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Expanding Integrated Vector Management to promote healthy environments

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Integrated Vector Management (IVM) strategies are intended to protect communities from pathogen transmission by arthropods. These strategies target multiple vectors and different ecological and socioeconomic settings, but the aggregate benefits of IVM are limited by the narrow focus of its approach; IVM strategies aim only to control arthropod vectors. We argue that IVM should encompass environmental modifications at early stages – for instance, infrastructural development and sanitation services – to regulate not only vectors but also nuisance biting arthropods. An additional focus on nuisance biting arthropods will improve public health and quality of life and minimize social-disparity issues fostered by pests. Optimally, IVM could incorporate environmental awareness and promotion of control methods proactively to reduce threats of serious pest situations.

IVM to enhance the environment

Responsible for 17% of the global burden of communicable disease, vector-borne diseases (VBDs) (see Glossary) [1–3] induce significant morbidity and mortality and have major effects on the socioeconomic development of affected countries [4]. Use of indoor residual spraying (IRS) and long-lasting insecticidal nets (LLINs) are among the most crucial measures used to protect humans from vectors [1]. As intensified control measures decrease the incidence of VBD in certain areas, herd immunity declines and the severity of arthropod-transmitted diseases increases as they spread to new regions [5,6]. Weakened political resolution to continue funding for vector control dissolves successful vector-control organizations and community awareness [5] and further propagates the public-health problem caused by VBDs. Lack of awareness by decision makers of the impact of VBDs on public health has limited research in this area and caused complacency toward the development of new vector-control methods [7]. Alterations in population dynamics and climate changes that modify the habitats of arthropods have led to the re-emergence and spread of VBDs to new regions [8].

The World Health Organization (WHO) has widely promoted vector control for the prevention and elimination of VBDs [9] and recommends the pragmatic use of both nonchemical and chemical strategies encompassed in IVM [10,11]. Through the use of a rational, evidence-based decision-making process to utilize available resources in an optimal manner, IVM aims to make vector control more effective by use of economical and ecologically sound strategies [11]. IVM encourages integrative and multidisease approaches to promote collaborative interventions [12] that better combat the spread of VBDs [13], but fails to address nuisance biting arthropods that affect inherent quality of life. Furthermore, its common reactive application following vector outbreaks limits the entirety of potential preventative benefits; an additional environmental enhancement component would significantly improve IVM strategies' capabilities to control all arthropods.

Glossary

Aedes albopictus: a highly anthropogenic mosquito species; most well known for transmitting dengue and chikungunya viruses but has also been found naturally infected with West Nile virus, eastern equine encephalitis, and Japanese encephalitis.
Arthropod: an invertebrate animal of the large phylum Arthropoda; for example, insects, ticks and mites, spiders, and or crustaceans.
Built environment: the surroundings established by humans for settlement.
Disability-adjusted life years (DALYs): the number of healthy years lost to illness, morbidity, or death; an assessment of the overall disease burden.
Entomological inoculation rate (EIR): the number of infectious bites an individual is exposed to in a given time period.
Herd immunity: a form of immunity that arises from most individuals in a community being resistant to a disease and limiting the presence of the disease for the minority.
Indoor residual spraying (IRS): the practice of spraying areas where people reside with an insecticide to kill mosquitoes.
Insecticide: a mixture containing a toxic active ingredient used specifically for killing insects.
Integrated Pest Management (IPM): a comprehensive strategy that incorporates best practices for controlling pests.
Integrated Vector Management (IVM): a process of optimizing decisions to utilize resources effectively for vector control.
Long-lasting insecticidal nets (LLINs): a fine net or screen treated with insecticide used to keep out mosquitoes.
Nuisance biting arthropods: arthropods that do not transmit pathogens but affect quality of life owing to nuisance biting.
Pesticide: a mixture containing a toxic active ingredient used for killing arthropods or other pests destructive to crops or animals.
Vector: an organism, typically a biting insect or tick, that transmits a pathogen from one animal or plant to another.
Vector-borne disease (VBD): a disease diffused by blood-feeding arthropods and caused by their transfer of infectious microbes.

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Keywords: IVM; vector control; biting density; pest management; social disparities.

1471-4922/
 http://dx.doi.org/10.1016/j.pt.2014.06.001

Goals of IVM

Through the use of evidence-based collaborative approaches such as governmental and community involvement, IVM promotes capacity building to further vector control [12] and uses dynamic strategies to incorporate the best use of tools to reduce vector populations and pathogen transmission (Figure 1). Given that arthropod vectors impact the health, agricultural, and environmental sectors, control through IVM strategies obliges local government and community involvement to implement goal-achieving interventions [13]. Vector control is an essential factor in improving public health and has the potential to alleviate poverty if fully exploited because disability-adjusted life years (DALYs) can be reduced [11]. The 2006 chikungunya epidemic in India burdened the country with an estimated 25 588 DALYs from infection [14]. Lack of proper vector control and environmental maintenance exacerbated the spread of the pathogen and caused extensive suffering to residents. Increasing productivity by limiting workdays lost to illness benefits the public and private sectors.

Increased insecticide resistance [1] augments the need for effective nonchemical and environmental control strategies. Pesticides, even when used correctly, can be hazardous to human and environmental health [15]. Medical literature records the negative impacts of consistently applied chemical control for agricultural pest management on the eyes, skin, and respiratory, neurological, and gastrointestinal systems [16]. A study of 152 Philippine rice farmers using levels of pesticides recommended by the US Environmental Protection Agency recorded numerous abnormalities: 36% for eye effects; 50% for skin effects; 30% for respiratory effects in farmers who did not smoke; 24% for neurological effects in farmers who did not drink; and 27% for gastrointestinal effects [16]. Furthermore, a study assessing the effects of household pesticides, which are frequently applied incorrectly and at incorrect doses during pest outbreaks, correlated pesticide levels found in plasma with decreased birth weight in children [17]. Insecticide exposure through use of indoor household pesticides was also associated with increased leukemia risk [18].

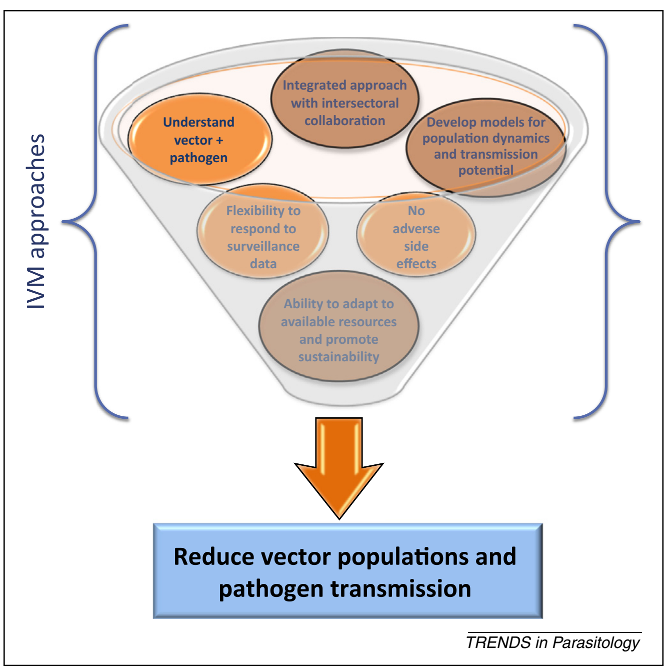

Figure 1. Multiple approaches used in Integrated Vector Management (IVM) to control vectors. The graphic illustrates how IVM strategies, each depicted as separate circular images, encompass a wide array of comprehensive and versatile approaches used for the achievement of a common goal: the reduction of arthropod vectors and their consequential transmission of harmful pathogens.

Given the aforementioned effects on human health as unintended consequences of pesticides, new, complementary strategies beyond pesticide application may be warranted. Through promotion of multiple evidence-based strategies to reduce VBDs – for instance, IRS and LLINs – along with the collaboration of various sectors including government agencies and community stakeholders [19], incorporation of IVM in the early stages of community development is the safest and most affordable approach to reduce host–vector contact and pathogen transmission and prevent serious vector and pest situations [11].

Many approaches, one target: what is missing?

The damaging effects of VBDs can impact human and animal health, outdoor recreation, and tourism [20]. In addition, nuisance biting arthropods such as non-vector mosquitoes, bed bugs, cockroaches, fleas, and head lice, which are largely disregarded in public-health research, play a role in quality of life [21]. A US study found that asthmatics sensitized to cockroach allergens and exposed to more than 8 units/g of allergen had more severe asthma symptoms than asthmatics with a lesser degree of cockroach-allergen exposure [22]. Economically, pests can also reduce crop yield by billions of dollars annually, clog water intakes, and impact landscape and housing infrastructure [23]. Invasive pest species alter ecosystem services and affect populations, community interactions, and habitats [24].

A quantitative relationship exists between vector population densities and pathogen transmission [25], yet there is no measure of mosquito population density or quality of life for individuals exposed to mosquitoes; the mosquito density in populated areas is rarely a concern for international authorities. High mosquito biting levels are not tolerated in the USA, yet globally tens of millions suffer and die from arthropod-transmitted pathogens [26]. The USA has up-to-date mosquito-control programs that target control of mosquitoes in larval and adult stages to reduce mosquitoes as nuisances, provided that pathogens are monitored through ongoing sentinel programs [27]. Residents of New Jersey are willing to pay close to US$8 per person per week to be able to spend mosquito-free time in their backyards [28]. In developing countries, however, access to and accountability for mosquito control is not a choice [27].

Environmental changes that reduce human–vector contact will take commitment from stakeholders and government institutions. National leadership and suitable resources are needed, but governments and international organizations must ensure that afflicted countries have adequate capital for development and vector control [4]. In underdeveloped areas where malaria is endemic, such as in Africa, the biting intensity is highly variable, with