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Combing Seasonal ARIMA Model and Adjusted Tukey's Control Chart with Interpretation Rules for monitoring Epidemic of Dengue Hemorrhagic Fever

J. Mekparyup[1] and K. Saithanu[2*]

[1, 2]Department of Mathematics, Faculty of Science, Burapha University
169 Muang, Chonburi, Thailand
[1]jatupat@buu.ac.th, [2]corresponding author: ksaithan@buu.ac.th*

Abstract

The research study objectified to propose a method to monitor epidemic of dengue hemorrhagic fever by combing seasonal ARIMA model with no constant (ARIMA(1, 0, 2)$(0, 0, 3)_{12}$) and adjusted Tukey's control chart with interpretation rules. Data, the number of DHF cases in Rayong, was used in this research study since 2007 to 2013. The epidemic of DHF would occur in June 2015 with the forecasted number of DHF (109 cases) and root mean squared error (RMSE=36).

Mathematics Subject Classification: 62-07, 62G35

Keywords: ATCC, interpretation rules, DHF, ARIMA model

INTRODUCTION

The epidemic of dengue hemorrhagic fever (DHF) caused by many factors such as social change from rural to urban let to increase mosquito breeding [1], convenient and comfortable transportation motivated the spread of dengue [2], growing of tourism industry [3][4], the climate change led to global warming which was a part to the spread of infected mosquitoes with dengue virus in several areas in the world [5][6]. The number of DHF cases in the past 5 years, 2009 – 2013 trended to increase significantly [7]. Rayong was encountering the epidemic of DHF [8] and the number of DHF cases was rising dramatically so the research study proposed to monitor epidemic of DHF in the year 2014 – 2015 in Rayong. The results were probably used by the Bureau of the Vector - Borne Diseases and the Bureau of Epidemiology of Thailand for planning, controlling and preventing the outbreak of DHF.

MATERIALS AND METHODS

The Bureau of Epidemiology, National Trustworthy and Competent Authority in Epidemiological Surveillance and Investigation, Thailand provided data, the number of DHF cases in Rayong, since January 2007 to December 2013.

1. **THE ADJUSTED TUKEY'S CONTROL CHART (ATCC):** the control chart was constructed following upper control limit (UCL.)=$F^{-1}(0.75)$+(3 x MADM), center line (CL.)=MADM and lower control limit (LCL.)=$F^{-1}(0.25)$–(3 x MADM) where MADM was the median absolute deviation to the median [9].
2. **THE SEASONAL ARIMA MODEL:** the model defined by p=1, d=0, q=2, P=0, D=0, Q=3 and S=12 with no constant or ARIMA(1, 0, 2)(0, 0, 3) [10].
3. **DETECTING EPIDEMIC OF DHF:** the procedure was conducted 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 [11]. 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 Rayong using ARIMA(1, 0, 2)$(0, 0, 3)_{12}$

Month / Year	1	2	3	4	5	6	7	8	9	10	11	12
2014	49.6	27.0	42.9	65.6	120.8	191.3	190.3	160.4	78.9	86.2	120.9	102.9
2015	101.8	69.4	69.8	61.1	73.1	109.2	103.8	77.8	42.2	33.8	42.5	29.0

RESULTS AND DISCUSSION

After the forecasted number of DHF case in January 2014 (49.6 cases) was added up the original data (2007-2013), then the UCL., CL. and LCL. of ATCC were set up and the result illustrated in Table 2 and 3. Then the epidemic of DHF was determined using interpretation rules and the results found that the epidemic of DHF would occur in June 2015 by the 5^{th} interpretation rule with the forecasted number of DHF (109 cases) and root mean squared error (RMSE=36) displayed in Figure 1. The remaining was not found the outbreak in Rayong.

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	3.01	3.01	2.96	3.04	2.98	2.98	3.03	3.02	3.03	3.06	3.09	3.06
	-2σ	2.01	2.00	1.98	2.01	1.98	1.98	2.01	2.02	2.02	2.03	2.05	2.03
	-1σ	1.00	0.99	0.99	0.99	0.98	0.98	0.99	1.01	1.01	1.00	1.01	1.01
CL		0.07	0.05	0.07	0.04	0.05	0.05	0.05	0.07	0.07	0.06	0.06	0.06
LCL	-3σ	−2.98	−3.02	−2.98	−3.07	−3.02	−3.01	−3.05	−3.00	−3.02	−3.07	−3.10	−3.06
	-2σ	−1.97	−2.02	−1.99	−2.05	−2.02	−2.01	−2.03	−1.99	−2.01	−2.04	−2.06	−2.04
	-1σ	−0.96	−1.01	−1.00	−1.02	−1.02	−1.01	−1.01	−0.98	−0.99	−1.01	−1.02	−1.01

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	3.02	3.06	3.03	3.03	3.07	2.92	3.14	3.09	3.17	3.02	3.27	3.21
	-2σ	2.01	2.03	2.01	2.08	2.05	1.95	2.09	2.06	2.11	2.02	2.17	2.13
	-1σ	1.00	1.00	0.99	0.98	1.03	0.98	1.05	1.02	1.06	1.02	1.07	1.06
CL		0.06	0.04	0.01	0.02	0.13	0.13	0.13	0.10	0.05	0.08	0.05	0.06
LCL	-3σ	−3.02	−3.08	−3.07	−3.07	−2.97	−2.82	−3.05	−3.03	−3.15	−2.94	−3.25	−3.19
	-2σ	−2.02	−2.05	−2.05	−2.05	−1.95	−1.85	−2.00	−2.00	−2.10	−1.94	−2.15	−2.12
	-1σ	−1.01	−1.02	−1.03	−1.03	−0.93	−0.88	−0.96	−0.96	−1.04	−0.94	−1.06	−1.05

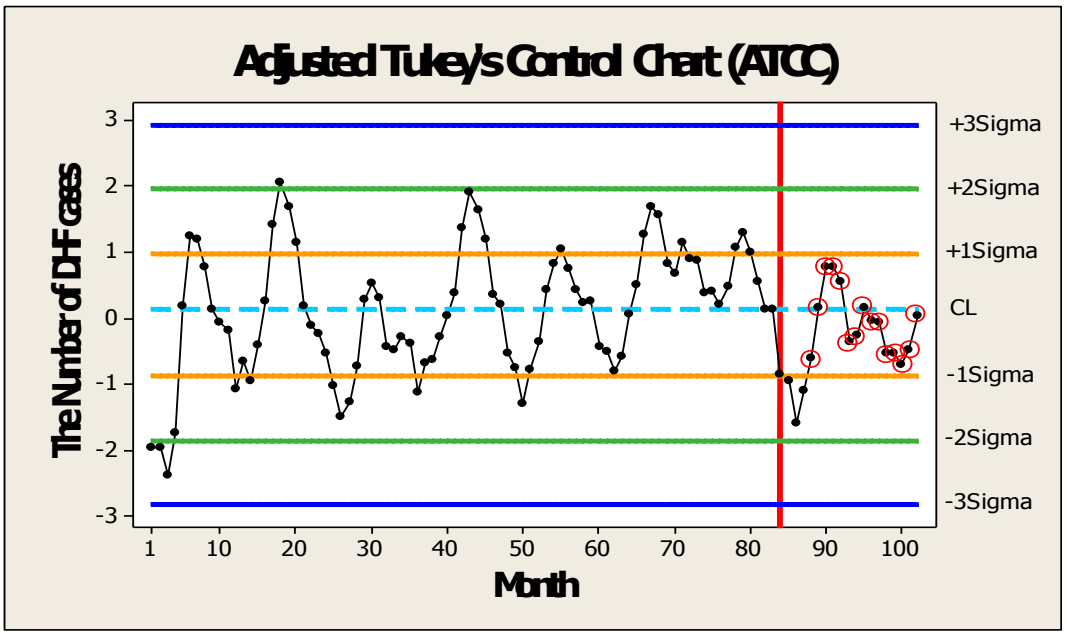

Figure 1. The control limit of ATCC of DHF cases in Rayong.

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