Utilization of a geographical information system for surveillance of *Aedes aegypti* and dengue haemorrhagic fever in north-eastern Thailand

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Abstract

The study aims to develop a geographical information system (GIS) for surveillance of *Aedes aegypti* and dengue haemorrhagic fever (DHF) in north-eastern Thailand. There are three steps in the development of the GIS – collecting primary and secondary data, analysing the data and searching the target location, and presenting the results via figures on a map. Two sub-districts in each of the five districts in Ubon Ratchathani province with high incidences of DHF cases in the last three years were investigated. Primary {e.g. House Index (HI), Container Index (CI) and Breteau Index (BI)} and secondary data (e.g. number of DHF cases/100 000 population) were collected. The time period was divided into two phases, a low disease incidence phase (February–March 2007) and a high disease incidence phase (June–July 2007). The GIS was developed via *ArcView* programme 3.2a®. The primary data of *Ae. aegypti* indices including HI, CI and BI indicated a rise in the rainy season period compared with the dry weather period, and the secondary data showed a similar rise and fall in the number of DHF cases in the rainy and dry weather periods respectively. GIS technology can help in planning, implementation and evaluation of the dengue control measures.

Keywords: Geographical information system (GIS); *Ae. aegypti* indices; Geographical positioning system (GPS); Dengue haemorrhagic fever (DHF).

Introduction

Dengue haemorrhagic fever (DHF) caused by the mosquito species *Aedes aegypti* is one of the world's major health problems.[1] In Thailand, the reported cases of DHF vary from 20 000 cases to more than 100 000 cases annually.[2] Recently, the incidence of DHF has increased in many provinces in the north-eastern part of the country, including Ubon Ratchathani, Si Sa Ket, Yasothon and Amnat Charoen.[3,4] Ubon Ratchathani is ranked as the province with the fourth highest incidence of DHF in Thailand with 172.20 cases per 100 000 population (Figure 1).[5,6]

A geographical information system (GIS) is an initiative to support dengue control in Thailand. It is an automated computer-based

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Figure 1: **Map of Thailand indicating location of Ubon Ratchathani province**

system with the ability to capture, retrieve, manage, display and analyse large quantities of spatial and temporal data in a geographical context. Roads, residential buildings and other relevant data can be obtained and mapped to form the base map layer using the software *Arcview GIS®*. Other layers, such as patient populations, mosquito breeding, dengue case incidences, addresses, sensitive areas and containers, can also be mapped into the GIS.[7-11] Among the publications on the use of GIS in DHF surveillance[12-18] is included one concerning the development of a database system of mosquito breeding habitats. This led to the development of a system called "Mosquito Information Retrieval System (MIRS)".[13] Another study conducted at the Nortre Dame University developed a computer programme called "MODABUND" that aimed to provide basic information about mosquitoes such as breeding habitats, life cycles, types, epidemiology, diseases transmitted by mosquitoes and means of surveillance and control.[12] However, there have been limitations that include lack of professionals, restricted budget, inadequate knowledge of GIS applications and a lack of updated data. As a result, significant benefits of the use of a GIS in dengue surveillance and control have not been as successful as anticipated.[10,11,18,19] Because of these limitations, researchers are trying to develop a GIS programme to help public health officers gather data and information on DHF to assist in the control of this health problem.

This study is an attempt to develop a GIS for surveillance of *Ae. aegypti* and DHF in north-eastern Thailand.

Materials and methods

Study area

Ubon Ratchathani is located in north-eastern Thailand, about 629 kilometres from Bangkok (Figure 1). The terrain is generally flat with the river Moon flowing through the central area. The total area of the province is 15 517 sq. km. with highlands and mountains in the east of the province. The total population is about 1 600 000. There are three distinct seasons, dry (March-May), rainy (June-September) and cold (October-February). Average temperatures are from 25 °C to 35 °C depending on the season. The average rainfall is 1300–1800 mm per year.

Implementing an *ArcView* programme 3.2a®

The GIS requires a language command programme called "Avenue" with the Dialog Design function of *ArcView* software 3.2a®. Users follow the menu and extract the required data. The overall structural functions include:

Figure 2: **Development programme of a geo-database for surveillance of Ae. aegypti and dengue haemorrhagic fever in Ubon Ratchathani province**

(a)

(b)

- Installation of primary and secondary data
- Analysis of data and a search of the target location
- Presentation of the results via figures on a map

In this study, epidemiological, digital, satellite and Global Positioning System (GPS) data were incorporated into GIS databases to better understand the spatial distribution of DHF cases {see Figures 2(a) and 2(b)}.

Process

Process of GIS development

The project started in February 2007 and concluded in July 2007. The species of dengue mosquito studied was *Ae. aegypti*. Ubon Ratchathani province in the lower north-eastern part of Thailand was selected as the study site due to its high incidence of DHF cases. The study focused on two sub-districts in each of the five districts in the province with the highest incidences of DHF cases in the last three years. Within each sub-district, one village was selected as part of the study, making a total of 10 villages.

Two categories of data were collected:

Primary data included:

- dengue vector indices
- water storage containers

To quantify the relative density of mosquitoes, House Index (HI), Container Index (CI), and Breteau Index (BI) were taken as indicators of the density. For CI, all natural and artificial indoor and outdoor containers, such as water jars, tyres, cement tanks and ant guard jars, etc. in every house, were inspected to determine the presence or absence of *Ae. aegypti*. The primary data were collected by the visual larval survey.[7] The positions of the houses in the ten villages were mapped using a GPS tool. Also, data including village names, house addresses, demographic primary data, breeding sites and containers were mapped and imported into a GIS software for further construction (*ArcView* 3.2a®).

Secondary data included:

- number of reported DHF cases/ 100 000 population

Secondary data on patient cases were reported by a primary care unit (PCU), local hospital or central hospital and collected by the staff of the Office of Disease Prevention and Control Department 7 (DPC), Ubon Ratchathani, using WHO case definition. Both primary and secondary data were collected by the same process. Data collections were divided into low disease incidence (February–March 2007; dry weather) and high disease incidence (June–July 2007; rainy season).

Method of data analysis

Analysis of the primary data

Dengue vector indexes were calculated into three variables:

- House Index (HI): Percent houses positive for containers with *Ae. aegypti* larvae or pupae
- Container Index (CI): Percent of water-holding containers positive for *Ae. aegypti* larvae or pupae
- Breteau Index: Number of containers positive for *Ae. aegypti* larvae or pupae per 100 houses.

Analysis of secondary data

The total number of DHF patients was presented as the number of reported cases of DHF/100 000 population of the province.

Results

Primary data

Dengue vector indices (HI, CI and BI) for each village during low incidence and high incidence periods are presented in Figures 3(a) and 3(b).

It may be seen from Figure 3(a) that during the low disease incidence period, HI ranged from 15.04 in village Pakhuaiwangnong to 50.88 in Nacharoen village while during the high disease incidence period it ranged from 25.16 in village Ang Hin Tai to 56.36 in Nongpaung village. CI and BI also followed similar trends as indicated in Figures 3(a) and (b).
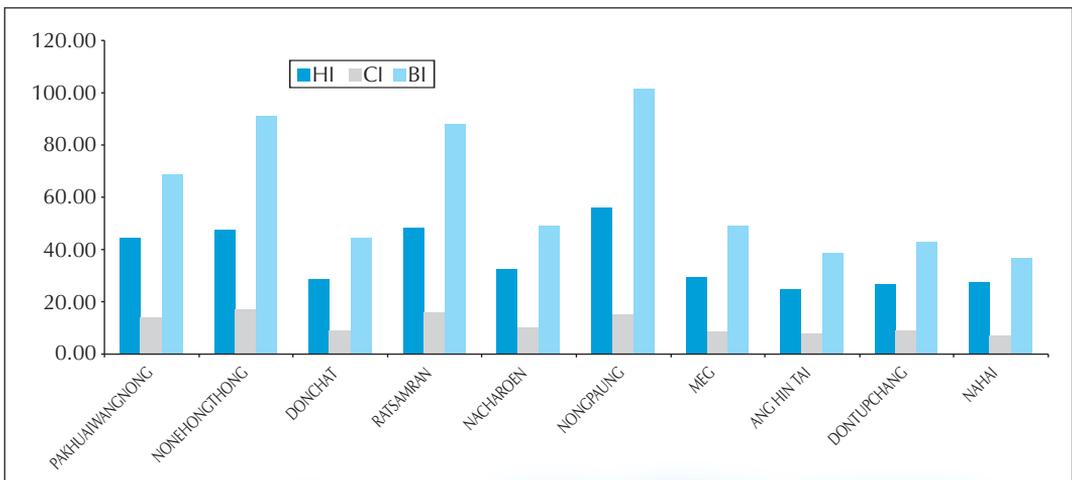
Secondary data

The total number of reported DHF cases per 100 000 population in Ubon Ratchathani province are given in Figure 4. Comparisons were

Figure 3: *Ae. aegypti indices (HI, CI, and BI) for 10 villages*

3(a): *Low disease incidence period (February–March 2007)*
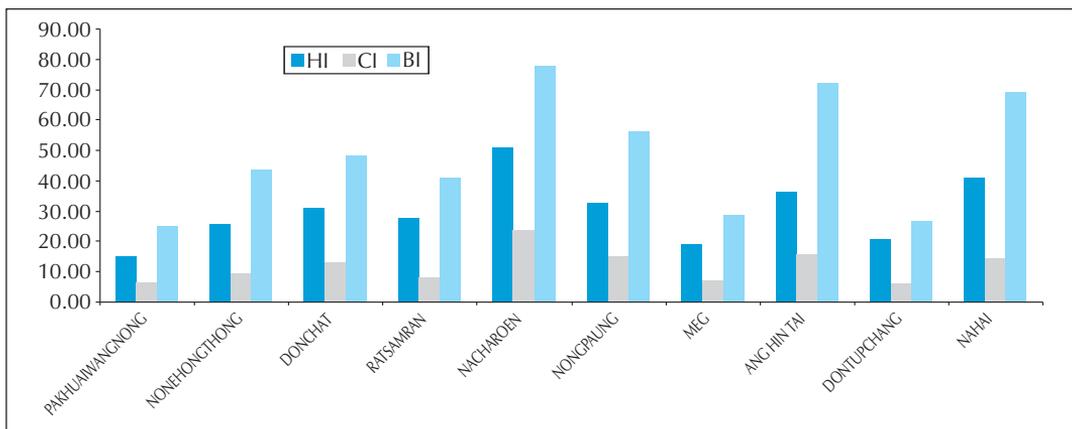
3(b): *High disease incidence period (June–July 2007)*

made between the low disease incidence period and high disease incidence period (Figure 4).

Discussion

The results show that the number of DHF cases increased during the high disease incidence period compared to the low disease incidence period, suggesting a positive correlation between the peak rainfall period in June-July and the high density of *Ae. aegypti* mosquitoes and high incidence of DHF cases. This finding is similar to that identified in other South-East Asian countries.[20,21] Since the spread of the disease is facilitated by the movement of viraemic people, source-reduction methods should get priority in vulnerable areas (hotels, hospitals and other places of congregations). Generally, such practices undertaken in the low disease incidence period lead to a reduction

in the vector receptivity (breeding potential) at the beginning of the wet season and this will have an impact on the number of DHF cases.

In Ubon Ratchathani, *Ae. aegypti* population density remains high in most areas and the incidence of DHF normally tends to increase every other year. This indicates that when an outbreak occurs, it spreads rapidly to nearby areas. The clustering of DHF cases in some big centres such as Muang, Detudon and Warinchamrap has also been attributed to the characteristics of *Ae. aegypti* because of its multiple feeding probe to complete one blood meal. In other south-east Asian countries, it has been reported that most infections occur among children who spend most of their time indoors and are bitten by the usually day-biting *Ae. aegypti*. The high incidence of DHF continues to occur due to lack of standard

Figure 4: *Total number of reported dengue haemorrhagic fever cases in Ubon Ratchathani province during low and high disease incidence periods*
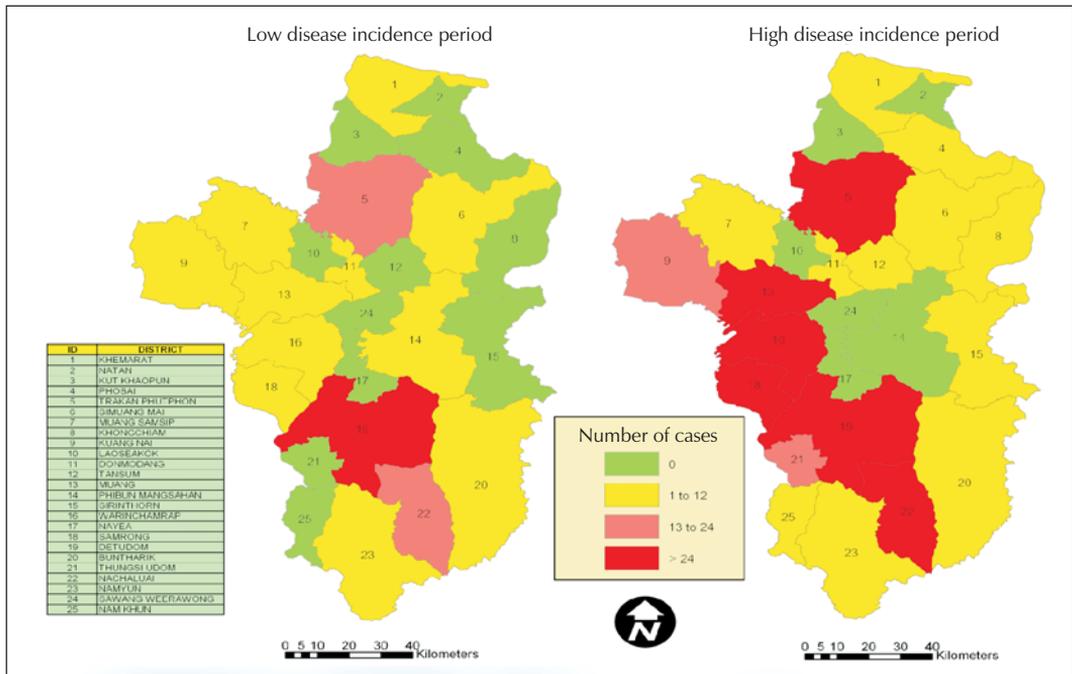
mosquito control policies, poor sanitation and poor preventive measures.

The introduction and implementation of an effective remote-sensing tool such as a geographical information system (GIS) into the routine activities of the Disease Prevention and Control Programme staff needs to be considered. This tool can address some limitations regarding *Ae. aegypti* and DHF surveillance like updating, collecting, editing, locating and analysing dengue indices and DHF case data. By this process, rapid and effective prevention and control strategies can be developed prior to the onset of the disease that would eventually reduce both the morbidity and mortality rates of dengue infection.

Acknowledgements

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