CUSPE Cambridge University Science and Policy Exchange

Communications
April 2019

Public Health in the Developing World: Tackling Vector-Borne Diseases

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One of the most pressing policy issues of the modern era is how to improve public health in the world's poorest regions. Of particular concern are those diseases spread by mosquitos: the World Health Organisation estimates a total of 96 million cases of dengue [1] and, in 2017 alone, 219 million cases of malaria [2]. Policies targeting such vector-borne diseases (VBDs) represent nothing new. However, there seems to be a continuing inability to move the agenda from one of disease reduction to eradication: clearly, current policy initiatives are not proving effective enough. This report aims to tackle this issue by outlining the problems associated with current policies and how they can be addressed through epidemiological innovation, with need to not only improve the efficacy of such policies, but also their cost-effectiveness and sustainability. Two innovative policies will be presented: that of manipulating the urban environment to reduce mosquito habitat and of harnessing predation pressure to better regulate mosquito populations.

The Problem with Current VBD Policy

The major issue with current VBD disease policies is their reliance on chemical interventions, which can include measures ranging from insecticidal spraying to treated bed nets [3]. The spread of insecticide resistance presents a major challenge to such interventions, along with other ecological limitations like mosquito behavioural avoidance [4]. Altogether, this means that, even if chemical use were intensified further, it would have diminishing public health returns [5].

Aside from limited effectiveness, chemical interventions are also expensive [6]. A study by Ng'ang'a et al. 2008 in Mwea, Kenya found that, although residents in the area perceived malaria to be a major public health problem, only 7% could afford to use insecticides, while 67% of inhabitants could not afford to use any known vector control strategies regularly [7]. This unaffordability stems from the fact that chemical interventions rely on continual application since they target disease incidence and not disease prevalence. Cost is not an issue in the higher-income regions where most VBD policies originate, although in lower-income regions it is creating an economic barrier. Moreover, chemical interventions are associated with numerous negative environmental impacts. These include: environmental contamination, accumulation of chemical products in the food chain, food contamination, dangers to animal and human health, and elimination of nontarget species, with concern directed towards pollinator species [8].

The world's poorest regions – notably sub-Saharan Africa – are disproportionately affected by VBD. For public health policies targeting VBD to improve, their overreliance on chemical interventions needs to be addressed to overcome economic limitations, work around ecological obstacles, and improve their sustainability. Policies that target disease prevalence instead of incidence provide a mean of doing this.

VBD Policies need to focus on urban environments

To design VBD policies that are better-suited to the needs of the developing world, we must first examine the context in which such diseases find themselves. Most significantly, there is a well-established difference in VBD prevalence between urban and rural areas [9]. For example, Li et al. 2014 found in a study of Guangzhou, China that the urban area had three-fold higher densities in adult mosquito populations compared with suburban and rural areas [10]. This means not only that VBDs are more of an urban problem than a rural one, but also that the urban environment acts as an ecological filter favouring mosquito populations.

A number of factors render urban areas as ideal habitats for mosquitos. In general, mosquitos have a high reproductive capacity, meaning that after chemical interventions have ceased, population numbers can recover shortly afterwards [11]. Moreover, a mosquito's ability to reproduce is directly related to the presence of still surface water, with poorer urban environments providing many such situations, including discarded pots, water storage containers and even footprints [12]. Some mosquito species, such as *Aedes aegypti*, have also adapted to feed preferentially off of humans, thus, cities provide an ecological draw [13]. In addition, urban environments are characterised by more simplified habitat structures (vegetation and debris) compared to less altered environments, which reduces the potential for mosquito predator colonisation and thereby diminishes predation pressure [14].

The greatest impact on the prevalence of VBDs can be made by focusing on urban areas: a negotiation between the use of the urban environment and its suitability to mosquitos that addresses the limitations of chemical interventions must occur.

Towards Better Urban Environments

If most urban areas represent suitable habitats for certain disease-carrying mosquito species, then it stands to reason that those environments should be manipulated to reduce this suitability.

This idea has already been promoted in the primitive intervention of simply trying to remove artificial water containers from urban areas [9]. However, this requires widescale community engagement to have substantive impacts, which itself is a challenge amongst the lack of socio-political infrastructures in developing-world urbanism. Moreover, the complete eradication of still surface water in urban areas is not a realistic aim, because of the wide variability of possible water vessels mentioned above. Therefore, a more significant manipulation of the urban environment is needed, and the greatest potential for this can be found in increasing the habitat complexity of urban environments and harnessing predation pressure on mosquito populations.

The reduced structural complexity of urban areas decreases predation pressure, which is a mechanism that controls the size of mosquito populations. Sanitation measures in urban areas decreases their structural complexity through the removal of vegetation and debris from ditches and water storage structures, while the temporal nature of artificial containers provides a suitable habitat for mosquito larvae by failing to provide the lengthy development time required by many predators [15]. It has also been demonstrated that grassy habitats are associated with higher mosquito productivity [16], which is particularly concerning when considering the overwhelming choice of lawn cover for homes, schools, businesses and public space [17].

Increasing the prevalence and structural complexity of vegetation in urban areas could therefore be a key vector control strategy engendering greater predation pressure. Simply, greater structural complexity provides more ecological niches that mosquito predator species can exploit, thus increasing their numbers and reducing the prevalence of disease-carrying mosquitos [15]. More generally, increasing complex green space in urban areas is also associated with greater spill-over of mosquito predators into the urban environment from less-disturbed areas [18]. Chosen wisely, vegetation can absorb more rainwater and filter urban runoff, while also providing food and shelter for small wildlife and mosquito predators [19]. Correspondingly, more green space and greater vegetation species richness can also increase the amount of non-disease carrying mosquitos, thereby generating greater competition for resources and further supressing disease-carrying species [20]. A cost-effective intervention that could incorporate all of this is simply planting more trees throughout urban areas [21].

Natural predators of mosquitos can also be artificially introduced and encouraged in urban areas. This has already been demonstrated through aquatic predation, with many aquatic species known to strongly suppress mosquito abundance [15]. However, their utility is limited since they require permanent water habitats and cannot inhabit containers that are too small [22]. Therefore, finding predators that can overcome this is important, with airborne predators showing the greatest potential [13]. This was demonstrated in a study by Weterings et al. 2014 which found that the dragonfly species *Toxorhynchites splendens* was successful in its colonisation of experimental units designed to mimic the artificial containers commonly found in urban environments [23]. Moreover, the results of a study by Reiskind and Wund 2009 suggested that the impact of aerial predators on VBD transmission may be large, reporting a significant reduction in mosquito reproductivity associated with bat predation [24].

While results from biological and environmental interventions to control VBDs are very encouraging, current policy frameworks are still highly skewed towards chemical and medicinal development with regulatory structures incorporating biological interventions currently being inadequate or non-existent [4]. This does, unfortunately, mean that the development of biological and environmental interventions may incur relatively high research costs, but it is reasonable to assume that such research costs are well within the affordability of many non-governmental and governmental organisations. Non-chemical environmental interventions also promise the possibility of continuous and 'free' mosquito suppression once established, minimal side effects compared to chemical interventions, and minimal maintenance [6]. The existing evidence is enough to encourage policies aiming to increase the structural complexity of urban environments, particularly in the developing world, in order to decrease the size of mosquito populations through very simple and cost-effective measures such as decreasing lawn-cover and increasing tree-cover.

Conclusions

Current VBD policies based on chemical interventions show multiple issues in terms of cost-effectiveness and sustainability. These problems can be alleviated through exploring alternative solutions; here, manipulating the urban environment to reduce mosquito habitat and harnessing predation pressure are presented. It is not suggested that such measures can altogether replace chemical interventions, but the former can work to minimise the use and overcome some of the limitations of the latter as part of a more holistic approach to developing public health policy for the world's poorest regions.

Acknowledgements

The author wishes to thank Dr Lydia Drumright and Dr Bhaskar Vira for their guidance at the University of Cambridge Conservation Research Institute. No conflicts of interest are declared. First editor: Michele Sanguanini. Second editor: Roxine Staats.

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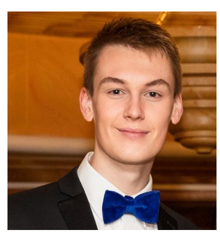

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