

Science & Society

Global Vector Control Guidelines – The Need For Co-Creation

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In response to the global expansion and re-emergence of vector-borne diseases, WHO launched the Global Vector Control Response program in 2017. The aim is to strengthen vector control through increased capacity, innovation, improved surveillance, better coordination, and integrated action. Will this new approach overcome the failings of previous initiatives?

The Advent of the 2017–2030 Global Vector Control Response

The flat-lining of the global reduction of malaria, the recent chikungunya and Zika pandemics, the unabated spread of dengue, and the re-emergence of yellow fever come as a sharp reminder of the continuing threats posed by mosquito-borne diseases [1,2]. National public health authorities are facing an ever-increasing disease burden but have little ability to define the extent of the challenge, the tools that might be used in response, or the mitigation strategies that would effectively integrate local stakeholders. In response to this escalating problem and increasing criticism of global vector control capacity, the WHO has attempted to galvanize mosquito-control strategies by redrafting the integrated vector management plan [3,4]. This 2017–2030 Global Vector Control Response (GVCR) aspires to reduce vector-borne disease mortality by 75%, and incidence by 65%, by 2030, and halt the further spread of vector-borne disease to new countries by

2025. The GVCR aims to strengthen the foundations of vector control and improve implementation (Figure 1). Here we discuss the feasibility of the approach and suggest potentially productive avenues to explore.

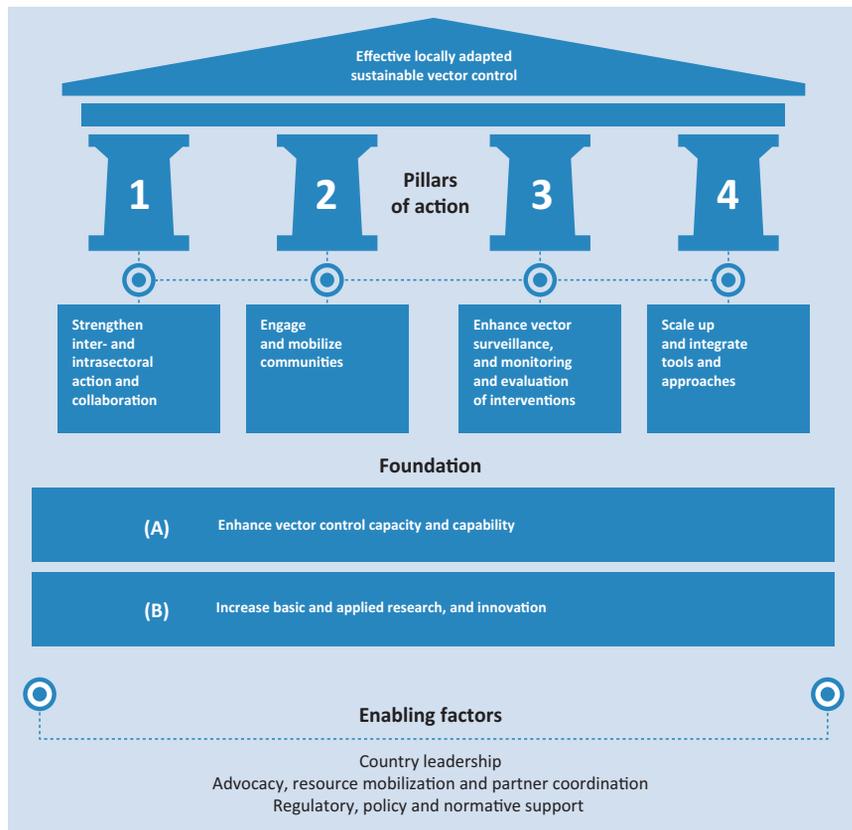
Innovation, Efficacy, and Implementation

In 2017, in a bid to accelerate vector-control product evaluation and harmonize pathways with those in place for vaccines and medicines, the existing WHO Pesticide Evaluation Scheme (WHOPES) was replaced by the WHO Prequalification Team for Vector Control (PQT-VC). It is responsible for the safety, efficacy, and quality of vector-control products and is supported by the Vector Control Advisory Group (VCAG), which assesses the public health value of new tools and paradigms (Figure 2). As our existing vector-control tools are inadequate [5,6], VCAG's role in evaluating new tools is clearly a cornerstone of the innovation required to achieve the ambitious goals of the GVCR. Without effective tools and appropriate training, the pillars of the GVCR (engage, strengthen, and scale) will crumble.

One major development is to insist that vector control tools and methodologies have proven epidemiological efficacy, preferably in the form of two randomized control trials (RCTs), each repeated over two transmission seasons. These trials are essential for proving the public health benefit of interventions, but we must also recognize that they are extremely expensive and time-consuming. Whilst the Global Fund and others have supported trials for malaria interventions, no such financial backing exists for other vector-borne diseases. *Aedes*-borne diseases, such as dengue, will be problematical because of their unpredictability in time and space, even in endemic countries. Without sufficient infections an epidemiological impact cannot be determined, and

this will confound the best efforts of trial designers to deliver definitive epidemiological results. Novel approaches for dealing with *Aedes* transmission are under development, but are currently not recommended for full-scale deployment. The risk therefore is that the delivery of new tools and strategies will be glacially slow, frustrating innovators and leaving national control programs to manage disease with conventional tools that also have a very limited evidence base. The VCAG guidelines do allow consideration of nonrandomized trials [7] and that flexibility might help to alleviate the onerous costs of RCTs for *Aedes*-borne pathogens. Interim recommendations, in the absence of a complete epidemiological package, were once available under the WHOPES scheme.

A crucial factor determining the number of epidemiological trials required to develop a new and reliable tool box for vector control is careful rationalization of product classes and identification of 'first in class' prototypes. New paradigms under consideration will need to be defined carefully, in order to maximise the speed at which similar products come through the pipeline [8]. New products that fall under an existing product class with an extant WHO policy recommendation will follow the Prequalification Pathway, under which epidemiological trials are not required (e.g., pyrethroid-treated bednets with similar entomological impact to the 'first in class' product). Interventions deemed to function under a new paradigm will have to be evaluated for their public health claims. Many current product classes in the pipeline have remarkably narrow definitions. Is a pyrethroid net treated with a synergist really a new paradigm? Is it necessary to list endectocidal interventions host by host? (i.e., a current listing states: 'Systemic cattle treatment for vector control'). What about more generally in livestock?



Trends in Parasitology

Figure 1. WHO Global Vector Control Response Framework. The GVCR aims to reduce the burden of all vector-borne diseases (VBDs) through vector control. This goal is to be achieved by building upon the foundations of enhanced vector-control capacity and improved basic and applied research through four pillars of action [3].

The pillars of the GVCR are built around integrated vector management (IVM): the accepted model for many vector-control programs that implement a number of management approaches simultaneously [9]. Perhaps epidemiological efficacy does not have to be established for every component of those programs. In some instances it might make more sense to prove entomological efficacy across a range of components and then carry out epidemiological trials on an integrated design (accepting that this would result in an endorsement for the entire strategy and not for any single intervention) [10,11].

Whilst awaiting the proven efficacy of future tools, existing mosquito-

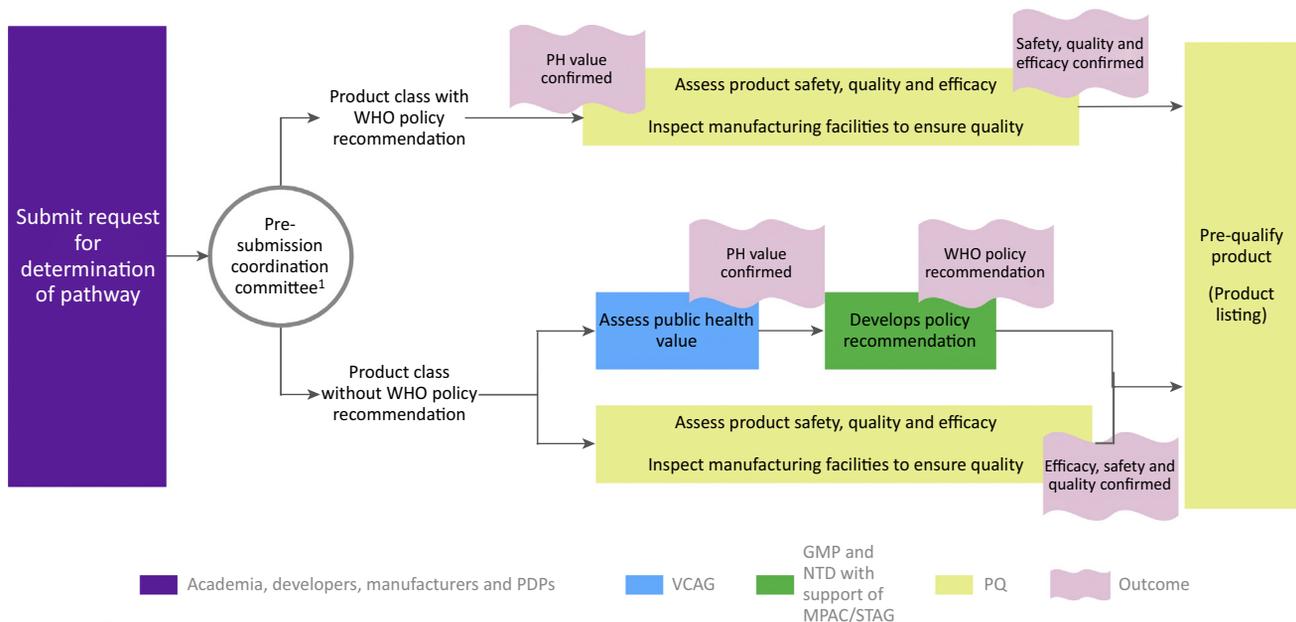
management strategies require optimization. This is especially the case for arboviral diseases. Currently, we are stuck in an outdated dengue-control paradigm of fogging and larviciding with low impact due to poor implementation and ineffective insecticides. How to break the status quo? The improved deployment of currently available vector-control tools is key. Whilst insecticide resistance is an issue for several products, there are other integrated programs that deserve attention, most particularly in the development of noninsecticidal, community-based approaches [10]. Substantial improvements in the impact of insecticides might also be possible: targeted indoor residual spraying with effective

insecticides may reduce the time and effort required to protect selected transmission hotspots [12].

There is no 'one size fits all' paradigm for any vector-borne disease. Local characteristics of transmission, resources, and vector ecology will drive the choice of tools. Strategy development must be executed at the country level, and even within country for those with a decentralized health system and varying environmental contexts. Operationally, the programs that result must be appropriate, feasible, and cost-effective. Currently, there are problems of resourcing, training, community engagement, building an evidence base, and retaining a positive expectation from the vector/disease-control units [13]. This consequently leads to the implementation of suboptimal programs that are draining precious resources from public health authorities. The continued inability of countries to develop appropriate strategies could be alleviated through their reassessment and codevelopment by stakeholders, including innovators, the community, disease and control units, and policy makers (e.g., National Control Programs, WHO).

Intrasectoral and Intersectoral Collaborations: Co-Creation of Vector Control Strategies

The importance of intra- and intersectoral collaborations (ISCs) has been repeatedly emphasized as one of the keys to successful vector controlⁱⁱ and yet beyond the Roll Back Malaria initiative their added value remains unquantified [14]. The majority of current programs lack ISC, and a vertical top-down decision-making process remains with little recourse to dialogue with communities. This is surprising for mosquito control, where the importance of community involvement is always advocated and clearly beneficial [10,14], but whose effective participation is rarely achieved. Increased efforts to educate communities to take



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Figure 2. WHO Prequalification Evaluation Pathway for Vector-control Products. The evaluation pathway that will be applied to assess the public health value of new vector-control tools, technologies, and approaches submitted to the WHO[®]. PH value, public health value; VCAG, Vector Control Advisory Group. GMP, Global Malaria Programme; MPAC, Malaria Policy Advisory Committee; NTD, Department of Control of Neglected Tropical Diseases; PDPs, Productive Development Partnerships; PH value, public health value; PQ, WHO Prequalification; STAG, Strategic and Technical Advisory Group; VCAG, Vector Control Advisory Group. The superscript 1: Consisting of staff from PQT, GMP, and NTD.

responsibility for disease mitigation are necessary but will require novel methods for engagement and incentivizing. Community-based trapping schemes for monitoring mosquito populations at nationally representative scales for continuous assessment have been shown to be cost-effective and may be a viable long-term sustainable option [15]. Likewise, one key component of recent *Wolbachia*-mediated approaches to control has been the inventive and energetic engagement with stakeholders [16].

Lack of resources is a central roadblock to the development and implementation of new strategies and one that impacts upon health care globally. Private sector involvement in malaria control has proven fruitful [17] and yet is absent for other mosquito-borne diseases, despite the increase in arboviral epidemics and the concomitant demand for mosquito-

control products. The market for new products is rapidly expanding in Asia and the Americas, and opportunistic investment and involvement by the private sector and enhanced corporate social responsibility might ease the financial shackles faced by governments and plug the gaps in funding required for product evaluations. Investment in new control paradigms will, however, remain fragile unless all stakeholders can clearly see the benefit.

What is needed is improved dialogue among national and international stakeholders to plan what is feasible with the resources available and to negotiate the minimal adequate solution. The paucity of proven tools, and our limited grasp on what strategies will actually work, mean that such negotiated planning must be based on simulated scenarios with included uncertainty margins. In this

way a suite of potential scenarios adapted to the country and within-country sites can be budgeted and discussed. These can then be used to identify the key gaps and requirements through a process of co-creation, co-production and co-delivery. By trying to speed up and prioritize innovations with stakeholders, we may make development more affordable, or at least define the market opportunity, thereby making investment, financial or otherwise, more attractive.

While we await the outcomes of more stringent evaluation processes, co-creation and stakeholder collaboration offers an imperfect but necessary assessment of the value of innovation and development. Consultation with end-users will help to prioritize the evaluation of new product classes, encourage their local and regional relevance, and improve their community 'ownership'.

Greater interaction between research, industry, community, and policy will improve the relevance and adoption of public health tools. This is crucial for the all-important scale-up of new strategies. Rather than simple provision of a guide-book, policy makers and innovators might better serve communities by considering strategies that are co-designed and co-produced. That dynamic and contextual process can explicitly address local and regional priorities around ecosystems, climate change, health risks, and economics.

The vector-control management agenda is formidable, and despite substantial research efforts, control programs remain little changed. Meanwhile, the global burden of vector-borne disease continues to increase. The global community is ill-equipped to face that threat and unsure of what to do given the long lead-in times for the evaluation of new public health tools. Perhaps it is time that, rather than relying solely on vertically communicated guidelines, governments and communities mobilize to develop their own pragmatic action plans, as was achieved in an integrated approach with community involvement [10], in full acknowledgement of their inevitable shortcomings but in recognition that the status quo cannot deliver. These action plans are bound to be integrated and based on the evidence base as it exists, however flimsy and however much it has to be based on entomological rather than epidemiological proofs. This surely must be an immediate consideration whilst waiting for the vector-control panacea.

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Resources

ⁱwww.who.int/neglected_diseases/news/mosquito_vector_control_response/en/

ⁱⁱwww.who.int/heli/risks/vectors/malariacontrol/en/

ⁱⁱⁱwww.who.int/vector-control/vcag/vcag-may2018-sustainability-improvement.pdf?ua=1

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References

- Wilder-Smith, A. *et al.* (2017) Epidemic arboviral diseases: priorities for research and public health. *Lancet Infect. Dis.* 17, e101–e6.2
- Ghebreyesus, T.A. and Admasu, K. (2018) Countries must steer new response to turn the malaria tide. *Lancet* 392, 2246–2247
- World Health Organization (2017) *Framework for a National Vector Control Needs Assessment*, WHO
- World Health Organization (2017) *Global Vector Control Response 2017–2030*. WHO
- Reiner, R.C. *et al.* (2016) Quantifying the epidemiological impact of vector control on dengue. *PLoS Negl. Trop. Dis.* 10, e0004588
- Killeen, G. *et al.* (2017) Developing an expanded vector control toolbox for malaria elimination. *BMJ Global Health* 2, e000211
- World Health Organization (2017) *How to Design Vector Control Efficacy Trials, Guidance on Phase III Vector Control Field Trial Design*, WHO
- World Health Organization (2018) *Overview of Product Classes and Prototype/Products under Vector Control Advisory Group (VCAG) Review for Assessment of Public Health Value*, WHO
- Marcos-Marcos, J. *et al.* (2018) Impact, economic evaluation, and sustainability of integrated vector management in urban settings to prevent vector-borne diseases: a scoping review. *Infect Dis. Poverty* 7, 83
- Andersson, N. *et al.* (2015) Evidence based community mobilization for dengue prevention in Nicaragua and Mexico (Camino Verde, the Green Way): cluster randomized controlled trial. *BMJ* 351, h3267
- Overgaard, H.J. *et al.* (2016) A cluster-randomized controlled trial to reduce diarrheal disease and dengue entomological risk factors in rural primary schools in Colombia. *PLoS Negl. Trop. Dis.* 10, e0005106
- Vazquez-Prokopec, G.M. *et al.* (2017) Combining contact tracing with targeted indoor residual spraying significantly reduces dengue transmission. *Sci. Adv.* 3, e1602024
- Horstick, O. *et al.* (2010) Dengue vector-control services: how do they work? A systematic literature review and country case studies. *Trans. R. Soc. Trop. Med. Hyg.* 104, 379–386
- Herdiana, H. *et al.* (2018) Intersectoral collaboration for the prevention and control of vector borne diseases to support the implementation of a global strategy: a systematic review. *PLoS One* 13, e0204659

15. Sikaala, C.H. *et al.* (2014) A cost-effective, community-based, mosquito-trapping scheme that captures spatial and temporal heterogeneities of malaria transmission in rural Zambia. *Malar. J.* 13, 225

16. O'Neill, S.L. *et al.* (2018) Scaled deployment of *Wolbachia* to protect the community from *Aedes* transmitted arboviruses. *Gates Open Res.* 2, 36

17. Kleinschmidt, I. *et al.* (2009) Marked increase in child survival after four years of intensive malaria control. *Am. J. Trop. Med. Hyg.* 80, 882–888

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Adaptive e-Learning: Emerging Digital Tools for Teaching Parasitology

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Adaptive learning activities can respond to a learner's needs in real time, facilitating the development of higher-level skills including bringing together knowledge from different disciplines to solve real-world problems. Here we discuss the use of online adaptive learning activities designed to help veterinary students apply their knowledge to work through parasite case studies.

Why Do We Need Adaptive Learning?

Consider an ideal face-to-face learning experience. You might imagine a classroom where individual instructor's attention is freely available to the learner; where the learner progresses at their own pace, asking questions as they arise; where an extra explanation is given as needed, and the learning task is adapted to the learner's needs 'on the fly'.

These ideal learning experiences are difficult to create, including in tertiary education where instructors must manage the

