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Urban adaptation to climate sensitive health effect: Evaluation of coping strategies for dengue in Delhi, India

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ABSTRACT

In absence of adaptation initiative, residents resort to coping strategies to manage climate-related health risks. Delhi, the capital city of India, is highly endemic to the climate sensitive vector-borne disease of dengue. The weeks of a year with risk of dengue occurrence due to weather patterns are identified by using Poisson regression which uses data for climate variables and reported dengue cases. The coping strategies adopted by household are then evaluated using survey data of 559 households. An economic evaluation of coping strategies to serve as an important decision tool in developing adaptive capacity was carried out using household health production function approach. The econometric tools of Negative Binomial Regression and probit regression have been used for evaluation. The methodological framework provides a novel approach by linking climatic variability, health impact and economic evaluation of adaptation strategies. The results reveal that the dengue risk is mainly addressed by coping strategies at the household level and intervention measures are ineffective due to inappropriate timing and selective approach. The annual economic benefit of adopting coping strategies is estimated as US$ 65 per household. The benefits of coping strategies in reducing dengue risk contribute to the planning of adaptation strategies at city level.

1. Introduction

As with most cities, Delhi, the capital city of India is vulnerable to the health impacts of climate change. Among the climate sensitive infectious diseases, the vector-borne disease (VBD) of dengue is most prevalent, occurring regularly in Delhi. There has been a significant increase in the number of confirmed cases in the last fifteen years with outbreaks in 2003, 2006, 2010 and the worst in 2015 with a staggering 15867 dengue cases (Chakravarti & Kumaria, 2005; Nandi et al., 2009; Kumari, Kumar, & Chauhan, 2011; NVBDCP, 2015; WHO, 2016). This makes interventions necessary to increase the adaptive capacity of the urban residents for future dengue risk. Appropriate adaptation strategies would make the city resilient to future risk and contribute to achieving the sustainable development goals (SDGs) of combating climate change impacts (SDG – Targets 13.1; 13.2 and 13.3), healthy lives for all (SDG − Target 3.3), and resilient and sustainable cities (SDG – Target 11.b) (SDSN, 2017). In India, the average economic burden of dengue has been estimated to be US$ 29.3 million (Garg, Nagpal, Khairnar, & Seneviratne, 2008; Conteh, Engels, & Molyneux, 2010). Therefore, the effectiveness of interventions as adaptation strategies is crucial in reducing the economic burden of the disease.

Dengue is the most important mosquito-borne viral disease which is caused by four closely related viruses. It is mainly transmitted by *Aedes aegypti* mosquito, the principal urban vector (Reiter, 2001; Hales, de Wet, Maindonald, & Woodward, 2002; Hopp & Foley, 2003; Morin, Comrie, & Ernst, 2013; Ebi & Nealon, 2016). In Delhi, both *Aedes aegypti* and *Aedes albopictus* transmit dengue viruses with *Aedes aegypti* being the most prevalent vector (Kumari et al., 2011, 2013; Sharma, Kumari, Srivastava, Barua, & Chauhan, 2014). Dengue is the only VBD having strong association with climate variables, both at the local as well as global level (Smith et al., 2014). Incidence of dengue is exacerbated by increase in temperature, rainfall and humidity that alter the vector and pathogen life-cycle (Patz, Martens, Focks, & Jetten, 1998; Hales et al., 2002; Hopp & Foley, 2001, 2003; Bhatt et al., 2013; Morin et al., 2013; Naish et al., 2014; Estallo, Luduena-Almeida, Introini, Zaidenberg, & Almiron, 2015; Ebi & Nealon, 2016). Increase in rainfall creates pools of water suitable for mosquito breeding. While increase in temperature shortens extrinsic incubation period (EIP) of the pathogens and increases the biting and egg laying activities of the mosquitoes (Bradley, 1993; Costello et al., 2009), thereby increasing the vectoral capacity (VC) of the mosquitoes (Reiter, 2001; Kovats, Campbell-Lendrum, McMichael, Woodward, & Cox, 2001; Kramer & Ebel, 2003). High relative humidity increases the life span of the mosquitoes, thereby enabling them to infect more hosts (Patz et al., 2000).

Recurrence of dengue in Delhi over the years shows that interventions have not been very effective and provides evidence of inadequate

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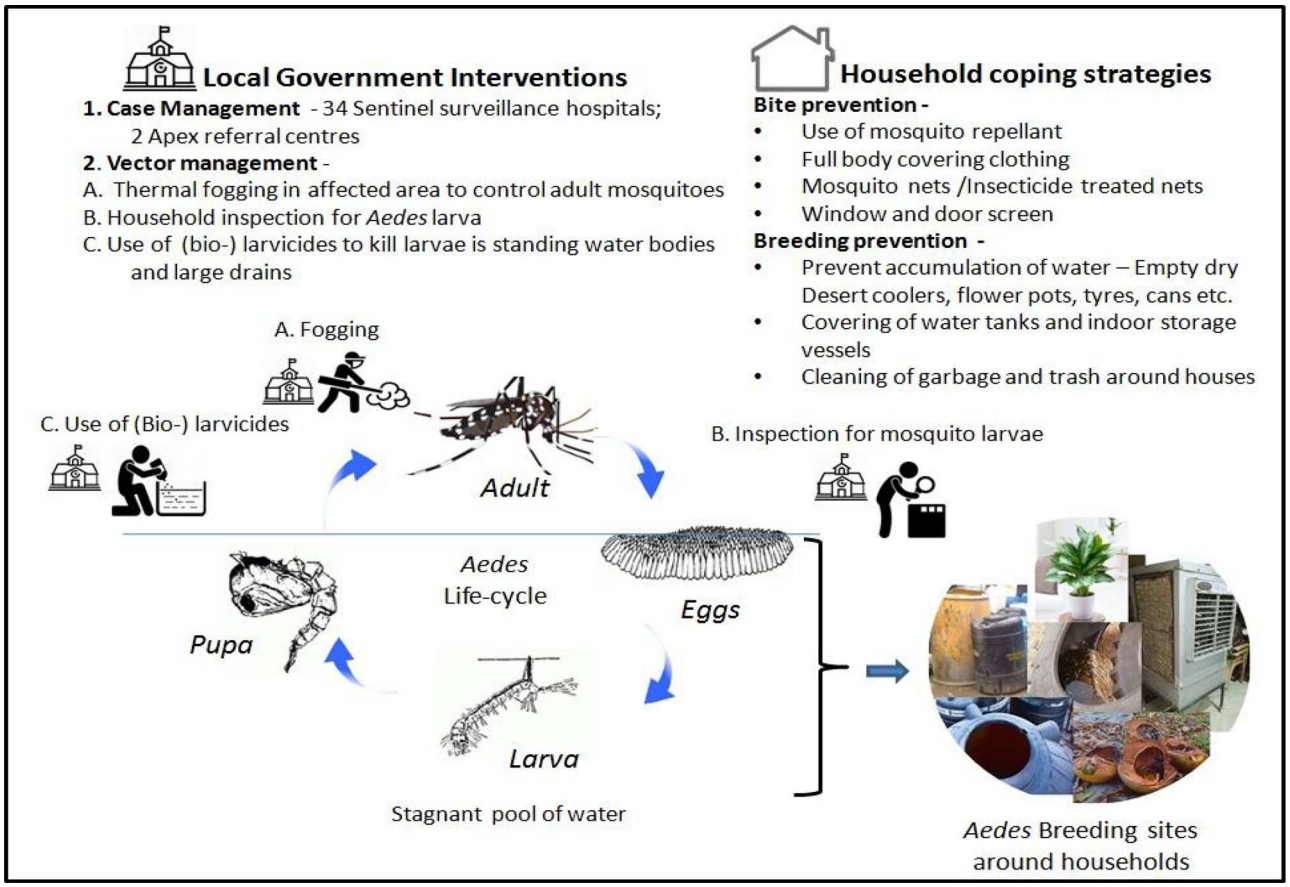

Fig. 1. Interventions by the local government (MCD) and coping strategies by households.

planning. The present study makes an effort towards finding the reasons for ineffectiveness of intervention measures and shortcomings in planning. There is lack of evidence on the impact of weather patterns on dengue incidence and so far it has not been taken into account while planning interventions. Hence, no adaptation strategies have been planned for dengue risk due to weather patterns. For the first time, this study analyses the effectiveness of the intervention measures for dengue in Delhi by economic evaluation of household data for strategies adopted by them to cope with dengue risk due to weather patterns. The methodology used in this paper links climatic variability, health impact and coping strategies, thus, providing a novel framework for monitoring and evaluation of adaptation strategies for climate related health risk at city level.

In most of the cities, in the absence of planned adaptation, residents resort to coping strategies (private adaptation) which are autonomous, reactive and with short-term benefits, practised at the individual, household and community level but also with initiative by the private sector (Revi et al., 2014; Ford et al., 2015; Araos et al., 2016). Households in Delhi also practise coping strategies. However, repeated use of coping strategies does not ensure resilience to future risk as it does not contribute in building adaptive capacity, thereby making the residents increasingly more vulnerable to the health hazards (Lavell et al., 2012; Berman, Quinn, & Paavola, 2012; Revi et al., 2014). Coping strategies need to be supplemented by supportive measures by the local government to build the adaptive capacity in the long-run (Revi et al., 2014). The existing coping strategies can be considered as building blocks for the adaptation strategies. This calls for evaluation of the coping strategies adopted by households in Delhi.

The economic evaluation of coping strategies serve as an important decision tool for policy makers as it provide information on costs, benefits and effectiveness of coping strategies in reducing the dengue risk. Such evaluation identifies the effectiveness of coping in contributing to urban resilience and determining the existing adaptation deficiet (gaps in effectiveness of the intervention practices as a part of public health policies and additional strategies which would be required specifically to minimize the risk). The paper aims at providing the necessary policy inputs required for formulation of the adaptation strategies by local government. This is achieved by determining the impact of climate variables on dengue incidence and evaluating the coping strategies at the household level. The weeks of a year with high probability (risk) of dengue occurrence due to weather patterns are identified by determining the relationship between climate variables and dengue cases. This has been modelled using Poisson regression applying the generalized estimating equation (GEE) approach which takes care of overdispersion, serial correlation, non-linearity and allows for hypothesis testing. Household coping strategies have been evaluated using the health production function (HPF) approach. A system of simultaneous equations has been estimated using 2SRI (two-staged residual inclusion) approach to deal with endogeneity. The econometric tools of Negative Binomial Regression (NBR) and probit regression are used for estimating the main and reduced form equations respectively.

2. Interventions and coping strategies

At the national level, a long term action plan was formulated by the National Vector Borne Disease Control Programme (NVBDCP) in 2007 for control and prevention of dengue. It required the endemic states in India including Delhi, to implement strategies for early case reporting and management through establishment of sentinel surveillance sites, vector management including anti-larval and anti-adult measures, and supporting interventions such as capacity building (NVBDCP, 2007). Recently NVBDCP has also come up with operational guidelines specific

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