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Climatic Factors Affecting Influenza Cases in Southern Thailand

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Abstract**—**This study investigated climatic factors associated with influenza cases in Southern Thailand. The main aim for use regression analysis to investigate possible causual relationship of climatic factors and variability between the border of the Andaman Sea and the Gulf of Thailand. Southern Thailand had the highest Influenza incidences among four regions (i.e. north, northeast, central and southern Thailand). In this study, there were 14 climatic factors: mean relative humidity, maximum relative humidity, minimum relative humidity, rainfall, rainy days, daily maximum rainfall, pressure, maximum wind speed, mean wind speed, sunshine duration, mean temperature, maximum temperature, minimum temperature, and temperature difference (i.e. maximum – minimum temperature). Multiple stepwise regression technique was used to fit the statistical model. The results indicated that the mean wind speed and the minimum relative humidity were positively associated with the number of influenza cases on the Andaman Sea side. The maximum wind speed was positively associated with the number of influenza cases on the Gulf of Thailand side.

Keywords**—**Influenza, Climatic Factor, Relative Humidity, Rainfall, Pressure, Wind Speed, sunshine duration, Temperature, Andaman Sea, Gulf of Thailand, Southern Thailand.

I. INTRODUCTION

INFLUENZA is an important health problem in Thailand and other countries around the world. Influenza is a contagious respiratory illness caused by Flu viruses. Flu viruses can cause mild to severe illness, and at times it can lead to death [1].

While most healthy people recover from the influenza without complications, some people, such as older people, young children, and people with certain health conditions, are at high risks for serious complications from the influenza [2].

Each year, influenza viruses cause epidemics somewhere in the world and an annual average of more than 20,000 deaths in the United States. New strains of the virus continually evolve, causing remarkable variability in the intensity and severity of illness. Periodically, but unpredictably, a major genetic change in the virus results in a strain that can cause widespread disease and death [3]. Three such global epidemics called pandemics occurred in the 20th century. In recent years, public health experts have raised concerns about the ability of the public health system to detect and respond to emerging infectious disease threats, such as pandemic influenza [4]. The response effort would need to include the ability to quickly produce and distribute a vaccine and antiviral drugs effectively against the pandemic strain [5].

Since 1971, Influenza cases in Thailand increased, reached its maximum in 1988 and then decreased (Fig. 1). In 2005, the Bureau of Epidemiology Department, Department of Disease Control, Ministry of Public Health of Thailand reported 42,371 Influenza cases in Thailand with the incidence rate of 65.21 per 100,000 populations [6]. The Influenza incidence rate in Southern Thailand is highest among four regions of Thailand [6] (Fig. 2) and fluctuates around 1,000 cases in the past 20 years period (Fig. 3). The top ten provinces that have the highest influenza cases in Thailand in 2005 are Trang, Suratthani, Lopburi, Songkhla, Ratchaburi, Nakhonsithammarat, Chantaburi, Rayong, Narathiwat and Phetchaburi. Five out of these top ten provinces are located in Southern Thailand [5].

Southern Thailand is a narrow peninsular that separated into two coasts that are under different monsoon seasons: southwest and northeast monsoon. On the Andaman Sea side of the Southern peninsula, the wettest period of the year is from August to September from southwest monsoon. On the Gulf of Thailand side, the wettest period of the year is from November to January from Northeast monsoon. The impact of climatic factors on Influenza in Thailand is probably the least well understood. A good understanding of the current causal relationship between climatic factors and Influenza is essential for a study of the impact of potential climate change on Influenza in future. This study aims at studying how climatic factors influencing influenza cases on the Andaman Sea side and the Gulf of Thailand side.

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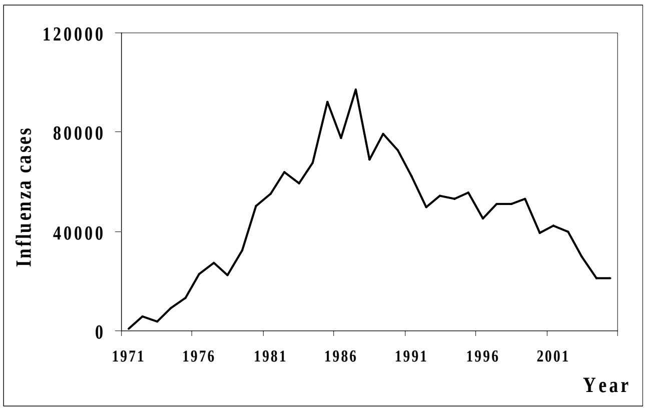

Fig. 1 Influenza cases in Thailand from 1971 – 2005

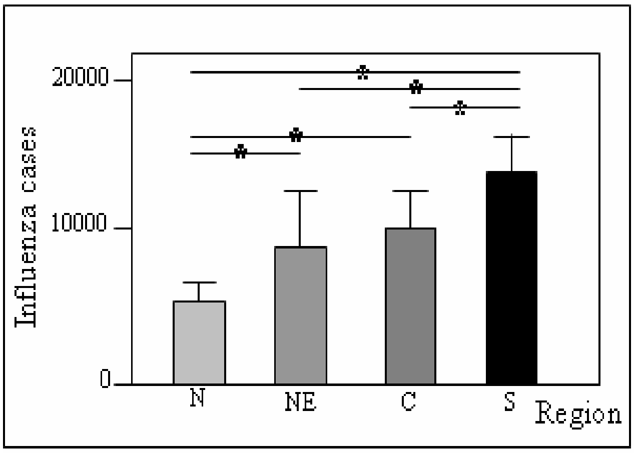

Fig. 2 Influenza cases in four regions of Thailand from 1996-2005. N, NE, C and S represent North, Northeast, Central and Southern Thailand

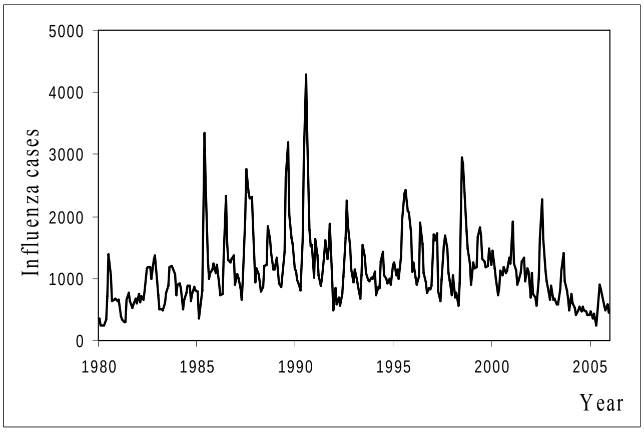

Fig. 3 Influenza cases in Southern Thailand from 1980–2005

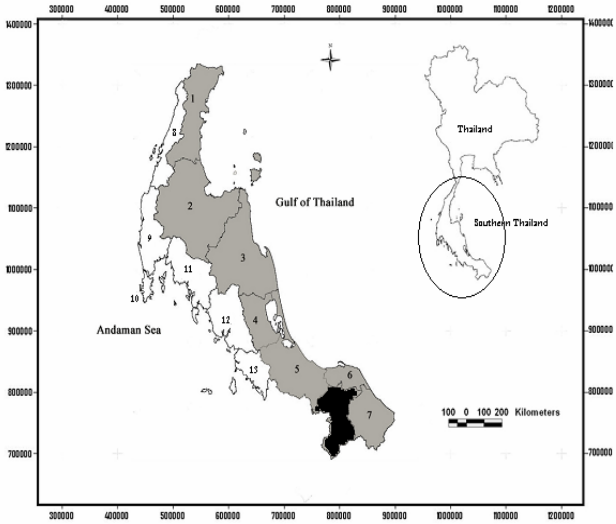

Fig. 4 Map of administrative boundaries of 14 Southern provinces, Thailand. No. 1-7 (shaded area) represent provinces on the Gulf of Thailand side. No. 8-13 (non-shaded area) represent provinces at the Andaman Sea side. Black area represents Yala province that does not have border connected to the sea

II. Materials and Methods

Southern Thailand is located at 5° 37'- 11° 42' N, 98° 22'- 102° 05'E and covers 70,715.2 Km^2. Southern Thailand is composed of 14 provinces. In this study, we used only thirteen provinces that had ocean boundary (Fig. 4). The climate is equatorial and humid with rainfall, high temperature of over 20 °C, and relative humidity of 80% throughout the year [4].

The Climatology Division of the Meteorological Department provided climatic data for Southern Thailand from 1980-2005. The monthly influenza cases data over the same period were collected by Bureau of Epidemiology, Ministry of Public Health. Fourteen climatic factors comprised of mean relative humidity, maximum relative humidity, minimum relative humidity, rainfall, rainy days, maximum rainfall, pressure, maximum wind speed, mean wind speed, sunshine duration, mean temperature, maximum temperature, minimum temperature, and temperature difference (i.e. maximum – minimum temperature).

One-way ANOVA and post-Hoc tests (i.e. Student Newman Keuls) were used to test the mean differences of Influenza cases among four regions [7]. Independents sampled *t*-tests were used to test the mean differences of influenza cases and monthly climatic factors between the two coasts of southern Thailand. Pearson’s correlation coefficient test was used to detect primary association between influenza cases and climatic factors [8]. Multiple stepwise regression technique was employed to explore and identify statistically significant risk indicators [9].

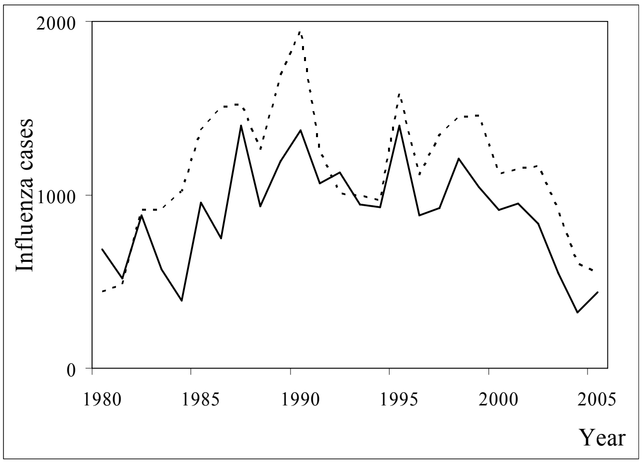

Fig. 5 Mean Influenza cases at the Andaman Sea side (─) and the Gulf of Thailand side (---)

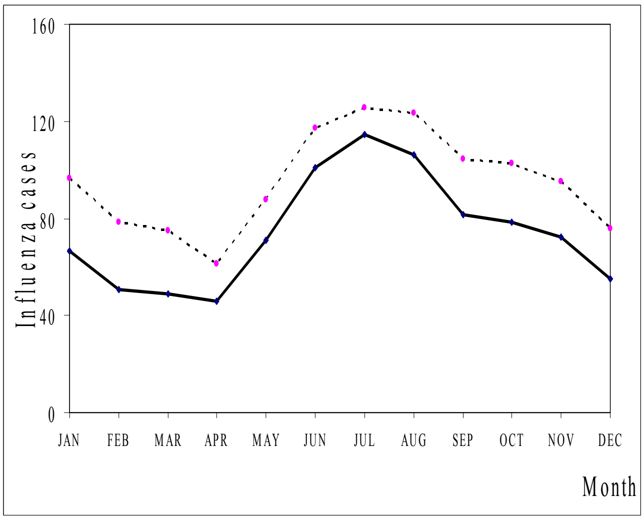

Fig. 6 Mean Influenza cases of southern provinces bordering the Andaman Sea side (—■—) and the Gulf of Thailand side (- -●- -) from 1980 – 2005

III. Results

Influenza cases in Southern Thailand varied from 241-4,290 cases with a mean and standard deviation of 1112.93±573.57 cases. The highest influenza case was observed on the Gulf of Thailand side in 1990 (Fig. 5). Influenza cases were highest in July on both the Andaman Sea side and the Gulf of Thailand side (Fig. 6). There were similar trends of Influenza cases on both sides of Southern Thailand (Fig. 6). Influenza cases on the Gulf of Thailand side were higher than the Andaman Sea side (Fig. 6, Table I).

The amount of rainfalls, rainy days, mean wind speed, mean temperature, maximum temperature and temperature difference on the Andaman Sea side were higher than those on the Gulf of Thailand side (Table I). The maximum relative humidity, pressure, maximum wind speed, minimum temperature and sunshine duration on the Andaman Sea side were lower than on the Gulf of Thailand side (Table I). However, the mean relative humidity, the minimum relative humidity and the amount of rainfalls were not significantly different between both sides of Southern Thailand (Table I).

The mean wind speed and minimum relative humidity were positively associated with influenza cases on the Andaman Sea side (Table II). Maximum wind speed was positively associated with influenza cases on the Gulf of Thailand side (Table II).

Multiple stepwise regression models from six provinces on the Andaman Sea side showed that there were nine climatic factors associated with Influenza cases including mean relative humidity, rainy days, mean wind speed, mean temperature, maximum wind speed, minimum relative humidity, pressure, maximum temperature and minimum temperature (Table II). There were five climatic factors that were not associate with Influenza cases at the Andaman Sea side (i.e. maximum relative humidity, rainfalls, maximum rainfalls, temperature difference and sunshine duration) (Table II).

Multiple stepwise regression models from seven provinces on the Gulf of Thailand side showed that there were ten climatic factors associated with Influenza cases including maximum wind speed, maximum relative humidity, mean wind speed, mean temperature, temperature difference, rainfall, rainy days, pressure, maximum temperature and minimum temperature (Table II). There were four climatic factors that were not associated with Influenza cases at the Gulf of Thailand side (i.e. mean relative humidity, minimum relative humidity, maximum rainfalls, and sunshine duration) (Table II).

IV. Discussion

The results of this study indicated that climatic factors play an important role in the Influenza transmission. However, the relative importance of these climatic factors varied with geographical areas. Influenza cases on the Gulf of Thailand side were higher than that on the Andaman Sea side probably due to a higher maximum wind speed. Our results showed that the seasonal patterns of Influenza incidence on the Andaman Sea side and the Gulf of Thailand side were similar.

Our results showed that the maximum temperature was positively associated with the transmission of influenza in some provinces of southern Thailand. As the maximum temperature increased, the transmission rate of Flu viruses also increased. Higher temperature may reduce the length of Flu viral extrinsic incubation periods (EIPs) in the air and may make human body become weak and more susceptible to Flu viruses. Even though the relation between temperature and influenza prevalence had been referred to in many texts [10, 11, 12, 13, 14], substantial empirical evidence for a temperature-influenza association is still lacking.

TABLE I
MEAN ± SD OF CLIMATIC FACTORS ON THE ANDAMAN SEA AND THE GULF OF THAILAND
*P<0.05, **P<0.01, ***P<0.001

Climatic factors	Variable	The Andaman Sea	The Gulf of Thailand	t-test
Influenza cases	Y	445.71 ± 257.73	667.21 ± 346.52	$t_{1,311}$ = -18.648***
Relative Humidity				
- Mean Relative Humidity	X_1	80.83 ± 5.19	81.53 ± 7.66	$t_{1,311}$ = -1.422
- Maximum Relative Humidity	X_2	93.37 ± 2.34	94.71 ± 8.09	$t_{1,311}$ = 2.78**
- Minimum Relative Humidity	X_3	63.09 ± 8.24	63.05 ± 5.00	$t_{1,311}$ = 0.045
Rain				
- Rainfall	X_4	229.40 ± 171.01	169.15 ± 146.92	$t_{1,311}$ = 5.140***
- Rainy Days	X_5	14.69 ± 7.75	13.28 ± 5.64	$t_{1,311}$ = 45.91***
- Maximum Rainfall	X_6	53.03 ± 29.85	49.53 ± 36.88	$t_{1,311}$ = 1.44
Pressure				
- Pressure	X_7	9.57 ± 1.07	9.92 ± 1.40	$t_{1,311}$ = -11.244***
Wind				
- Maximum Wind Speed	X_8	20.85 ± 4.45	23.00 ± 3.75	$t_{1,311}$ = -10.689***
- Mean Wind Speed	X_9	2.59 ± 0.98	2.37 ± 0.63	$t_{1,311}$ = 5.446***
Temperature				
- Mean Temperature	X_{10}	27.39 ± 0.80	27.11 ± 0.94	$t_{1,311}$ = 9.794***
- Maximum Temperature	X_{11}	34.44 ± 1.38	34.20 ± 1.53	$t_{1,311}$ = 2.66**
- Minimum Temperature	X_{12}	21.66 ± 1.27	21.71 ± 1.23	$t_{1,311}$ = 1.99*
- Temperature Difference	X_{13}	12.76 ± 2.03	12.48 ± 1.29	$t_{1,311}$ = 2.789**
Sunshine				
- Sunshine Duration	X_{14}	183.95 ± 61.00	202.41 ± 51.71	$t_{1,224}$ = - 7.06***

TABLE II
STEPWISE REGRESSION MODELS ON CLIMATIC FACTORS AND INFLUENZA CASES IN SOUTHERN THAILAND
*P<0.05, **P<0.01, ***P<0.001

PROVINCE	STEPWISE REGRESSION MODEL	F Value
Andaman Sea	$Y= -759 + 16.54 X_3 + 79.90X_9$	$F_{2,222}$ = 47.10***
- Ranong	$Y= 283.45 – 3.96X_7 +0.81 X_8 -11.38X_9 - 3.64X_{10}$	$F_{5,252}$ = 13.32***
- Phangnga	$Y= -370.61 + 3.02X_1 + 14.96X_9 – 8.67X_{10} + 10.77X_{11}$	$F_{4,195}$ = 43.87***
- Phuket	$Y= 5.67 + 1.36X_5 + 5.24X_9$	$F_{2,221}$ = 33.75***
- Krabi	$Y= 102.75 + 3.11X_1 + 2.43X_8 – 12.76X_{12}$	$F_{3,244}$ = 13.68***
- Trang	$Y= -126.71 + 7.11X_3 – 5.98X_5 – 25.46X_9$	$F_{3,288}$ = 17.89***
- Satun	$Y= -422.37 + 8.28X_1 – 4.23X_2 – 2.42X_5 + 9.23X_{10}$	$F_{4,286}$ = 17.11***
Gulf of Thailand	$Y= 183.19 + 22.41X_8$	$F_{1,229}$ = 12.47***
- Chumphon	$Y= 718.77 – 3.90 X_2 – 7.35X_7 – 8.43X_9 – 7.95X_{10}$	$F_{4,281}$ = 5.85***
- Suratthani	$Y= -221.20 + 14.85 X_{12}$	$F_{1,153}$ = 27.53***
- Nakhonsithammarat	$Y= 635.64 – 97.74 X_{10} + 65.59 X_{11}$	$F_{2,248}$ = 13.23***
- Phathalung	$Y= 1041.35 – 9.12 X_2 + 1.16 X_8 – 9.54 X_{13}$	$F_{3,304}$ = 10.66***
- Songkhla	$Y= 56.88 + 2.22 X_8$	$F_{1,195}$ = 7.99**
- Pattani	$Y= 54.63 – 6.49 X_9$	$F_{1,233}$ = 20.09***
- Narathiwat	$Y= -63.88 – 0.05 X_4 + 2.98 X_5 + 1.18 X_8 + 6.81 X_{13}$	$F_{4,299}$ = 11.97***

In this study, we found that the mean and minimum relative humidity had positive associations with the transmission of influenza on the Andaman Sea side and on the Gulf of Thailand side. On the other hand, the maximum relative humidity had a negative association with the transmission of influenza on the Andaman Sea side and on the Gulf of Thailand side. Relative humidity influences longevity, dispersal, and rapid replication of Flu viruses. In the U.S., cold and dry (i.e. low relative humidity) conditions may promote the transmission or increase the survival of the virus and dispersion, which is shed through coughing or sneezing and could result in a higher incidence of disease transmission [10, 11, 13, 15, 16].

We found that the maximum wind speed was an important factor influencing influenza transmission in Southern Thailand. The maximum wind speed varied from 30-72.4 knots. Strong wind speed often accounted for the loss of both sensible and latent heats of the body. Arid airflow can cause tiny creases on the nose where virus/bacterium can easily invade the respiratory tract [15].

In this study, we found that the amount of rainfalls had a negative effect on the Influenza transmission in Narathiwat province. This negative effect has been conventionally explained by human behavioral changes, and during the heavy rainfalls, people tend to congregate indoors more often. Thus, there is a less likelihood of Influenza infection among houses, districts or provinces because of decreased human interaction in greater distances [16]. The number of rainy days was an important climatic factors affecting influenza viral transmission on both sides. The number of rainy days may influence the life-cycle of Flu viral replication rates.

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