The Epidemiologic Surveillance of Dengue-Fever in French Guiana: When Achievements Trigger Higher Goals

Claude FLAMAND[a,1], Philippe QUENEL[a], Vanessa ARDILLON[a],
Luisiane CARVALHO[a], Sandra BRINGAY[b,c], Maguelonne TEISSEIRE[d]

[a] *Cellule de l'Institut de Veille Sanitaire en Région Antilles-Guyane*
[b] *Départment MIAp, University Paul-Valéry, Montpellier 3*
[c] *LIRMM, CNRS, UMR 5506, Montpellier 2*
[d] *TETIS Laboratory Départment of Information System*

Abstract. The epidemiology of dengue fever in French Guiana is marked by a combination of permanent transmission of the virus in the whole country and the occurrence of regular epidemics. Since 2006, a multi data source surveillance system was implemented to monitor dengue fever patterns, to improve early detection of outbreaks and to allow a better provision of information to health authorities, in order to guide and evaluate prevention activities and control measures. This report illustrates the validity and the performances of the system. We describe the experience gained by such a surveillance system and outline remaining challenges. Future works will consist in the use of other data sources such as environmental factors in order to improve knowledge on virus transmission mechanisms and determine how to use them for outbreaks prediction.

Keywords. Dengue Fever, Epidemiologic Surveillance, Vector-borne disease, Infectious disease, Public Health Surveillance, French Guiana

1. Introduction

One of the main objectives of infectious disease surveillance systems is to provide early warning of disease outbreaks to those who can take appropriate response. In the last decade, the critical need for better surveillance became more urgent with the threat of bioterrorism, the recognition of the potential for an influenza pandemic [1] and the emergence or reemergence of infectious diseases in some regions of the world such as the introduction of West Nile Virus in the United States, the Chikungunya in Reunion Island or cholera in Haïti. Dengue virus, which is most commonly acquired through the bite of *Aedes aegypti* mosquito, is the most important mosquito-borne viral disease affecting humans [2]. This infection is caused by an arbovirus of the *Flaviviridae* family. There are four viral serotypes designated as DENV-1, DENV-2, DENV-3 and DENV-4. The infection produced a spectrum of clinical illnesses that ranges from an influenza-like illness to potentially fatal dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS), encephalitis or hepatitis. Despite the current development of

---

[1] Claude Flamand, Epidemiologist. Cellule de l'Institut de Veille Sanitaire en Région Antilles-Guyane. E -Mail: claude.flamand@ars.sante.fr

several dengue vaccines [3], no vaccine and no curative treatment are available for the moment. So the strategies of prevention are limited to vector control and treatment strategies are limited to supportive care aiming at avoiding shock [4]. French Guiana is a 200,000 inhabitant's French overseas department located in South America. Tropical vector-borne diseases such as dengue fever are responsible for disease outbreaks. Since 2006, a multi-source surveillance system, coordinated by the *Cellule de l'Institut de Veille Sanitaire (InVS) en Regions Antilles-Guyane (Cire AG)* was implemented to monitor dengue fever patterns, to improve early detection of outbreaks and to allow a better provision of information to health authorities to guide and evaluate prevention activities and control measures. The aim of this paper is to describe the experience gained by such a surveillance system and to outline remaining challenges.
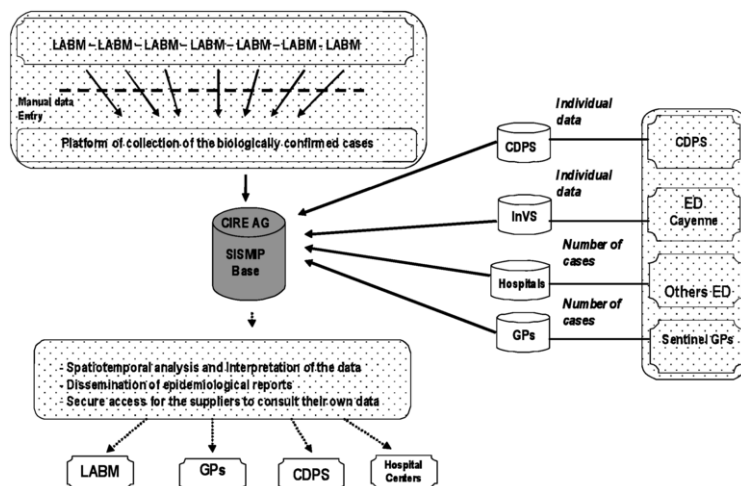

Figure 1. Global architecture of the surveillance system

2. Materials and Methods

2.1. General Description of the Surveillance System

The surveillance system integrates health information from multiple data sources, located on the coast and in the inland of French Guiana (Figure 1).

1. *Biological laboratories (LABM):* From 1991 to 2004, the surveillance system was based on the weekly surveillance of cases diagnosed by the French National Reference Center (NRC) for Arbovirus and Influenza virus, based at the *Institut Pasteur de Guyane* in Cayenne. From 2004 to 2006, the number of laboratories able to perform the biological confirmation of dengue gradually increased up to 7 laboratories distributed on 5 municipalities located on the coast in the northern part of the country. The definition criteria are virus isolation, viral RNA detection by reverse transcription-PCR (RT-PCR), or the detection of secreted NS1 protein or a positive serological test based on immunoglobulin M (igM)-capture enzyme-linked immunosorbent assay (MAC-ELISA) [5; 6].

2. *Sentinel network:* In 2006, a sentinel network composed of 30 voluntary general practitioners (GPs) located in the coast (representing around 35% of total GP's

activity) was implemented to collect clinical cases. A clinical case of dengue fever was defined by the occurrence of fever (equal to, or more than 38°C) with no evidence of other infection and associated with one or more non-specific symptoms including headache, myalgia, arthralgia and/or retro-orbital pains. Every week, public health nurses of the Health Regional Agency (ARS) surveillance unit call the sentinel GPs to collect the number of cases seen during the previous week. The weekly incidence of dengue fever in the coast area is estimated using the ratio of all GPs to participating sentinel GPs.

3. *Hospital Centers:* Since 2006, surveillance from Emergency Departments (EDs) of the three hospitals in French Guiana was set up to collect ED visits for "isolated fever" or "suspicion of dengue". Furthermore, InVS set up a volunteer surveillance network of hospital EDs to collect data on a daily basis [7]. For each patient, age, gender, zip-code, reason for admission and main medical diagnosis based on the 10th edition of the International Classification of Diseases (ICD-10) are collected. Since 2008, the Hospital of Cayenne, the main city, is connected to this network and enables the monitoring of ED activities related to dengue fever medical diagnosis. Follow-up of hospitalized cases of dengue was also set up to monitor the severity of the epidemics.

4. *Health Centers (CDPS):* The health care system in isolated territories of French Guiana is based on 17 Health Centers, which are remotely coordinated by the hospital center of Cayenne. Since 2006, a surveillance system based on a data transmission by satellite connection enables the Cire AG to collect, from each center, the weekly number of suspected cases of dengue, following the same criteria as sentinel GPs.

2.1.1. Data Analysis and Statistical Methods

Data have been monitored from January 2006 to December 2010. An analysis system using the Shewhart Control Chart based on moving ranges (MR) [8] was implemented to allow a continuous real-time assessment aiming at early outbreak detection. This analysis compares the weekly number of reported cases with a control limit calculated on the basis of the average of previous observations and standard deviation estimated by the moving range of size 2. Every week, data were analyzed according to the Program for Surveillance, Alert and Response (PSAGE) for dengue fever. The PSAGE was elaborated in 2008 by a local vector-borne disease committee composed of epidemiologists, biologists, clinicians, entomologists, specialists in charge of vector control. The program aims at specifying the role and the missions of all stakeholders in the integrated vector management, epidemiological surveillance, laboratory diagnosis, environmental management, clinical case management and communication.

Five distinct epidemiological situations have been established:
– Stage 1: Sporadic transmission
– Stage 2: Presence of dengue fever clusters in some areas
– Stage 3: Pre-alert epidemic
– Stage 4: Confirmation of the epidemic
– Stage 5: End of epidemic

For each stage, a commensurate combination of preventive and control measures has been determined. The observations from epidemic periods were excluded from the calculation of the alert threshold. The pre-alert epidemic stage was activated if alert

thresholds were exceeded for two following weeks. We confirm the outbreak if the exceeded thresholds lasted two additional weeks.

Others points brought to the table, such as the significant increase of the positivity rate of biological analysis or the re-emergence of a serotype were used to confirm the entry into the next stage. The end of epidemic stage was announced when the number clinical cases and biological confirmed cases returned under the thresholds.

Table 1. Description of the outbreaks detected from 2006 to 2010, French Guiana

Outbreaks period	Cases (N)		Serotypes	Hospitalization	Deaths
	Clinical cases	Confirmed cases			
W2006-01[2] – W2006-34	15 700	2 300	DENV-2	204	4
W2009-01 – W2009-38	13 900	4 129	DENV-1	241	2
W2009-53 – W2010-38	9 400	2 431	DENV-4, DENV-1	92	1

3. Results

Confirmed and clinical cases were collected and recorded in the database from the 2006 to 2010. Over the study period, 37 812 clinical cases and 10 724 confirmed cases were recorded. The global activity was strongly influenced by the occurrence of outbreaks periods (Figure 2).
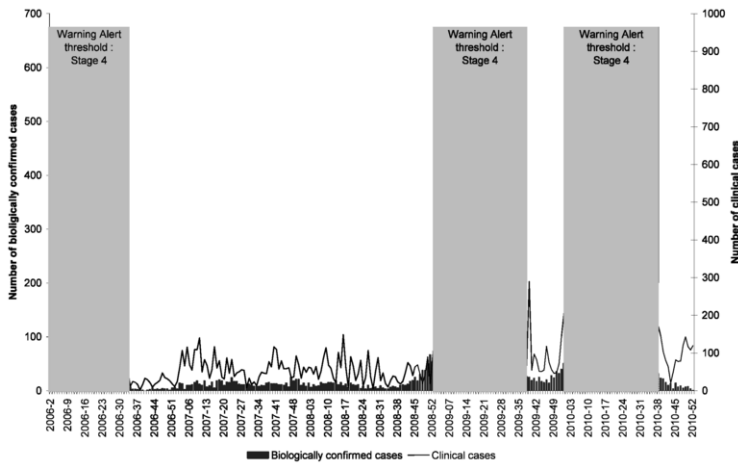

Figure 2. Weekly number of biologically confirmed and clinical cases of dengue-fever and outbreaks periods, French Guiana, January 2006 – December 2010

As shown in Figure 2, three major outbreaks were detected during the study period (Table 1). During these outbreaks, 80 signals were triggered for confirmed cases and 64 for clinical cases. The occurrence of all these outbreaks was confirmed by the vector borne disease committee. The average duration of the epidemics varied between 38 and 41 weeks. According to the PSAGE, health authorities decided upon a reinforcement of collective and individual vector control measures proportionate to the severity and magnitude of the epidemiological situation. Aside from the outbreak periods, 19 and 9 signals were respectively triggered by the control chart for confirmed and clinical

---

[2] The surveillance of biologically confirmed cases allowed identifying the beginning of this outbreak in W2005-48.

cases. While conducting epidemiologic investigations in order to explain these signals, some relevant clusters also happened to be identified in some municipalities.

4. Discussion

The achievements presented in this paper highlight the validity of the surveillance system and its performance to monitor dengue patterns in the whole country of French Guiana, to detect outbreaks and to provide real time information to health authorities. The great variety of data sources constitutes a very sound basis for the analysis and interpretation of the epidemiological situation and an essential tool for decision-making within the vector-borne disease committee. In the future, other statistical methods should be implemented using time-series methodology and taking into account data characteristics such as secular trends, seasonality and abrupt changes. Recent outbreaks showed that the implementation of the PSAGE at a region-wide level was not relevant considering the significant distances between municipalities. Future challenges and developments should focus considering smaller territories by spreading the PSAGE in relevant spatial units. Another major challenge will be outbreak prediction. This step will consist in the use of other data sources for surveillance such as environmental factors (*i.e.* climatic, meteorological, plant cover and land use) so as to help monitor and predict the spatial and temporal distribution of the virus. A research project is now being developed to use an alternative approach as the spatiotemporal data mining. The approach will consist in highlighting the relevant spatial units and the factors which are associated with a subsequent increase of cases. As an example, the project aims at applying data mining algorithms to identify frequent sequential patterns like *< (NDVI ++, Rainfall ++) (BCC ++)>*, which means that the combination of high Normalized Difference Vegetation Index (NDVI) and important rainfalls leads "frequently" to an increase in the number of biologically confirmed cases (BCC) of dengue. We'll follow the spatial and temporal distribution of these sequential patterns to better understand the mechanisms of the virus transmission in order to use them for outbreak prediction.

References

[1] M'ikanatha NM, Lynfield R, Van Beneden CA, De Valk H. *Infectious Disease Surveillance*. Blackwell Publishing. 2007

[2] Gubler DJ. The global emergency / resurgence of arboviral diseases as public health problems. *Arch Med Res* 2002, 334 : 330-342;

[3] Guy B, Saville M, Lang J. Development of Sanofi Pasteur tetravalent dengue vaccine. *Human Vaccin* 2010. 6(9).

[4] Beatty ME, Stone A, Fitzsimons D, et al. Best Practices in Dengue Surveillance: A Report from the Asia-Pacific and Americas Dengue Prevention Boards. *Plos Negl Trop Dis*. 2010. 4(11):e890.

[5] Tran A, Deparis X, Dussart P, et al. Dengue spatial and temporal patterns, French Guiana, 2001. *Emerg Infect Dis* (2004), 10(4):615-621.

[6] Dussart P, Petit L, Labeau B, et al. Evaluation of Two Commercial Tests for the Diagnosis of Acute Dengue Virus Infection Using NS1 Antigen Detection in Human Serum. *PLoS Negl Trop Dis*. 2008.2(8):e280.

[7] Josseran L, Fouillet A, Caillere N, et al. Assessment of a Syndromic Surveillance System Based on Morbidity Data: Results from the Osccour Network during a Heat Wave. 2010. *PLoS ONE* 5(8): e11984.

[8] Montgomery DC. *Introduction to Statistical Quality Control*, 5th ED. John Wiley & Sons, New York, 2005.