

## Socio-economic Burden of Dengue on Brazil

## Abstract

Dengue has a significant impact on our society. This paper will be discussing the socio-economic impact of dengue on Brazil. In recent years, the global incidence of dengue has increased drastically and more than half of the world's population is at risk. Dengue is most prevalent in tropical and sub-tropical regions (WHO, 2015). Dengue has caused severe impact on humanity both socially and economically. It has a distressing impact on the health of the general population and the national and global economies. Approximately 500,000 people suffering with dengue are hospitalized every year, a large amount being children. Out of these affected people approximately 2.5% die each year. The rates of people getting dengue in Brazil are alarming and these numbers keep on increasing every year (WHO, 2015). The disease not only affects the global economies, it also influences the lives of the general population. We will also explore the history of the pathogen responsible for this disease, its characteristics, various disease mechanisms and some risk factors that make people living in Brazil more prone towards dengue. A considerable amount of research has been done and is still going on to find ways to combat this disease. Various prevention and control techniques have been invented and implemented in order to fight against dengue. This paper will also focus on various efforts that have been put into the management of this disease and the research that has been going on in order to find ways to either cure or eradicate dengue.

## Introduction

### Pathogen background

Dengue is a mosquito-borne disease. It is caused by the *Dengue virus* (DENV), which is a member of the *Flavivirus* genus, which belongs to the *Flaviviridae* family. DENV is an enveloped, single stranded, positive- strand RNA virus. There are four antigenically distinct serotypes of DENV which are DENV-1, DENV-2, DENV-3 and DENV-4 (Fares, Souza, Añez & Rios, 2015). Once a person gets infected by one serotype of DENV, he/she acquires lifelong immunity to that specific serotype. No cross-protective immunity exists against other serotypes, thus a person residing in a dengue-prone region can get infected by all four serotypes during his/her lifetime.

The full transmission cycle of DENV involves the role of the *Aedes* species mosquitoes as a transmitter or vector. These mosquitoes usually dwell in rain forests of tropical and subtropical regions. Various *Aedes* mosquito species such as *Ae. aegypti*, *Ae. albopictus*, *Ae. polynesiensis*, and some members of *Ae. scutellaris* group can act as vectors in spreading the disease (Jain & Jain, 2005). The viruses are transmitted to humans when they get bit by an infected female *Aedes* mosquito, which acquires the virus while feeding on the blood of an infected person. Thus, the viruses are maintained in an *Ae. aegypti*- human- *Ae. aegypti* transmission cycle. Once the virus enters the mosquito, it infects the mosquito's stomach and then eventually makes its way to the mosquito's salivary glands. This takes place over a period of approximately 8 to 12 days. Subsequently, after this 8 to 12 days long incubation period, the virus is now present in the salivary glands of the mosquito, ready to be transmitted to a human during the mosquito's next feeding period (WHO, 2016). *Aedes* mosquitoes usually lay their

eggs in water filled habitats which are closely associated with human households. The adult *Ae. aegypti* mosquitoes are often found indoors and usually feed during daytime hours. Female *Ae. aegypti* mosquitoes can feed on several humans during a single feeding period and can thus transmit the virus to a large number of people during a short span of time. This kind of feeding pattern and ability to quickly spread the virus among several humans makes these mosquitoes an epidemic vector, which is one of the main factors that cause dengue pandemics (Jain & Jain, 2005).

Once humans are exposed to the virus, it then invades and multiplies inside them. When the mosquitoes bite the humans, DENV is transmitted into their bloodstream. The virus then invades the cell and releases a nucleocapsid. The virus binds to the receptors present in the plasma membrane of the target cell. These conformational changes lead to an interaction of the target cell's plasma membrane and the envelope of the virus, leading to fusion of the virus and the target cell. The circulation of the virus and spread of infection is caused by the transfer of viral genes and viral proteins from an infected cell to uninfected cells. After the virus has entered a target cell, its viral genome is uncoated and the viral proteins are synthesized by the target host cell. The viral particles then auto-assemble themselves inside the infected cell. The infected cell then releases the infective virions into the extracellular space where these virions can infect other uninfected cells (Jain & Jain, 2005). The mononuclear cells in the blood also get infected and soon enough, the infection reaches the lymph nodes. The monocytes and macrophages residing in the lymph nodes become the targets of infection. Once the virus infects the monocytes and macrophages, the infection intensifies and the virus is circulated through the lymphatic system (Martina, Koraka & Osterhaus, 2009). Since the mononuclear cells of the blood also get infected

by DENV, it circulates in the blood of an infected person who can now transmit the infection via *Aedes* mosquitoes (WHO, 2016)

The infection caused by any of the DENV serotypes can be either asymptomatic or can cause a variety of symptoms. These symptoms can range from a mild flu- like syndrome known as dengue fever to a more severe form of disease which is characterized by coagulopathy, increased vascular fragility, and permeability known as dengue hemorrhagic fever (DHF). In some cases the dengue hemorrhagic fever may progress to dengue shock syndrome, a hypovolemic shock (Martina, Koraka & Osterhaus, 2009). After the mosquito bite, the disease goes through its incubation period of about 4 to 10 days when there are no symptoms. Then the disease enters the phase where the symptoms suddenly appear and usually last for approximately 2 to 7 days. The characteristics of the disease vary according to the age of the infected person (WHO, 2016). The sudden onset of dengue fever is characterized by severe flu-like symptoms such as high fever accompanied by intense frontal headache, fatigue, retroorbital pain, myalgia, arthralgia, and rash (Fares, Souza, Añez & Rios, 2015). Severe dengue or dengue hemorrhagic fever is potentially lethal due to the increase in vascular permeability, also known as plasma leakage which leads to fluid accumulation, respiratory distress, severe bleeding, or organ failure. The sign of severe dengue is often the decrease in body temperature 3 to 7 days after the first symptoms appear. Symptoms of severe dengue or dengue hemorrhagic fever include severe abdominal pain, persistent vomiting with blood, rapid breathing, bleeding gums, fatigue and restlessness (WHO, 2016). The hemorrhagic manifestations of severe dengue accompanied by decreased platelet counts can lead to clinical hypotension and shock which is known as dengue shock syndrome. Severe dengue is a medical emergency and in this stage if proper care is not

provided, the complications of the disease can lead to death of the infected person (Fares, Souza, Añez & Rios, 2015).

There is no particular treatment for dengue fever. There are no effective vaccines or antiviral medications available, but a considerable amount of research is going on to find possible vaccines and probable cures for this disease. Patients should seek medical advice as soon as possible because an early diagnosis of severe dengue and its appropriate management can prevent the fatalities. Although there is no absolute correlation of the distinct DENV serotype with the clinical features of the disease, various reports suggest that DENV-2 and DENV-3 cause severe illness more often than other serotypes. DENV-4 is usually associated with milder illness. DENV-2 is linked with the highest number of intense outbreaks all over the world followed by DENV-3, DENV-1 and DENV-4 respectively (Fares, Souza, Añez & Rios, 2015). One of the main features of disease management involve maintaining the patient's circulating fluid volume. Therefore, patients are advised to rest and drink plenty of fluids. In order to reduce fever and decrease joint pains, patients are advised to take paracetamol. Ibuprofens should be avoided because they can escalate the risk of bleeding (WHO, 2016).

### **Brazil at Risk**

The global dengue pandemic has grown very fast in recent decades. One of the reasons for this is the probable ecological changes that favor the geographical expansion and increase in density of the vectors or mosquitoes. This significantly increases the susceptibility of a large number of people towards this disease. The mobility of these susceptible individuals creates conditions that facilitate the distribution of the virus. Population growth, urbanization, poverty, and health inequality are some other factors that contribute to the occurrence and recurrence of dengue. There has been a drastic increase in the number of cases of dengue and severe dengue all

over the world. Among the countries of the Southern cone, Brazil recorded the highest incidence rate of dengue among its population in 2014. Moreover, Brazil is a tropical country where the climate is hot and humid, which is extremely favorable for the proliferation of *Aedes* mosquitoes. This also makes the people of Brazil more prone to dengue (Fares, Souza, Añez & Rios, 2015).

According to a study there has been an increased number of cases of symptomatic dengue fever among the inhabitants of the poor urban slum community of Salvador, the third largest city in Brazil. Poverty struck slum communities have environmental features, such as the presence of refuse deposits, improper sanitary infrastructure and contaminated containers for water storage. These characteristics facilitate *Aedes spp.* breeding, thus increasing the risk of getting an infection. Furthermore, poor geographical access from slums to health care services also acts as an obstacle in proper diagnosis of the disease, leading to fatalities (Kikuti et al., 2015).

Brazil's urbanization has also created conditions that facilitate the breeding of *Aedes* mosquitos. Industries produce vast amounts of disposable material and there is inadequate distribution of water. Also, public garbage collection and inadequate garbage disposal promotes the existence of small water reservoirs which serve as breeding sites for mosquitos. Urbanization has also increased the frequency of private and public transportation, which has increased the migration and commuting of people and goods from one place to another. This has increased the probability of dispersion of the disease (Dallmann, 2015).

Thus, there are several risk factors which have contributed to the increased susceptibility of the inhabitants of Brazil towards dengue fever. These factors include tropical climate and high population density. Precarious socioeconomic status, lack of infrastructure, and improper sanitation in the slum areas makes the poor people more prone to the disease. Further, even

though there has been increased urbanization, improper waste disposal and inadequate water supplies in the urban regions still pose risks of acquiring an increased number of infections. The number of people in Brazil getting infected by DENV are increasing every year. Therefore, dengue fever has a very substantial socioeconomic effect on Brazil.

### **Dengue's Socio-economic Impact on Brazil**

Dengue fever is one of the most serious endemic diseases of the tropical and sub-tropical regions. Brazil is a hotspot for this disease. The effect of dengue and dengue hemorrhagic fever in Brazil is massive, placing an enormous economic burden on the country. Massive amounts of investments are made by the government, households, employers, and the insurance companies to support the healthcare systems so that they can effectively treat the infected populations to compensate for the loss of productivity. Infected individuals are unable to maintain their normal daily routines. They are unable to work, children miss out on their studies, and tourists tend to avoid places popular for dengue outbreaks. As Brazil is a developing country, all of these factors exemplify a substantial financial drain on already limited resources (Pasteur, 2012).

There has been a dramatic increase in the number of symptomatic cases of dengue in the Americas over the last few decades. A significant amount of these cases are severe enough to require hospitalization. Approximately 40% of these cases have occurred in Brazil. There is significant expenditure of resources in the healthcare system where the healthcare staff at clinical levels work in diagnostic laboratories and on epidemiological assessment and prevention. The average cost of treating a patient suffering with dengue fever is quite substantial. The economic burden of dengue illness across the Americas is approximately US\$2.1 billion per year with Brazil being responsible for about 40% (US\$0.8 billion) of these costs (Martelli et al., 2015). Most cases of dengue illness do not require hospitalization but the patients are encouraged to



seek medical help for proper diagnosis and disease monitoring. During the time of an outbreak, the inflow of patients puts additional strain on the healthcare system. The non-hospitalized patients are accountable for almost three quarters of the total healthcare expenditure. Thus, even mild to moderate cases of dengue fever lead to considerable financial strain and drain the healthcare resources (Pasteur, 2012).

The economic impact of dengue in Brazil is not confined to just medical-related costs. Approximately 60% of the dengue-related expenses are indirect costs due to productivity losses that are not directly related with healthcare expenditures. Common sources of indirect costs include loss of productivity due to severe illness or premature death and decline in outputs from industrial and service sectors. The industrial workers who are suffering with dengue fever are unable to work. Even if these workers are not affected, they may have to stay at home to take care of their children or relatives who are suffering with the illness. This affects both household incomes and the employers putting their businesses at stake. All of these factors in turn influence the national economy to a great extent (Shepard, Coudeville, Halasa, Zambrano & Dayan, 2011). Another indirect economic expense of dengue fever is its impact on the tourism industry in Brazil. The economic impact of dengue on Brazilian tourism is difficult to quantify. Rio de Janeiro in Brazil is one of the most profitable tourist attractions, therefore because of international travel and trade, dengue fever is becoming an increasingly common viral disease among visiting tourists. Many countries issue dengue fever warnings for travelers to areas where the disease is endemic, which has a negative impact on various regions of Brazil that rely on tourism to sustain their local economy (Pasteur, 2012). Moreover, since there is no proper treatment or vaccination available yet, controlling the breeding of the *Aedes spp* mosquitoes, or vector control, is the only strategy available to alleviate

the spread of this disease. Vector control techniques also lead to considerable financial drain and substantially impact the national and global economies (Shepard et al., 2011). A significant amount of funds are allocated towards various vector control techniques. Brazil spends an overwhelming amount of US\$ 1.2 billion every year on vector control on top of the direct healthcare and indirect costs (Pasteur, 2012). Thus, the total economic consequences of dengue are extremely alarming.

Lastly, the incidence of dengue significantly deteriorates the quality of life of the affected individuals and their families. According to a survey conducted by WHO, the various impairments associated with dengue fever among infected individuals include decline in cognitive and interpersonal activities, low levels of energy, loss of sleep, decreased mobility and self-care, pain, and discomfort. Most people perceive their health as good or very good before an incidence of dengue fever. However, after a severe episode of dengue, most patients report a lowered health status and an increased dependence on their family for care and support. Also, the long term effects of dengue include depression and anxiety, usually because of decreased quality of life. Various patients self-rate their general health as bad or very bad even after several days of hospitalization and disease management. According to an investigation, the adults and adolescents suffering with dengue fever in Brazil generally report a poor quality of life during an episode of dengue (Martelli et al., 2011). Furthermore, when the livelihood of people is threatened by dengue outbreaks, the vulnerable population engages in a wide variety of coping mechanisms. These include spending their savings, selling their assets, diversifying their income to reduce risks and alleviate the immediate effects of lost income. However, when these strategies fail people become more vulnerable to external shocks and stresses, increasing their

likelihood of getting another infection, which will impose additional social and financial burdens on them (Chang, Fuller, Carrasquillo & Beier, 2014).

### **Discussion**

Dengue is a fast emerging pandemic-prone viral disease in Brazil. This disease puts an enormous socioeconomic burden on the affected communities. The affected families and communities suffer loss of lives, loss of income because of loss of work, overwhelming medical expenses for hospitalization and disease management, extensive expenditures for community programs for mosquito control and negative impacts on local economy due to loss of tourism. Therefore, it is crucial for the Brazilian government and international decision makers to have a clear understanding of the negative impact of dengue on national and global economies. They need to continue to remain highly involved in the process of better management of this disease in order to reduce its social and economic burden on society.

There is no safe and effective vaccine available for dengue currently available. The control of infections caused by DENV relies on vector or transmitter control. Various preventative measures have been employed in Brazil, including development and implementation of public awareness campaigns to enlighten the general population about the disease, how it spreads and how standing water acts as a breeding site for the mosquitoes. All of these measures are aimed at reducing the breeding sites of the mosquitoes in order to decrease spread of the disease. The healthcare providers of the country are also provided with special training to improve the early diagnosis and treatment of severe dengue in order to avoid fatalities caused by the disease (Fares et al., 2015). Educating the general population about the ways in which they can protect themselves from acquiring a dengue infection is also of utmost importance. WHO also

encourages various individual and household protection techniques for the inhabitants of Brazil. These include wearing clothing that minimizes skin exposure during outbreaks, insecticide treated mosquito nets, using mosquito repellents and window and door screens to reduce biting. Environmental management is another step towards vector control. This involves manipulating or modifying the environment to prevent or reduce mosquito reproduction and to reduce human contact with mosquitoes. Various methods that have been employed or are being encouraged include installation of a dependable piped water supply to communities, frequent emptying and cleaning of water storage vessels, and the proper storage, collection and disposal of waste (WHO, 2016).

A new biological vector control strategy has been established. According to this strategy, *Wolbachia* bacteria is introduced into the target vector populations. The mosquitoes that are exposed to this bacteria upon getting infected by DENV after biting a human infected by the virus are unable to transmit the virus. On the downside, only a few strains of the *Wolbachia* bacteria can inhibit the transmission of DENV, and the bacteria cannot provide complete protection against the viral infection. This *Wolbachia* based technique can be boosted if it is used in combination with other vector control techniques (Araújo, Carvahlo, Ioshino, Costa-da-Silva & Capurro, 2015). Another vector control strategy known as genetic strategy has been recently employed by the biotechnology company Oxitec. According to this strategy, genetically modified or transgenic mosquitoes are released to decrease the amount of wild mosquitoes. These transgenic mosquitoes are sterile male mosquitoes which then mate with female mosquitoes and reduce the fertility of the female mosquitoes. Since female mosquitoes are the target vectors, decreasing their reproduction further reduces the insect population, which in turn reduces the mosquito-borne transmission of the virus. Both of these strategies are very

reassuring, but more research needs to be done in this field to ensure that implementation of these techniques is safe and effective in the long run (Fares et al., 2015).

Various dengue vaccines are in the developmental stages. National and international efforts are being employed in order to create a safe and effective vaccine. The major hurdle in the way of developing a safe and effective vaccine is to create a tetravalent vaccine that could generate immunity against all four DENV serotypes. The main reason behind this is that immunity against one of the serotypes does not provide immunity against the other DENV serotypes. Moreover, recovery from a dengue infection caused by one DENV serotype increases the likelihood of developing severe dengue fever on encountering another DENV serotype. Several vaccines are being examined in clinical trials and a safe and effective vaccine may be potentially available in a few years. Once available, vaccination may be an affordable and cost effective solution to fight against dengue. According to a recent study in Brazil, even at lower efficacy, vaccinations are extremely cost effective. The total vaccination cost is lower than the significant amount of money that is spent every year on the various disease management techniques (Fares et al., 2015).

Moreover, the Brazilian government should initiate a thorough monitoring and evaluation strategy which can be used to assess the effectiveness of the various disease management techniques. The government should also keep track of the spread and impact of the disease over different periods of time. Effective disease surveillance is essential and therefore, the Brazilian government should closely observe the trends of incidence. This information can help assess the possibility of future outbreaks, which is necessary to initiate timely and effective disease control measures. Also, the impact of the various vector control techniques should be monitored so that these techniques can be improved from time to time (WHO, 2016).

As discussed earlier, the socioeconomic impact of dengue is tremendously overwhelming. The Brazilian government and various international organizations are making countless efforts to manage this disease, but these efforts are not sufficient. In our opinion, the public health workers and the general population of Brazil should also adopt a proactive attitude towards accurate identification and elimination of various vector breeding sites. They should monitor the sites of standing water around their houses, which are potential mosquito habitats. Public involvement in vector control strategies is necessary in order to reduce mosquito breeding sites which will lower the mosquito population. The local communities should combine their efforts to reduce waste and also encourage appropriate waste removal. This also reduces the breeding sites, further decreasing the population density of the mosquitoes. Public health workers should also try to improve the sanitary conditions, particularly in the rural areas. They should encourage healthy behavioural practices among the general population, such as frequently cleaning water storage vessels to avoid contamination. Thus, public awareness about the disease is necessary as it empowers the people to be actively involved in the process of disease management. Public involvement in vector control will further support the Brazilian government to accomplish effective and sustainable disease prevention. This in turn will reduce the colossal disease burden of dengue on Brazil.

Thus, successful solutions to combat this disease involve interdisciplinary approaches that consider the pathogen, vector, host, and environmental elements that are responsible for the increasing incidences of dengue fever. Collaborative efforts of the Brazilian government, local communities, and the general population are required to combat this disease.

## Conclusion

Dengue is considered one of the most important mosquito-borne viral diseases in the world. It continues to pose a significant threat to the population of Brazil. Dengue fever is accountable for the pain and suffering among the individuals affected by the disease. Treatment, management, and prevention of dengue imposes a significant economic burden upon the communities and the government of Brazil. Various risk factors increase the susceptibility of the people of Brazil towards acquiring dengue infections. Since the development of vaccines is still in progress, vector control is the only effective measure that should be employed to reduce the spread of the disease. Large-scale structural improvements within the public health care system and implementation of effective healthcare interventions are necessary to address the national and global intensification of dengue fever (Fares et al., 2015). The combined efforts of the Brazilian government, local communities and various international organizations are required to fight against the progression of this tropical disease.

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