

Hybrid Method to Forecast Epidemic of Dengue Hemorrhagic Fever

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Abstract

The research study's objectivity proposed hybrid method, time series model and robustness control chart with interpretation rules, to forecast epidemic of dengue hemorrhagic fever (DHF) in Trat. Time series model used in this research study was seasonal ARIMA(1,0,0)(2,1,2)₁₂ with no constant and adjusted Tukey's control chart (ATCC) was used as a robustness control chart. Data used in this research study was the number of DHF cases in Trat since 2007 to 2013. The results found that the epidemic of DHF would occur in June 2014 with the forecasted number of DHF (114 cases) and root mean squared error (RMSE=13).

Mathematics Subject Classification: 62-07, 62G35

Keywords: hybrid method, interpretation rules, DHF, ARIMA model

INTRODUCTION

The number of patients with dengue hemorrhagic fever (DHF) increased dramatically 30 times in the last 50 years and nearly half world population was at risk of dengue virus infection [1] mostly in the tropical and subtropical regions [2][3][4]. Trat, one of the eastern provinces in Thailand, was facing the epidemic of DHF [5] and becoming a serious problem for public health and medicine because the number of DHF cases increased expeditiously in each year [6][7] shown in Figure 1. The research study's objectivity was to forecast epidemic of DHF using hybrid method for planning and protecting the outbreak in the future.

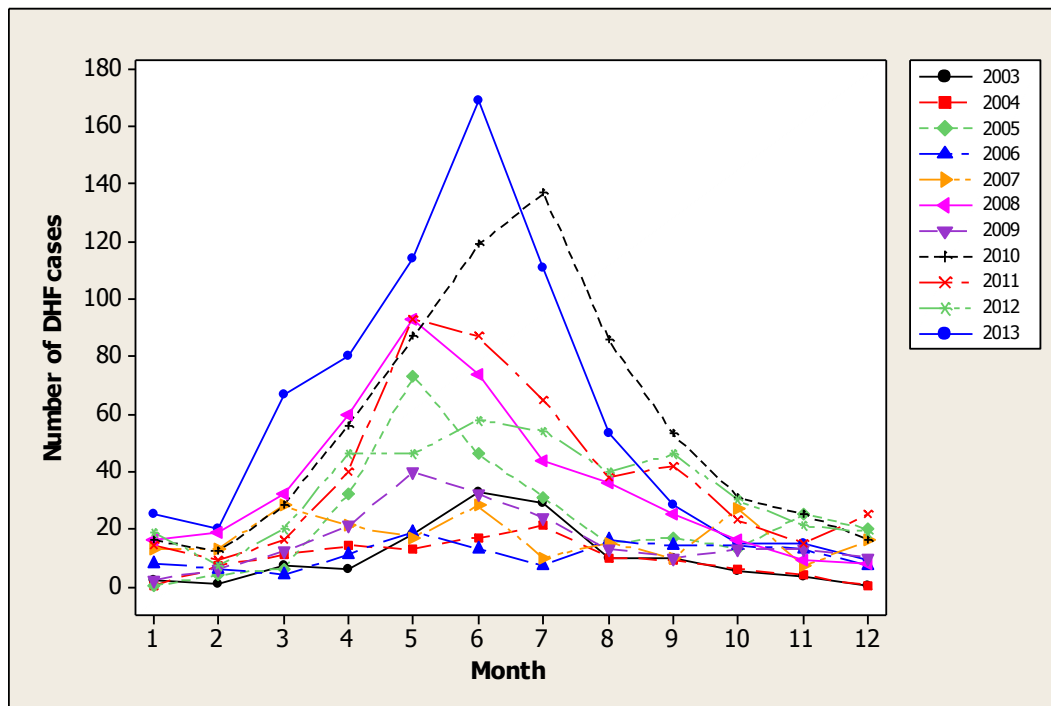


Figure 1: Time series plot of DHF cases in Trat

MATERIALS AND METHODS

The number of DHF cases in Trat was collected from the Bureau of Epidemiology, National Trustworthy and Competent Authority in Epidemiological Surveillance and Investigation, Thailand since January 2007 to December 2013. Hybrid method, time series model and robustness control chart with interpretation rules, was used to forecast epidemic of DHF.

1. **THE TIME SERIES MODEL:** the seasonal ARIMA model was defined by $p=1, d=0, q=0, P=2, D=1, Q=2$ and $S=12$ with no constant or $ARIMA(1,0,0)(2,1,2)$ [7].
2. **THE ROBUSTNESS CONTROL CHART:** the adjusted Tukey's control chart (ATCC) was constructed following upper control limit $(UCL.)=F^{-1}(0.75)+(3 \times MADM)$, center line $(CL.)=MADM$ and lower control limit $(LCL.)=F^{-1}(0.25)-(3 \times MADM)$ where MADM was the median absolute deviation to the median [8].
3. **THE INTERPRETATION RULES:** the control chart was divided into 3 zones, zone A, zone B and zone C, shown in Figure 2. There were 7 rules of interpretation for detecting whether the process was out-of-control [9]. Rule 1, any point falls outside the control limits $(\mu \pm 3\sigma)$. Rule2. 2/3 consecutive points fall in zone A and B. Rule3. 4/5 consecutive points fall in Zone A, B and C. Rule4. 8 consecutive points fall in Zone A, B and C. Rule5. 15 consecutive points fall in Zone C. Rule6. 8 consecutive points fall on both

sides of center line (CL.) with none of points fall in Zone C. Rule7. 7 consecutive points without a change in direction (trend)

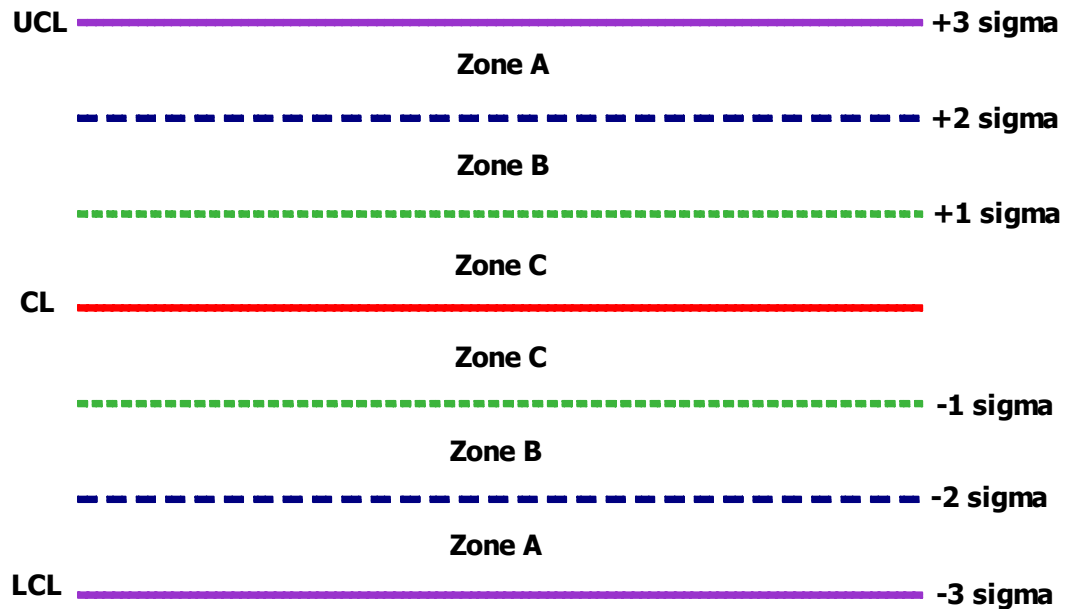


Figure 2: Control chart with different zone

4. **DETECTING EPIDEMIC OF DHF:** the procedure was performed as follows:
 - 4.1 Forecasting the number of DHF cases used the model in step 1 and the results shown in Table 1.
 - 4.2 Adding up one forecasted number of DHF cases into the original data (2007-2013).
 - 4.3 Setting up UCL., CL. and LCL. of the process used data in step 4.2 with ATCC.
 - 4.4 Detecting the epidemic of DHF; the epidemic DHF occurred when the process was out-of-control using the interpretation rules. The epidemic DHF did not occur when the process was in-control.
 - 4.5 Repeating Steps 4.2–4.4 until the process was found the out-of-control state.

Table 1. The forecasted number of DHF cases in Trat using ARIMA(1,0,0)(2,1,2)₁₂

Month Year	1	2	3	4	5	6	7	8	9	10	11	12
2014	7.1	6.4	37.2	31.6	63.5	86.8	21.8	0	4.0	8.8	7.0	15.5
2015	19.0	10.9	46.4	64.2	67.2	114.1	89.5	51.5	37.1	24.6	19.9	11.4

RESULTS AND DISCUSSION

The epidemic of DHF was forecasted that it would occur in June 2015 by the 7th interpretation rule with the forecasted number of DHF (114 cases) and root mean squared error (RMSE=13) displayed in Figure 1. The remaining was not found the outbreak in Trat.

Table 2. Control limit of ATCC using data since 2003 to 2014.

To		Month											
		1	2	3	4	5	6	7	8	9	10	11	12
UCL	-3σ	2.97	3.01	2.73	3.00	2.78	2.98	2.76	2.77	2.71	2.77	2.80	2.90
	-2σ	1.97	2.00	1.84	2.00	1.87	1.98	1.84	1.85	1.81	1.85	1.87	1.93
	-1σ	0.98	0.98	0.95	1.01	0.95	0.98	0.93	0.93	0.91	0.94	0.94	0.95
CL		-0.00	-0.00	0.09	0.03	0.08	-0.08	0.01	0.08	0.07	0.10	0.08	0.06
LCL	-3σ	-2.97	-2.97	-2.57	-2.97	-2.73	-3.00	-2.70	-2.69	-2.68	-2.74	-2.78	-2.89
	-2σ	-1.98	-1.96	-1.69	-1.97	-1.81	-2.00	-1.78	-1.78	-1.78	-1.72	-1.85	-1.92
	-1σ	-0.98	-0.95	-0.80	-0.97	-0.89	-1.00	-0.87	-0.86	-0.88	-0.91	-0.92	-0.94

Table 3. Control limit of ATCC using data since 2003 to 2015.

To		Month											
		1	2	3	4	5	6	7	8	9	10	11	12
UCL	-3σ	2.91	2.81	2.99	2.90	2.83	2.94	3.04	3.01	3.03	2.99	2.91	2.96
	-2σ	1.93	1.86	1.98	1.90	1.86	1.93	2.00	1.96	1.98	1.96	1.93	1.97
	-1σ	0.96	0.92	0.96	0.90	0.89	0.91	0.96	0.92	0.94	0.92	0.95	0.97
CL		0.03	-0.04	0.04	0.00	0.01	0.04	0.08	0.03	0.00	-0.00	-0.04	0.01
LCL	-3σ	-2.91	-2.90	-2.99	-2.98	-2.90	-3.01	-3.00	-3.11	-3.21	-3.02	-2.95	-3.01
	-2σ	-1.93	-1.95	-1.97	-1.97	-1.93	-2.00	-1.96	-2.06	-2.16	-1.99	-1.98	-2.01
	-1σ	-0.96	-1.00	-0.96	-0.97	-0.96	-0.99	-0.92	-1.01	-1.11	-0.95	-1.00	-1.02

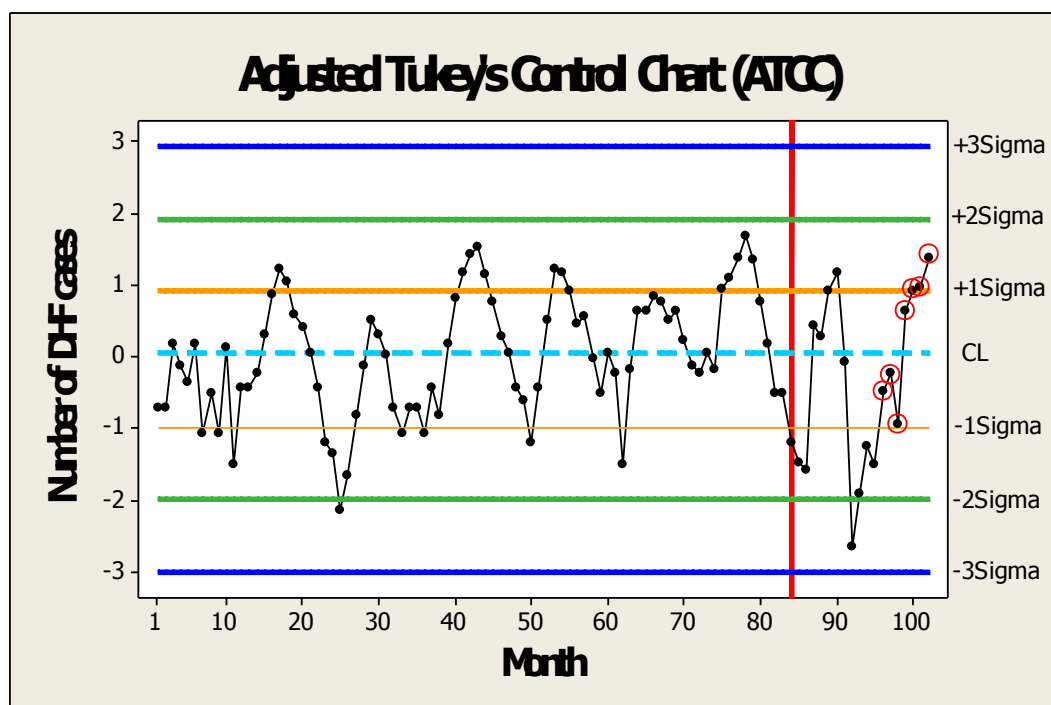


Figure 1. Hybrid method to forecast epidemic of DHF in Trat.

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