Vector Control
Strategies and Successes
… and challenges

Building on Success – Malaria Control and Elimination

Swiss TPH Winter Symposium 2016

Basel, Switzerland

Global **Malaria** Programme

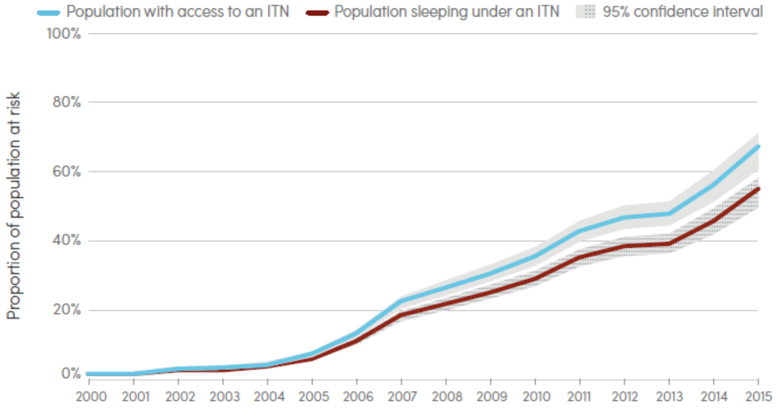
World Health Organization

Wide-spread deployment of core vector control tools

↑ ITN coverage

↓ IRS coverage

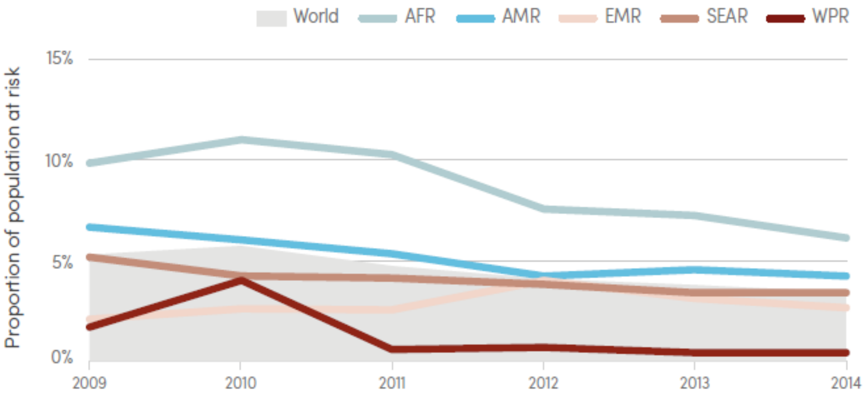
Figure 3.1 Proportion of population at risk with access to an ITN and proportion sleeping under an ITN, sub-Saharan Africa, 2000–2015



ITN, insecticide-treated mosquito net

Source: *Insecticide-treated mosquito net coverage model from Malaria Atlas Project (20), with further analysis by WHO*

Figure 3.4 Proportion of the population at risk protected by IRS by WHO region, 2009–2014



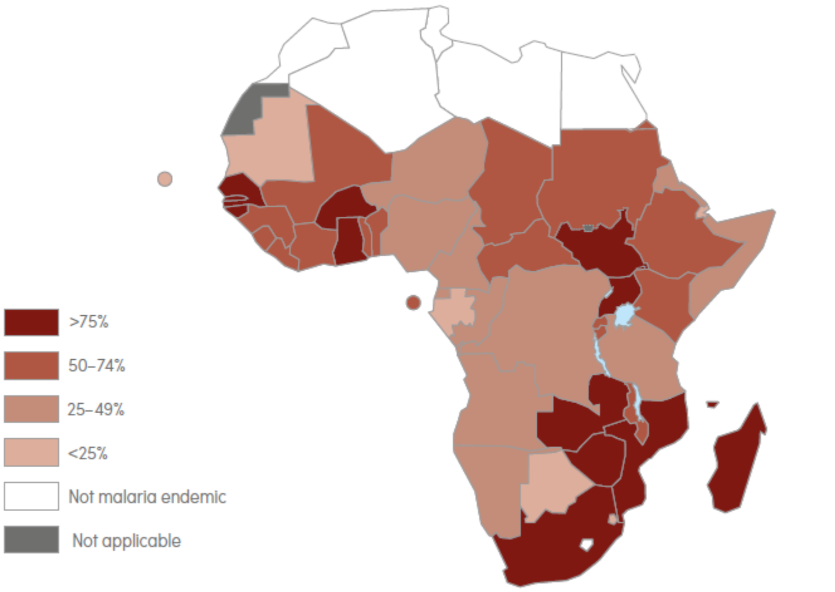
AFR, African Region; AMR, Region of the Americas; EMR, Eastern Mediterranean Region; SEAR, South-East Asia Region; WPR, Western Pacific Region

Source: *National malaria control programme reports*

Source: World Malaria Report 2015

Significant increases in coverage with vector control

Figure 3.5 Proportion of the population protected by IRS or with access to ITNs in sub-Saharan Africa, 2014



Source: *National malaria control programme reports and insecticide-treated mosquito net coverage model from Malaria Atlas Project (20), with further analysis by WHO*

Massive increase in the number of ITNs delivered to endemic countries:

- 2004: 6 million
- 2015: 178 million

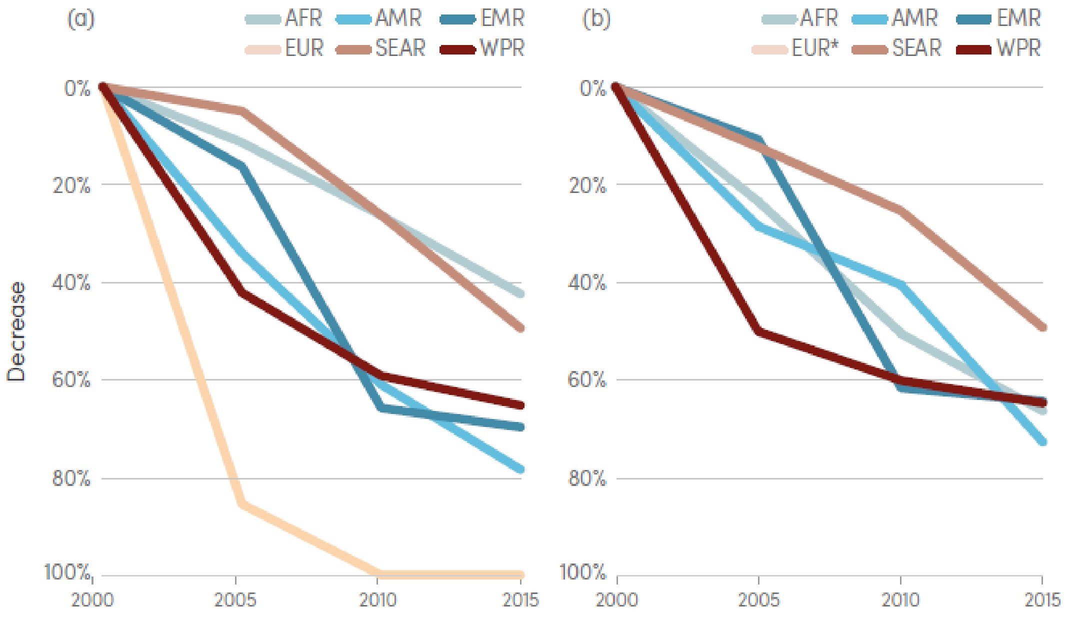
> 1 billion nets delivered worldwide 2004-2015

↑ overall protection with vector control

Source: World Malaria Report 2015

Significant decline in burden across all regions

Figure 2.2 Percentage decrease in (a) estimated malaria case incidence and (b) malaria death rate, by WHO region, 2000–2015



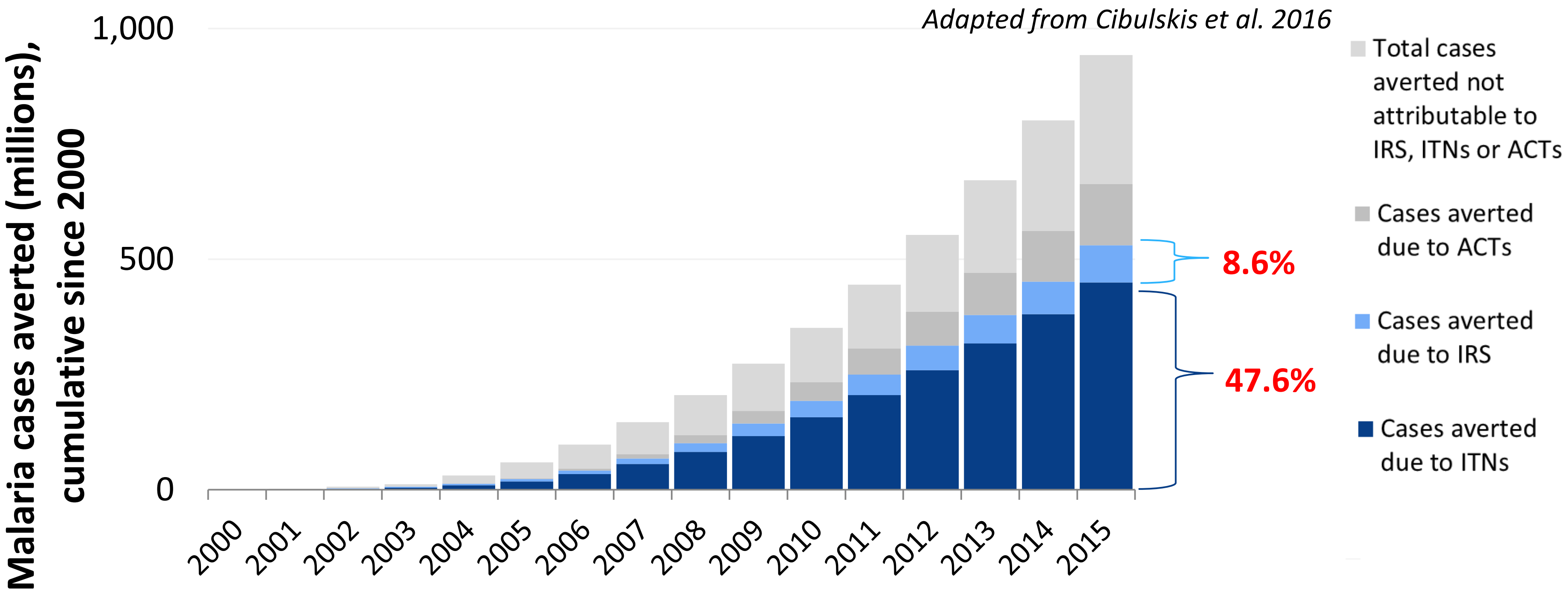
AFR, African Region; AMR, Region of the Americas; EMR, Eastern Mediterranean Region; EUR, European Region; SEAR, South-East Asia Region; WPR, Western Pacific Region

* There were no recorded deaths among indigenous cases in the WHO European Region for the years shown.

Source: *WHO estimates*

Source: World Malaria Report 2015

Major contribution of insecticidal vector control



- In sub-Saharan Africa, 70% of reductions were attributed to interventions; of this, 69% was attributed to ITNs, 21% to ACTS and 10% to IRS.

Source: World Malaria Report 2015

Numerous challenges remain

In 2015:

- 214 million cases
- 438,000 deaths
- 3.2 billion at risk

- **Funding gaps**
  - Current annual spending: US$ 2.7 billion
  - Annual spending required by 2030: US$ 8.7 billion
  - Financing will need to ***triple*** from current levels
- **Coverage gaps**
  - 1 in 4 children in sub-Saharan Africa still living in household without ≥1 ITN or IRS
  - 60 million malaria cases undiagnosed & untreated
  - 15 million pregnant women do not receive any IPTp
  - Scale-up of core interventions must continue
- **Biological challenges**
  - *P. falciparum hrp2/3* gene deletions
  - Antimalarial drug efficacy and insecticide resistance
  - New and approaches tools are required to address challenges

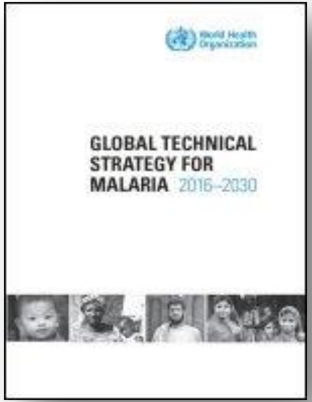
Adapted from Alonso 08/12/2016

Global Technical Strategy sets out key priorities

For vector control and entomology:

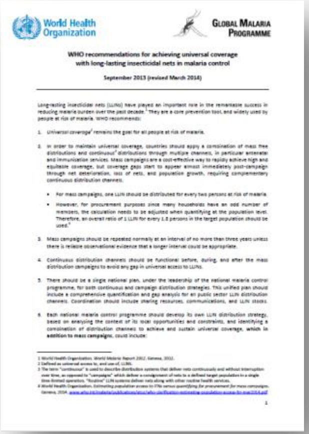
- Maximize the impact of current vector control interventions (LLINs and IRS – plus other supplementary measures)
- Maintain adequate entomological surveillance and monitoring - strengthen capacity for evidence-driven vector control
- Implement targeted vector control where transmission has declined
- Prevent and manage insecticide resistance and residual malaria parasite transmission
- Support the development and uptake of new tools (harness innovation)
- Improve quality control of vector control products

http://www.who.int/malaria/areas/global_technical_strategy/en/



Achieving and sustaining LLIN coverage essential

- Mass free LLIN distributions to at-risk populations continue to be necessary
  - Generally every 3 years (assuming routine systems are also functional)
  - In the absence of functional routine systems, campaigns should occur more frequently than every 3 years
  - Target 1 LLIN for every 2 persons (with procurement metric for campaigns of 1 LLIN for every 1.8 persons)
- ANC and EPI - highest priority channels for continuous distribution (before, during and after mass campaigns)


World Health Organization
GLOBAL MALARIA PROGRAMME
WHO recommendations for achieving universal coverage with long-lasting insecticidal nets in malaria control
September 2013 (revised March 2014)

http://www.who.int/malaria/publications/atoz/who_recommendation_coverage_llin/en/

Risks associated with scale-back of vector control

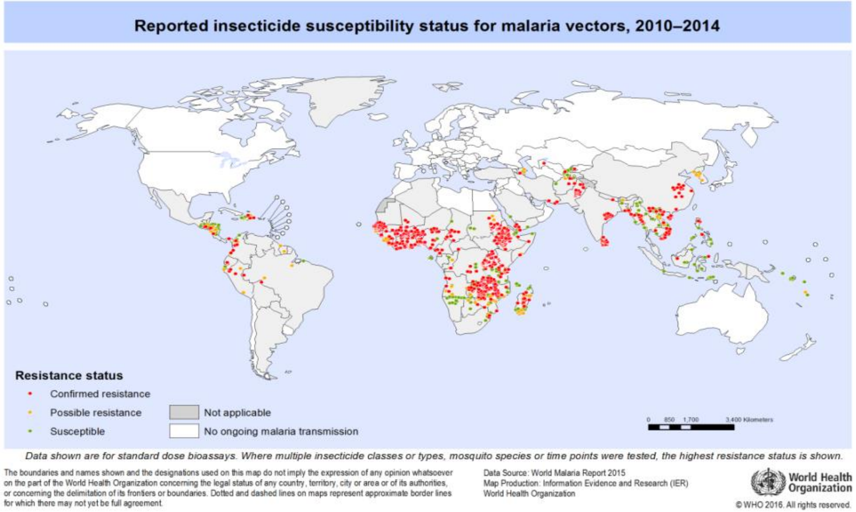
Are there situations in which reduction in coverage of vector control activities will not result in resurgent transmission?

1. In areas with ongoing local malaria transmission (irrespective of both the pre-intervention and the current level of transmission), **the scale-back of vector control is not recommended**. Universal coverage with effective malaria vector control should be pursued and maintained.
2. In areas where transmission has been interrupted, the scale-back of vector control should be based on a detailed analysis that includes assessment of receptivity, vulnerability and disease surveillance coverage, and capacity for case management and vector-control response
3. Countries and partners are therefore requested to invest in health systems particularly strengthening of disease and entomological surveillance, as identification of areas for geographical scale-back depends on the availability of this capacity.

http://www.who.int/malaria/publications/atoz/scale-back-vector-control/en/

Insecticide resistance threatens gains

- Resistance reported:
  - For 60 countries
  - For all major vectors
  - To all 4 insecticide classes
- GPIRM – urgent efforts needed to ensure correct use of existing interventions and availability of new tools in order to **maintain the effectiveness of malaria vector control**



- But GPIRM adoption to policy and operational implementation at country level have generally been poor due to a lack of political will coupled with major financial, human and infrastructural resource deficiencies
- No clear idea of resistance impact on intervention effectiveness

Insecticide resistance implications: multi-country evaluation

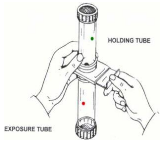
WHO-coordinated evaluation conducted 2009 – 2016 in Benin, Cameroon, India, Kenya and Sudan

Primary objectives

- To assess trends in insecticide resistance status and underlying mechanisms in main malaria vector species in response to different interventions.
- To determine the impact of insecticide resistance in malaria vectors on the protective effectiveness of LLINs and IRS, and therefore on malaria disease burden.

IR evaluation: study design and considerations

- Need for a common study design across all countries
- Need for standardisation of methods, outcomes and measurements
- Need for adequate statistical power, hence replication in many places (clusters)
- Design had to be observational since resistance cannot be randomly assigned



Entomological indicators

Insecticide susceptibility of main vectors (% mosquito mortality in WHO tube tests)

Epidemiological endpoints

- Active case detection in cluster cohorts
- Active infection detection in cluster cohorts
- Prevalence of infection in clusters

➢ Trends in insecticide resistance

➢ Effectiveness of nets (incidence in LLIN users versus non-users)

➢ Associations between resistance and morbidity

Method published: Kleinschmidt I, et al. Design of a study to determine the impact of insecticide resistance on malaria vector control: a multi-country investigation. Malar J. 2015;14:282.

IR evaluation: implementation sites

EVALUATION AREAS		BENIN	CAMEROON	INDIA	KENYA	SUDAN
Region/s		Département de Plateau	North Region	Kondagaon, Chhattisgarh	Western Kenya	Gezira, Gedarif and Kassala States
Sub-region/s		Ifangni Sakété Pobé Kétou	Garoua Mayo Oulo Pitoa	Keshkal	Bondo Nyando Rachuonyo Teso	El Hoosh Galabat Hag Abdalla New Halfa
***PfPR* $_{2–10}$ endemicity class [a]**		High	High	Low	High	Low
Baseline *P. falciparum* incidence		1.4 / year	0.6 / year	0.015 / year	1.4 / year	0.03 / year
Key vector/s		*An. gambiae s.s.*	*An. arabiensis* *An. gambiae s.s.* *An. coluzzii* *An. funestus*	*An. culicifacies*	*An. gambiae s.s.* *An. arabiensis* *An. funestus*	*An. arabiensis*
Baseline pyrethroid susceptibility [b]		20–100%	43–100%	86–100%	1–100%	47–100%
Evaluation design						
Number of clusters, by intervention	**LLINs**	32	38	80	50	70
	LLINs + IRS	0	0	0	0 [c]	70 [d]
Main indicator		Active case detection incidence				
Av. number children in cohort, per cluster		70	80	80	80	200

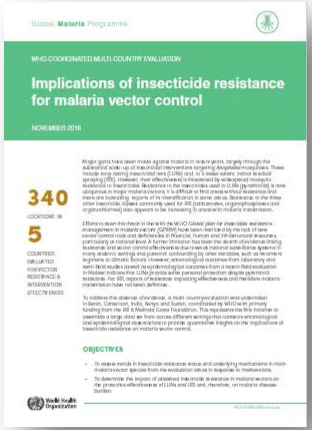
[a] proportion of 2–10 year olds in the general population that are infected with *P. falciparum*, averaged over the 12 months of 2010 as estimated by Malaria Atlas Project (MAP); low = 0% < *PfPR* $_{2–10}$ ≤ 5%; intermediate = 5% < *PfPR* $_{2–10}$ ≤ 40%; high = *PfPR* $_{2–10}$ > 40%; [b] mortality as measured in standard WHO susceptibility tests with the insecticide used in local LLINs; [c] IRS with deltamethrin and lambda-cyhalothrin in Rachuonyo and Nyando in 2012 only; [d] IRS with bendiocarb but with deltamethrin in Galabat in 2011 and 2012.

IR evaluation: outcomes

1. Insecticide resistance was highly variable between years and was heterogeneous on a relatively fine scale. There was a **significant trend of increasing pyrethroid resistance** in the main malaria vector species.
2. There was **no evidence of an association between malaria disease burden and pyrethroid resistance** across all locations.
3. There was **evidence that LLINs provided personal protection against malaria in areas with pyrethroid resistance**. There was no difference detected in LLIN effectiveness between higher and lower pyrethroid resistance.
4. There was evidence from an area (Galabat) with high LLIN coverage that IRS with an insecticide to which there is resistance provided no additional protection whereas **IRS with an insecticide to which there is susceptibility almost halved malaria incidence** relative to LLINs alone.
5. The development of pyrethroid resistance was slower in areas with LLINs plus a non-pyrethroid IRS than in an area with LLINs only.

IR evaluation: Implications for vector control & surveillance

- Universal coverage with effective vector control of all at-risk populations is essential to protect against malaria. LLINs continue to provide protection even in the face of resistance.
- Despite gains made against malaria, transmission is still occurring. New tools and strategies are required.
- Countries are urged to develop and implement national insecticide resistance monitoring and management plans.
- Better measures of insecticide resistance are needed.


Global Malaria Programme

WHO-COORDINATED MULTI-COUNTRY EVALUATION

Implications of insecticide resistance for malaria vector control

NOVEMBER 2016

340

LOCATIONS IN

5

COUNTRIES EVALUATED FOR VECTOR RESISTANCE & INTERVENTION EFFECTIVENESS

OBJECTIVES

http://www.who.int/malaria/publications/atoz/insecticide-resistance-implications/en/

Limited options for insecticide resistance management

LLINs: *Now:* nets with pyrethroid or pyrethroid+synergist
In process: nets with pyrethroid+other AI

IRS: *Now:* formulations of pyrethroid, DDT, carbamate or organophosphate
In process: formulations of other AI or pyrethroid+other AI (mixture)

- Multiple classes can be used in rotation or mosaics

Combination of IRS and LLINs:

Now: pyrethroid LLINs plus non-pyrethroid IRS can be used to manage resistance - but limited evidence that combining reduces malaria burden.

- Programmes should focus on delivery of either IRS or LLINs at high coverage and high quality rather than adding to compensate in deficiencies of the first.

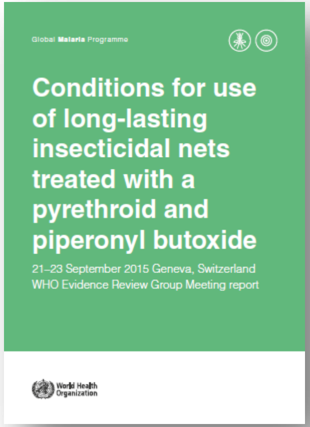
http://www.who.int/malaria/publications/atoz/who-guidance-combining-irs_llins-mar2014.pdf

Evidence base for LLINs with synergist PBO reviewed

Recommendations (abbreviated)

- While PBO LLINs appear to have an increased efficacy in certain settings, the evidence is still limited to justify a complete switch from pyrethroid-only LLINs to PBO LLINs across all settings.
- PBO LLINs should be used only where universal coverage with effective vector control (LLINs and/or IRS) of populations at risk of malaria will not be reduced, as PBO LLINs may be more expensive than pyrethroid-only LLINs.
- In order to build the evidence base that would support accelerated deployment of PBO LLINs, pilot “exploratory” implementation is necessary.

Full text: http://www.who.int/malaria/publications/atoz/use-of-pbo-treated-llins/en/


Global Malaria Programme

Conditions for use of long-lasting insecticidal nets treated with a pyrethroid and piperonyl butoxide

21–23 September 2015 Geneva, Switzerland
WHO Evidence Review Group Meeting report

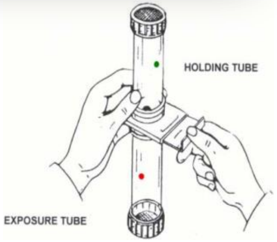
World Health Organization

Test procedures for monitoring resistance updated

- Supersedes the 2013 test procedures

- Updated to include:
  - **Diagnostic concentrations for additional insecticides** that may be used in vector control interventions
  - **Intensity assays** to measure the strength of the resistance in a mosquito population
  - **Synergist assays** that can operate as a proxy for metabolic mechanism involvement in resistance

http://www.who.int/malaria/publications/atoz/9789241511575/en/



Control of residual malaria parasite transmission an issue

Transmission that continues even with good access to LLINs or well-implemented IRS, or in situations where LLIN use or IRS implementation are not practical; due to a combination of human and mosquito behaviours.

Recommendations (abbreviated)

1. Generate local evidence on the magnitude of the problem of residual transmission of malaria
2. Develop new vector control tools to address residual transmission.
3. Ensure that registration processes support the rapid availability to the local market of validated new vector control products.

http://www.who.int/malaria/publications/atoz/technical-note-control-of-residual-malaria-parasite-transmission-sep14.pdf


World Health Organization

Global Malaria Programme

Control of residual malaria parasite transmission

Guidance note – September 2014

Background

The current core malaria vector control interventions are long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS), with larval source management (LSM) applicable in certain settings where mosquito breeding sites are few, fixed and findable.[1,2,3] Long-lasting insecticidal nets reduce malaria parasite transmission mainly by killing or blocking mosquitoes that attempt to feed upon humans under nets. Indoor residual spraying kills mosquitoes and reduces longevity when they rest on insecticide-sprayed surfaces inside houses or other structures, usually after they have fed on occupants.

The effectiveness of these interventions relies on a number of factors including susceptibility of mosquitoes to the insecticides used, adequate coverage rates, quality and timely implementation, and user acceptance or compliance. While factors that can limit the effectiveness of existing interventions are extremely important and must be addressed, even full implementation of core interventions would not halt malaria parasite transmission across all settings.

Indeed, evidence from a variety of settings over the last half century indicates that *residual malaria parasite transmission* occurs even with good access to and usage of LLINs or well-implemented IRS,[4,5,6,7] as well as in situations where LLIN use or IRS are not practical. A combination of human and vector behaviours are responsible for this transmission, for example when people reside in or visit forest areas or do not sleep in protected houses[8,9] or when local mosquito vector species exhibit one or more behaviours that allow them to avoid the core interventions.

Strengthened capacity in public health entomology needed

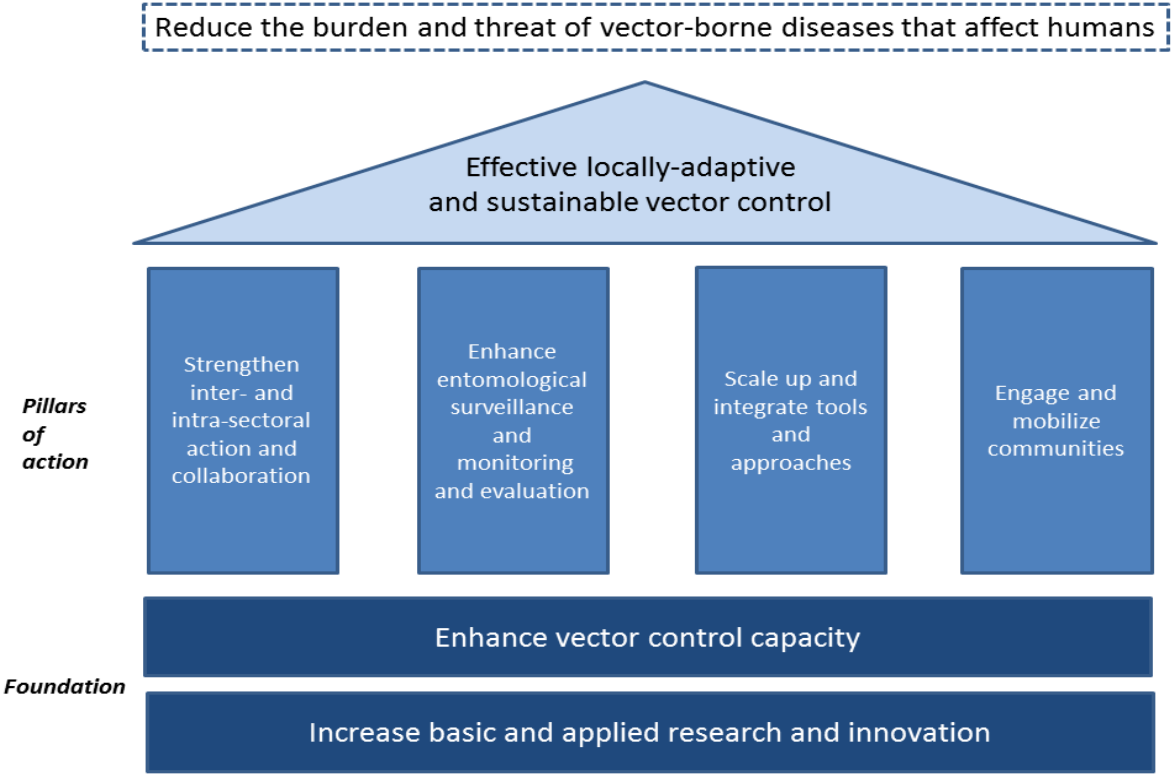

World Health Organization
Global Malaria Programme
WHO Guidance Note on Capacity Building in Malaria Entomology and Vector Control
September 2013

- Ensure basic capacity of human and infrastructure to support vector control and entomological monitoring
- Establish/strengthen an intersectoral coordination mechanism, for developing a long-range strategic plan for building human resources and systems
- Conduct training needs assessments and curricula review for pre-service and in-service training (including epidemiology and management)
- Review, revise or establish posts and career development structures at all levels
- Ensure there are sufficient resources for human and infrastructure capacity-building factored into bi-lateral and multi-lateral projects and programmes, based on the established national strategic plan.

http://www.who.int/malaria/publications/atoz/who_guidance_cap_building_entomology/en/index.html

A comprehensive approach to vector control required

Draft global vector control response



Conclusions

Malaria as "a problem to be solved – not simply a task to be performed"

Vector control

- **Strategies:** are proven but require augmentation to achieve elimination
- **Successes:** are evident but much work remains to optimize implementation
- **Challenges:** are numerous but so too are **opportunities** to strengthen "problem solving" capacity and capability

Thank you

Web www.who.int/malaria/areas/vector_control

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