

Steve W Lindsay et al.

## Controlling mosquito-borne diseases in urban areas

This online first version has been peer-reviewed, accepted and edited,  
but not formatted and finalized with corrections from authors and proofreaders.

# Improving the built environment in urban areas to control *Aedes aegypti*-borne diseases

Steve W Lindsay,<sup>a</sup> Anne Wilson,<sup>a</sup> Nick Golding,<sup>b</sup> Thomas W Scott<sup>c</sup> & Willem Takken<sup>d</sup>

<sup>a</sup> Department of Biosciences, Durham University, South Road, Durham, DH1 3LE, England.

<sup>b</sup> School of BioSciences, University of Melbourne, Melbourne, Australia.

<sup>c</sup> Department of Entomology and Nematology, University of California Davis, Davis, United States of America.

<sup>d</sup> Laboratory of Entomology, Wageningen University, Wageningen, Netherlands.

Correspondence to Steve Lindsay (email: S.W.Lindsay@durham.ac.uk).

(Submitted: 12 December 2016 – Revised version received: 3 April 2017 – Accepted: 6 April 2017 – Published online: 9 June 2017)

The vector *Aedes aegypti* is now present in nearly every tropical and sub-tropical region in the world and poses a threat to health globally. The mosquito can transmit several viruses that cause diseases, such as dengue fever, chikungunya, yellow fever and Zika virus infection. Recent outbreaks of *Ae. aegypti*-borne diseases have shown that urban areas are particularly vulnerable to such outbreaks, because the built environment provides ideal conditions for mosquito proliferation and contact with humans. Unless the global public health community takes a coordinated, pre-emptive approach to controlling the *Ae. aegypti* population, these outbreaks will become more common and widespread as urban populations expand and movement of people and their goods increase. Improving the built environment would contribute to a long-term solution to reducing the threat of *Aedes aegypti*-borne diseases.

Our ability to deal with *Ae. aegypti*-borne viral epidemics is limited. Apart from supportive care, specific treatments for vector-borne viral diseases are lacking. No commercial vaccines for Zika or chikungunya are available, the only licensed dengue vaccine is only partially protective<sup>1</sup> and globally the yellow fever vaccine is in short supply.<sup>2</sup> Although current vector control programmes are often poorly resourced and under-used,<sup>3</sup> historically, vector control was the main method for controlling mosquito-borne diseases. By using container inspections, oiling of breeding sites and later perifocal spraying of DDT (dichlorodiphenyltrichloroethane) in water containers and nearby walls, *Ae. aegypti*, yellow fever and dengue fever were successfully eliminated from much of South America in the 1960s.<sup>4</sup> In the 1970s and 1980s in Singapore and in the 1980s and 1990s in Cuba, controlling

adult and larval *Ae. aegypti* reduced dengue. In the future, new methods of vector control, such as novel delivery systems for insecticides with new modes of action and release of *Wolbachia* infected or genetically modified mosquitoes, may contribute to the control or elimination of mosquito-borne diseases.<sup>5</sup> Affected towns and cities, however, already have several options to reduce *Ae. aegypti*-borne diseases and these options should be built into future planning strategies.

Current *Ae. aegypti* control focuses on reducing densities of immature and adult mosquitoes with larvicides or adult insecticides. While these interventions can be effective, continued reliance on these single-intervention control programmes is resource-intensive and threatened by insecticide resistance. The World Health Organization<sup>3,6</sup> and other major international organizations<sup>7</sup> have recommended an intersectoral approach to achieve more effective and sustainable vector control. Governments, however, have often overlooked such approaches when designing vector control programmes.

An underutilized aspect of integrated vector management is improving the urban built environment to reduce *Ae. aegypti* populations and their contact with humans.<sup>8</sup> The built environment in many urban areas provides abundant habitats for the immature stages of *Ae. aegypti*, and high human population densities create the potential for large outbreaks of *Aedes*-borne diseases. More than half of the world's population currently lives in urban areas and by 2050 it is estimated that 70% of the population will live in cities.<sup>9</sup> This urban expansion will increase the frequency and intensity of *Aedes*-borne outbreaks. However, developing urban areas that minimize human contact with mosquitoes could enable sustainable and cost-effective prevention of mosquito-borne diseases.

Several aspects of urban planning can be targeted to reduce human contact with *Ae. aegypti*. Reducing the availability of small plastic containers around homes, by improving solid waste management, will remove habitats for *Ae. aegypti* larvae development. Provision of constant piped water will reduce the need to store water in containers in and around homes, since water-filled containers are known to be favoured habitats for *Ae. aegypti*. Designing and delivering housing to prevent adult mosquitoes from entering, either by sealing or screening openings, would be a critical long-term step towards reducing their biting on humans, and thus, viruses they transmit. Urban planning to reduce vector proliferation and biting can only be successful if it is combined with community engagement, so that communities understand the threat posed by these vectors and their associated diseases and contribute to control efforts.

Reducing vector-biting densities would not only reduce the chance of future epidemics occurring, but also reduce the biting nuisance by other urban pest mosquitoes. Furthermore, most improvements that reduce human contact with mosquitoes will have a range of other social and health benefits by improving the domestic environment, such as easy access to potable water and more sanitary living conditions. Delivering these urban improvements should not only been seen as gains for urban development, but also as a supplementary vector-control intervention to those interventions delivered through the health sector, such as space spraying or larviciding.

We argue that urban improvements that reduce the mosquito population should be a component of future *Ae. aegypti*-borne disease prevention strategies, and be seen as an important component of sustainable development. This approach is closely aligned with the sustainable development goals (SDGs), particularly SDG 11 and 17. SDG 11 demands action to “make cities and human settlements inclusive, safe, resilient and sustainable” through improvements to housing and basic services. SDG 17 calls for “sustainable development through global partnerships” and building out *Ae. aegypti* will require partnerships between governments, the private sector and civil society.

A policy framework exists through which these changes can be implemented. The New Urban Agenda, which is a product of the SDGs, was adopted by the United Nations (UN) conference on housing and sustainable development (Habitat III) in Quito, Ecuador in October 2016 and endorsed by the General Assembly of the UN on 23 December 2016.<sup>10</sup> The agenda is an attempt to readdress the way in which towns and cities are planned, designed, financed, developed, governed and managed to make them more resilient and sustainable. Specifically, the agenda recognizes that urban centres, particularly in developing countries, are vulnerable to environmental risks including those from vector-borne diseases and therefore promotes disaster risk reduction and management.<sup>10</sup>

To build settlements that are resilient against *Ae. aegypti*-borne diseases, vector control experts should reach out and work with those who plan and design the built environment. By creating a safe, reliable and protective water supply system, removing domestic waste and sealing or screening homes we can hinder immature mosquito development and reduce biting densities of mosquitoes. Creating environments unfavourable for *Ae. aegypti* must be a priority when building safe, resilient and sustainable towns and cities.

### Competing interests:

None declared.

### References

1. Villar L, Dayan GH, Arredondo-García JL, Rivera DM, Cunha R, Deseda C, et al.; CYD15 Study Group. Efficacy of a tetravalent dengue vaccine in children in Latin America. *N Engl J Med*. 2015 Jan 8;372(2):113–23. PMID:25365753 <http://dx.doi.org/10.1056/NEJMoa1411037>
2. Barrett ADT. Yellow fever in Angola and beyond—the problem of vaccine supply and demand. *N Engl J Med*. 2016 Jul 28;375(4):301–3. PMID:27276108 <http://dx.doi.org/10.1056/NEJMp1606997>
3. Global Vector Control Response 2017–2030 (Version 5.4). Geneva: World Health Organization; 2017.
4. Camargo S. History of *Aedes aegypti* eradication in the Americas. *Bull World Health Organ*. 1967;36(4):602–3. PMID:5299460
5. von Seidlein L, Kekulé AS, Strickman D. Novel vector control approaches: the future for prevention of Zika virus transmission? *PLoS Med*. 2017 01 17;14(1):e1002219. PMID:28095418 <http://dx.doi.org/10.1371/journal.pmed.1002219>
6. Handbook on integrated vector management (IVM). Geneva: World Health Organization; 2010. p. 78.
7. Roll Back Malaria Partnership, United Nations Development Programme. Multisectoral action framework for malaria. Geneva: Roll Back Malaria Partnership; 2013.
8. Global strategy for dengue prevention and control 2012–2020. Geneva: World Health Organization; 2012.
9. Revised zero draft of the New Urban Agenda released. Winnipeg: International Institute for Sustainable Development; 2016. Available from: <http://sdg.iisd.org/news/revised-zero-draft-of-new-urban-agenda-released/> [cited 2017 May 12].
10. Resolution adopted by the General Assembly on 23 December 2016. 71/256. New urban agenda. New York: United Nations; 2017. Available from: [http://www.un.org/en/ga/search/view\\_doc.asp?symbol=A/RES/71/256](http://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/71/256) [cited 2017 May 2].