Combating Dengue in India: Challenges and Strategies

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The limited official data available on dengue in India fails to define its epidemiological profiles. However, it reveals how little has been done in the surveillance of this disease at the level of the states, and gives an idea of the quantum of effort required to fight dengue. The National Vector Borne Disease Control Programme faces some classic pitfalls in India with its implementation not mandatory in the states. Arguments about the number of cases and hospitalisation, both with wide ranges, persist. Applying integrated action plans at the district level in the states would have helped. Improvement of the system of public health services, strengthening skills of medical personnel, active surveillance components with a well-functioning surveillance system, enhancement or creation of suitable water distribution network and garbage collection are critical components of an integrated plan.

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Typical for a subtropical climate, the intense summer heat in most parts of India is followed by heavy rains and high humidity levels. And just as predictably, it is followed by monsoon-related diseases. Dengue is one of these major vector-borne diseases. It is transmitted to humans by several species of mosquito within the genus Aedes, principally Ae.aegypti in India. This type of mosquito has a strong craving for a hearty human blood meal, usually at sunrise or sunset, and as Ae.aegypti is a nervous feeder, it can bite several hosts to complete a single meal. Even with a low mosquito density, an epidemic can burst in a totally susceptible population or with the venue of a new strain, as it is probably the case with the DENV-4 in Delhi this season. Humans, once infected, can transmit the virus to any susceptible vector mosquito. As the vector population increases, this cycle becomes an avalanche that consumes all susceptible humans in its course, assuming the proportions of an epidemic.

Among the four closely-related dengue virus serotypes (DENV-1 to DENV-4), no long-term, cross-immunity vaccines are yet available that provide efficacy against all the serotypes. Infection to dengue can vary: a large proportion of infected people can exhibit asymptomatic responses, while a low proportion succumb to dengue shock syndrome (DSS) with intermediate steps such as clinically non-specific flu-like symptoms, dengue fever and dengue haemorrhagic fever (DHF). DHF and DSS are the most severe forms of the disease, and are the major cause for dengue-related deaths.

Recent estimations indicate that around 400 million infections occur annually in tropical and subtropical areas (Bhatt et al 2013) causing more than 20,000 deaths per year (Gubler and Meltzer 1999). Estimations of the latter are a real challenge, as the true disease burden is unknown, spread across India, Indonesia, Brazil, China and Africa (Guzman and Harris 2015). In these regions, migrations, high human population densities in a setting of unplanned urban expansions and inadequate public health system have contributed to hyper-endemic transmission of all four dengue serotypes.

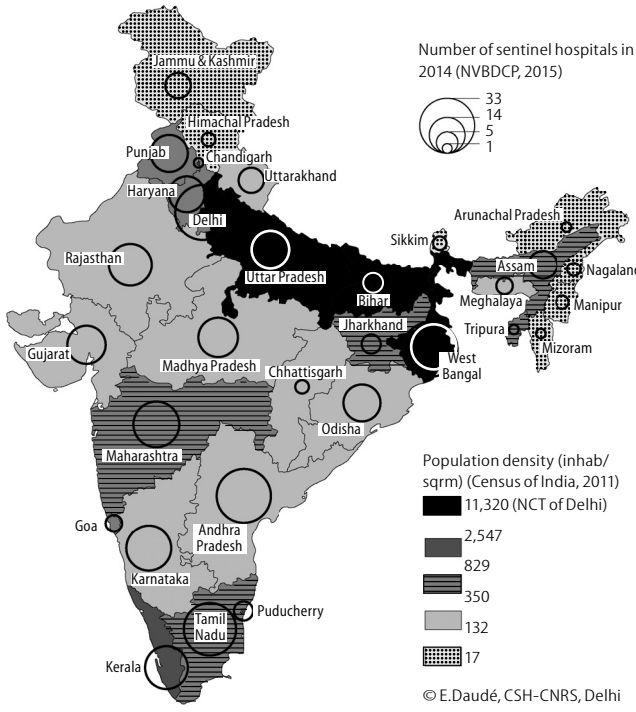
Dengue Burden in India

The official surveillance system in India reported an annual average (± standard deviation (SD)) of 28,518 (± 10,980) dengue cases between 2006 and 2012. The formal structural mechanism to generate information and undertake surveillance is built under the National Vector Borne Disease Control Programme (NVBDCP) through a network of sentinel hospitals, numbering to about 500 in 2015 across the country and linked with 15 apex referral laboratories having advanced diagnosis facilities. The disease notification comes from these shortlisted sentinel hospitals by states that are required to report all the confirmed dengue cases conducted with IgM MAC-ELISA test kits. These kits are provided by central government on the basis of states' demands to avoid confusion and misdiagnosis with similar symptoms of other diseases.

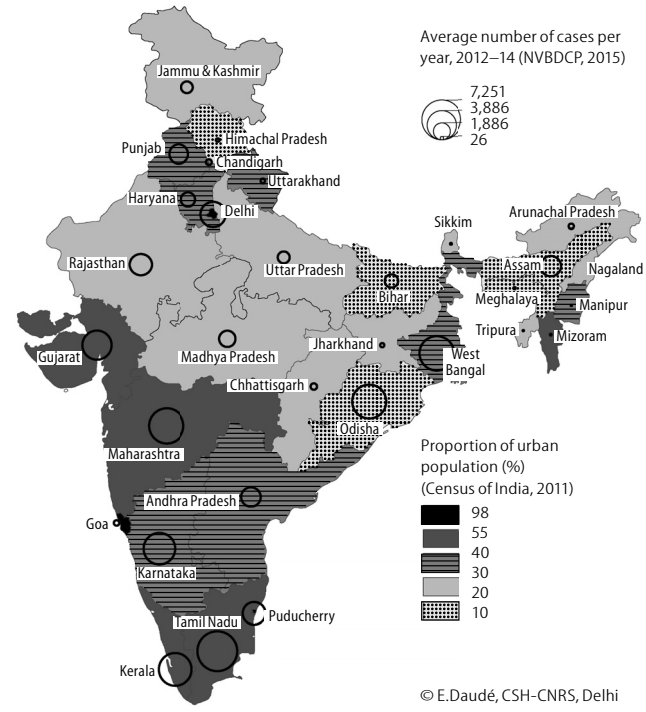
At the state level, the distribution of sentinel hospitals follows slightly the hierarchy of Indian population (r^2=0.43), but does not correlate any further, if we look at the most populated states with more than 10 million inhabitants. According to NVBDCP, presence of sentinel hospitals varies substantially between states: in 2014, Bihar, the third most populated state with a 100-million-plus population had only seven sentinel hospitals, whereas the National Capital Territory (NCT) of Delhi, 18th in terms of population size is covered by 33 such hospitals. The map of official dengue cases shows a higher concentration of cases in more urbanised states, especially the less populated and the wealthier. Madhya Pradesh, Andhra Pradesh, West Bengal, Bihar, Maharashtra and Uttar Pradesh,

Figure 1: Dengue Surveillance Network in India

Number of sentinel hospitals by state and population density



Dengue cases reported by sentinel hospitals by states and urban population



on the other side, have officially recorded only 18% of the 75,803 cases during the 2013 dengue epidemic. These figures reveal at least two major issues:

(i) The level of a state's wealth (according to the state gross domestic product (GDP) levels for 2012–13) is a determining factor (r^2=0.65) of its participation in the surveillance system (number of selected sentinel hospitals).

(ii) The number of recorded cases is correlated to the number of sentinel hospitals who monitor dengue cases (r^2=0.64).

However, other estimates for 2006–12 reckon hospitalised dengue cases at about 5,778,406 individuals annually, which is 282 times higher than the official recorded levels (Shepard et al 2014).

What could then be done to improve the situation in terms of surveillance and control of dengue? In this paper, we discuss some of the existing challenges in controlling dengue in India. We analyse health system preparedness and response, and lay out a few potential strategies that could be considered to mitigate the risks of disease and death posed by dengue in India.

Epidemiological Features

In India, dengue is endemic and hyperendemic in several parts of the country with interspersed epidemics reported every three to five years. A network of sentinel hospitals, clinics/physicians and laboratories should cover all the states/union territories, respective to their population. They should be spatially distributed in all urban districts and a selection of sentinel rural areas, through the primary healthcare system, to follow the spreads of infection in space and forecast the outbreaks in advance.

The supply of the IgM MAC-ELISA test kits by the central government to the states illustrates that this aim is not being achieved, where typically the demand for kits for the current year is based on the number of recorded cases of the previous year. For example, the volume of demand for test kits for 2014 (N_{tk}=4083) was based on the number of cases recorded in the states in 2013 (N_c=75,803, r^2=0.5), which is not correlated well to the number of cases recorded in 2014 (N_c=40,571, r^2=0.26). As a result of this strategy, the demand for test kits for 2015 is lower than in 2014, correlated to the recorded number of cases in 2014 (N_{tk}=3780, r^2=0.47), whereas the 2015 "dengue season" seems to reach new records.

The fight around numbers related to health issues is an old tradition, almost equally driven by the opposite ideas of lessening responsibilities by ignoring or downplaying the problem or to increase expected benefits by frightening people. But hard evidence and statistics—more so for imminent health system challenges such as disease burden and its epidemiological distribution—are of immense importance for any serious public health system. They help channelise investments and resource allocations, ensure that competence of healthcare actors and health priorities are both well-aligned and well-designed with the prevailing disease scenario. They can be used to evaluate the results of conducted actions also. Information, scientific, correct and timely, forms one of the basic building blocks of health system. Surveillance should accordingly be the first pillar of an effective public health response to fight diseases such as dengue, chikungunya, malaria, Japanese encephalitis or kala-azar, which always run the risk to explode into epidemics.

India has a passive-surveillance approach, relying on dengue notification by sentinel hospitals disseminated in the country. This hospital-based surveillance has low sensitivity during the inter-epidemic season. It only records the tip of the iceberg, because (i) globally 70%–80% of dengue viral infections are

subclinical or quasi-symptomatic (Bhatt et al 2014); (ii) only around 30% of symptomatic cases are estimated to be hospitalised in India (Shepard et al 2014); and (iii) the private sector covers between 40% and 80% of all cases of infectious diseases in India, including dengue (Chakravarti et al 2012; Shepard et al 2014).

In Delhi, a survey conducted in *jhuggi-jhopri* (JJ) clusters (Mazumdar et al 2014) has shown that among 263 households (8% of the total) with at least one family member diagnosed with dengue infection in 2013; about 24% (N=64) people were diagnosed in a sentinel hospital, and then potentially recorded as official dengue cases (Daudé et al 2015). These results show that even in a very poor population, visits to public hospital concern a minority. As dengue crosses the social and economical barriers, the sentinel hospitals are thus likely to capture only the most serious cases among the poorest population (Sundar and Sharma 2002) of endemic regions.

In the three states that have the most number of sentinel hospitals (NCT of Delhi, Andhra Pradesh and Tamil Nadu), only one among 95 is a private hospital. It is thus of utmost necessity to expand the provider-coverage, by incorporating private hospitals and major laboratories. Introduction of private hospitals would considerably increase the population covered by the surveillance system that would better allow defining the major at-risk group in the population. Introduction of laboratories for isolation and serotyping of the dengue virus in the surveillance system will be useful to detect changes in the predominant serotypes, which can precede a major outbreak, and record history of circulating strains. It will also complement the passive surveillance system with sample surveys during an inter-epidemic season to detect a sudden increase in the number of infection.

Moreover, active surveillance programmes to detect symptomatic infections such as school-based absenteeism records or community approaches could be deployed in the major cities to improve the sensitivity of the surveillance. Adding active dengue surveillance in the areas where disease activity and dengue serotypes have not been identified by a functioning passive surveillance system can assure that each state/district has a better knowledge of its epidemiological features and issues as well. This will also facilitate the state/district concerned to engage in preventive action and to prepare its health systems in case of the imminence of an epidemic. This involves that all information collected locally is sent at the central level and is accessible to all health departments and line departmental agencies in the public administration structure. Such regular, streamlined flow of information will help district, state and central health authorities to synchronise focus on higher-risk zones for their interventions and to follow the shift between serotypes and accordingly anticipate the importance of epidemics.

But variation remains in the system of reporting and transferring information in each state, linked with the state of their own health information systems, political involvements, and the skill and capacities of health authorities. Moreover, since reporting dengue cases is not mandated by legislation, control and notification systems at the state and district levels are voluntary, and accordingly, efforts must be done to reduce under-reporting. In a situation where dengue control and reporting is not mandatory and where health issues are under the responsibility of district officers, the general tendency is to deny the problem to avoid recriminations. While emphasising that surveillance must be appropriately done, related aspects of the skill, awareness and preparedness of health actors and citizens must be substantially strengthened.

Early Recognition of Symptoms

The officially reported levels of case fatality rate (CFR) for dengue, which represents the number of deaths per diagnosed cases, have remained below the threshold of 1% since 2008. To avoid contamination and maintain a low CFR, it is important that individuals are adequately aware about the transmission cycle, recognise the symptoms of the disease—high fever (40°C/104°F) with possibly severe headaches, pain behind the eyes, muscle and joint pains, nausea, vomiting, bleeding gums and blood in vomit—and consult rapidly a medical doctor to avoid complications and prevent risks of death. There is no anti-viral drug yet for DENV infection, the only treatment is supportive care with pain management and fluid replacement. This life supportive treatment can be very expensive if hospitalisation is needed—total cost per hospitalised episode cost in average (public and private) about $235 (Shepard et al 2014)—and thus out of reach for the poor communities.

The NVBDCP has set up media plans to be disseminated during the dengue season around the months of June–July, which have been referred to as the "anti-dengue months." Studies show that awareness of the disease and its symptoms are at medium levels in India (Acharya et al 2005; Singh et al 2011), and effective knowledge on the process of vector transmission and ways to prevent are not equally well-understood (Chinnakali et al 2012). Our earlier results show that more than 79% of the 3,350 households surveyed have a strong feeling of presence of mosquitoes in their surroundings, but in practice, less than 45% check their premises to detect and avoid breeding sites. It is all the more important to interrupt the vector-host transmission cycle to avoid local transmission (in the same house or premises) for infected people who should prevent further exposure to mosquitoes, but this message is followed only by 43% of households exposed to dengue (Daudé et al 2015).

At the same time, it does not make any sense if citizens know about the symptoms. But medical doctors are unaware of how to respond or do not have the equipment to respond to the needs. The central government provides training sessions for medical teams of sentinel hospitals on a regular basis, which remain inadequate as only a small proportion of the population visit public hospitals. The JJ cluster survey in Delhi indicates that 36% of reported dengue cases visited a private physician or a clinic, followed by 33% who visited a government hospital and 13% approached quacks or informal providers (Daudé et al 2015). Another

study found that 37% of physicians (63% in rural areas and 20% in urban areas) had inadequate or no medical training (Rao et al 2012) and that corruption was rampant in Indian medicine (Sachan 2013). Increased public spending on healthcare, expanding the number of health professional in urban slums, strengthening the management of public hospitals and ensuring minimum quality standards for private facilities are known recommendations to fill this gap (Joumard and Kumar 2015).

A properly functioning and responsive public health system, particularly before and during the dengue season, is of a paramount importance. Without any preparedness, most of the public hospitals lack of required beds, tests and blood/platelet for transfusion because of the uncontrolled inflow of patients. Anticipatory measures such as regular reporting of, and possible deferring non-critical surgery, increase of blood donation campaigns during the non-epidemic season, adding beds in hospitals and innovative measures such as transforming vacant spaces like hospital gymnasiums and lawns into provisory hospitals could release some pressure on the already stretched healthcare system during a dengue epidemic. The recent tragic death of a young child after his parents spent valuable time throughout a night looking for a hospital bed in September in Delhi is ubiquitous in India. Authorities as usual respond with emergency control operations, adding a certain confusion regarding the preparedness, which is always the case for implementation near or after the peak epidemic transmission.[1]

Environmental Conditions

Parallel to the surveillance of dengue cases, entomological studies of Aedes aegypti and Ae.albopictus should be regularly conducted as they are the main vectors of dengue and chikungunya in India, both in urban and rural areas (Kalra et al 1997). Few cities such as Delhi or Mumbai have set up entomological teams to check breeding sites activities and to eliminate premature and adult mosquitoes. But even in these cities there are no action plans employed to measure vector population densities throughout the year. Mass-deployment of employees is engaged in a mostly random-mannered checking of households and premises, and is supposed to make fumigation around houses whenever a dengue case is reported by the surveillance system. Both activities are of low-efficiency.

A sentinel network of mosquito traps to collect in regular base adult mosquitoes and to estimate locally their population density should be more useful. This surveillance of adult mosquitoes can indicate a risk of contamination when crossed-checked with dengue surveillance systems, and can orient control interventions in the most populated or frequented places. It could also be useful to inform and educate the population, for example, when the daily figures of vector densities are displayed in the neighbourhood with a symbolic level of risk. Finally, this data could be a tool for the district health authorities to put pressure on the other sectors at local scales. These issues assume greater importance due to the fact of long neglect of urban health issues, which are often perceived as not of a serious-enough challenge by public actors (Gupta and Mondal 2014). Rather than systematically criticising entomological teams for not doing the job, policymakers should understand the causality links between vector densities and disrupting sectors.

Vector density can be very high in slum areas where people tend to store water inside their house or in the premises. Lack of regular piped water connections is strongly correlated with a high mosquito density (Schmidt et al 2011). Another challenge is the discarded materials that are susceptible to act as breeding sites (soda cans, coconut shells, tires) and often pile up due to inadequate garbage collection (Thammapalo et al 2008). On the other hand, wealthier areas with green parks (plant axils and tree hollows), over-head tanks and air-coolers also provide breeding sites for mosquitoes (Vikram et al 2015).

The issue of reducing mosquito densities is then invariably linked in part to the lack of proper management of public amenities and partly to the lack of individual responsibilities. Some major cities have set up by-laws that allow officials to charge penalties to households or institutions that harbour likely positive breeding sites. But, even when entomological surveillance teams exist, they are often not allowed to visit rich areas or houses. In India, with a society strongly marked by social hierarchy, the poorest are probably most often punished with penalties and retributions as compared to the richest at equal mosquitogenic conditions. In this scenario, the common tendency to transfer the onus of responsibilities from local authorities (lack of water distribution) to individuals (storing water in jar) is palpable.

International Efforts

The research and development of a vaccine against dengue and anti-dengue treatment appear undoubtedly the best solutions as the disease continues its rampant spread across poor regions of tropical and subtropical countries. Even in rich regions such as Singapore, where pragmatism, meritocracy and lack of corruption are the key elements of public life, dengue spreads regularly. But at least the susceptibility of the population, the area-specific past and current circulating strain(s) and the vector density are operating information which help to engage an early and adaptive response by public and private healthcare facilities to reduce the intensity of spread of dengue, its economical cost and the case fatality rate (Ooi et al 2006).

Information coming from surveillance system is of an urgent need for evaluating success of dengue control, to identify risk-prone areas and to prepare any vaccination campaign in India. There is no extensive research on anti-dengue treatment, with an existing focus on medicinal plants (Abd Kadir et al 2013) and large-scale fields evaluations of these trials must be done. Vaccine research for dengue has a number of candidate vaccines, but the Dengvaxia (CYD-TDV) four chimeric yellow fever 17D vaccine viruses by the French Sanofi Pasteur Institute is in the most advanced phases as it has reached three years of observation on a six-year plan horizon (Hadinegoro et al 2015).

There are some critical results regarding safety and efficacy of the Phase-III

trials, one of them being its apparent inefficiency for DENV-2. The risk of hospitalisation is elevated for vaccinated children younger than nine years old and when they are naturally infected in their third years after vaccination (Cameron 2015). There are also promising results with the large reduction in dengue hospitalisation for children between the age of nine and 16 years (Hadinegoro et al 2015). The path to a commercialised vaccine is long, but they are good hopes that a dengue vaccine will be available in the coming years.

One step on this path is to be able to explain logic and rationale for introducing new vaccine in public health measure. Collaborations between stakeholders such as the National Technical Advisory Group on Immunisation, drug manufacturers, health professionals and academic institutions, patient groups, policymakers and health regulators such as the World Health Organization would permit engaging into new trials in India and assess risk–benefit ratio. Efforts must be pursued to improve efficacy of potential vaccines, and India can play an important role in developing field trials. With the need for India to protect intellectual property of its industrial partners and have pragmatic therapeutic essay laws, the counterpart of this collaboration should be appropriate negotiations related to the distribution and the price of a future vaccine in a country where close to half a billion people live in poverty. Care should be taken to ensure that such a vaccine does not serve only to enrich the private sector already largely commodified (Mazumdar 2015) and that the expected benefits of vaccination reach all the sections of the society.

Conclusions

If the cost that people should pay for a dengue vaccine and its availability is a crucial issue, the other, and possibly of higher importance, is the interrelation between health issues and basic amenities. As we have discussed above, surveillance of dengue can help to limit its diffusion and target vaccination campaigns. Vector surveillance can help reduce risk of transmissions. A proper sanitation system, garbage collection and disposal, and access to tap water can reduce mosquito densities considerably. Alongside this, to generate better-yielding and sustainable results, community participation must be enhanced. A functioning, responsive public health system with skilled health workers is a basic minimum that could have a positive effect not only on dengue control, but also on public health outcomes in general.

NOTE

1 During the 2013 epidemic, a senior doctor at the All India Institute of Medical Science said, "The city is flooded with dengue cases. Hospitals have fallen short of beds due to the rush and there is a near crisis situation as far as demand for platelets is concerned" (TNN 2013). The situation is still of actuality.

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