

A photograph of a crowded refugee camp. Numerous colorful tents are set up on a dusty ground, with many people, including children, visible in the background. The scene is busy and depicts a challenging living environment.

# Core Vector Control Tools

## Understanding their operational, contextual and biological limitations

Dr Richard Allan OBE



# Increasing Conflict and Forced Displacement



PHOTO/ OLIVIER JOBARD/MYOP - Tigray Conflict

Source: UNHCR

Since 1946, intrastate and international wars have quadrupled.

Over 120 armed conflicts in 2025

Until 2023 SSA accounted for 80% of violent forced displacement.



# An ongoing and worsening global displacement crisis

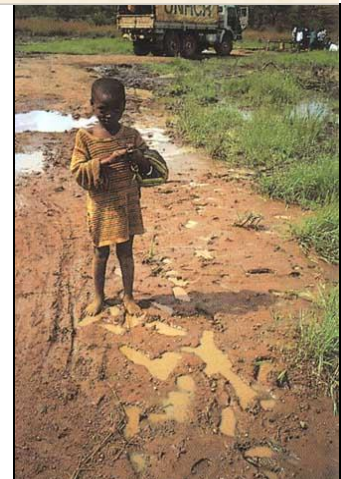




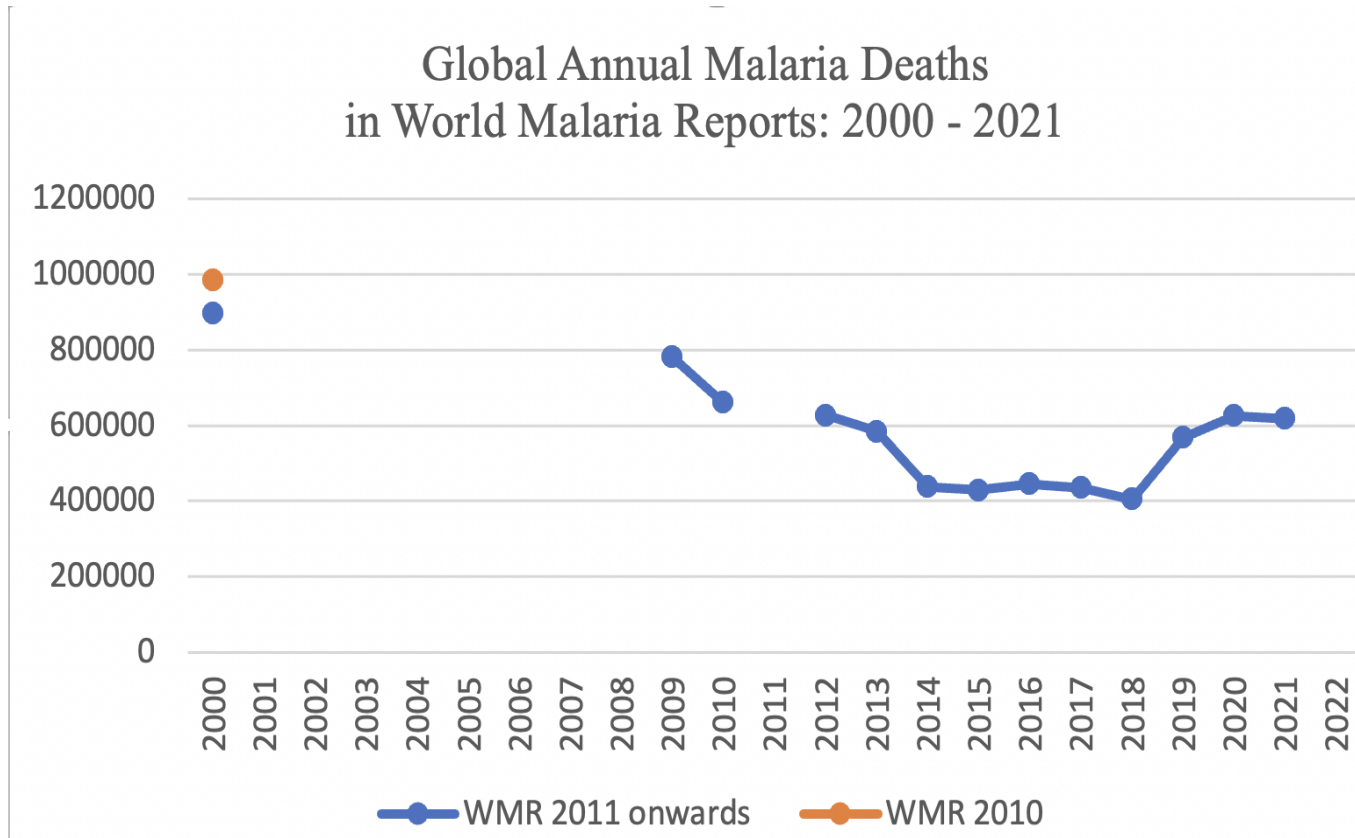
# Historical basis of malaria control thinking and planning

- Based on the behaviour of **a very few specialised and efficient** nocturnal anophelese mosquitoes
- People who need protecting live and sleep in long term structures/houses
- Mosquito feeding behaviour overlaps with human sleeping behaviour / indoor behaviour
- Mosquitoes prefer to lay their eggs on the surface of clean open surface pools of rain water
- Entomological research methods that whilst very good, were also limited and produced results that miss critical information on many malaria mosquito species likely to be present

		Time of biting:			
		Number caught (no.) and Number positive for sporozoites (+)			
Species		1800-2200h	2200-0200h	0200-0600h	Source
<i>An. gambiae</i>	no.	248	743	606	Tanganyika (Gilles, 1957)
	+	9	20	8	
<i>An. gambiae</i> <i>/An. funestus</i>	no.	5900	13000	10850	Burkina Faso (Robert 1991)
	+	295	1040	2061	
<i>An. gambiae</i>	no.	91	1269	1831	Sierra Leone (Bockarie 1996)
<i>An. gambiae</i>	no.	23	189	211	Tanzania (Maxwell 1997)
	+	2	14	9	
<i>An. funestus</i>	no.	31	232	86	“
	+	0	7	2	



# The global partnership to control malaria & millennium development goals (2000 - 2015) and beyond:



*Figures are constructed using exclusively the global annual malaria deaths as reported in the World Malaria Reports spanning the period from 2000 to 2022 (113).*

Extra-ordinary change and



Credited with  
69% of malaria  
cases averted



Credited with  
10% of  
malaria cases  
averted



Roll Back Malaria – halved of global By 2019 global deaths had increased sharply rannual malaria deaths between 2000 and 2015 to 438,000 then progress stalled Reaching 619,000 by 2021 and have remained around 600,000 a year to date. It causes 60% of VBD deaths.



Key factors:

- Mosquito resistance to pyrethroid insecticides, the core ingredient in all LLINs then.
- Conflict and forced population displacement have occurred across 8 of the 11 African countries accounting for more than 80% of deaths.
- Some malaria vectors may have changed where and when they attacked humans, to avoid VC
- Another malaria mosquito species has moved in from Asia



# VBD control lessons from humanitarian crises

- From efforts protecting victims of conflicts, floods, cyclones, and earthquakes in hard to reach and insecure settings since 2002
- Across Africa, Asia, M.E. and South America
- Learning about vectors and disease in different regions
- Understanding disaster affected people
- Exposing the inadequacy of a “magic bullet” approach to VC applied to different shelter, culture, vector and disease contexts
- Partnerships over two decades to develop, evaluate and use at scale innovative VC tools for humanitarian crises
- Demonstrating that attacking disease vectors at different points in their life cycle, integrating water, sanitation and shelter sectors with health improves disease mitigation and protection, and lowers costs









# Key findings:

A total of 398 nets were analysed for residual alpha-cypermethrin.

- The median baseline concentrations of insecticide were 175.5 mg/m<sup>2</sup> for the Interceptor® LLIN and 21.8 mg/m<sup>2</sup> for the CTN.
- Chemical residue loss after a one-year follow-up period was 22% and 93% respectively.

Parasitaemia prevalence decreased from 29.7% at baseline to 13.6% during the follow up survey ( $p = < 0.001$ ).

Retention and utilization of nets remained high (94%) after one year, irrespective of type.

Perceived effectiveness of nets was just as important as other physical attributes in influencing net utilization.

Net users knew what they liked or disliked (material, colour, shape and size) and this affects retention and utilization.

[Malaria J, 84 \(2010\) DOI: 10.1186/1475-2875-9-84](#)





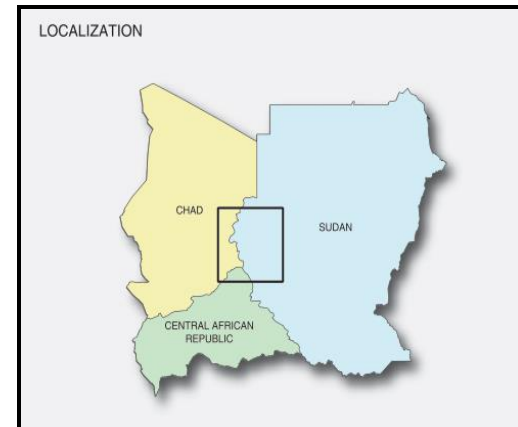
# An observational study of material durability of three WHO recommended LLINs in E Chad

**Second study question:** Would LLINs to be durable when used in temporary IDP shelters and host shelters real life returnee settings in Liberian villages, would the 3 top LLIN brands prove durable and a sensible choice for malaria control in an acute humanitarian crisis?

**Crises / study location:** Dar Sila District, Eastern Chad, bordering Darfur during a period of active conflict and forced displacement

**Methods:** (Late 2007) 58,658 LLINs were distributed to:  
Host (10,588 Interceptor<sup>®</sup>, 993 PermaNet<sup>®</sup> and 15,313 Olyset<sup>®</sup> &  
IDPs (17,222 Interceptor<sup>®</sup>, 3,346 PermaNet<sup>®</sup>, and 11,196 Olyset<sup>®</sup>)  
Plus sustained IEC: LLIN usage and maintenance

At 14 months post distribution: 876 LLINs (229 Interceptor<sup>®</sup>, 363 Olyset<sup>®</sup>, and 284 PermaNet<sup>®</sup>) were examined for physical condition, using a standardised method: 3 hole categories, and a proportional hole index.





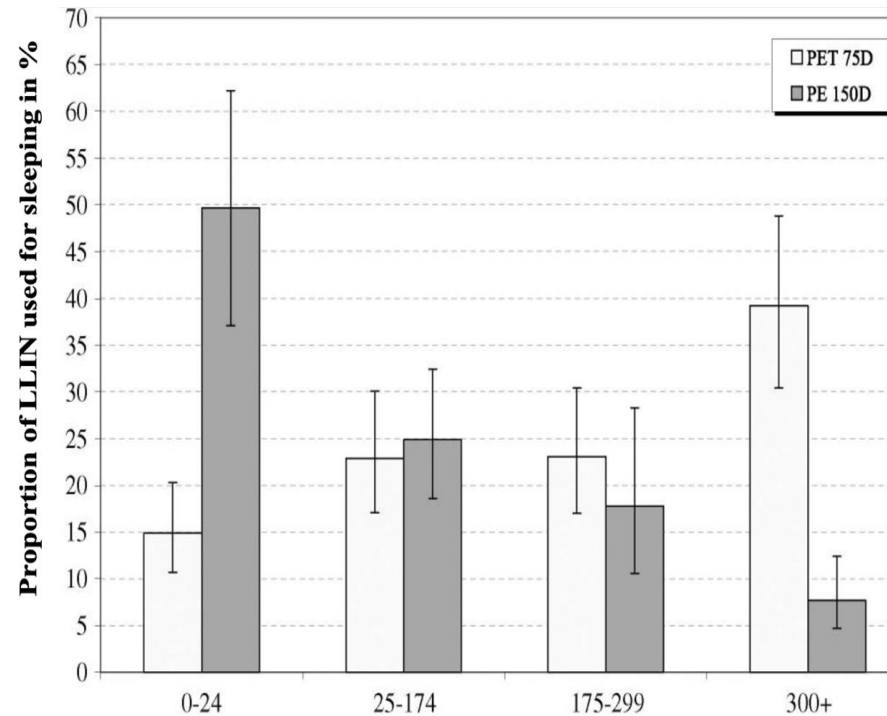
# Key findings:

In January 2009 the sample 876 nets were taken outside and examined on a simple wooden measurement frame, the number and size of holes of each category ( $\leq 2$ cm,  $>2-5$  cm,  $>5$ cm x a preset weight factor = a pHl measurement.

A net pHl of 0-24 was considered serviceable condition, reducing thereafter.

Analysis of net condition by multiple factors showed material type to be the most important:

(2 x PET 70D, and 1 x 150D PE) revealed that no LLIN type was useful in this acute emergency context as the level of damage to even the better performing material (PE) was bad.



**Am J Trop Med Hyg. 2012 Sep;87. doi: 10.4269/ajtmh.2012.11-0331. Proportionate Hole Index**





**The core VC products are designed to target mosquitoes with insecticides at human sleeping spaces**

"If the only tool you have is a hammer, it is tempting to treat everything as if it were a nail"

*Abraham Maslow in 1966, from the American philosopher Abraham Kaplan*

We are left with four major gaps to fill!



Gap 1: Preventing coverage failure due to funding shortfalls and growing costs of new products with new active ingredients

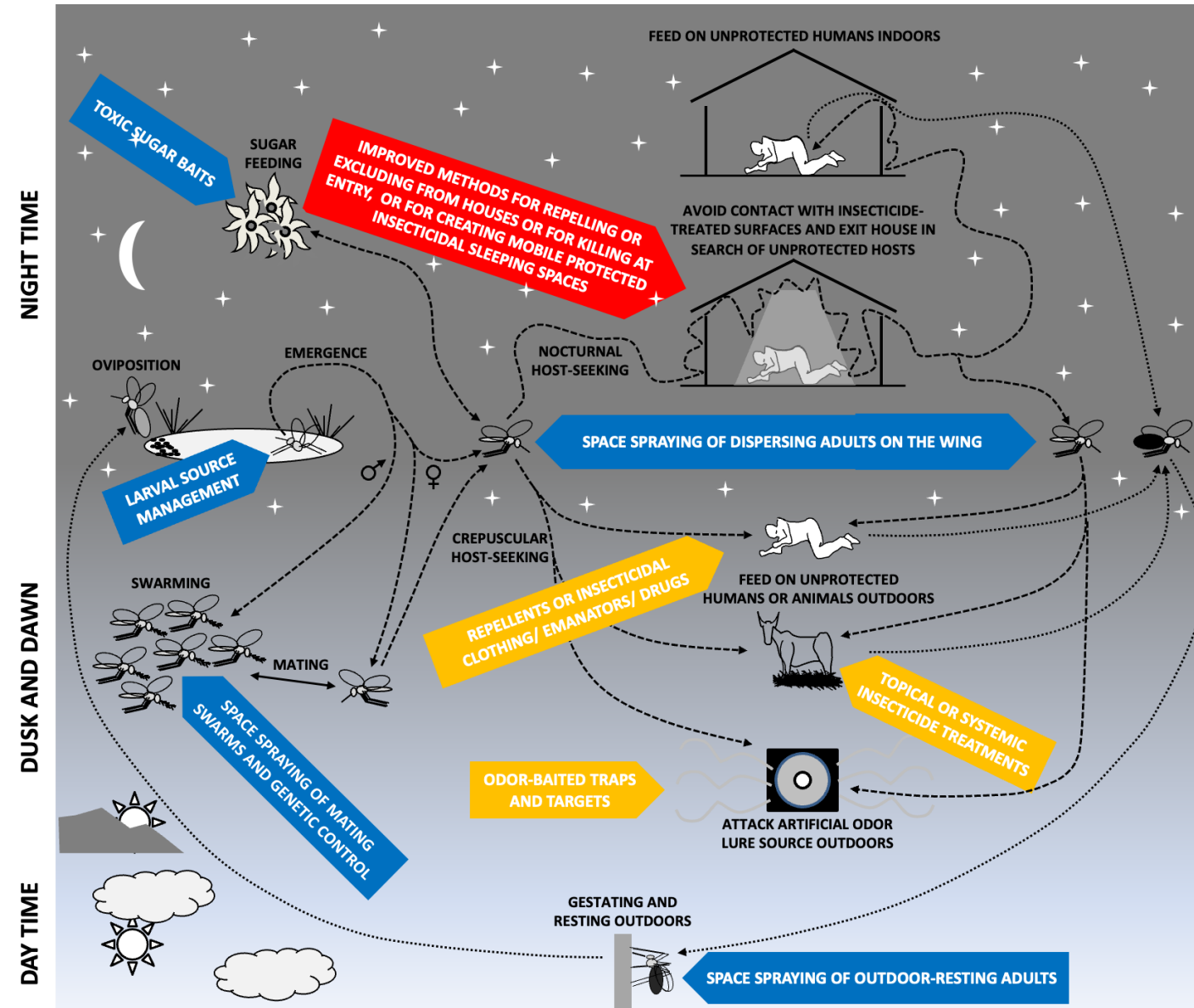
Gap 2: Prevent LLIN/IRS efficacy failure through insecticide resistance management using new products with diverse active ingredients

new products to deploy insecticidal barriers or resting surfaces around sleeping spaces

Gap 4: Control behaviourally resilient vectors mediating persistent residual transmission with new VC products that target mosquitoes outside of houses, shelters and other protected sleeping spaces



# Where new VC tool must target to close Gaps 3 & 4



Schematic:

Malaria vector mosquito life histories, highlighting the most important behaviours that mediate residual malaria transmission despite high coverage with LLIN, IRS or new VC products that expand the protected insecticidal sleeping space paradigm.

It also shows the many intervention opportunities that remain to be exploited with existing or emerging vector control methods.

Adapted from Killeen GF, *et al.* BMJ Glob Health 2017;2:e000211