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# Constructing a Public Health Information System for Assisting Dengue Fever Control

Patrick S. Chen, Shu-Chiung Lin
Dept of Information Management
Tatung University
Taipei, Taiwan, ROC
e-mail: {chenps, sclin}@ttu.edu.tw

WeiHeng Lin
Dept of Information Management
Tatung University
Taipei, Taiwan, ROC
e-mail: weiheng.lin@hltech.com.tw

***Abstract*—Dengue Fever has been threatening the areas where mosquitoes densely populate. It is often too late to take control measures after dengue cases are reported. Therefore, to implement a system to monitor the vector population dynamics and to give alerts for possible pandemic infection is of importance. We carried out an extensive study using a large amount of climatic and mosquito density data. After careful analysis on these data, we identify how these factors influence the multiplication of aedes aegypti. The relationship between density of mosquitoes and dengue infection is also determined. Based on this result, we develop a mathematical model for the expansion of aedes aegypti, which serves as a basis for building the intelligent surveillance system. The system has been implemented and put into practice.**

***Keywords - dengue fever, surveillance system, bioinformatics, environment engineering***

## I. INTRODUCTION

It goes without saying that pandemic control is one of the most important topics in public health, which deserves our rigorous study. Some researchers take a macroscopic viewpoint and study it from strategic, organizational, management, economical, environmental, logistical, or social-behavioral aspect while some from a microscopic viewpoint of medical, pathological, biological, or case-specific aspect. In either a macroscopic approach or a microscopic approach, information system plays an important role. Here we would like to discuss about dengue fever, a most widely distributed disease of mosquito-borne viruses that affect human being

Many tropical and subtropical areas where mosquitoes densely populate suffer from dengue fever (DF). Dengue haemorrhage fever (DHF) is even life- endangering. In order to help to control virus-transmitting mosquitoes and to block local pandemic, we developed a surveillance information system for monitoring the development of vectors and to assist the public health sectors to control the pandemic. In order to develop such a decision-support system, we have to consider many aspects: the system structure, the model it based, the knowledge generated, the way it works, and the continuous maintenance. All these aspects will be described in the following sections.

Dengue is the most widely distributed disease of mosquito-borne viruses that affect human being, threatening more than 1.5 billion people worldwide [1]. Hundreds of thousands of cases of dengue fever and dengue haemorrhagic fever are reported annually in tropical regions of the Americas, Africa, Asia, Oceania, and also in Taiwan where our surveillance system .

It is observed that dengue infection is made by two kinds of virus carriers: *aedes aegypti* and *aedes albopictus*. Till now, there are no effective dengue control measures: on the one hand, a dengue vaccine is still under development, and on the other hand, vector control does not provide a long-lasting effect. Gradual reduction of the density of mosquitoes is the most important criteria for dengue control. It is often too late to undertake cleaning-up until the larvae grow up, or until the mosquitoes massively multiply. A system for monitoring the development of mosquito population dynamics should be developed for this purpose.

## II. LITERATURE REVIEWS

Though the pandemic surveillance information system is widely used in every country, construction of such a system should consider many aspects [2]. Lister [3] described the US systems used for pandemic control in context of emergency preparedness and suggested that a distributed structure would work better. In Japan, they examined the systems during the 2009 H1N1 influenza [3]. Hu [5] suggested that a unified pandemic emergency system should be established throughout China.

Knowledge, derived from data, is central for constructing a decision-support system, among the various data we need for controlling dengue disease are larval density and climatic data that will be considered in this paper. High temperature and high humidity constitute a good living environment for both *aedes aegypti* and *aedes albopictus*. Larvae live in various containers: man-made containers (such as vases, plates, etc.) and natural containers (such as tree holes, bamboo holes, etc.). Some of them are kept indoors, some outdoors. According to Hwang [6] in the area of *aedes aegypti*, 77% of the incubators are outdoor containers, and 23% indoor containers. An interesting investigation made by Hwang shows the height where most mosquitoes stay is mostly between 0.5 meter and 1.5 meter favor to stay in living rooms, sleeping rooms, and basements, as shown in Table I and Table II.

TABLE I. The Height Where *Aedes Aegypti* Stay

| Height | Number of *aedes aegypti* | Percentage (%) |
|---|---|---|
| > 2m | 23 | 18 |
| 0.5m～2m | 96 | 76 |
| < 0.5m | 8 | 6 |

Adopted from [6].

TABLE II. The Places Where *Aedes Aegypti* Stay

| Aedes Aegypti | Living room | Sleep-ing room | Bath-room | Kit-chen | Base ment | Others |
|---|---|---|---|---|---|---|
| Number | 12 | 6 | 1 | 2 | 10 | 4 |
| Percent-age | 34.3 | 17.1 | 2.9 | 5.7 | 28.6 | 11.4 |

Adopted from [6].

Density of mosquitoes can be determined in various ways: count of eggs, count of larvae, or count of adult mosquitoes. Most often-used method is based on the count of larvae. We use Bretou Index (BI) in this research, which is calculated by the percentage of the number of containers divided by the number of houses. Vehemence of density of mosquitoes is expressed in nine grades, in which grade 1 is the lightest and grade 9 the most serious. Lien [7] asserts that there is least possibility of outbreak of dengue fever in grade 1 and there is high risk when the vehemence is greater than grade 5, as shown in Table III.

TABLE III. Scale of Bretou Index

| Grade | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Bretou Index | 1-4 | 5-9 | 10-19 | 20-34 | 35-49 | 50-74 | 79-99 | 100-199 | ≧200 |

Adopted from [7].

## III. RESEARCH METHODOLOGY

### A. *Structure for Data Analysis*

Based on geographical information and climate data, we will (1) analyze the impact of these data on proliferation of *aedes aegypti* and (2) determine the relation between density of *aedes aegypti* and dengue infection. Mathematical models are constructed to describe the pandemic dynamics. The data about density of *aedes aegypti* and the dengue illnesses in the considered area is a complete collection from 1998 on, given by Center of Disease Control (CDC). Simultaneously, we obtained weather data including temperature, humidity and rainfall of the same time interval from Central Weather Bureau. The volume of data related to dengue infection is 30,241 records, and the volume of weather data is about 160,000 records. Moreover, the framework of data analysis is shown in Fig. 1.

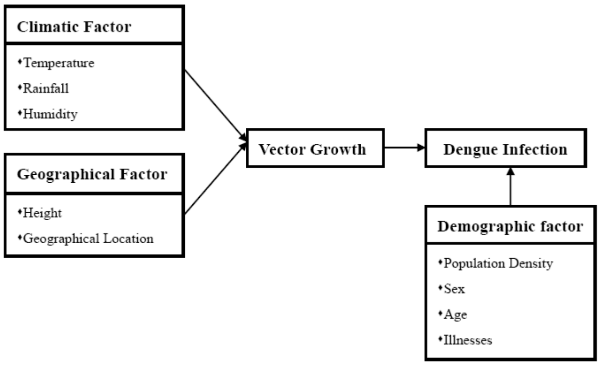


Figure 1. Structure for data analysis

### B. *Mathematical Model*

First we have to find out patterns regarding similar BI with similar weather and geographical conditions. The criteria used for clustering are BI, month, temperature, humidity, rainfall, location and height.

The clustering method is *k-means*, which is a method to find representative groups in a collection of elements with many attributes. The elements of each group are centered on its prototype (or cluster center). Since our data involve a diversity of factors, k-mean is an adequate method for finding representative. To obtain reliable results, the data are normalized before clustering.

After finding the data records with high BI, we identify the dates of the records and trace back for several days and observe the change of their BIs. Then, we obtain a pattern of BI development in these days. The development of BI curve is shown in Fig. 2.

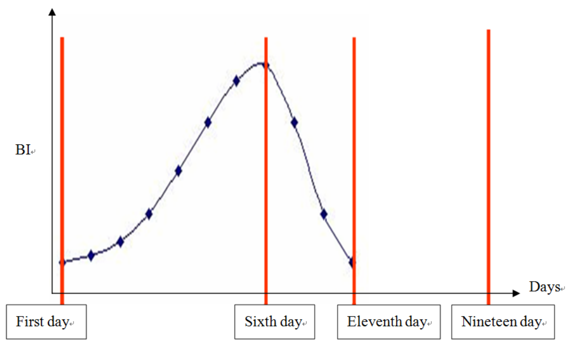


Figure 2. Graphical development of BI and its relation with dengue infection

Next, let us consider a typical, threatening aedes aegypti BI development: the BI curve ascends exponentially. The curve can be described as

$$x_n = x_0 * (1 + g(t,h) * \eta * e^{-\frac{X^2}{n}}) \quad (1)$$

*in which* $x_0$ *:the initial BI observed,*

$x_n$ *: possible BI of the n-th day,*

$g(t,h) \in [-1,1]$ *: a function of temperature(t) and humidity(h) ; g(t, h) = -1 denoting the environment unflavored to aedes aegypri ;*

$$\eta = \frac{x_{\max} - x_0}{x_0} : \textit{ascending rate.}$$

The graphical representation of equation (1) fits the actual development well as shown in Fig. 3.

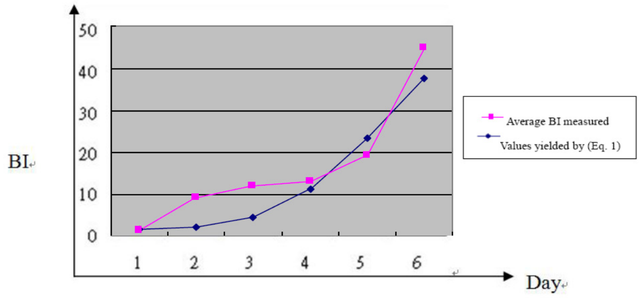


Figure 3. Graphical representation of the development of aedes BI

Based on the larval density and climatic data, we are able to undergo various analyses: number of the infected in relation to rainfall, number of illnesses in different seasons, number of illness in different geographical height. There are voluminous statistics. Please consult Lin [8] or details. In Fig. 4 is an illustration of the number of illness in relation to the temperature in the past years.

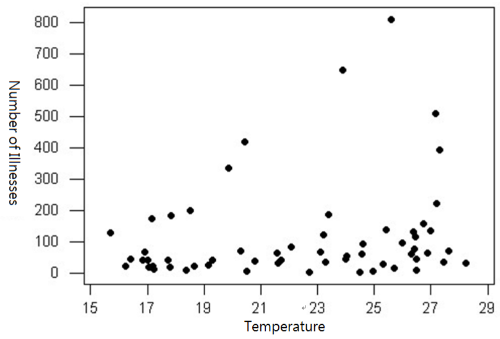


Figure 4. Number of illnesses in relation to temperature

Geographical control of mosquito activity area is important in dengue control. First we have to know the area where larval density is dense. From these areas on, we anticipate the expansion of their activity areas. In this way, we are able to limit the spread of dengue infection. In Fig. 5 shows a simulation for the expansion of a 6-day virus-transmitting mosquito's activity area. Then the responsible authority has to take effective measures in these areas.

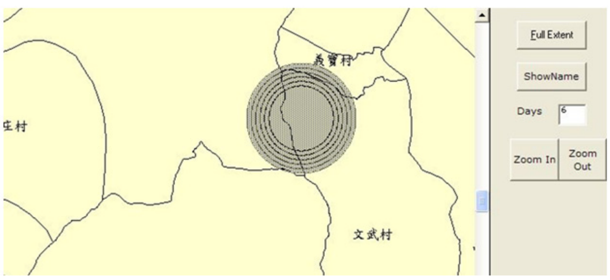


Figure 5. The expansion example of virus-transmitting for mosquito's activity area

The architecture of the surveillance system is described in Fig. 6 in which daily weather data come from the Weather Bureau and daily mosquito BIs come from CDC. There data are analyzed and modeled. A geographic information system provides background data for reasoning and presentation. The parameters will be updated from time to time. Some suggestions will be given by the system for public health professionals to monitor the pandemic.

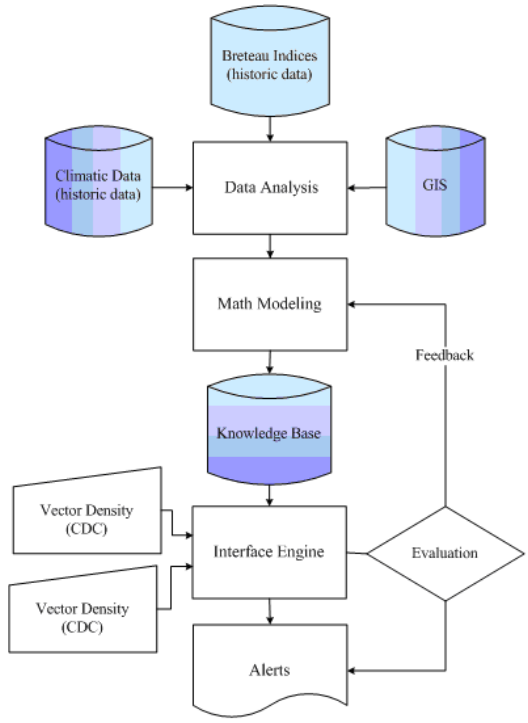


Figure 6. Architecture of the surveillance system

## IV. Conclusion and Discussions

Till now, dengue fever is still a threatening disease, and DHF is even lethal. In this paper we carried out an extensive study using a large amount of climatic and mosquito density data. After careful analysis on these data, we identify how these factors influence the multiplication of aedes aegypti. The relationship between density of mosquitoes and dengue infection is also determined. Based on this result, we construct a mathematical model for the expansion of aedes aegypti, which will serve as a basis for building an intelligent surveillance system. Specifically, we identified the development of mosquito density along the time. This is not only a rule for us to construct an alert system, but also an indication for us to empty indoor and outdoor containers to extinguish larvae so that we may avoid dengue prevalence.

As we took a microscopic viewpoint to develop the system, it is important to integrate the information system into a global system. Our system can provide valuable advices for public health professionals and serve as an integral component for pandemic control. The idea for constructing such a system can also be used to build surveillance system for other seasonal and pandemic diseases.

## ACKNOWLEDGMENT

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