COLUMBIA UNIVERSITY – EXECUTIVE EDUCATION

GROUP: HEALTH AND BIG DATA

ACCELERATING DENGUE FEVER OUTBREAKS DETECTION AND ACTIONS

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1. INTRODUCTION

The city of Rio de Janeiro is the second largest brazilian city and third in Latin America. It covers 1,182.296 km², having almost 6.5 million inhabitants and counts with 194 primary care health units. There are 160 neighborhoods in Rio de Janeiro. They are combined into groups which form the 5 Planning Areas (AP) of the city, for administrative purposes and to facilitate the actions of the government in the different territories: AP 1, AP 2, AP 3, AP 4 and AP 5. The APs are then split in sub areas of planning (for example, AP 2.1).

1.1. Unified Health System and Rio de Janeiro's Secretariat of Health

In 1988, half of Brazil's population had no health coverage. With the constitutional reform that set up the Unified Health System (SUS), 30% of the budget set aside for social security was to be allocated to health care. States are required to allocate a minimum of 12% of the total budget to health while municipal governments must spend 15% of their budget on health. In 2007, it raised approximately US$ 20 billion.

SUS is based on three principles: universality, equity, and comprehensiveness. Despite the various financing issues, there have been significant improvements in health-care outcomes in Brazil. Just to have an overview about the importance of this system, two decades after established its Unified Health System, more than 75% of the country's estimated 190 million people relied exclusively on it for their health care coverage.

The Health Department is responsible for plan, organize, control, and execute the health actions and services.

1.2. Dengue Fever – Historic and Today's Scenario

During the 19th century, dengue was considered a sporadic disease that caused epidemics at long intervals, a reflection of the slow pace of transport and limited travel at that time. Today, dengue ranks as the most important mosquito-borne viral disease in the world. In the last 50 years, incidence has increased 30-fold. An estimated 2.5 billion people live in over 100 endemic countries and areas where dengue viruses can be transmitted. Up to 50 million infections occur annually with 500,000 cases of dengue haemorrhagic fever and 22,000 deaths, mainly among children[1].

Dengue and haemorrhagic dengue fever (DHF) are present in urban and suburban areas in the Americas, South-East Asia, the Eastern Mediterranean, the Western Pacific and mainly in rural areas in Africa. Several factors have combined to produce epidemiological conditions in developing countries in the tropics and subtropics that favour viral transmission by the main mosquito vector, Aedes Aegypti: rapid population growth, rural-urban migration, inadequate basic urban infrastructure (eg. unreliable water supply leading householders to store water in containers close to homes) and increase in volume of solid waste, such as discarded plastic containers and other abandoned items which provide larval habitats in urban areas. Geographical expansion of the mosquito has been aided by international commercial trade particularly in used tyres which easily accumulate rainwater. Increased air travel and breakdown of vector control measures have also contributed greatly to the global burden of dengue and DHF.

Dengue fever is a potentially deadly tropical infection with symptoms that range from a mild fever to severe headaches and muscular pain. Although reported cases of dengue fever are increasing worldwide, some countries have experienced particularly sharp rises in the number of people becoming infected by the virus, which is spread by mosquitoes. In Brazil, dengue fever has become the country's fastest-spreading disease, and families living in the poorest regions are often at the highest risk.

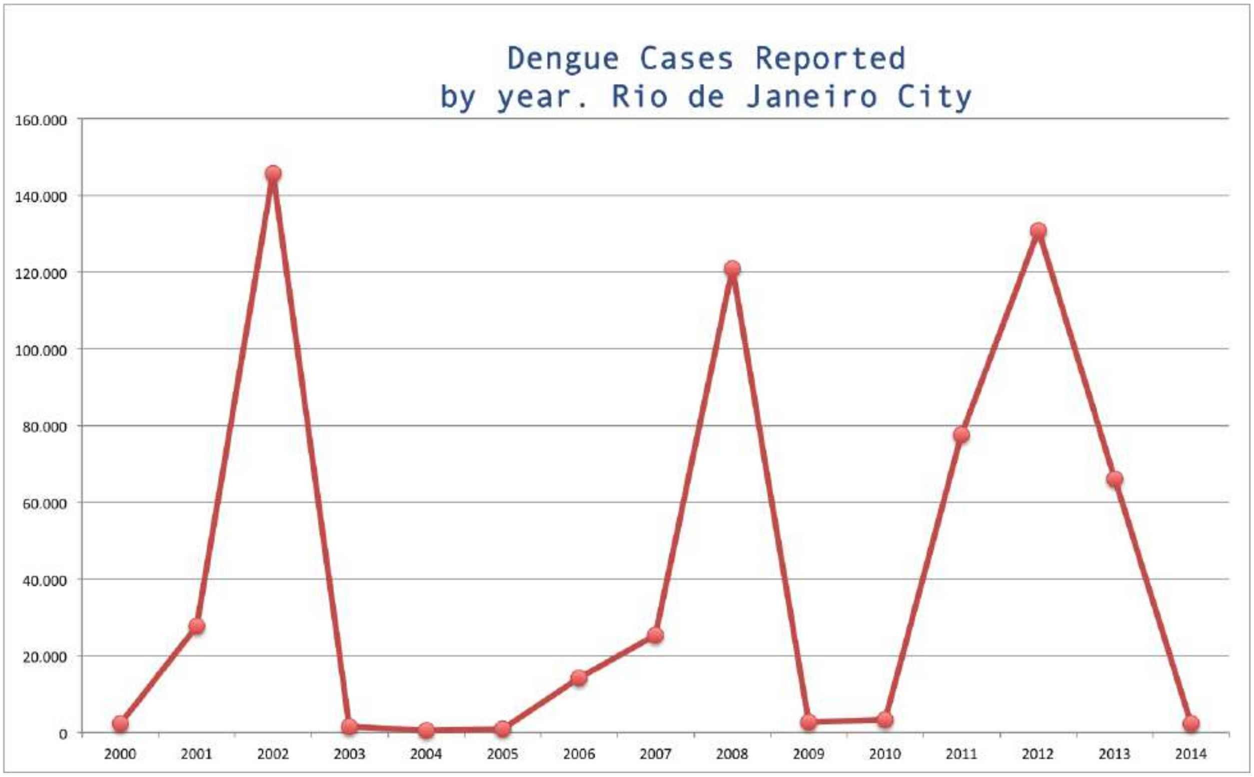
Cases of dengue fever in Brazil have risen considerably during the past 23 years. In 1990, there were approximately 78,000 cases of dengue fever reported across Brazil. By 2010, more than 980,000 cases were reported, and in January and February of this year alone, there were 200,000 reported cases of dengue fever in Brazil. In Rio de Janeiro, the first major outbreak took place in 2002. Since 2000, the city surveillance system has been monitoring this issue based on cases reported (fig. 1). Because of its structure, the surveillance system has a delay between the clinical identification of the case and its official inclusion as a reported case. This gap has been reduced but it is still around two weeks. The outbreaks are a huge burden to the health system and the mortality rate is directly dependent on the promptness and efficiency of the response. The health department has always struggled to define the perfect timing to trigger the

[1] Font: World Health Organization – WHO.

contingency phase of the dengue plan. This decision implies in a large sum of investments and mobilization of many professionals to cope with the epidemic period.

For instance, in 2014, a year of low Dengue activity, $120 million were spent by the Ministry of Health in Brazil. The Health Department of Rio spent $5 million.

FIGURE 1 – Dengue cases reported to the Rio de Janeiro Surveillance System by year



Source: Sistema de Informação de Agravos de Notificação – SINAN (Information System of Disease Notification)

1.3. Dengue Fever Alert System

Because it is a virus disease disseminated through a mosquito (Aedes aegypti) and have not, to date, vaccine, the only weapons available are the measures involving vector control. Still, because of the urban characteristics described above, the success of measures to combat the mosquito will only work with the involvement of the population adequately instructed.

Communication with over 6 million inhabitants as well as the City Hall checking of more than two million households are impressive challenges for the government. In this context, it becomes essential to adopt tools that anticipate the likelihood of increased disease transmission as well as the area of the city in which it is most likely. This was the primary goal of the partnership between Fundação Getúlio Vargas, Fundação Instituto Oswaldo Cruz, Universidade Federal de Minas Gerais, Universidade Federal do Paraná, Pensa – Sala de Ideias da Prefeitura do Rio de Janeiro and Secretaria Municipal de Saúde of Rio Janeiro, developing a system for early detection of outbreaks of Dengue, using hybrid data of Social Media (Twitter), Epidemiology and Temperature.

This partnership consists on the collaboration between four universities/research centers; and two agencies of the Municipality: the Health Secretariat and the Secretariat of Government, represented by Rio's Big Data Team.

The idea of developing the Dengue Alert System was based on a paper published in the scientific magazine Nature, in 2008: *Detecting influenza using search engine query data*. In this study, Google queries were used to faster detect influenza growth across the globe.

Using a similar principle, the Dengue Alert System uses Twitter Data combined with other variables to accelerate the prediction and detection of Dengue Fever Outbreaks. It can be accessed on http://alerta.dengue.mat.br.

A very important fact to highlight is the Municipality of Rio de Janeiro is the first city to have such system and this present work comes in a very good moment, where the discussion on how to use this technology into the public health administration is starting. And, by having four members of the Health Secretariat on this group – including the sponsor of the project -, this work's conclusions will be implemented in the routine of the Secretariat and the city.

To construct the model, it was observed a close correlation between the activity in the "Tweets" for "Dengue" and the number of cases reported.

FIGURE 2 – Correlation between the activity in the "Tweets" for "Dengue" and the number of cases reported

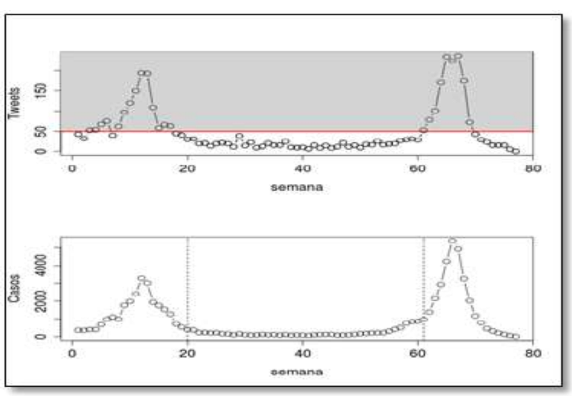


FIGURE 3 – Number of cases reported by 1746 Central, since 03/2011

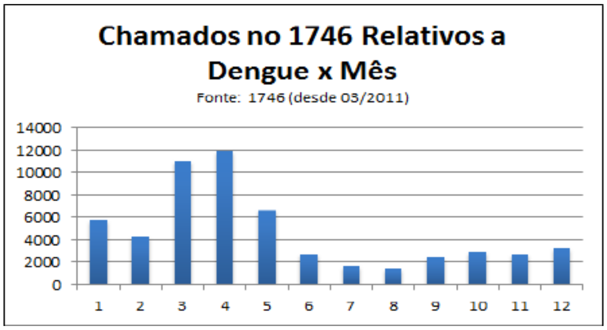


FIGURE 4 – Number of confirmed cases of dengue in Rio de Janeiro, from 2012 to 2013

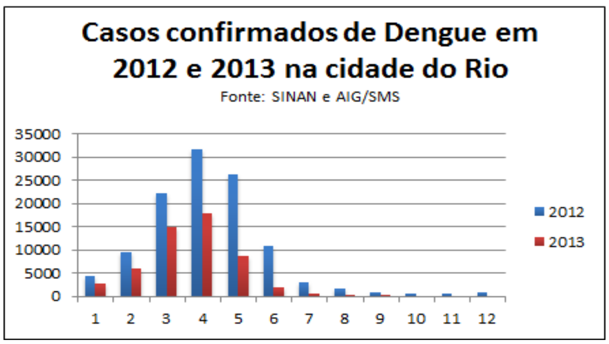
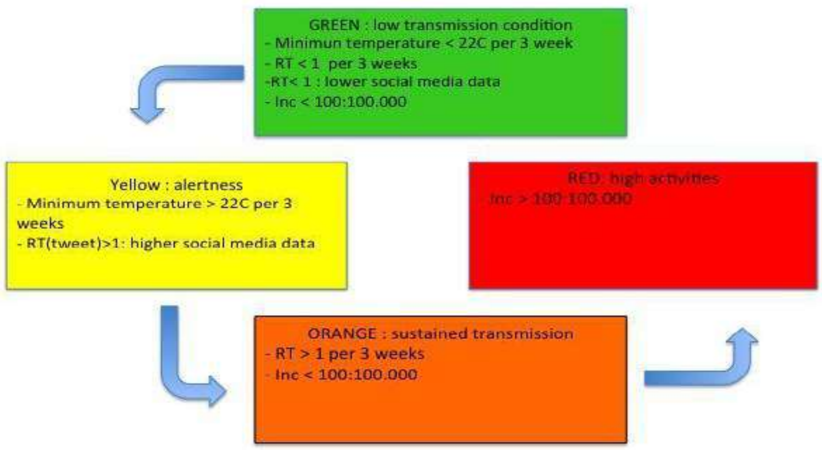


FIGURE 5 – Research on Google about Dengue, per month, in Brazil, since 2011

Temperature rise as well as the existence of minimum rainfall are the conditions needed to ensure sustained transmission of Dengue. Therefore, for the construction of a predictive algorithm for an outbreak, were incorporated into the model the number of georeferenced cases already reported (SINAN), weather conditions (temperature) and activity on Twitter. As a result, each sub-planning area of the city receive a different color of risk alert:

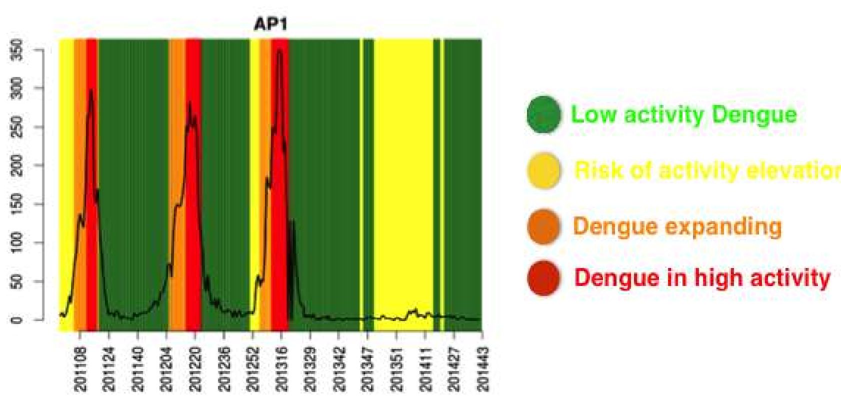
- GREEN: conditions of low transmission
- YELLOW: alert condition
- ORANGE: sustained transmission
- RED: high activity

FIGURE 6 – Color Decision Model



The model was tested through retrospective application to prior years, when three outbreaks occurred in Rio de Janeiro City. In the figure below, there is the pattern of alertness and sustained transmission in the weeks before the high activities in 2011, 2012 and 2013.

FIGURE 7 – Pattern of Alertness and Sustained Transmission in the weeks before the high activities in 2011, 2012 and 2013

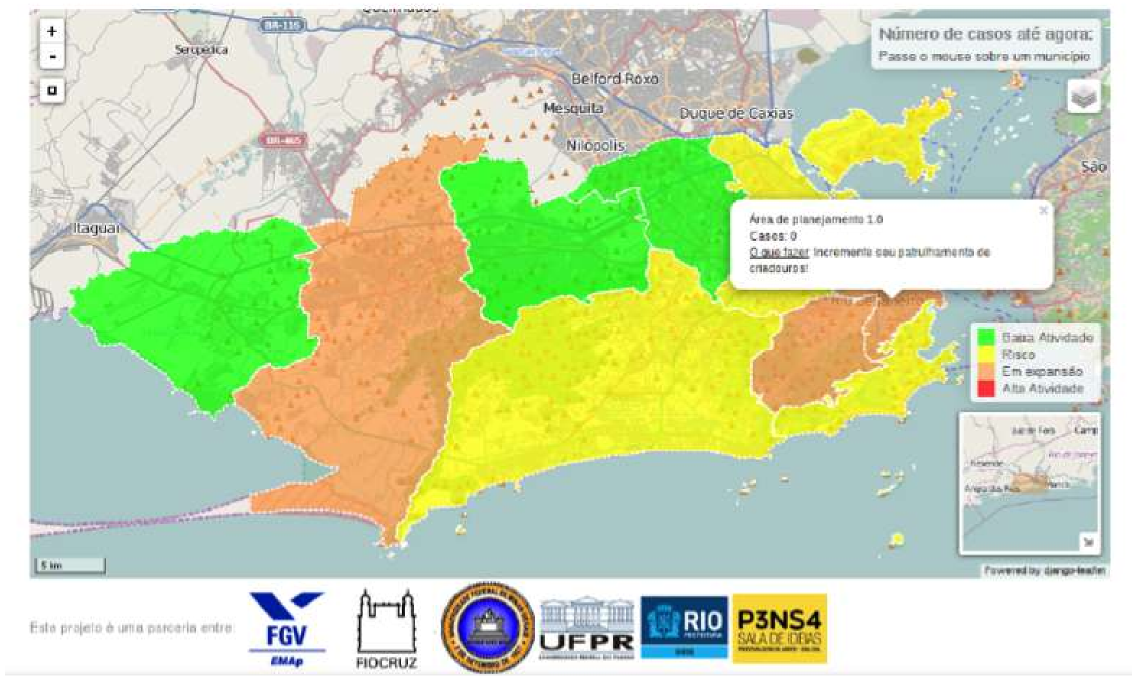


The temperature data is collected from the weather stations on the four airports in Rio de Janeiro. It is collected thru an Application Programming Interface (API) from the website www.weatherunderground.com.

The Twitter data is obtained thru an API from the project Observatorio da Dengue, that has been collecting data from this social media since 2010. The tweets are considered in the municipality level, which means that there is not the possibility to know the activity by AP specifically.

The Dengue confirmed cases comes from SINAN and, by having address, is the most accurate data, in terms of georreferencing.

FIGURE 8 – Example of online Dengue Alert Map, by Planning Areas (APS)



2. OBJECTIVES

This work aims to develop and describe the practical application of Dengue Alert System by the Municipal Health Secretariat of Rio de Janeiro to use the "Alerta Dengue" in order to help and improve the following issues:

i. define the allocation of efforts to vector control;
ii. direct communication messages and mobilization activities;
iii. increase community awareness about the risks and their role in preventing the transmission;
iv. orientate the intersectorial effort, like the garbage collection, in different neighborhoods;
v. provide transparency to the population.

It is expected that the use of this tool will contribute to the management of dengue issue, assisting in anticipation of the measures to be taken. Therefore, the next session will address the methodology to be adopted for achieving the objectives set.

3. METHODOLOGY OF ACTION

Clear coordination, planning and intelligence are keys to deal with the complexity of Dengue fever outbreaks, as an enourmous public health issue it has implications including the political dimesion and midia repercution.

Every year the Health Department operates a Dengue Situation Room (DSR), usually starting in October running throughout the hot season until March/April. The level of risk or occurrence of outbreak defines the meetings frequency.

The "alerta dengue system" will be incorporated as an analytic tool, combined with other traditional measures to orientate the prevention and health care actions. This will give us an opportunity to validate the system prospectively as it current validation was on previous data. As mentioned before, the georeference tool will help to deploy resources in risk areas and the follow up will give us an indicator of the effect of this data centered regionalized strategy.

High rank health officials from all the undersecretaries and the communication and press department, attend the DSR to coordinate the response. Decisions made in the DSR are communicated to the ten different Area Coordinators (AC) that operates the action in the ground. The data from the DSR, from the ten areas, are discussed with the AC comparing their performances and setting goals for the next period. Beneath the ten areas the neighborhoods are subdivided in blocks covered by Surveillance Health Agents (SHA) accountable for each of the microareas, they visit houses, businesses, and closed or abandoned facilities to find and destroy mosquitoes breeding areas. At more advanced phases of the alert system, informed by the DSR, health facilities extend their operational hours and receive extra pesrsonel.

Still considering the incorporation of the system in DSR, other impacts of the use of this new tool are:

i. **To set priority areas for actions designed to combat vector** – The predictive power of the model indicates the priority areas for actions to combat the vector and for the development of the socio-educational measures. Here we find great similarity to the established model of "Compstat" in New York, directing the preventive actions of the NYPD to the regions with the highest incidence of crimes;

ii. **To communicate with citizens** – Access to the system via the web will serve as an important tool of communication with the population of Rio de Janeiro City, pointing them the risk situation of their region as well as suggesting measures that should be adopted. The platform even indicates the location of the existing health units in the area. As an evolution, maybe the Secretariat of Health could send text messages when the alert is critic.

Besides this, communication from the DSR also goes up in the hierarquical chain with reports to the Health Secretary and the Mayor.

The overall goal of the Dengue alert System is to enhance and abbreviate risk detection impacting on dengue transmission (incidence), morbidity and mortality.

4. EVALUATION AND MONITORING

Certainly, the long term goal of applying Dengue Alert is to reduce the incidence of disease in the population of Rio de Janeiro. This is a late goal and influenced by many factors. The specific effects of Dengue Alert System are difficult to isolate.

Moreover, we believe that indicators that measure specific actions to combat Dengue can be extremely useful for the evaluation and monitoring of the model. Therefore, to evaluate the immediate impact of the system, we intend to quantify the various actions for the combat of Dengue that were oriented by Dengue Alert. Some potential indicators are:

i. **Correlation between the total amount of actions against Dengue and the risk level (color) in each territory** – It is expected that a greater number of actions occur in areas with higher risk of transmission (red and orange);
ii. **Health Promotional activities oriented by Dengue Alert** – Both the amount of promotional activities such as the correlation of this number and risk level in each territory will be monitored;
iii. **Activities of vector combat oriented by Dengue Alert** – Both the amount of vector combat activities such as its correlation with territory risk level will be monitored.

In summary, we expect a strong correlation between the amount of Dengue combat action and the risk level set by Dengue Alert in each territory of the Rio de Janeiro City.

5. FOR THE FUTURE

As the system is being used for the first time, it is assumed that some points can be further developed and the system improved, both in its use and in its operation. The next three sections will present some possibilities.

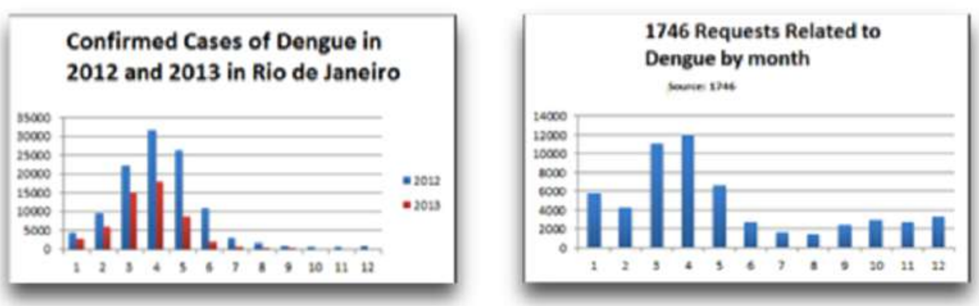
5.1. Accountability

Adding to the model a component of feedback to the educational activities and especially for control actions is a way of improving the accountability of the use of the system.Teams involved in educational activities and teams responsible for mosquito control will check their actions in an established mechanism so that the location of their activities will be plotted in the same risk map.

5.2. Incorporation of new variables

Rio de Janeiro City has a call center system similar to 311 of New York. It is called 1746 and was designed to include a dedicated space for complaints about probable focus of mosquitoes. We believe that the incorporation of georeferenced requests to the model could increase the predictive value of the algorithm. Indeed, there are indications of correlations between 1746 calls and confirmed cases, as it may be seen in the figure 5.

FIGURE 9 – Confirmed Cases of Dengue X 1746 Requests Related to Dengue by month, in Rio de Janeiro



Likewise, the popularity of Facebook indicates another valuable source for assessing the level of activity of the Dengue issue. Wikipedia has also some studies that show correlation between the queries on it and health issues. It has an opened API, so it might be another good source of data.

The majority of ERs in the city is operated by the municipality and use electronic medical record (EMR), real-time data from the units about fever or other symptoms could also be monitored to track changes in the patterns allowing for early action.

There are other variables that could be tested in this model, like rain precipitation and data about the mosquitos trap (ovitraps) that have been tested to recuperate eggs that are examined to determine if they are infected with the virus.

5.3. New applications

The "Alerta Dengue" system could be adapted to other transmissible diseases based on different parameters. Brazil is now monitoring the advance of Chikungunya virus in its territory, local transmission has already been confirmed, and as the local population has no immunity to this disease an outbreak is a real threat. As the globalization imposes new challenges for the health in big cities the use of big data could be a powerful ally for planning and timely response.

6. CONCLUSION

Definitively, dengue fever is an issue to be faced by governments in areas affected by this illness, such as Americas, South-East Asia, Eastern Mediterranean and others. Because of its potential lethality, as soon as people know they are sick, the greater the chances of recovery. In adition, to the government is extremely important to monitor the situation of dengue in its territory, since it needs to act fast, involving many sectors of government, and society.

The adoption of Dengue Fever Alert System came to improve Health Secretary's management capacity focused on this theme, making it more accurate and swift action. Furthermore, it will provide better communication with citizens, allowing it to have a more effective participation in the fight against dengue.

Finally, beyond this system it is a great innovation, having been built on a partnership between government and academia and using the concept of "big data" to generate information, one of his most important points is the potential for use. Not only to help fight dengue, a topic that may have even better results with the system improvement, but it can be adapted or serve as inspiration for many other approaches in health.

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