelerate the availability and use of cost-effectiveness data in purchasing decisions</b>	<p>Quality: Lower quality products are being purchased over higher quality ones</p> <p>Acceptability/adaptability: Country purchasing decisions driven by short-term impact</p>
7 <b>Catalyse the adoption of innovative products and paradigms</b>	<p>Availability: Manufacturers hesitant to invest in R&amp;D for new paradigms, particularly to address resistance and durability concerns</p>
8 <b>Diversify delivery channels to support the transition to routine distribution</b>	<p>Delivery: Current scale-up distribution systems are not efficient</p>

### 7.2.1 Increase transparency of demand

#### Principles

- Periodically consolidate and publish geographic breakdown of coverage and delivery data to produce forward-looking estimates highlighting risk of discontinuation of services and areas of currently underserved populations;
  - ◆ or support organizations that are currently engaged in this activity.
- Enable donors to access this information to align investment decisions with their priorities and to facilitate longer-term planning.
- Manufacturers will be better able to plan for the quantity and location of demand.

#### Enablers

- Access to geographic coverage and delivery data from NMCPs and other country organizations or surveillance efforts.
- Assess the effective duration of products and services applied in a relevant geographic area.

#### Market impact: market inefficiency fixing

- Enable manufacturers to better align their capacity with demand needs, potentially decreasing lead time for orders or mobilizing resources.
- In a resource-limited environment, increase the effectiveness of funding by facilitating targeted investments based on investor priorities.

### Health Impact

- Assess discontinuation of services risk in the near term to reduce backsliding in critical, high burden areas.

### 7.2.2 Stabilize funding for continuation of services

#### Principles

- Prioritize replacement or upkeep of products and services in areas where funding will be temporarily discontinued (i.e. due to priorities set in the GFATM TFM or overall reduced funding available from donors in the upcoming year).
- Address the current instability in funding by providing direct emergency funding to countries to enable the continuation of services.
- Stabilize funding indirectly through financial arrangements (e.g. loan, bonds) with GFATM such that the donor can meet existing funding needs for continuation of services until the next replenishment.

#### Enablers

- Strong partnerships with donors such as GFATM identify areas most at risk once funding levels are known.
- Sufficient levels of financial support available to address the gap.

#### Market impact: market sustaining

- Ensuring cyclical distribution systems are not scaled back due to a missed cycle of funding.

#### Health impact

- Ensure continued access to prevention commodities, thereby reducing the risk that gains in burden reduction and coverage will be reversed.

### 7.2.3 Catalyse the extension of services to currently underserved populations

#### Principles

- Increase coverage of historically underserved populations—e.g. populations financially stable enough to purchase products; children over 5.
- Catalyse the engagement of the private sector as a sustainable funder in targeted geographical communities by co-funding the establishment of bednet distribution or IRS programmes and demonstrating the value to the donor.

#### Enablers

- Strong engagement by local organizations to commit to funding the extension of services and products beyond the initial scale-up.
- Private sector companies in financially stable regions recognize the value of providing their employees with prevention commodities such as reduced sick time and increased productivity as well as for social responsibility and publicity.

#### Market impact: market expansion

- Greater coverage of currently underserved population segments and geographic regions not historically prioritized by core donors.
- Diversify the concentrated delivery and donor landscapes.

### Health impact

- Increased access will lead to burden reduction.
- Community focus with high coverage in a concentrated area may increase the effectiveness of the interventions.

## 7.2.4 Stabilize supply by securing manufacturer capacity

### Principles

- Facilitate long-term purchase agreements between manufacturers and purchasers in order to increase predictability of supply and funding requirements, and to ensure capacity is retained by manufacturers.
- Enable smaller manufacturers to engage in long-term planning for capacity rather than ad hoc tender process.

### Enablers

- Strong relationships with a range of manufacturers and purchasers.
- Ability to demonstrate benefit of long-term purchase agreements to both parties.

### Market impact: market inefficiency fixing and market expansion

- Transparency and predictability on supply and capacity for products.
- Reduced risk that manufacturers will scale down capacity prematurely and can instead plan for cost-effective production timing.
- Increased access for smaller manufacturers, potentially increasing competition.

### Health impact

- Coverage levels will be driven by available funding rather than availability of products, and may ultimately increase the ability to achieve higher coverage.

## 7.2.5 Accelerate the adoption of IRM strategies

### Principles

- Co-fund a limited set of countries to establish IRM programmes to offset the costs of introduction.
- Supplement with funding for technical support and surveillance to ensure effective implementation and ability to demonstrate impact and value for money.
- Leverage country findings and results to increase uptake of strategies, particularly in areas at high risk for insecticide resistance.

### Enablers

- Countries must recognize the advantage of being a first mover in adopting IRM strategies while co-funding is available.
- Technical expertise is required (e.g. entomological experts) that can be deployed in countries to identify the level and form of resistance and incorporate IRM techniques into countries' longer term strategies.

### Market impact: market sustaining and market expansion

- Increased overall awareness and urgency around insecticide resistance.
- Reduce the cost to countries to implement IRM strategies.
- Build capacity within the community to develop appropriate IRM plans.
- Generate demand and facilitate uptake of new products, providing an incentive to manufacturers.

### Health impact

- If insecticide resistance reduces the effectiveness of existing tools, introduction of IRM strategies in high-risk regions potentially can sustain the effectiveness of existing tools longer (e.g. by removing pyrethroids from the community) as well as maintain burden reduction gains in the area.

### 7.2.6 Accelerate the availability and use of cost-effectiveness data for purchasing decisions

#### Principles

- Accelerate the uptake of standard testing methods for durability with manufacturers once methods are established through WHO.
- Facilitate the dissemination of durability data to donors and countries to inform cost-effective decision-making through the development of case studies or a more direct approach in supporting the development of specific durability rating systems.

#### Enablers

- Country and donor acceptance of durability testing methods and impact on cost-effective decision-making.
- Guidelines prepared in collaboration with WHO on how best to incorporate cost-effectiveness data in purchasing decisions.

#### Market impact: market inefficiency fixing

- New methods and data on durability testing will enable countries and donors to distinguish products based on physical durability, previously highlighted as the primary variant in the effectiveness of nets in different settings.
- Manufacturers will be incentivized to develop robust products for a range of settings or to develop specialized products in areas with particularly low durability/effectiveness.

### Health impact

- Deeper understanding of the duration of effectiveness of products will ensure that products are replaced and procured on appropriate cycles, increasing the overall effectiveness of control programmes.
- Increased cost-effectiveness of programmes may increase the sustainability of long-term control programmes by making the most of limited resources.

### 7.2.7 Catalyse the adoption of innovative products and paradigms

#### Principles

- Catalyse the adoption of new intervention paradigms as they become available through a range of potential levers, including advance purchase agreements, co-funding of initial scale-up and providing funding for the establishment of surveillance and impact evaluation systems to validate the health impact.
- Mitigate the risk of countries and donors in adopting new tools by identifying areas of highest potential effectiveness.

#### Enablers

- New tools and paradigms (e.g. sugar-baited traps) are in the pipeline, but their ultimate effectiveness or availability is not guaranteed.

### **Market impact: market sustaining and market expansion**

- Manufacturers will be incentivized to invest in new paradigms if uptake is being facilitated through cofounding and evaluation of impact.
- Demonstration of effectiveness of these tools may indirectly demonstrate effectiveness of new channels.

### **Health impact**

- New tools and paradigms can address challenges due to resistance, be effective against a broader range of vectors and possibly reach previously underserved groups, all ultimately helping to sustain and increase gains in burden reduction.

## **7.2.8 Diversify delivery channels towards routine distribution**

### **Principles**

- Catalyse channel diversification away from mass campaigns through pilot programmes in schools, companies/employers, general health clinics and more.
- Identify the landscape of tools available and where coverage can be increased through alternative, non-mass campaign delivery.

### **Enablers**

- Ability to evaluate the impact of alternative distribution channels. (5)
- Commitments from countries to continue funding these new delivery channels beyond the pilot phase.

### **Market impact: market inefficiency fixing**

- Current delivery mechanisms are overly dependent on mass campaigns that may not be sustainable in the long term.
- Leverage underutilized channels for near-term scale-up needs and to meet coverage gaps in targeted populations.

### **Health impact**

- With the goal of universal coverage, underutilized channels may be better suited to target historically underserved populations such as the elderly and children over 5.
- Expanding the channels for distribution may increase the coverage in targeted geographic areas and, therefore, may increase the overall effectiveness of the interventions in use.

## 8 Annex 1: References and acknowledgements

### 8.1 References

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## 9 Annex 2: Insecticide Resistance Management Strategies

According to GPIRM, there are five main approaches to deal with insecticide resistance. The first four leverage insecticide variation, while the last one is based on enhancing the performance of an insecticide already in use (Table 1).<sup>8</sup> With pyrethroids being the only insecticides used in LLINs, IRS becomes the intervention to strategically focus on in case of insecticide resistance until LLINs with other insecticides are available.

**Table 1: IRM approaches recommended in GPIRM**

IRM approach	Description	IRS	Use
Rotations	<ul style="list-style-type: none"> <li>■ Rotation over time of two or preferably more insecticide classes with different modes of action, leveraging the fitness costs of resistant vectors, using compound A in one area and compound B in another, so some mosquito populations are exposed to A while others are exposed to B</li> <li>■ Incremental costs include IRS teams training and equipment and the supply of different and probably more expensive insecticides</li> <li>■ Proven success in agriculture</li> <li>■ Needs local capacity for monitoring and enforcement strategy, since the strategy must be understood and stakeholders must adhere to it</li> <li>■ There is a need to better understand cross-resistance dynamics</li> </ul>	✓	
Mosaics	<ul style="list-style-type: none"> <li>■ Using compound A in one area and compound B in another, so some mosquito populations get exposed to A while others get exposed to B</li> <li>■ Fine mosaics (hut-by-hut) allow for potential vector exposure to both insecticides in one feeding, in a mimic to mixtures</li> <li>■ Broad mosaics (province-by-province), which operate in a similar principle to rotations, try to contain developing resistance to one mechanism of action with bordering each mosaic segment with a different insecticide</li> <li>■ Loses effectiveness in small regions or regions with wide mosquito range, e.g. regions with high winds where mosquitoes may be widely dispersed</li> <li>■ It is difficult to implement, requiring intensive monitoring and precise geographical segmentation, training of spray teams to handle multiple products appropriately and purchasing appropriate amounts of insecticide in advance to ensure availability and coverage</li> </ul>	✓	✓
Mixtures	<ul style="list-style-type: none"> <li>■ Two or more compounds mixed within a single product or formulation so that mosquitoes are guaranteed to come into contact with both at the same time; similar principle to use of combination therapy for drugs</li> <li>■ Currently, no companies have sought approval for mixture products for use in public health/malaria control and potential mixtures also are limited; only four classes covering two distinct mechanisms of action currently approved for public health use</li> <li>■ Need to ensure there is no significant pre-existing resistance in populations exposed to a mixture</li> <li>■ There is currently limited formulation, safety and efficacy data when formulation must ensure that chemicals decay at the same rate and the toxicology package must account for both pesticides</li> <li>■ Significant cost increase: both insecticides must still be used at the prescribed dose to maintain efficacy, significantly increasing cost per square metre</li> </ul>	✓	✓
Combination	<ul style="list-style-type: none"> <li>■ Use of two or more insecticide tools within a building (e.g. one insecticide on walls and another one on nets in the same household)</li> <li>■ The approach is different from mixtures as the same insect is likely, but not guaranteed, to come in contact with the second insecticide if it survives exposure to the first</li> <li>■ IRS can be used only in peak transmission period, as “spot reduction” tool</li> <li>■ There is a significant cost increase and uncertain effectiveness since some studies are still ongoing and others show contradictory conclusions</li> </ul>	✓	✓

8 WHO Global Malaria Programme. Global plan for insecticide resistance management in malaria vectors. Geneva: World Health Organization; 2012.

Synergists	<ul style="list-style-type: none"> <li>■ A substance that does not have insecticidal properties itself but, when mixed or applied with insecticides of a particular class, considerably enhances their potency (e.g. by inhibiting an enzyme that normally has detoxifying activity against the insecticide)</li> </ul>		
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Currently available



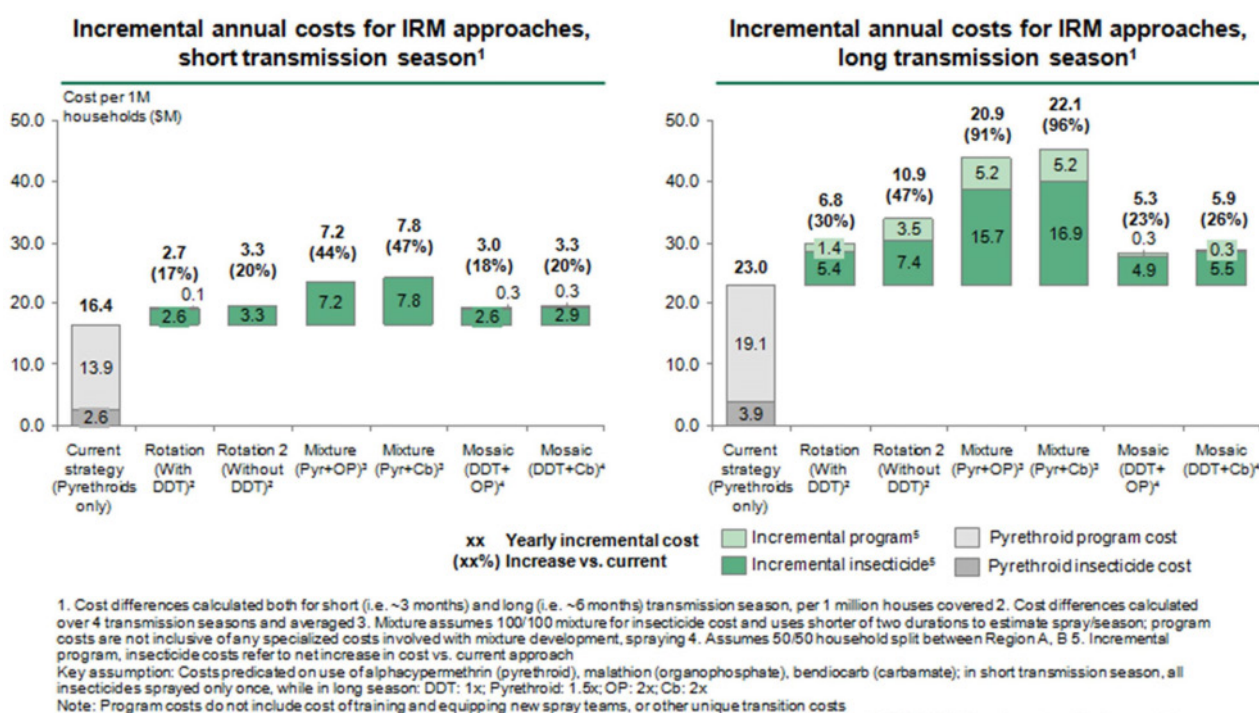
Could be available in the future

<sup>1</sup> Vetergaard Frandsen PermaNet 3.0 already includes piperonyl butoxide, but only into the “roof” of the net.

Source: Global Plan for Insecticide Resistance Management in Malaria Vectors, 2012

All approaches bring a cost increase, estimated to range from 17% to 96% depending on the approach used and the length of the high transmission period (Figure 2).<sup>9</sup> However, it is important to note that this cost increase does not apply to the overall malaria control programme, but rather in the specific villages or districts where it is implemented. As countries continue to implement the GPIRM recommendations, a better understanding of the cost implications (including impact and savings) will likely become available.

**Figure 1: Cost increase for IRM approaches**



Source: Global Plan for Insecticide Resistance Management in Malaria Vectors, 2012

<sup>9</sup> WHO Global Malaria Programme. Global plan for insecticide resistance management in malaria vectors. Geneva: World Health Organization; 2012.

### 10 Annex 3: Profiles of major stakeholders

There are several key stakeholders in the vector control commodities space, including manufacturers, R&D funders and drivers as well as donors and multilateral organizations. Profiles of the major R&D funders and drivers, donors and multilateral organizations are found below.

#### 10.1 R&D stakeholders

##### 10.1.1 Bill & Melinda Gates Foundation

The primary funder for malaria vector control R&D is the Bill & Melinda Gates Foundation, which regained its position as the top malaria R&D funder overall in 2011 by increasing funding by US\$ 57.7 million. The foundation provided 78% of malaria vector control R&D funding in 2011<sup>10</sup>, and during 2008–2012 it invested US\$ 131 million in malaria vector control R&D, with plans to invest another US\$ 81 million during 2013–2015.

The Bill & Melinda Gates Foundation has identified malaria as one of their top funding priorities. They work with global partners to support efforts to expedite malaria research, expand access to life-saving drugs and prevention methods and advocate for greater action in the development of vaccines, prevention strategies, drugs and public awareness. The foundation is the largest funder of both malaria vector control and malaria overall. However, the recipient pool for their funds for vector control is very concentrated. Historically, 55% of the funds has gone to IVCC, 20% to the Liverpool School of Tropical Medicine, 16% to the Foundation for the National Institutes of Health and less than 3% to the remaining ~20 recipients.<sup>11</sup>

##### 10.1.2 United States NIH

The NIH is committed to maintaining the research momentum needed to eradicate malaria. Their investments include programmes designed to strengthen research capacity in countries most affected by malaria. Their research portfolio includes an array of projects aimed at better understanding the disease process, finding new and improved ways to diagnose and treat people with malaria, control the mosquitoes that spread it and prevent malaria altogether through vaccination. Their top fund recipients are various product developers, the Virginia Polytechnic Institute and State University, and the London School of Hygiene and Tropical Medicine, accounting for 22%, 22% and 15% of their overall funding, respectively.<sup>12</sup>

##### 10.1.3 IVCC

IVCC, established in 2005, is a Product Development Partnership aiming to overcome the barriers to innovation in the development of new insecticides for public health vector control and to develop information systems and tools that will enable new and existing pesticides to be used more effectively. They also work with disease endemic country stakeholders and industry to establish target product profiles for new paradigms in vector control. IVCC is the primary recipient of funding from the Bill & Melinda Gates Foundation; between 2007 and 2010, IVCC received approximately 55% of the foundation's funding.<sup>13</sup> Still, IVCC remains a large supporter of the R&D pipeline.

#### 10.2 Donors

##### 10.2.1 GFATM

GFATM was established in 2002 to dramatically increase resources to fight these devastating diseases. It is a public–private partnership working as an international financing institution dedicated to attracting funds and directing them to areas of greatest need. Since its inception and until January 2011, GFATM has received 95% of its funds from governments.

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10 Global Funding of Innovation for Neglected Diseases. G-FINDER. 2013. Available from: <http://g-finder.policycures.org/>

11 Global Funding of Innovation for Neglected Diseases. G-FINDER. 2013. Available from: <http://g-finder.policycures.org/>

12 Global Funding of Innovation for Neglected Diseases. G-FINDER. 2013. Available from: <http://g-finder.policycures.org/>

13 Global Funding of Innovation for Neglected Diseases. G-FINDER. 2013. Available from: <http://g-finder.policycures.org/>

GFATM brings together, at the country level, a wide diversity of implementing government bodies, international development partners (including UN agencies and donors), national civil society organizations (including local media, professional associations and faith-based institutions), the private sector and communities living with or affected by the diseases.

With regard to malaria vector control, GFATM has been the key driver for the major scale-up of insecticide treated nets delivery. By September 2012, it had funded the distribution of more than 270 million nets (ITNs and LLINs). It also has supported IRS for more than 40 million houses.<sup>14</sup>

### 10.2.2 PMI (USAID)

PMI was established in 2005 as a five-year, US\$ 1.2 billion expansion of United States government resources to reduce the burden of malaria and help relieve poverty on the African continent. It is an interagency initiative led by USAID and implemented together with the United States Centers for Disease Control and Prevention of the United States Department of Health and Human Services.

The goal of PMI is to reduce malaria-related deaths by 50% in 19 countries in Africa that have a high burden of malaria by expanding coverage of four highly effective malaria prevention and treatment measures to the most vulnerable populations. In 2008, the programme received an increase of up to US\$ 5 billion in PMI funding for five more years, aiming to halve the burden of malaria of 70% for at-risk populations in sub-Saharan Africa.

PMI works closely with a wide variety of organizations, including host country governments, other United States government agencies, international organizations, other bilateral, multilateral and private donors, nongovernmental and faith-based organizations and the private sector.

Vector control supported initiatives include ITNs and IRS. In its 2012 financial year, PMI sprayed over 7 million houses with insecticide and procured over 21 million LLINs.<sup>15</sup>

### 10.2.3 UNICEF

UNICEF plays a key role in many global, regional and country malaria partnerships. It is a founding partner and key board member of RBM, a global partnership established in 1998 to halve the world's malaria burden by 2010. UNICEF is also strengthening partnerships in malaria with the World Bank, PMI, GFATM, Malaria No More and UNITAID. In recognition of its role as one of the biggest killers of children in Africa, malaria prevention and control interventions form an integral component of a minimum package of the UNICEF high-impact maternal and child survival interventions.

UNICEF is one of the largest purchasers of LLINs, purchasing over 170 million nets over the past 11 years.<sup>16</sup> Together with its partners, UNICEF distributes ITNs using routine health services and campaign approaches. It works with ministries of health and NGOs as well as community and village health workers to develop local distribution systems.

## 10.3 Multilateral organizations

### 10.3.1 WHO

WHO is the directing and coordinating authority for health within the UN system. It is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends.

WHO hosts the Global Malaria Programme, which provides the community with policy guidance and annually publishes the World Malaria Report, a document that consolidates the status of the fight against malaria.

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<sup>14</sup> The Global Fund. Progress reports. The Global Fund: 2013. Available from: <http://www.theglobalfund.org/en/publications/progressreports/>

<sup>15</sup> PMI. Seventh annual report to Congress. Washington D.C.: PMI; 2013.

<sup>16</sup> Trajkovska, E. UNICEF The approach to procurement and challenges. The Global Fund LLIN Supplier Conference; 2013; Geneva.

WHO also hosts WHOPEPES, which, since its establishment in 1960, has been serving as a reference for setting norms and standards for public health pesticides and their life-cycle management for the entire malaria community.

### 10.3.2 RBM

The RBM Partnership was launched in 1998 by WHO, UNICEF, the United Nations Development Programme and the World Bank in an effort to provide a coordinated global response to the disease. It is comprised of more than 500 partners, including malaria endemic countries, their bilateral and multilateral development partners, the private sector, NGOs and community-based organizations, foundations and research and academic institutions.

The RBM overall strategy aims to reduce malaria morbidity and mortality by reaching universal coverage and strengthening health systems. GMAP defines two stages of malaria control: (i) scaling-up for impact (SUFI) of preventive and therapeutic interventions; and (ii) sustaining control over time. In 2008, world leaders and the global malaria community endorsed GMAP, which provides a global framework for action around which partners can coordinate their efforts.

RBM has been holding a Vector Control Working Group since 2003, with the purpose of facilitating the alignment of partners on strategy and “best practices” to rapidly scale-up malaria vector control interventions, particularly ITNs and IRS, in order to meet targets for malaria control. The working group has several work streams according to the challenges the vector control community is currently facing:<sup>17</sup>

- Insecticide resistance
- Outdoor malaria transmission
- Continuous LLIN distribution systems
- Durability of LLINs in the field
- Capacity-building for IRS
- Larval source management
- Optimizing evidence for vector control interventions
- Entomological monitoring and integrated vector management (IVM).

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<sup>17</sup> Vector Control Working Group (VCWG). Roll Back Malaria: 2013: Available from: <http://www.rollbackmalaria.org/mechanisms/vcwg.html>

## 11 Annex 4: WHOPES approval process

While vector control is being scaled up in disease endemic countries, a large share of countries is characterized by very limited capacity in vector control and in regulation of public health pesticides. In many cases, the in-country regulatory process lacks the capacity to perform a full evaluation of products, and the management of pesticides post-registration is also limited. In this context, WHOPES plays an essential role in evaluating and recommending pesticide products as well as building in-country capacity for pesticide testing, evaluation and management. In fact, a recent survey showed that ~75% of WHO Member States rely, partly or solely, on WHOPES product recommendations for their pesticide registration decisions.<sup>18</sup>

WHOPES was set up in 1960 to promote and coordinate the testing and evaluation of pesticides for public health. Today, almost all donor-funded nets have been granted a WHOPES recommendation. The global objectives of WHOPES are to:

- facilitate the search for alternative pesticides and application methodologies that are less hazardous and more effective;
- develop and promote policies, strategies and guidelines for the selective and judicious application of pesticides for public health use, and assist and monitor their implementation by Member States.

WHOPES functions through the participation of representatives of governments, manufacturers of pesticides and pesticide application equipment, WHO collaborating centres and research institutions as well as other WHO programmes, notably the Chemical Safety and the Global Malaria Programme.

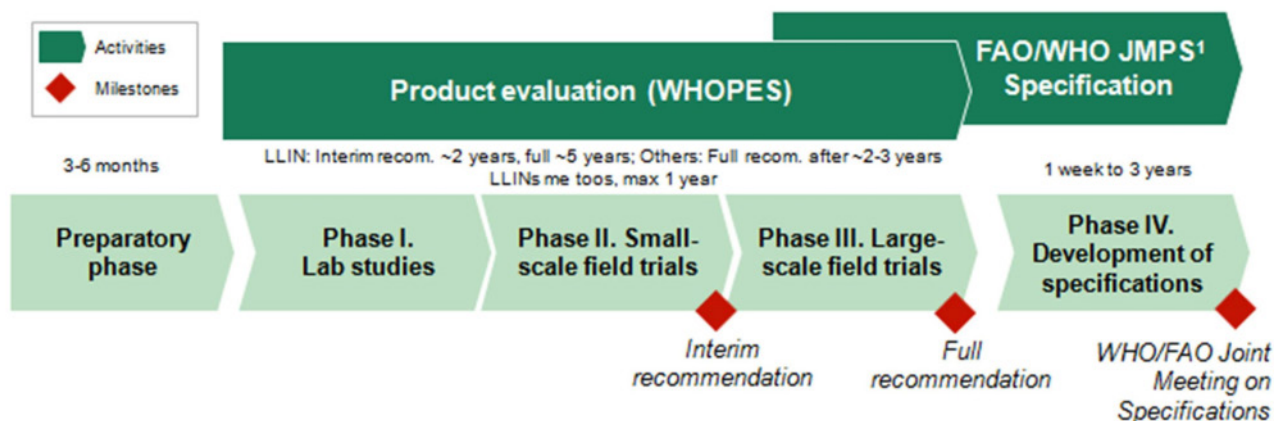
WHOPES has prepared guidelines for evaluating ITNs/LLINs for both safety and efficacy. The objective of WHOPES is twofold: to evaluate and specify public health pesticides and to promote and develop guidelines for the development of public health pesticide management.

In its present form, WHOPES comprises a four-phase evaluation and testing process that products must pass through before they are given a full recommendation. The process evaluates the safety, efficacy and operational acceptability of public health pesticides and develops specifications for quality control and international trade. As a complementary activity, it also develops guidelines for testing, evaluation and specification of the main categories of pesticide products. The product recommendations issued by WHOPES facilitate the registration of pesticides by Member States, whereas the product specifications provide a point of reference for product quality control and commercial trade of pesticide products.

The testing and evaluation programme consists of the following activities (Figure 1):

- Preparatory phase: the dossier of evidence submitted by the manufacturer is reviewed by the WHOPES secretariat to assess if any additional data are required, based on the established testing guidelines for the product. The secretariat informs the manufacturer of any complementary trials required and defines trial protocols and time plans together with its collaborating research centres and the manufacturer.
- Phase 1: The properties of the product are evaluated in a laboratory setting. In particular, the biological efficacy and the residual effect of the product are evaluated. This phase also includes a risk assessment of the product for the intended use.
- Phase 2: The product properties are evaluated in small-scale field trials, the biological efficacy and impact on vector behaviour is evaluated in field settings and the perceived adverse effects on users are investigated.
- Phase 3: The product is evaluated in large-scale field trials. The biological efficacy and residual activity of a product as well as operational acceptability is assessed.
- Phase 4: Upon satisfactory completion of WHOPES Phases 1, 2 and 3, WHO specifications of the product are developed and published.

<sup>18</sup> WHO. Public health pesticide registration and management practices by WHO Member States. Geneva: WHO; 2011.

**Figure 1: WHOPES approval process**

<sup>1</sup> Food and Agriculture Organization of the United Nations (FAO); Joint Meeting on Pesticide Specifications (JMPS).

The WHOPES Working Group, a scientific committee, assists WHOPES in reviewing the existing information as well as the reports of WHOPES-supervised trials. The group makes recommendations on the suitability of these products for public health use. The reports of the WHOPES Working Group are issued as WHO documents and are widely distributed.

The WHOPES approval process can take over five years for a full recommendation. All products except LLINs are reviewed after completing Phase 3, whereas LLINs, because of the extensive Phase 3 study required, may receive an interim recommendation after satisfactory completion of Phase 2. An interim recommendation implies that the product is made with a WHO-recommended insecticide, it has satisfactorily completed laboratory tests and small-scale field testing for efficacy, and after 20 standard WHO washes it performs as well as or better than a conventionally treated net that has been washed until just before exhaustion. This test of withstanding 20 washes is theoretically equivalent to a lifespan of three years. To be given a full recommendation, a product also must undergo three years of large-scale field trials<sup>19</sup>. Not only is this long approval process a challenge for innovative products to reach the market in a timely fashion, but as it is based on minimum standards it provides limited recognition for new products that have innovative characteristics. A key issue is that metrics to differentiate innovation in net-based products (e.g. longer efficacy, increased durability, insecticide resistance mitigation) are not in place beyond the WHOPES minimum quality standards. The new VCAG will promote innovation in new tools and paradigms (e.g. for insecticide resistance mitigation) and establish evaluation criteria when they do become available.

WHOPES-recommended LLINs should last for a minimum of three years, but recent reports have shown that the lifespan variability is higher than originally expected, in terms of physical condition, insecticidal effect and perceived usefulness depending on the geographic and cultural context. WHO has admitted that some data suggest that actual durability in fact could be less than three years<sup>20</sup>, “There is clear evidence that the fabric integrity of LLINs varies widely, not only among different products but also among different locations and settings, due perhaps to local variations in sources of wear and tear (e.g. snagging, rodents, washing and burns) and differences in the vulnerability of products to these factors”<sup>21</sup>. Knowing the real lifespan of nets is critical to predicting demand and keeping up coverage.

In order to address this challenge, RBM has established a work stream for durability within the Vector Control Working Group. The Global Malaria Programme also has released guidelines on methods for monitoring the relative durability of LLIN products in the field, and methods for using this data in procurement decisions will be released in the future<sup>22</sup>. However, there is still significant progress to be made. WHO is

<sup>19</sup> WHO. Guidelines for monitoring the durability of long-lasting insecticidal mosquito nets under operational conditions. Geneva: WHO; 2011.

<sup>20</sup> WHO. World Malaria Report 2012. Geneva: WHO; 2012.

<sup>21</sup> WHO. Guidelines for monitoring the durability of long-lasting insecticidal mosquito nets under operational conditions. Geneva: WHO; 2011.

<sup>22</sup> WHO Global Malaria Programme, A system to improve Value for Money in LLIN procurement through market competition based on cost per year of effective coverage—Concept Note. Geneva: WHO; 2011.



currently working to improve the usefulness of physical tests and indicators of ITN/LLIN strength to predict the eventual durability in a variety of domestic use scenarios in collaboration with the R4D Institute.

In addition, technical support to Member States in capacity strengthening for pesticide management constitutes a major activity of WHOPES. This includes optimizing and harmonizing pesticide registration requirements and procedures as well as capacity strengthening for postregistration monitoring and evaluation of public health pesticides and reducing trade in substandard pesticide products. The global monitoring of the use of insecticides for vector-borne disease control by WHOPES has served as an international reference for monitoring trends in the use of public health pesticides and for product development.

One of the biggest challenges surrounding the WHOPES process is how to best enable so-called me too products to enter the market without disincentivizing manufacturers to invest in R&D. These manufacturers must be able to recoup their R&D costs, while remaining competitive in the price-sensitive procurement market. The WHOPES governing body publishes all technical specifications of the reference products that have been granted full recommendations without providing the manufacturer protection, as is seen in the pharmaceutical industry.

Looking forward, the WHOPES approval process currently only addresses products for existing vector control interventions (IRS, ITNs/LLINs, space spray products and pesticide products for personal protection). When a new product is recommended by VCAG, WHOPES must establish relevant testing guidelines for safety and efficacy, make recommendations on use after its safety and efficacy assessment and develop specifications for its quality control and international trade.<sup>23</sup> The ability of WHOPES to respond to a growing number and new types of products is critical to the success of accelerating the vector control R&D pipeline. This will require increasing the capacity of WHOPES in terms of both human and financial resources. Capacity must be increased not only within WHOPES, but also throughout the network of organizations that conduct assessments on its behalf.<sup>24</sup>

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<sup>23</sup> WHO. Global plan for insecticide resistance management in malaria vectors. Geneva: WHO; 2012.

<sup>24</sup> WHO. Global plan for insecticide resistance management in malaria vectors. Geneva: WHO; 2012.