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Real time epidemic modeling using Richards model: application for the Covid-19 outbreak in East Kalimantan, Indonesia

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Abstract. The coronavirus pandemic has spread to all provinces in Indonesia within a few months. Coronavirus has entered East Kalimantan province in early March 2020. The number of people confirmed as COVID-19 increased dramatically after March. In this paper, we propose a simple mathematical model to predict coronavirus cases in East Kalimantan province. We applied the Richards growth model to the active case and probable case (PDP case) curves. We used the initial parameter values obtained from China's Jiangsu province. This means that the strategy for handling coronavirus in East Kalimantan province is assumed to be the same as in China's Jiangsu province. We have presented the final prediction for the coronavirus pandemic over a range of periods.

Keyword: mathematical model, growth model, Richards model, Covid-19, East Kalimantan..

1. Introduction

The spread of the Covid-19 outbreak in Indonesia occurred in early March 2020. The first province affected by Covid-19 was DKI Jakarta. After several weeks, Covid-19 has spread to all provinces and cities throughout Indonesia. This situation led the government to carry out several preventive interventions to minimize the spread of Covid-19, such as large-scale social restriction, work from home, advice on wearing mask, restrictions on the operation of public transportation, etc. In addition, each region has different ways of preventing the transmission of Covid-19. Differences in prevention in each region have resulted in differences in the spread of Covid-19.

The Covid-19 outbreak spread in East Kalimantan on March 19, 2019 [1]. The first positive case of Covid-19 in East Kalimantan was 1 patient who traveled from the cities of Jakarta and Bogor. Several policies taken by the East Kalimantan government to reduce the number of Covid-19 cases are the closing of crowded places such as markets, cafes, and airports, visitor restrictions in hospitals, etc.

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Researches on the prediction of the spread of infectious diseases using growth models have been widely conducted. Guofa and Guiyun [2] predicted a SARS pandemic by fitting the cumulative data on SARS cases in Hong Kong, Singapore and Beijing. Yin-Hen [3] performed Richards model with multiple time periods from the 2003 SARS outbreaks in Taiwan, Beijing, Hong Kong, Toronto, and Singapore. Recently, Nuning, et al [4] predicted the spread of Covid-19 by developing Richards model for data in Indonesia. Ke et al [5] predicted the spread of the Covid-19 pandemic in 29 provinces in China using several types of logistic models. Giovani et al [6] modeled the data on Covid-19 deaths using Richards model.

To assess the effectiveness of interventions during the Covid-19 pandemic, it is necessary to predict the time of the pandemic. In this study, we used Richards model to predict the peak dates and the end dates of Covid-19 cases. We used the accumulation of positive and PDP (en: patient under sepervision) cases of Covid-19 in East Kalimantan. We obtained the data from East Kalimantan Public Health Office [1].

2. Model Formulation

The logistic growth model was first introduced by Verhulst [6] and developed by Thomas Malthus [7]. The logistic growth model:

$$\frac{dC(t)}{dt} = rC(t)\left(1 - \frac{C(t)}{K}\right).$$

$C(t)$ is the population density at time t. r is the rate of growth and K is the carrying capacity. In 1959, a logistic model was developed by Richards by adding the asymptote effect [8]. Equation (1) shows the Richards model.

$$\frac{dC(t)}{dt} = rC(t)\left(1 - \left(\frac{C(t)}{K}\right)^{\alpha}\right). \qquad (1)$$

Equation (2) is the analytical solutions of equation (1) [9]

$$C(t) = \frac{K}{\left(1 - e^{-\alpha r t}\left(1 - \left(\frac{C_0}{K}\right)^{-\alpha}\right)\right)^{\frac{1}{\alpha}}}. \qquad (2)$$

We used equations (1) and (2) to predict the spread of Covid-19 in East Kalimantan. Richards model is a growth model with 3 parameters, parameter r is the growth rate of Covid-19 cases (person/day), K is the carrying capacity, and C_0 is the number of Covid-19 cases initially. Furthermore, α is the asymptote effect.

We estimated the model parameters using the least square method in equation (3)

$$\theta(\alpha, r, K, C_0) = \sum_{i=1}^{n}(c_i - \hat{c}_i)^2. \qquad (3)$$

c_i and $\hat{c}_i$ are the actual data and the prediction respectively. n is the number of the actual data. The curve matching was performed by minimizing the value of θ, then we calculated the coefficient of determination (R-squared) using equation (4)

$$R^2 = 1 - \sum_{i=1}^{n}\frac{(c_i - \hat{c}_i)^2}{(c_i - \bar{c}_i)^2}. \qquad (4)$$

$\bar{c}_i$ is the mean of c. Furthermore, we measured the prediction accuracy by calculating the root mean squared error (RMSE).

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(c_i - \hat{c}_i)^2}{n}}. \qquad (5)$$

We estimated the model parameters for Covid-19 cases in East Kalimantan Province using the initial parameter values obtained from Covid-19 cases in Jiangsu Province, China. We chose Jiangsu

Province because the ratio between the total population and the number of positive cases of Covid-19 was close to the condition in East Kalimantan, namely 80 million: 631 positive cases [5]. Parameter in Table 1 used for estimation.

Table 1. Parameter values of Richards model for data of COVID-19 in Jiangsu Province.

Province	r	α	C_0	K	R-Squared
Jiangsu	0,22	1	3	697	93,2%

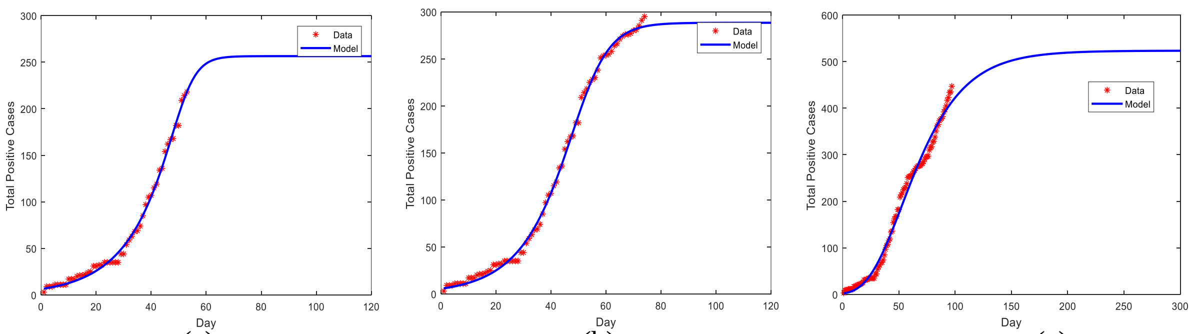
3. Result and Discussion

We examined the results of estimated parameters of Covid-19 using an analytical solution of Richards model. Model parameters were estimated using least square method to obtain the new parameters values. For the predictive accuracy of the Richard model, we calculated RMSE and R-squared in equations (4) and (5). These results are summarized in Table 2.

Table 2. Parameters Estimation for Each Case

Scenario	Case	r	α	C_0	K	R-Sqr of Accumulative Data	R-Sqr of New Case	RMSE
1	Positive Case	0.0707	3.844	6.29	256.45	99.49%	30.93%	4.4252
	PDP case	1453.9	0.0000215	44.7	1279.24	98.79%	0.91%	20.7090
2	Positive Case	0.0757	2.219	5.509	288.36	99.76%	27.31%	4.6088
	PDP case	331.51	0.0000443	76.23	4317.28	98.21%	7.73%	41.7151
3	Positive Case	2103.3	0.00001557	1.82	523.48	98.91%	10.84%	14.46
	PDP Case	0.0338	11.4791	104.2	9975.65	99.06%	24,21%	70.1276

We simulated the new parameters to predict the Covid-19 for the next few days. The simulation was divided into three scenarios. We used data from March 19 until May 10, 2020 for the first scenario, data from March 19 until May 31, 2020 for the second scenario, and data from March 19 until June 21, 2020 for the third scenario.



(a) (b) (c)

Figure 1. Accumulation of Positive Cases of Covid-19 for Scenarios 1 (a), 2 (b) and 3 (c)

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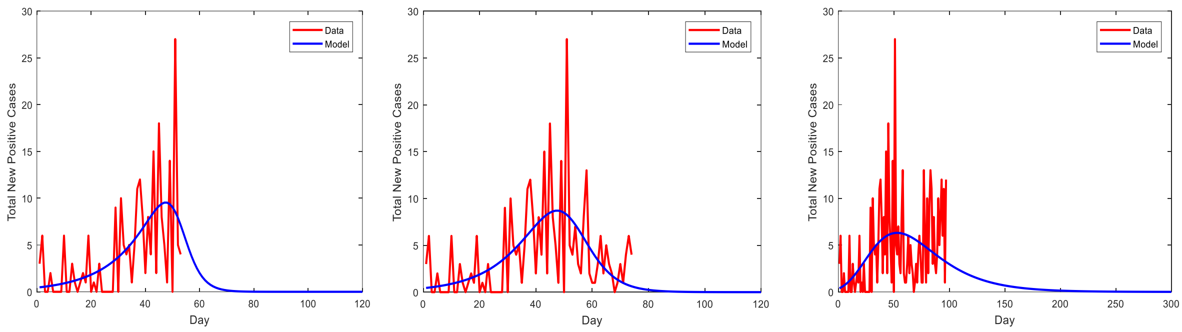

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Figure 2. New Positive Cases of Covid-19 per day for Scenarios 1 (a), 2 (b) and 3 (c)

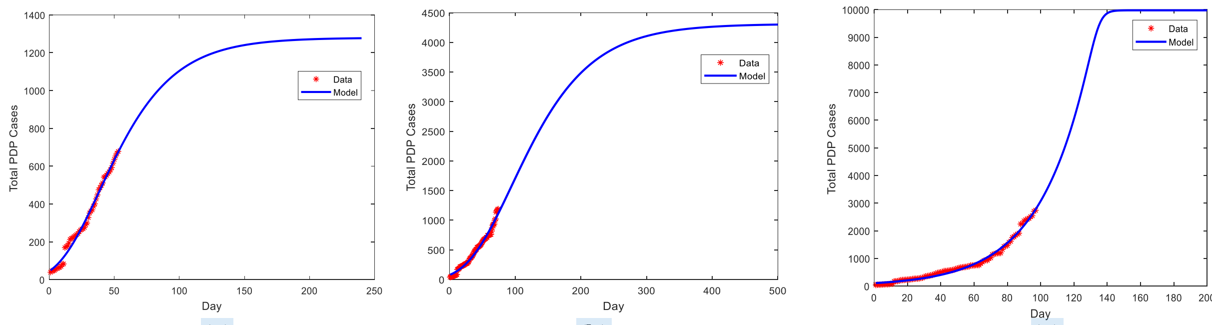

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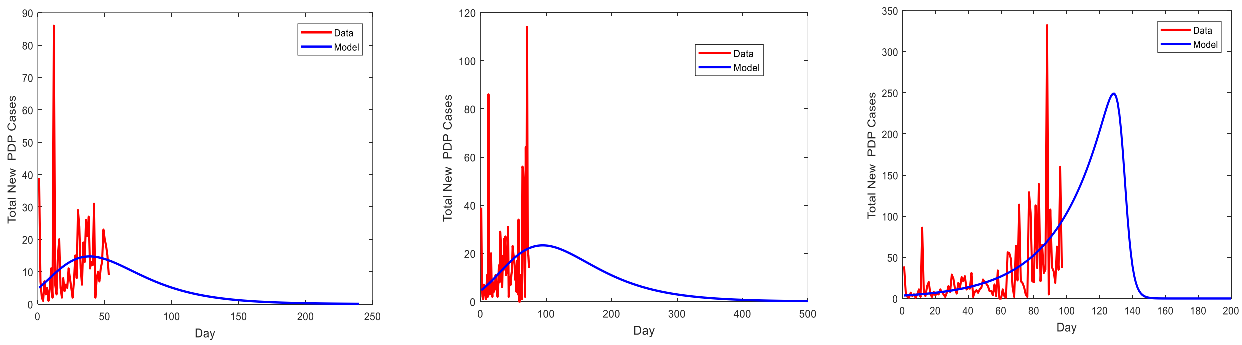
Figure 3. Accumulation of PDP Cases for Scenarios 1 (a), 2 (b) and 3 (c)



(a) (b) (c)

Figure 4. New PDP Cases per day for Scenarios 1 (a), 2 (b) and 3 (c)

R-squared value is used to evaluate the accuracy of the model. Table 2 shows that the R-squared values of accumulated positive cases for scenarios 1, 2 and 3 are 99.49%, 99.76% and 98.91% respectively. The R-squared values of new positive cases per day for scenarios 1, 2 and 3 are 30.93%, 27.31% and 10.84% respectively. Meanwhile, the R-squared values of PDP cases for scenarios 1, 2 and 3 are 98.79%, 98.21% and 99.06% respectively. The R-squared values of new PDP cases for scenarios 1, 2 and 3 are 0.91%, 7.73% and 24.21%, respectively. Table 2 shows the r-squared values of accumulative predictions are higher than the cases new per day, in positive case, scenario 1 has the highest r-squared value, meanwhile, in PDP case, scenario 3 has the highest r-squared value.

igure 2 shows the prediction of the peak dates and the end dates of pandemic for positive cases. We predict the peak date of positive cases for all scenarios is on May 2020. Meanwhile, the end dates of positive cases for scenarios 1 and 2 are on June and October for scenario 3. Furthermore, Figure 4 shows the prediction of the peak dates of PDP cases for scenarios 1, 2, and 3 are on April, June, and July 2020, respectively. Meanwhile, the end dates of pandemic for scenarios 1, 2, and 3 are on October 2020, March 2021, and September 2021. We summarized the predictions in Table 3.

Table 3. Predictions for The Covid-19 Pandemic

Case	Scenario	Peak of Pandemic	End of Pandemic	Number of Cases
Positive Covid-19	1	May 4, 2020	June 16, 2020	256
	2	May 5, 2020	June 29, 2020	288
	3	May 10, 2020	October 14, 2020	523
PDP Covid-19	1	April 26, 2020	October 26, 2020	1279
	2	June 21, 2020	March 29, 2021	4317
	3	July 25, 2020	September 7, 2021	9975

4. Conclusion

In this study, we present the growth model of Covid-19 cases in East Kalimantan. We simulated and verificated the model using the positive and PDP cases. The Richards growth model was estimated using several scenarios over time periods of data. We found that the time span of the data influenced the predictions of the model. This indicates that the accuracy of the model depends on the time period of the data. In addition, this prediction model can be used as an informative reference to describe the growth curve of Covid-19 pandemic in the future.

References

[1] East Kalimantan Province Health Office of Indonesia *East Kalimantan province press release regarding Covid-19 2019* (COVID-19). 2020. https://covid19.kaltimprov.go.id/
[2] Guofa G and Guiyun Y 2003 Severe acute respiratory syndrome epidemic in asia *Emerg Infect Dis* **9** (12) 1608-10
[3] Ying-Hen H 2009 Richards Model: A simple procedure for real-time prediction of outbreak severity. *Mod and dyn of infect dis* 216-36.
[4] Nuning N Kamal K and Mochamad A 2020 Modeling simulation of COVID-19 in Indonesia based on early endemic data.. *Commun Biomath Sci*. **3** (1):1-8
[5] Ke W Didier D Qian W and Didier S 2020 Generalized logistic growth modeling of the COVID-19 outbreak in 29 provinces in China and in the rest of the world. *Arxiv*. http://arxiv.org/abs/2003.05681. Acces on 9 June 2020
[6] Giovani L V Antônio M S M Raydonal O Francisco A G A Gerson C D-F and Inês C L S 2020 Modelling fatality curves of COVID-19 and the effectiveness of intervention strategies. *medRxiv*. 2020:2020.04.02.20051557. Acces on 4 April 2020
[7] P.F. Verhulst 1838 Notice sur la loi que la population suit dans son accroissement, *Corr. Math. Physics*, **10** 113
[8] Thomas M 1830 An Essay on the principle of population, (1798 1st edition) with a summary view and introduction by professor anthony flew *Penguin Classics*. ISBN 0-14-043206
[9] F.J. Richards 1959 A flexible growth function for empirical us. *J Exp Botany*, **10** (29) 290–300
[10] Tsoularis A and Wallace J Analysis of logistic growth models 2002 *Math Biosci*. **179** (1) 21-55

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