Patient Visit Forecasting at Emergency Department using Autoregressive Integrated Moving Average (ARIMA) and *Exponential Smoothing Method in RSUD Kembangan*

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Keywords: Forecasting, Autoregressive Integrated Moving Average (ARIMA), Exponential Smoothing, Best Model, Emergency Department.

Abstract: The situation in the Emergency Department (ED) at RSUD Kembangan is generally overcrowded where many patient's arrival is unpredictable. Based on the results data in 2015-2019, patient visits to the emergency department tend to increase by around 42% per year. The limited number of beds and medical personnel causes a decrease in productivity and mobility when conducting health services. Therefore, forecasting for patient visit is needed to minimize these problems. This study aims to predict patient visits at the Emergency Department in RSUD Kembangan using Autoregressive Integrated Moving Average (ARIMA) and Exponential Smoothing. Secondary data obtained from April 2015 to June 2019 retrieved from RSUD Kembangan. The results showed that the ARIMA model (1,1,2) was chosen as the best model with MSE 22600.3 and MAPE 10.6 while Exponential Smoothing from Brown showed MSE 26900.6 and MAPE 11.8. ARIMA (1,1,2) has the smallest error size parameter so that a suitable model is applied in forecasting the number of emergency patient visits at RSUD Kembangan in the future.

1 INTRODUCTION

General hospitals provide excellent service for 24 hours non-stop which is marked by the availability of Emergency Department (ED). Emergency Department is a clinical treatment that requires immediate medical treatment to save lives and replace disability further (Republik Indonesia, 2009). Carrying out these activities distributed to various reports made to improve hospital services, one of which is visit reporting.

Patient visit reports are reported periodically every month. This needs to be done as an evaluation of management regarding decision making, strategic planning, and indicators of workload calculations for health workers.

The results of Warijan's research (2018) showed that the number of outpatient visits at RAA Soewondo Hospital each year has increased by an average of 21.67%. (Warijan *et al.*, 2018). The increase in the number of patient visits is likely to occur every year so forecasting needs to be done in the future.

Forecasting is an activity of predicting future events based on prior knowledge obtained through a systematic process or intuition (Makridakis, 2010). Forecasting is an attempt to predict something that will happen based on previous data and related variables. Forecasting is important for health care institutions that can be used as parameters or references in planning and making decisions significantly.

The purpose of forecasting is to find patterns in historical data series and extrapolate these patterns into the future, to reduce management risk and errors in decision making (Makridakis, 2010). Forecasting has several models that can be adjusted to the actual data and events. Among them are the Autoregressive Integrated Moving Average (ARIMA) and Exponential Smoothing models.

The results of Choudhury's research (2019) stated that ARIMA (3,0,0) (2,1,0) was chosen as the appropriate model for forecasting and fulfilling the requirements with the Box-Ljung correlation test and Jarque-Bera test for normality so that it can estimate arrivals the number of patients in the emergency room

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accurately and also as an indicator of decision support systems in the health industry (Choudhury, 2019).

In line with Putri's research (2018), the exponential smoothing model that shows the possibility of hypertension cases shows a MAPE value of 25.71% for men and 19.63% for women so that it can be concluded that this forecasting model can help the decision making process for a long period of time will come based on forecast data that has similarities with actual data (Putri, Herawati and Ramani, 2018).

Based on Choudhury's research (2019), the density in the ED is triggered by various factors including the patient population, physical capacity, practical capacity, functional capacity, and fiscal capacity. Density in the emergency room can potentially hinder patient care which causes treatment delay and the possibility of errors in the medical treatment process (Choudhury, 2019).

RSUD Kembangan is a hospital that has emergency services. The situation in the Emergency Department is generally overcrowded where many patients come and are unpredictable. The overcrowded emergency room also results in reduced productivity and mobility of services for doctors and nurses so as to reduce the quality of excellent health services.

Based on the results of preliminary observational data in 2015-2019, patient visits in the emergency room tend to increase with an increase of 42% per year and the average number of patients who come per day in the span of the year is 29 patients. With a limited number of beds which are as many as 6 units, this is considered less effective in conducting emergency services. Moreover, the problem that occurs is that patients in the ED are generally queued like in a polyclinic and not infrequently they are served in the patient's waiting chair. This condition if left unchecked can trigger many errors in medical services. Therefore, there is a need for modeling and forecasting of patient visits in the emergency room so that health care providers can have anticipation when there is excessive density.

However, it is necessary to conduct research on modeling and forecasting of patient visits in emergency departments using the Autoregressive Integrated Moving Average (ARIMA) and Exponential Smoothing methods at RSUD Kembangan.

2 METHOD

This research is a time-series study that uses the Autoregressive Integrated Moving Average (ARIMA) and Exponential Smoothing method to predict patient visits in Emergency Departments based on observations of data from April 2015 to June 2019 to forecast the number of IGD patient visits in July 2019 to December 2020.

The population in this study is the data of the number of patient visits Emergency Services at RSUD Kembangan in 2015-2019 as many as 53,633 patient data with details of 3,992 patients in 2015, 10,939 patients in 2016, 13,482 patients in 2017, 14,842 patients in 2018 and 10,378 patients until June 2019. This research using total sampling.

Collected data derived from secondary data namely emergency patient visit data by looking directly at the annual report data and the daily report book of the emergency department of RSUD Kembangan in 2015-2019. The instrument used in this study was a checklist sheet.

Data processing techniques in this study were done manually and computerized. The data processing stage is started from editing, income, categorization, cleaning, and presentation data.

3 RESULT

3.1 Identify of ED Patient Visit Data Pattern in RSUD Kembangan

Historical data on patient visits in the ED for the past 5 years starting from April 2015 to June 2019 can be seen in figure 1.

Based on Figure 1, overall the actual data tends to increase even though there are some values that show a decrease. The lowest patient visit data occurred in April 2015 with 289 patients while the highest patient visit during the study period occurred in February 2019 with a total of 2227 patients due to cases of Dengue Hemorrhagic Fever (DHF).

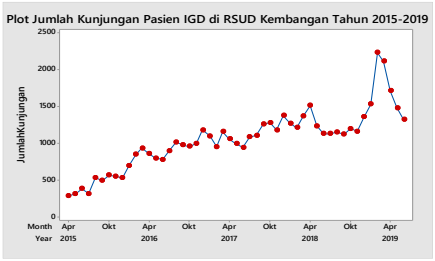

Figure 1: Total Patient Visits in RSUD Kembangan 2015-2019.

Before forecasting, it is necessary to know the decomposition of data patterns to determine whether

the type of data pattern contains elements of trends, seasonal, cyclical, or random and in accordance with the historical data of emergency room patient visits at RSUD Kembangan.

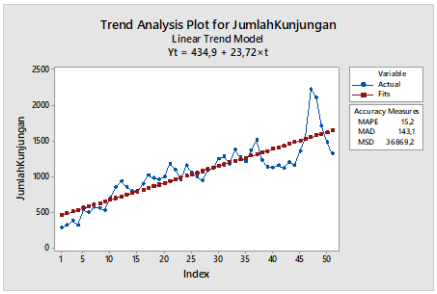

Figure 2: Data Pattern Type of Patient Visit.

Figure 2 shows a straight red line that goes up. It can be concluded that the types of data patterns that are consistent with historical data only contain trend elements.

3.2 Arima Model

3.2.1 Stationarity

1. *Box-Cox Transformation Test*

It needs to know that stationarity data to variant.

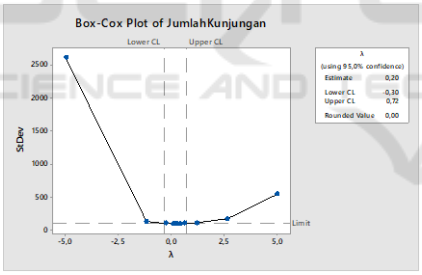

Figure 3: Unstationary Variant.

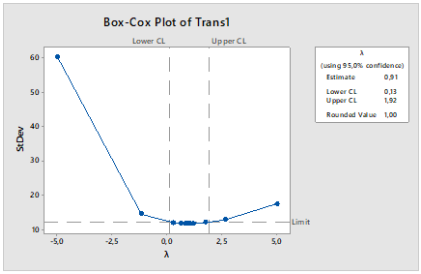

Figure 4: Stationary Variant.

Box-Cox Transformation test results obtained after the first data transformation by converting into a log form so that it gets a value of λ = 0.00 and indicates that the data is not stationary because stationarity in the variant if the value λ ≠ 1. Therefore it is necessary transformation is performed again and the value λ = 1. It concluded that the data is stationary for the variant.

2. ACF and PACF Test

These test necessary to know stationary data to mean.

Based on the figure 4 Lag on the ACF touches the number 3 and exceeds the 95% confidence level so the data is not stationary and a differencing process must be performed.

The ACF plot results show that the autocorrelation value forms a cut of the pattern on the lag and the pacf plot results after differencing show a pattern that does not cross the line of trust so that the data has been stationary.

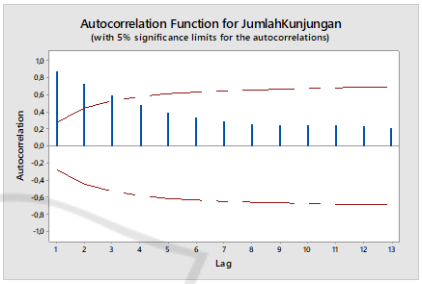

Figure 5: ACF historical data.

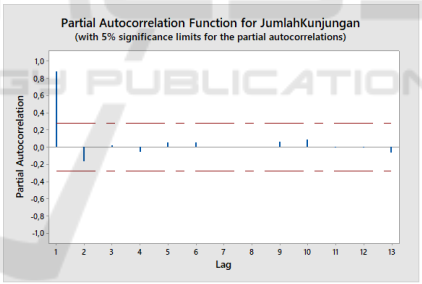

Figure 6: PACF historical data.

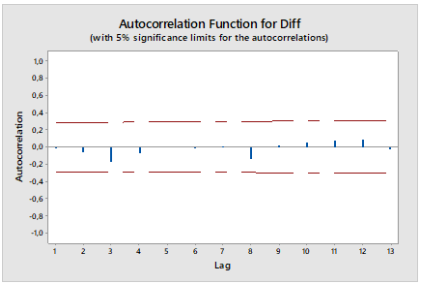

Figure 7: ACF after differencing.

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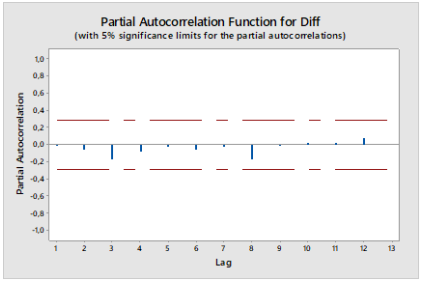

Figure 8: PACF after differencing.

3.2.2 ARIMA Result Forecast

Forecasting the number of patient visits in the emergency room at RSUD Kembangan using the Autoregressive Integrated Moving Average (ARIMA) method with the best model p, d, q (1,1,2), AR parameters (1) 0.05 ma (1) 0.03 and MA (2) 0.05 significant with constant value 0.00 and has a MSE value of 22600.3. Diagnostic checking is carried out to determine the level of significance of the arima model, can be seen in the following table:

Table 1: Patient Visit in ED with Diagnostic Checking.

Model	AR	MA	MSE	Result
0,1,1		0,28	26984,4	
1,1,0	0,42		27128,7	
1,1,1	0,81	0,67	27462,8	
1,1,2	0,05	(1) 0,03 (2) 0,05	22600,3	Significant
2,1,0	(1) 0,36 (2) 0,22		26831,0	
2,1,1	(1) 0,20 (2) 0,64	0,12	28272,2	
2,1,2	(1) 0,00 (2) 0,06	(1) 0,00 (2) 0,71	21979,0	

* p-value (p <0,05)

So the forecasting plot using ARIMA (1,1,2) can be seen in the figure below:

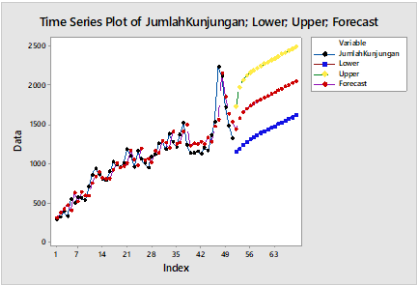

Figure 9: Forecasting of ED with ARIMA (1,1,2).

3.3 Exponential Smoothing Model

The actual data of emergency room patient visits contain trend values, so it can be concluded that the model used is Brown's double exponential smoothing. This technique uses two smoothes that can be calculated with only three data values and one alpha value.

Based on Figure 10, the graph shows a trend pattern shown by the blue line. While the red color chart shows the value of the upper and lower limit of forecasting with 95% CI. The trend value in this model is significant at 0.04957 so that the <p-value is 0.05. The average MSE error value is 26900.6. An increase in the average number of patient visits in this forecast each month is 4 patients starting from July 2019-December 2020.

3.4 Comparison between ARIMA and Exponential Smoothing Model

The ARIMA and Exponential Smoothing models have in common that is only using univariate data containing trend patterns. Both of these models also assume that values and errors from the past can be used as the basis for forecasting.

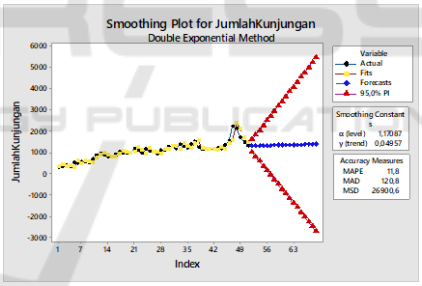

Figure 10: Forecasting of ED with Exponential Smoothing.

The weakness of the ARIMA model is that it cannot produce good predictions in the long run whereas double exponential smoothing brown requires alpha, beta, and gamma values by trial and error but the complexity level is lower than ARIMA.

Based on table 2, between the two forecasting models, namely ARIMA and exponential smoothing have the same upward trend. But each month the difference between both is quite significant. Therefore, it is necessary to measure the MSE and MAPE parameters to determine the best model that can be used as an indicator of forecasting the number of emergency patient visits at RSUD Kembangan in the future.

3.5 Determining Best Model

The results of parameter measurements for determining the forecasting model for the number of emergency patient visits at Kembangan Hospital can be seen in the table 3.

Table 2: Comparison forecasting data of Patient Visit at ED using ARIMA AND *Exponential Smoothing.*

Year	Month	Forecasting Result in ARIMA	Forecasting Result in *Exponential Smoothing*
2019	July	1431	1299
	August	1571	1303
	September	1648	1307
	October	1696	1312
	November	1731	1316
	December	1760	1320
2020	January	1785	1324
	February	1810	1329
	March	1834	1333
	April	1858	1337
	May	1881	1341
	June	1905	1346
	July	1928	1350
	August	1952	1354
	September	1975	1358
	October	1998	1363
	November	2021	1367
	December	2045	1371

Table 3: Parameter Measurement Best Model.

Model	Parameter Measurement	
	MSE	MAPE
ARIMA (1,1,2)	22600,3	10,6
Exponential Smoothing	26900,6	11,8

According to Ningtiyas's journal states that with the limitations of MSE as a measure of forecasting accuracy, an alternative measure is used as an indication of accuracy in forecasting, namely MAPE (Ningtiyas, 2018).

For make sure, the research did a significant test using Akaike Information Criterion (AIC) to know the lowest value of this result. Then, it got 650.86 for ARIMA and 710.67 for Exponential Smoothing.

From the research that has been done, it is known that the error value from ARIMA is smaller than Exponential Smoothing. So it can be concluded that forecasting accuracy with ARIMA (1,1,2) is better than Exponential Smoothing.

4 CONCLUSIONS

The number of ED patient visits at the RSUD Kembangan period of April 2015 to June 2019 has increased every month. The largest surge in patients was in February 2019 with a total of 2227 people due to an Extraordinary Event of Dengue Hemorrhagic Fever (DHF) or commonly referred to as Dengue Fever. Whereas the least number of patient visits occurred in April 2015 amounted to 289 patients because the Kembangan Regional Hospital had just been inaugurated which was previously the Kembangan District Health Center.

Forecasting is done with two models namely ARIMA and Exponential Smoothing. The results obtained by the ARIMA model (1,1,2) were chosen because they have MSE values of 22600.3 and MAPE 10.6. Whereas in the Exponential Smoothing Model because the data contained trend elements, Exponential Smoothing was chosen, which received MSE 26900.6 and MAPE 11.8. For make sure, the research did a significant test using Akaike Information Criterion (AIC) to know the lowest value of this result. Then, it got 650.86 for ARIMA and 710.67 for Exponential Smoothing.

Determination of the best model is done by looking at the smallest error value so that the ARIMA model (1,1,2) is chosen because it has a smaller value compared to Exponential Smoothing.

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