Chapter 1

Introduction

1.1 Background

Dengue haemorrhagic fever and other fever-symptomatic diseases

In the last 20 years, the incidence of dengue and its more severe manifestation, dengue haemorrhagic fever (DHF) has increased and become a very serious health problem in the tropical regions of the world. As Figure 1.1 shows (source: Clark et al, 2003), the disease has worldwide distribution in sub-Saharan Africa, South and South-East Asia, tropical Latin America, the Caribbean Islands, the South Pacific Islands and Northern Australia. Since its initial epidemic in 1958, when there was an outbreak of DHF in Bangkok and other surrounding provinces (Division of Epidemiology, 2003), outbreaks of the *Aedes aegypti* vector of the dengue fever virus have created major health problems in Thailand.

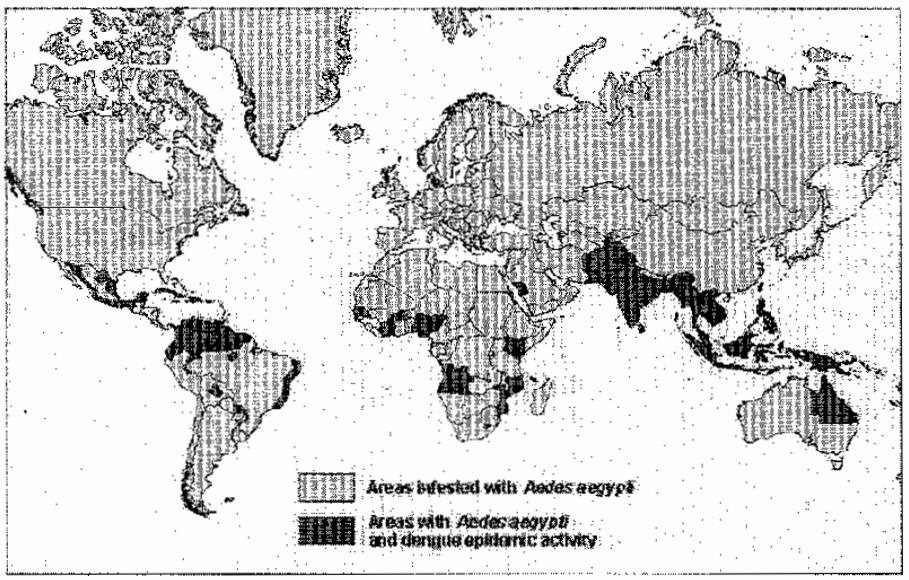

Figure 1.1: World distribution of dengue, 2002

In Thailand dengue haemorrhagic fever has increased substantially over the last 40 years (Tiprat, 2004), with its epidemics peaking between November and April. However, while the Thai Ministry of Public Health has projected decreased morbidity in the provinces where the disease is most prevalent, the current DHF incidence remains a major public health problem. The Division of Epidemiology, Ministry of Public Health, reported the number of cases for the years 1998-2001 to be 129,954, 24,826, 18,617 and 132,082, respectively, with corresponding deaths 424, 56, 32, and 238. In 2002, the DHF incidence was estimated to be 108,905 cases and 172 deaths, with the highest incidences occurring in Yala, Suratthani, Krabi, Phatthalung, and Nakhon Si Thammarat provinces. In 2003, however, these numbers had reduced to 62,526 cases and 78 deaths (Division of Epidemiology, 2003), indicating the volatility of DHF disease incidence from year to year.

Geographical mapping

The volatility and spatial variation in the incidence of dengue and related diseases has prompted various authors to use geographical mapping techniques to analyse and display their spatial patterns. The idea involves building a risk map in order to plan prevention strategies and better understand the epidemiology and geographical distribution of the disease. For example, Carbajo et al (2001) created contour maps of dengue fever incidence based on sampled locations in Argentina, and Rattanasiri et al (2004) used thematic maps to show malaria incidence in provinces of Thailand.

Yala Province of Southern Thailand

Our study focuses on Yala province in southern Thailand, where dengue, DHF and other fever-symptomatic diseases including malaria, diarrhea, pneumonia, conjunctivitis and pyrexia are endemic. Yala is the southernmost province of Thailand with an area of

4,521 square kilometers. It lies between latitude 6°54´N, and longitude 101°28´E, it is 1,055 kilometers from Bangkok by rail and 1,440 kilometers by road. It is the only one of the 14 southern provinces that does not have a sea coast. Yala is mostly mountainous and covered with forests.

Figure 1.2 shows altitude maps of Yala province.

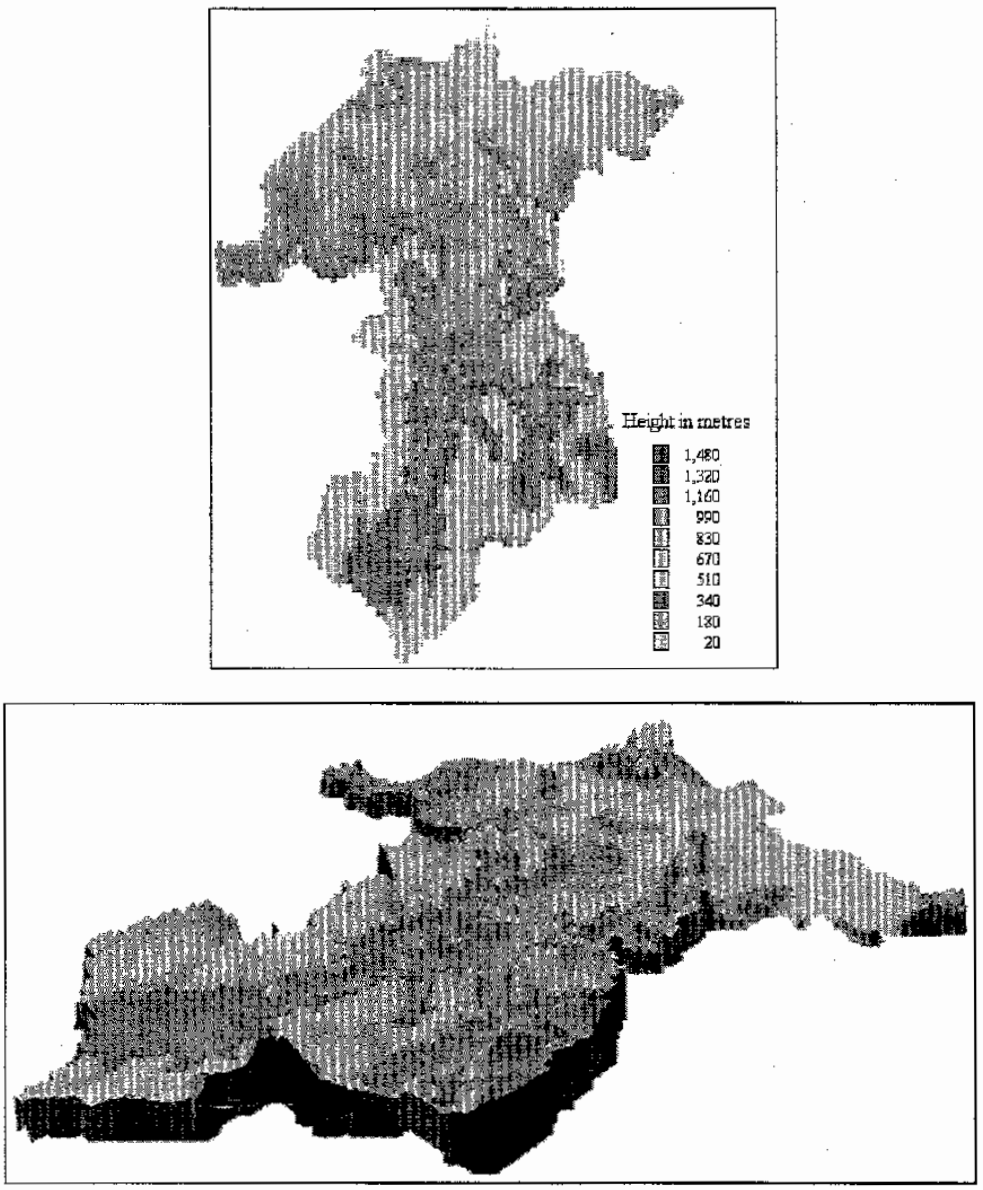

Figure 1.2: Altitude contour maps of Yala Province

The top panel shows colour-shaded contours of elevation, extending from a low of 20 meters in the north to a high point of 1420 meters in the mountainous south-east, with the Pattani River flowing from the south and forming a basin down the middle of the province. The bottom panel shows a three-dimensional altitude map of the province.

Figure 1.3 shows the names and locations of the 58 statistical subdistricts.

1 Sa Tae
2 Bu DI
3 Yu Po
4 Li Don
5 Yala
6 Tha Sape
7 Lam Mai
8 Na Tham
9 Lam Phaya
10 Po Seng
11 Phron
12 Ban Nang Sareng
13 Sa Tae Nog
14 Ta Se
15 Betong
16 Ya Rem
17 Tanomaro
18 Al Yoe Ven
19 Than Nam Tip
20 Banang Sata
21 Bacho
22 Tanopute
23 Tamtalu
24 Talinchun
25 Banglan
26 Than To
27 Ban Hae
28 Maeward
29 Korikat
30 Yaha
31 La Ae
32 Pa Tae
33 Ba Ro
34 Tachi
35 Bangoisenae
36 Ko Tang
37 Ka Yu Bo Ko
38 Ka Lu Pang
39 Ka Loe
40 Ko To Tu Ra
41 KuTaBaRu
42 Ke Ro
43 Cha Kua
44 Ta Tong
45 Ncarnnam
46 Ba Lo
47 Ba Ngoi
48 Bu Mang
49 Ya Ta
50 Wang Paya
51 Ae Song
52 Ta Lo Ha Lo
53 Ka Bang
54 Ba La
55 Krong Pinang
56 Sa E
57 Hoekatin
58 Pu Rang

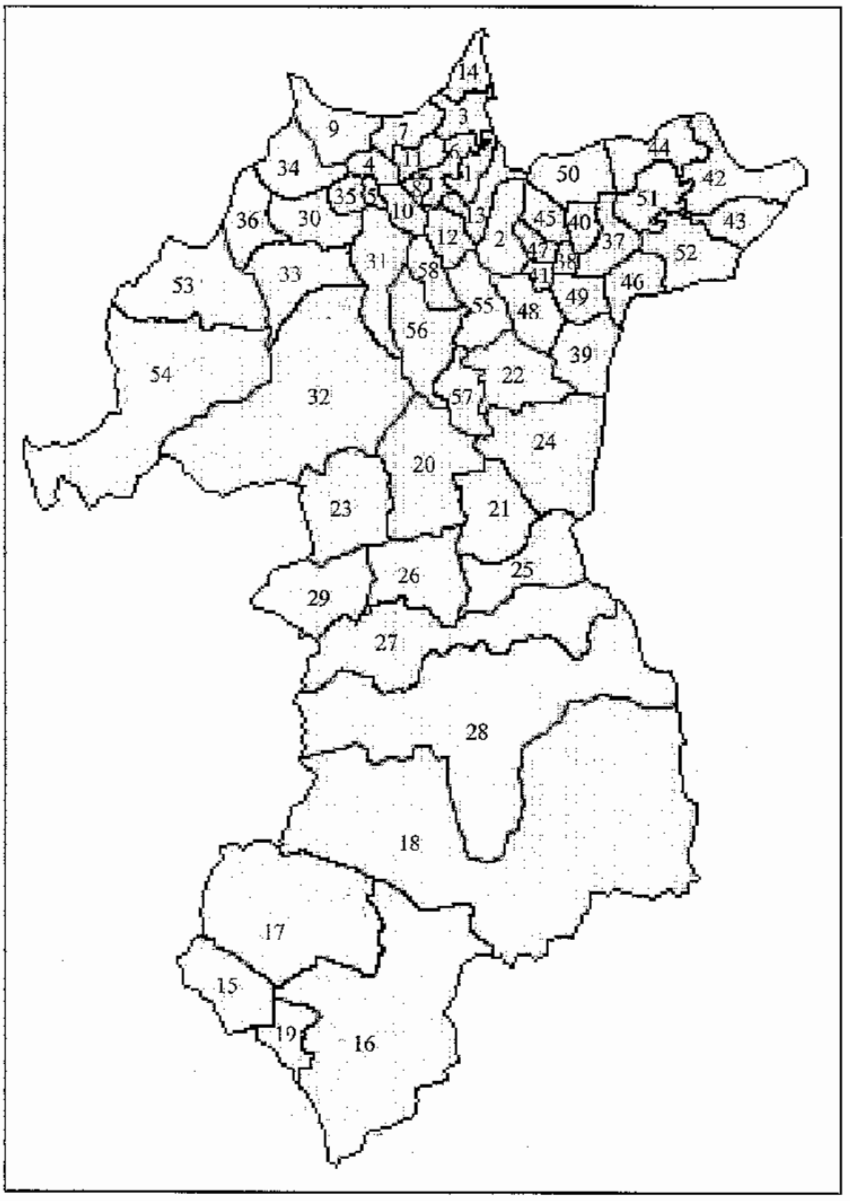

Figure 1.3: Statistical subdistricts of Yala Province

Districts in the province are as follows. Muang Yala district (14 subdistricts), Betong district (five subdistricts), Yaha district (seven subdistricts), Raman district (16 subdistricts), Bannang Sata district (six subdistricts), Than To district (four subdistricts), Ka Bang district (two subdistricts) and Krong Pinang district (four subdistricts). Figure 1.4 shows these districts.

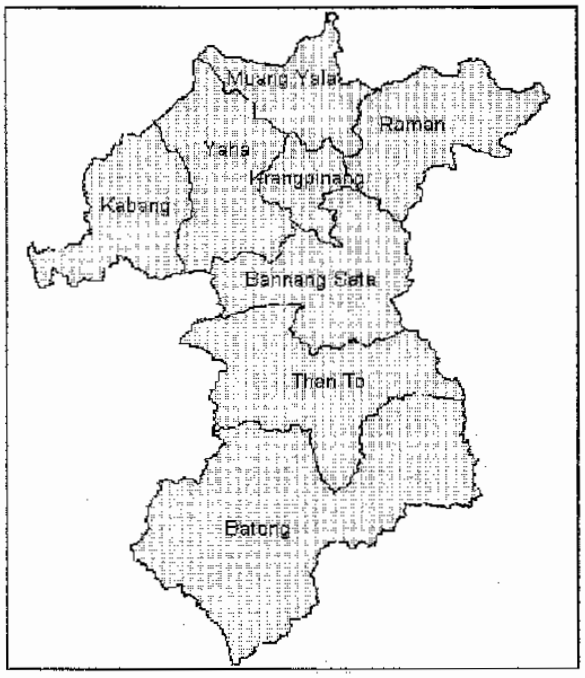

Figure 1.4: Districts of Yala Province

The epidemic pattern of DHF in Yala province has alternated by year from 1999 to 2003. The highest number of cases was recorded in 2002, particularly in Betong, Yala city, and Yaha districts, with morbidity rates of 434.0, 310.4 and 281.0 per 100,000 residents, respectively. In 2003, the number of cases was highest in Yala city, Betong, and Raman districts, with respective morbidity rates 201.3, 185.8 and 129.6 (Yala Public Health Provincial Office, 2003).

Table 1.1 shows the total numbers of cases of each of the seven diseases and the overall total for all diseases in Yala Province from 1999 to 2003. The volatility of the dengue fever and DHF incidences is very apparent from this table, showing massive increases in 2001 and 2002. The number of cases of malaria also shows substantial short-term variation, doubling from 2000 to 2001 and almost doubling from 2002 to 2003.

Disease	Year				
	1999	2000	2001	2002	2003
Dengue fever	68	58	1,213	1,548	317
DHF	99	121	1,273	1,217	326
Malaria	376	350	719	797	1,471
Conjunctivitis	2,025	1,859	2,295	3,719	1,571
Diarrhea	12,112	13,081	16,212	14,499	16,071
Pneumonia	3,174	3,368	3,385	2,770	2,845
Pyrexia	1,794	1,499	4,098	4,329	3,924
Total	22,455	23,235	23,741	28,879	28,528

Table 1.1 Disease cases in Yala Province, 1999-2003

1.2 Objectives and study design

The need to explain the volatility in disease rates has prompted us to examine the data in Yala Province in greater detail. The objectives of our study are as follows.

1. To study the epidemic patterns of the major diseases (dengue fever, DHF, malaria, hemorrhagic conjunctivitis, diarrhea, pneumonia, and pyrexia of unknown type) in Yala Province of southern Thailand with respect to the geographical distribution of their annual rates, based on data collected routinely by the Yala Public Health Provincial Office.

2. To analyze the correlations between the prevalence of these diseases in terms of their geographical distributions.

3. To develop a methodology that may be applied routinely to geographical

epidemiologic research for the spatio-temporal mapping of disease, that will facilitate data linkage to population demographic statistics that will become available in the future from government census collections.

The study design is a cross-sectional hospital-based survey of all the cases of disease provided by the Provincial Health Office in Yala Province. The sample comprised all such data collected in 2002 and 2003. These data were classified by disease type, subdistrict, gender and age.

1.3 Disease definitions

The following disease definitions were obtained from the Centers for Disease Control and linked web sites.

Dengue fever is an infectious disease carried by mosquitoes and caused by any of four related dengue viruses. This disease used to be called break-bone fever because it sometimes causes severe joint and muscle pain. Health experts have known about dengue fever for more than 200 years. Dengue fever is found mostly during and shortly after the rainy season in tropical and subtropical areas of Africa, Southeast Asia and China, India, the Middle East, the Caribbean and Central and South America, Australia and the South and Central Pacific. The World Health Organization estimates that 50 million cases of dengue infection occur each year. This includes 100 to 200 cases reported annually to the U.S. Centers for Disease Control and Prevention, mostly in people who have recently travelled abroad. Many more cases go unreported because some doctors do not recognize the disease.

Dengue haemorrhagic fever is a potentially deadly complication that is characterized by high fever, haemorrhagic phenomena - often with enlargement of the liver - and in

severe cases, circulatory failure. The illness commonly begins with a sudden rise in temperature accompanied by facial flush and other non-specific constitutional symptoms of dengue fever. The fever usually continues for two to seven days and can be as high as 40-41°C, possibly with febrile convulsions and haemorrhagic phenomena. In moderate DHF cases, all signs and symptoms abate after the fever subsides. In severe cases, the patient's condition may suddenly deteriorate after a few days of fever; the temperature drops, followed by signs of circulatory failure, and the patient may rapidly go into a critical state of shock and die within 12-24 hours, or quickly recover following appropriate volume replacement therapy.

Malaria is an infectious disease caused by a parasite (plasmodium) which is transmitted from human to human by the bite of infected female Anopheles mosquitoes.

Malarial attacks present over 4 to 6 hours with shaking chills, high fever, and sweating, and are often associated with fatigue, headache, dizziness, nausea, vomiting, abdominal cramps, dry cough, muscle or joint pain, and back ache. The attacks may occur every other day or every third day.

Cerebral malaria and death can occur, sometimes within 24 hours, if the infection is caused by plasmodium falciparum. Fever or other symptoms can develop in malaria as early as 8 days or as late as 60 days after exposure or stopping prophylaxis. For plasmodium virus in temperate areas, the delay may be up to one year.

Diarrhoea is the passing of increased amounts (more than 300g in 24 hours) of loose stools. It is often caused by a virus or bacteria and can be acute (short term) or chronic (long term) lasting more than two to three weeks. Most people are affected by diarrhoea at some time in their lives. It is often accompanied by stomach pains, feeling sick and vomiting. It is usually due to consumption of drinking water contaminated with bacteria,

undercooked meat and eggs or inadequate kitchen hygiene - in other words, an infection. Globally, seven children die of diarrhoea every minute, mainly due to poor quality drinking water and malnutrition, which still affects the majority of the world population.

Haemorrhagic conjunctivitis is an acute inflammation of the thin, transparent layer that lines the inner eyelid and covers the white part of the eye. One of the most common types is called pink eye. It can be caused by viruses or bacteria and can be very contagious. Other causes include allergies, irritation from chemical pollutants, smoking, fungus, parasites, or even poor hygiene.

Pneumonia is a general term that refers to an infection of the lungs, which can be caused by a variety of micro-organisms, including viruses, bacteria, and parasites. Often pneumonia begins after an upper respiratory tract infection (an infection of the nose and throat). When this happens, symptoms of pneumonia begin after 2 or 3 days of a cold or sore throat.

Pyrexia (of unknown origin) is defined as fever for more than 3 weeks where no cause is found despite seven days of basic investigations in hospital. However, in a hospital with the full availability of sophisticated diagnostic techniques, a reduced period of two weeks with unexplained oral temperatures of 38 degrees centigrade or more has been considered to meet the definition. In clinical practice, the acronym PUO is used widely.

1.4 Literature Review

Although there is a large literature devoted to the statistical analysis of seasonal and annual cycles of DHF and other fever-symptomatic diseases and their vectors (see, for example, Phong and Nam, 1999, Kanchanapairoj et al, 2000, Keating, 2001, Guzman and Kouri, 2003, Hayes et al, 2003, Sriprom et al, 2003, and Reiter et al, 2003), it is

only since the availability of desktop geographical information systems (GIS) that methods properly incorporating spatial distributions have been widely used.

An early attempt to use GIS methods was published by Sithiprasasna et al (1997), who digitized village locations in Tak province of western Thailand and thus mapped DHF incidence. Berquist (2001) provided a review of trends in data collection and risk assessment applying GIS methods to data collected by GPS and remote-sensing instruments.

Carbajo et al (2001) used GIS software and mathematical modelling to create hypothetical transmission risk maps of Dengue fever in Argentina, based on climatic data rather than actual disease cases.

In contrast, Rattanasiri et al (2004) used reported annual disease rates for provinces in Thailand over three years (1995, 1996 and 1997) to fit a generalized linear statistical model to these data and thus create thematic GIS maps.

Strickman and Kittapong (2002) created contour maps for mosquito larval indexes of dengue mosquito vectors in villages Chachoengsao Province of eastern Thailand based on data collected from water containers in households from 1989 to 1994.

Odoi et al (2004) used GIS and a spatial scan statistic to map 22,496 cases of giardiasis disease in an area of Ontaria, Canada.