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Review article

Viruses vector control proposal: genus *Aedes* emphasis

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ABSTRACT

The dengue fever is a major public health problem in the world. In Brazil, in 2015, there were 1,534,932 cases, being 20,320 cases of severe form, and 811 deaths related to this disease. The distribution of *Aedes aegypti*, the vector, is extensive. Recently, Zika and Chikungunya viruses had arisen, sharing the same vector as dengue and became a huge public health issue. Without specific treatment, it is urgently required as an effective vector control. This article is focused on reviewing vector control strategies, their effectiveness, viability and economical impact. Among all, the Sterile Insect Technique is highlighted as the best option to be adopted in Brazil, once it is largely effectively used in the USA and Mexico for plagues related to agribusiness.

Introduction

Dengue fever is a major public health problem in the world. The World Health Organization (WHO) estimates that 2/5 of the world's population are at risk of having the disease.[1] It is the most common disease caused by an arbovirus.[2] The distribution of *Aedes aegypti*, the vector, is widespread, along with the simultaneous circulation of four serotypes of the virus (DENV1, DENV2, DENV3, and DENV4).[1,3]

Associated with this problem, once they have the same vector, Zika and Chikungunya are on the rise. Since 2007, 55 countries from America, Asia, Africa, and Oceania have detected local transmission of Zyka virus. However, the first outbreak occurred in 2015 affecting almost 1.5 million people in Brazil, with 80% asymptomatic cases. Since then, it has been reported in 31 countries and American territories. Recently, a severe association between Zyka virus and microcephalia, retina lesions, and Guillian-Barrè syndrome have been reported.[4] The recent outbreaks in the South America, Central America, and the Caribbeans represent the arbovirus most severe episode in the East hemisphere on the last 20 years.

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Chikungunya emerged in 2013, and leaves a trail of joint symptoms. Notably, there are no specific treatments for these arboviruses. In this severe scenario, effective vector control is crucial, specially *A. aegypti* and *Aedes albopictus*, highly invasive species.[5]

In 2015, between January and November, 1.5 million Dengue cases was identified in Brazil, according to the Ministry of Health. In the same period, 17,146 Chikungunya suspect cases was identified, 6726 being confirmed later. Furthermore, Zyka was detected in 18 Brazilian states, with 739 suspected cases of microcephaly till 21st of November, 2015.[6]

In 2016, 1,399,480 probable Dengue cases were registered around the country, between 3rd of January and 9th of July. Additional 499,317 cases were dropped later. Regarding Zyka, 14,739 were registered as probable, 6903 being confirmed later by clinical and epidemiological criteria or laboratory testing. In relation to Chikungunya, it was 169,656 probable cases.[7]

Economic impact

The real economic impact of Dengue is not well documented. It is estimated as an average per patient of US 541 dollars and 1394 dollars, respectively, for outpatient and inpatient treatment. The mean disease duration is 11.9 days for outpatients and 11 days for inpatients. Among inpatients, students lost 5.6 school days and adults 9.9 working days due to this condition. This disease imposes substantial costs either on the health sector and general economy.[8]

The total estimated cost was 468 million dollars a year, in a study performed between 2009 and 2013. Adjusting for the unreported cases, the cost jumps to 1212 million dollars a year.[9]

The incidence, mortality, and morbidity of Dengue are underestimated. "Global Burden of Diseases Study, 2013" report estimated an average of 9221 deaths, caused by this arbovirus, a year, between 1990 and 2013, being 8277 in 1990 and peaking 11,302 in 2010. It resulted in a total of 576,900 years of life lost by premature death due to dengue fever in 2013 alone. The incidence considerably raised between 1990 and 2013, with the number of cases doubling each decade. Considering acute, mild and severe cases, and post-dengue chronic fatigue there will be about 566,000 lived years with incapacity. Considering fatal and non-fatal outcomes together, dengue was responsible for 1.14 million years lost due to incapacity, in 2013. It is believed that these numbers were even higher.[2]

In Brazil, the incidence in 2014 was 555,462 cases. The potentially severe clinical presentation accounted for 8975 cases and 453 deaths. In 2015, there were 1,534,932 cases, being 20,320 severe and 811 deaths.[2,10] If laboratory testing were routinely performed on the suspect cases, there would certainly be even more diagnosed patients.[11]

Regarding Zyka and Chikungunya, the studies on incidence, mortality, morbidity, and sequelae rates of mid- and long-term are at early stages. In microcephaly cases due to Zika, it is estimated that the social and economical costs will be huge and long lasting.

The *A. aegypti* control and dengue prevention in São Paulo, Brazil, in 2005, had an estimated cost of 1.99 dollars per person. It was considered: human resources, uniforms, field material, individual protection material, pulverizing equipments, strategic supply (insecticide and larvicide), and vehicles. It should be added to the costs of laboratory testing, educational information, and press material.[12] According to the Brazilian Ministry of Health, 2010–2014, the federal government spent around R$ 4.2 billion in preventive measures and Dengue treatment. During that period, the expenditure with the disease raised 48% – from R$ 613.4 million in 2010 to R$ 911.8 million in 2014.[13]

The Dengue vector and other viruses

The Dengue vector in Brazil, in urban areas is the *A. aegypti*.[14] It is also the Yellow Fever, the Zika virus, and the Chikungunya vector. It prefers places with higher human concentration. Species from Africa, belong to the phylum *Arthropoda*, class *Insecta*, order *Diptera*, family *Culicidae*, genus *Aedes*. The reproduction and dispersion stages occur when the mosquito is adult. During the nuptial flight, the winged adult, female and male mate once. A single insemination is enough to fertilize all the eggs. They can travel up to 300 m, and the pregnant female can fly up to 3 km. They feed on plant syrup, but the female need blood protein to mature their eggs.[15] Other species of the *Aedes* genus have been detected in Brazil.[16]

Vector control methods

The *Aedes* mosquito is a crescent public health concern, and its control or eradication is urgent. The available or in development control methods can be divided into five categories: 1 – environmental breeding sites control; 2 – mechanical traps; 3 – insect fertility reduction technique; 4 – insecticides; and 5 – transgenic insect.[17]

Reduction of vector breeding sites in the environment

It is the control of the vector breeding sites in standing water. Permanent actions decrease breeding focus. Education and population's participation are necessary. It is recommended continuing preventive measures and visits to all risk spots in order to fight the vector in early stages.[1]

Mechanical traps

There are different types of traps, which imprison the insects, the eggs, and the larvae.

Insect fertility reduction techniques

There are two biological strategies of vector control: *Wolbachia* related technique and sterile insect production by radiation technique.

On the first strategy, it was proposed the infection of *Aedes* mosquitoes with *Wolbachia* endosymbiotic, which inhibits the viral replication and dissemination. On the 14th day of infection, the *Wolbachia* completely blocks the Dengue transmission in at least 37.5%. These results highlight the potential usefulness of *Wolbachia* based strategies to protect the population from Dengue fever.[18]

On the second strategy, the males produced in laboratory are exposed to low radiation and sterilized, while keeping the copulation capacity. The insect made with impaired fertility is released into the environment to mate with wild insects and