

Monitoring Epidemic of DHF using time series model and robustness control chart

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Abstract

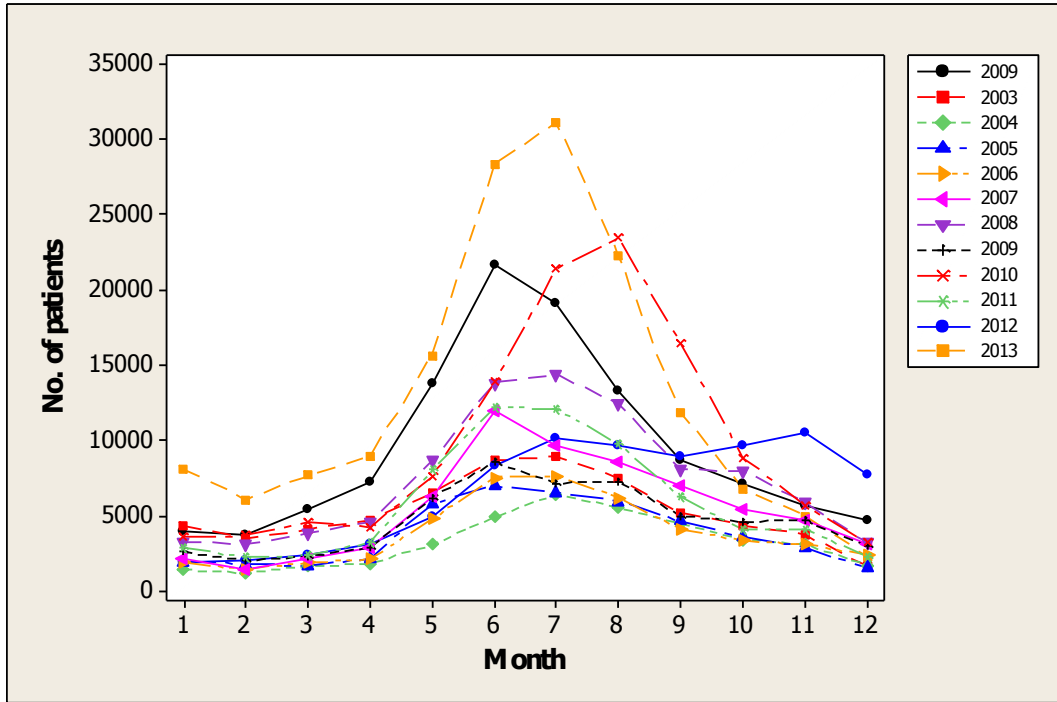
The object of this research was to monitor epidemic of dengue hemorrhagic fever (DHF) using time series model, seasonal ARIMA (1, 0, 2) (1, 0, 2)₁₂ with no constant, and robustness control chart, adjusted Tukey's control chart (ATCC). Data used in present research was the number of DHF cases in Chanthaburi since 2007 to 2013. The results found that the epidemic of DHF would occur in July 2014 with the forecasted number of DHF (275 cases) and root mean squared error (RMSE=27).

Mathematics Subject Classification: 62-07, 62G35

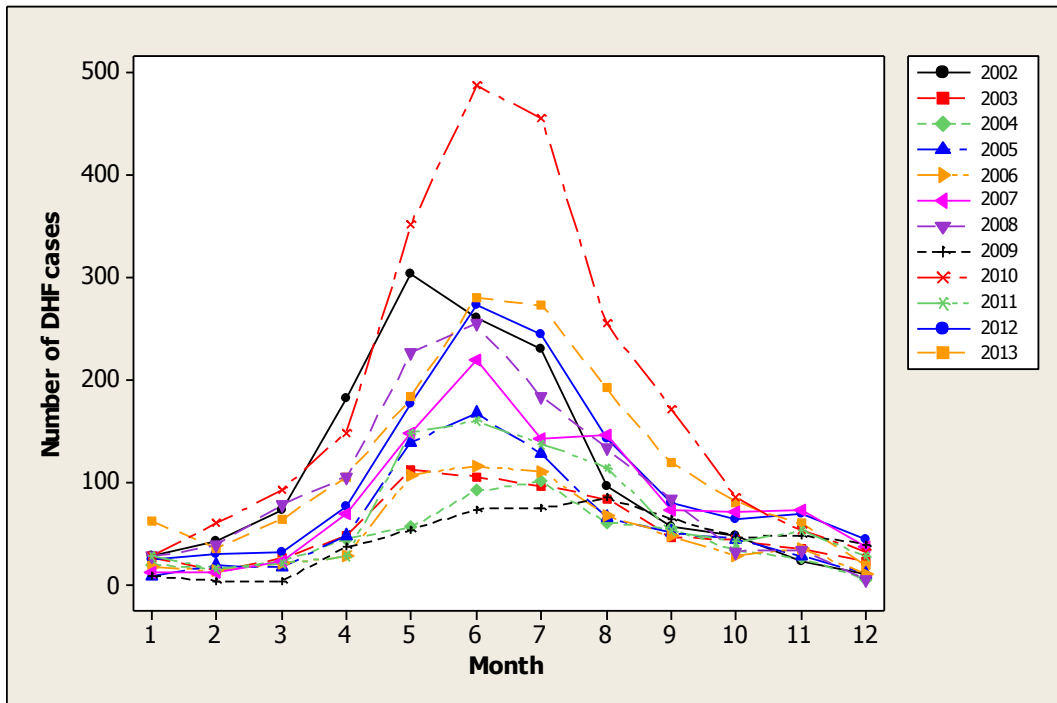
Keywords: Robustness control chart, interpretation rules, DHF, ARIMA model

INTRODUCTION

Epidemic of dengue hemorrhagic fever (DHF) was more than 100 countries especially in tropical and sub-tropical regions [1][2]. In Thailand, the number of DHF cases in past 5 years since 2002 – 2013 [3][4] trended to expand continually, especially from May to September displayed in Figure 1a. The outbreak occurred exactly in Chanthaburi province shown in Figure 1b. The object of this research was to monitor epidemic of DHF in Chanthaburi using time series model and Adjusted Tukey's control chart to plan for prevention the outbreak of DHF in the future.



(a)



(b)

Figure 1: Time series plot of DHF cases a) in Thailand b) in Chanthaburi

MATERIALS AND METHODS

The number of DHF cases in Chanthaburi was collected from the Bureau of Epidemiology, National Trustworthy and Competent Authority in Epidemiological Surveillance and Investigation, Thailand since January 2007 to December 2013.

1. **THE ROBUSTNESS CONTROL CHART:** the adjusted Tukey's control chart (ATCC) was constructed following upper control limit (UCL.)= $F^{-1}(0.75) + (3 \times \text{MADM})$, center line (CL.)= MADM and lower control limit (LCL.)= $F^{-1}(0.25) - (3 \times \text{MADM})$ where MADM was the median absolute deviation to the median [5].
2. **THE TIME SERIES MODEL:** the seasonal ARIMA model was defined by $p=1, d=0, q=2, P=1, D=0, Q=2$ and $S=12$ with no constant or ARIMA (1, 0, 2) (1, 0, 2) [6].
3. **DETECTING EPIDEMIC OF DHF:** the procedure was performed as follows:
 - 3.1 Forecasting the number of DHF cases used the model in step 2 and the results shown in Table 1.
 - 3.2 Adding up one forecasted number of DHF cases into the original data (2007-2013).
 - 3.3 Setting up UCL., CL. and LCL. of the process used data in step 3.2 with ATCC.
 - 3.4 Detecting the epidemic of DHF; the epidemic DHF occurred when the process was out-of-control using the interpretation rules [7]. The epidemic DHF did not occur when the process was in-control.
 - 3.5 Repeating Steps 3.2–3.4 until the process was found the out-of-control state.

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

Month Year	1	2	3	4	5	6	7	8	9	10	11	12
2014	3.6	17.2	22.2	56.5	212.1	289.5	275.0	151.2	86.8	54.8	55.7	42.7
2015	50.4	39.2	47.1	81.0	192.6	289.2	279.6	173.2	98.0	74.5	68.6	36.0

RESULTS AND DISCUSSION

The UCL., CL. and LCL. of ATCC were built when the forecasted number of DHF case in January 2014 (3.6 cases) was added up the original data (2007-2013) and the result displayed in Table 2 and 3. After setting up the ATCC, the epidemic of DHF was detected and the results found that the epidemic of DHF would occur in July 2014 by the 7th interpretation rule with the forecasted number of DHF (275 cases) and root mean squared error (RMSE=27) displayed in Figure 1. The remaining was not found the outbreak in Chanthaburi.

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	3.20	2.95	3.02	3.05	3.07	3.19	3.19	3.16	3.24	3.24	3.20	3.21
	-2σ	2.10	1.94	1.98	2.00	2.02	2.10	2.10	2.09	2.13	2.13	2.12	2.12
	-1σ	1.01	0.93	0.94	0.94	0.96	1.02	1.01	1.01	1.03	1.03	1.02	1.02
CL	-0.04	-0.03	-0.04	-0.07	-0.04	-0.03	-0.04	-0.04	-0.04	-0.02	-0.02	-0.05	-0.06
LCL	-3σ	-3.28	-3.03	-3.12	-3.16	-3.16	-3.23	-3.25	-3.20	-3.28	-3.28	-3.25	-3.27
	-2σ	-2.19	-2.02	-2.08	-2.11	-2.11	-2.14	-2.15	-2.13	-2.17	-2.17	-2.16	-2.18
	-1σ	-1.09	-1.01	-1.04	-1.06	-1.05	-1.06	-1.06	-1.06	-1.07	-1.07	-1.07	-1.08

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	3.18	3.15	3.08	3.25	3.29	3.20	3.13	3.00	3.16	3.16	3.18	3.20
	-2σ	2.10	2.06	2.03	2.13	2.15	2.09	2.05	1.98	2.08	2.08	2.09	2.09
	-1σ	1.01	0.98	0.98	1.01	1.01	0.98	0.96	0.95	0.99	0.99	1.00	0.99
CL	-0.06	-0.02	-0.05	-0.00	-0.01	-0.03	-0.05	-0.09	-0.05	-0.05	-0.05	-0.05	-0.04
LCL	-3σ	-3.24	-3.19	-3.09	-3.25	-3.31	-3.25	-3.22	-3.08	-3.24	-3.24	-3.25	-3.27
	-2σ	-2.16	-2.06	-2.05	-2.13	-2.17	-2.14	-2.14	-2.05	-2.16	-2.15	-2.15	-2.16
	-1σ	-1.07	-1.02	-1.00	-1.01	-1.04	-1.03	-1.05	-1.02	-1.07	-1.07	-1.06	-1.05

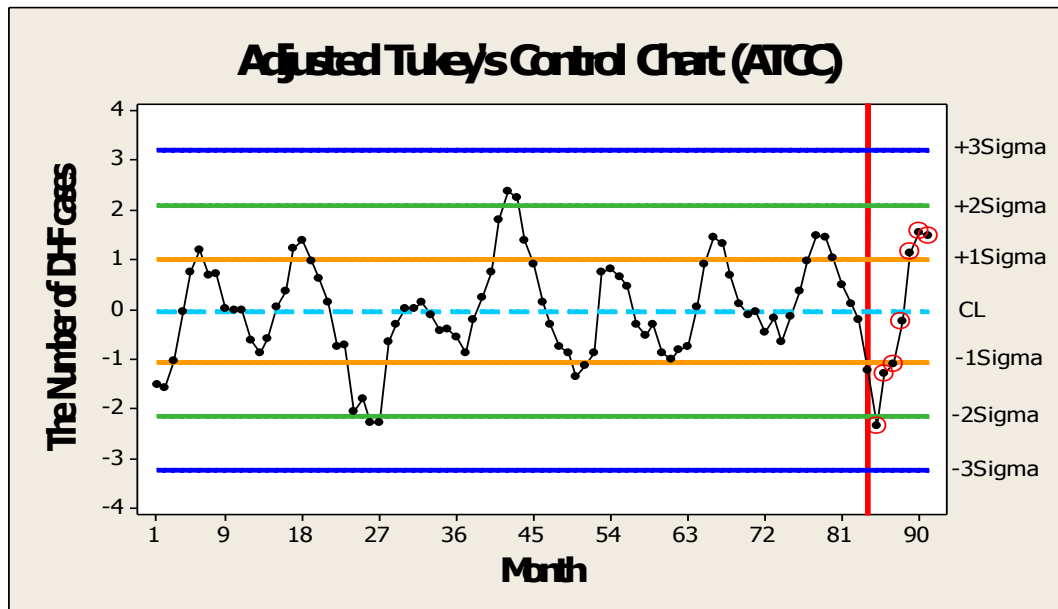


Figure 1. The control limit of ATCC for combination of the original data and the forecasted number of DHF.

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