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Application of Triple Exponential Smoothing Method for Predicting the Number of Patients at RSUD dr.Fauziah Bireuen

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ABSTRACT

RSUD dr. Fauziah Bireuen is the main referral hospital in Bireuen Regency which has an important role in public health services. Fluctuations in the number of patients per polyclinic are a challenge in managing resources such as medical personnel, medicines, and other supporting facilities. This study aims to apply the triple exponential smoothing method in predicting the number of patients per polyclinic. The results showed that the triple exponential smoothing method has a high level of accuracy with a MAPE value of 1.456% (98.544% accuracy). Predictions using triple exponential smoothing predict 211,460 patients in January 2025, 211,454 in February 2025, and 211,455 for March 2025 to December 2026. Based on these results, triple exponential smoothing is recommended as it provides accurate results and supports the hospital's operational efficiency.

I. Introduction

Hospitals are health care institutions that provide comprehensive individual health services, including inpatient, outpatient, and emergency services [1] [2] [3]. Regional General Hospital Dr. Fauziah Bireuen is one of the main referral hospitals in Bireuen district which plays an important role in providing health services to the entire community. As the population increases and the need for health services for the community increases, the number of patient visits to the hospital tends to increase from year to year. Hospitals must have a good system to calculate the number of patients per polyclinic in order to prepare more effective resources, such as medical personnel, medicines and other supporting facilities. Because these fluctuations in patient numbers are often influenced by various factors, such as seasonality, seasonal disease trends and demographic conditions. Hospitals provide the best service to patients or the public. As health workers, there should be no mistakes in providing services to patients [4].

One of the challenges in hospital management is ensuring that healthcare needs are always ready to meet patient demand at each polyclinic. The inability to accurately predict the number of patients can lead to patient backlogs and poor service quality, which in turn can affect patient satisfaction and hospital reputation [5] [6]. Therefore, an accurate and reliable prediction of the number of patients per polyclinic is needed to estimate the number of patients to come [7]. Prediction is a way to use previous data trends to make future decisions [8] [9]. The goal of prediction is to make predictions that can reduce the prediction error (forecast error) which can be measured by Mean Absolute Percentage Error (MAPE), this method calculates the difference between predicted data and original data [10] [11] [12].

Triple Exponential Smoothing is a prediction technique that can be utilized to project time series data that experiences seasonal and trend fluctuations, this method consists of parameters that each set the level of smoothing for levels, trends and seasonality in the data, This method has two models, more precisely additive and multiplicative [13] [14] [15]. To choose the right model, one thing to consider is whether the seasonal fluctuations are stable over a period of time. If the seasonal fluctuations appear to be stable over a period of time, the additive model is a good choice. Conversely, if the seasonal fluctuations in the time series data tend to change over time, a multiplicative model is a better choice [16] [17] [18].

There are several related previous studies that have been conducted with the triple exponential smoothing method, "Application of Triple Exponential Smoothing Method to Predict LQ45 Stock Price," discusses triple exponential smoothing (TES) is a time series analysis forecasting method, especially for data that has seasonal fluctuations or complex trends. The results show that the triple exponential smoothing method is quite effective in forecasting the movement of LQ45 stock prices in the short term, with an error rate of around -0.1% to 1% [19]. "Comparison of Triple Exponential Smoothing and ARIMA in Predicting Cryptocurrency Prices," in this study, TES excels in predicting Bitcoin and Binance Coin prices with lower error rates (MAPE 10.38% and 13.81%, respectively), while ARIMA is better at predicting Ethereum, Solana, and Ripple prices (lowest MAPE 8.78%) [20]. "Forecasting Non-Oil and Gas Exports in Indonesia Using Double and Triple Exponential Smoothing Methods," the results show that the additive Holt-Winters model has the best performance with the lowest MAPE value (below 10%) compared to other models [21]. "Comparison of exponential smoothing and ARIMA time series models for forecasting COVID-19 cases: a secondary data analysis," the results showed that the Holt-Winters model is better for long-term prediction than the ARIMA model, which is better for short-term prediction. The exponential smoothing method is considered quite accurate for projecting pandemic cases, especially for long and stable time series data [22] [23]. Analysis of prediction of number of inpatients at GMIM Siloam Sonder hospital using Triple Exponential Smoothing method this study aims to assist hospital management in planning to improve service facilities by predicting the number of patients in the next three years. the triple exponential smoothing method has a higher level of accuracy with a MAPE value of less than 10% and the smallest sum square error value is 3690.655 [14].

Currently, simple applications are used to manage information in many medical centers, but they can only collect data and do not yet have the ability to analyze and predict subsequent data. If the system used can analyze the data entered into the system, this process will become easier for hospital management. Predicting the right number of patients at RSUD dr. Fauziah Bireuen is very important to optimize the management of hospital resources. The hospital can project the number of patients and anticipate changes in the number of patients. This ensures that service quality is maintained and patient satisfaction is increased. This research is expected to produce a reliable prediction model to support the hospital's readiness to provide the best health services to the community through the use of the Triple Exponential Smoothing technique. This research aims to compare the two methods in order to produce a reliable prediction model of the number of patients to support the readiness of the Hospital.

II. Method

The method used in this study is the triple exponential smoothing method to predict the number of patients per polyclinic at RSUD dr. Fauziah Bireuen January 2020 - December 2024 in the next period. To measure the accuracy of prediction using the Mean Absolute Percentage Error (MAPE) method.

A. System Scheme

The system scheme to be built in this research uses the triple exponential smoothing method with the following process:

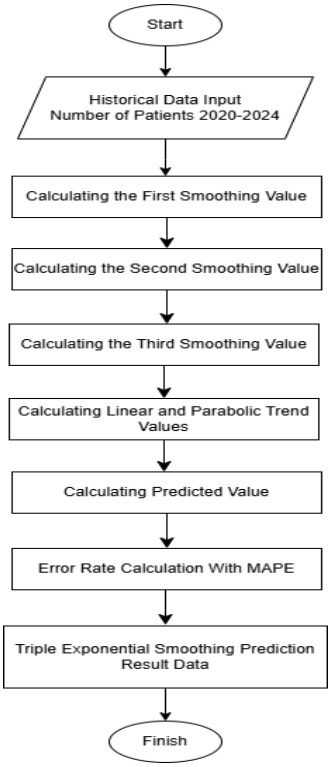

Fig 1. System Scheme *Triple Exponential Smoothing*

III. Results and Discussion

This study will apply the use of triple exponential smoothing method in predicting the number of patients per polyclinic at RSUD dr. Fauziah Bireuen, Aceh. This method is commonly used for time series-based forecasting, where historical data is used as a guide to predict future data. The prediction period used can be adjusted as needed, either on a weekly, monthly, or annual basis. In this study, the data used is the number of patients per polyclinic monthly, so that the prediction results will provide an overview of the number of patients per polyclinic estimated in the following month. This research is expected to provide useful information for the hospital in planning services and managing resources more effectively.

A. Manual Calculation of Triple Exponential Smoothing

This study uses data on the number of emergency room patients at RSUD Dr. Fauziah Bireuen from January 2020 to December 2024.

Tabel 1. Historical data on the number of emergency room patients

No	Period	Number of Patients	No	Period	Number of Patients	No	Period	Number of Patients
1	Jan-20	368	21	Sep-21	273	41	May-23	479
2	Feb-20	320	22	Oct-21	287	42	Jun-23	480
3	Mar-20	444	23	Nov-21	360	43	Jul-23	480
4	Apr-20	324	24	Dec-21	315	44	Aug-23	564
5	May-20	378	25	Jan-22	349	45	Sep-23	569
6	Jun-20	388	26	Feb-22	408	46	Oct-23	640
7	Jul-20	377	27	Mar-22	413	47	Nov-23	329
8	Aug-20	350	28	Apr-22	306	48	Dec-23	210
9	Sep-20	357	29	May-22	351	49	Jan-23	246
10	Oct-20	295	30	Jun-22	265	50	Feb-23	278
11	Nov-20	318	31	Jul-22	302	51	Mar-23	191
12	Dec-20	315	32	Aug-22	378	52	Apr-23	150
13	Jan-21	351	33	Sep-22	371	53	May-23	138

No	Period	Number of Patients	No	Period	Number of Patients	No	Period	Number of Patients
14	Feb-21	333	34	Oct-22	441	54	Jun-23	157
15	Mar-21	315	35	Nov-22	516	55	Jul-23	157
16	Apr-21	324	36	Dec-22	412	56	Aug-23	184
17	May-21	367	37	Jan-23	473	57	Sep-23	199
18	Jun-21	307	38	Feb-23	462	58	Oct-23	220
19	Jul-21	310	39	Mar-23	455	59	Nov-23	206
20	Aug-21	373	40	Apr-23	423	60	Dec-24	212

The following is a manual calculation process to predict the number of emergency room patients at Dr. Fauziah Hospital using the triple exponential smoothing method. This study will use an alpha value = 0.3. With data on the number of emergency room patients collected during February 2020 as many as 320, then:

1. Calculate the first smoothing value

$$S't = \alpha(Xt) + (1-\alpha)\, S'_{t-1} \quad (1)$$
$$= 0.3\,(320) + (1 - 0.3)(368)$$
$$= 353.6$$

2. Calculating the second smoothing value

$$S''t = \alpha(S't) + (1-\alpha)\, S''_{t-1} \quad (2)$$
$$= 0.3\,(353.6) + (1 - 0.3)(368)$$
$$= 363.68$$

3. Calculating the third smoothing value

$$S'''t = \alpha(S''t) + (1-\alpha)\, S'''_{t-1} \quad (3)$$
$$= 0.3\,(363.68) + (1 - 0.3)(368)$$
$$= 366.704$$

4. Calculating the average value of the period

$$a_t = 3S'_t - 3s''_t + S'''_t \quad (4)$$
$$= 3(353.6) - 3(363.68) + 102.81$$
$$= 336.464$$

5. Calculating the linear tendency/trend value

$$b_t = \frac{\alpha}{2(1-\alpha)^2}[(6-5\alpha)\, S'_t - (10-8\alpha)\, S''_t + (4-3\alpha)\, S'''_t] \quad (5)$$
$$= \frac{0.3}{2(1-0.3)^2}[(6 - 5 \times 0.3)\, 353.6 - (10 - 8 \times 0.3)\, 363.68 + (4 - 3 \times 0.3)\, 366.704]$$
$$= 0.306\,(1591.2 - 2763{,}968 + 1136.7824)$$
$$= -11.016$$

6. Calculating the parabolic trend value

$$c_t = \frac{\alpha^2}{(1-\alpha)^2}[S'_t - 2S''_t + S'''_t \quad (6)$$
$$= \frac{0.3^2}{(1-0.3)^2}[353.6 - 2(363.68) + 366.704$$
$$= 0.1836\,(-7.056)$$
$$= -1.296$$

7. Calculating the prediction value

$$F_{t+m} = a_t + b_t m + \frac{1}{2}c_t m^2 \quad (7)$$
$$= 336.464 + \left(-11.016(1)\right) + \frac{1}{2}\left(-1.296(1)\right)$$
$$= 324{,}8$$

The following table shows the overall calculation which includes information about the number of emergency room patients, period, first smoothing value, second smoothing value, third smoothing value, average period value, linear trend value, and parabolic trend, as well as the prediction results obtained using the triple exponential smoothing method.

Tabel 2. Results of Prediction of the Number of Emergency Room Patients TES Method

Period	Number of Patients	S't	S''t	S'''t	at	bt	ct	Ft
Jan-20	368							
Feb-20	320	353.60	363.68	366.70	336.464	-11.01	-1.29	324.80
Mar-20	444	357.20	331.16	323.34	401.468	28.45	3.34	431.60
Apr-20	324	408.00	433.20	440.76	365.160	-27.54	-3.24	336.00
May-20	378	340.20	328.86	325.45	359.478	12.39	1.45	372.60
Jun-20	388	381.00	378.90	378.27	384.570	2.29	0.27	387.00
Jul-20	377	384.70	387.01	387.70	380.773	-2.52	-0.29	378.10
Aug-20	350	368.90	374.57	376.27	359.261	-6.19	-0.72	352.70
Sep-20	357	352.10	350.63	350.18	354.599	1.60	0.18	356.30
Oct-20	295	338.40	351.42	355.32	316.266	-14.22	-1.67	301.20
Nov-20	318	301.90	297.07	295.62	310.111	5.27	0.62	315.70
Dec-20	315	317.10	317.73	317.91	316.029	-0.68	-0.08	315.30
…	…	…	…	…	…	…	…	…
Dec-24	212	207.80	206.54	206.16	209.942	1.37	0.16	211.40

8. Calculating prediction accuracy

MAPE is used to calculate the average percentage of absolute error between actual data and prediction results. A smaller MAPE value indicates that the prediction method used is more accurate. The following is the calculation of MAPE for the Triple exponential smoothing method.

$$\text{MAPE} = \frac{100\%}{n}\sum_{t=1}^{n}\left|\frac{y_t - \widehat{y_t}}{y_t}\right| \quad (8)$$
$$= \frac{100\%}{59} \times (1.500 + 2.793 + 3.704 + 1.429 + 0.258 + \cdots + 0.292)$$
$$= \frac{100\%}{59} \times 85.907$$
$$= 1.456$$

Tabel 3. MAPE Value of Number of Emergency Room Patients TES Method

Year	Month	Number of Patients	Prediction	MAPE
2020	January	368		
	February	320	324.800	1.500
	March	444	431.600	2.793
	April	324	336.000	3.704
	May	378	372.600	1.429
	June	388	387.000	0.258
	July	377	378.100	0.292
	August	350	352.700	0.771
	September	357	356.300	0.196
	October	295	301.200	2.102
	November	318	315.700	0.723
	December	315	315.300	0.095
...	...	...	...	...
	January	246	242.400	1.463
	February	278	274.800	1.151
	March	191	199.700	4.555

Year	Month	Number of Patients	Prediction	MAPE
2024	April	150	154.100	2.733
	May	138	139.200	0.870
	June	157	155.100	1.210
	July	157	157.000	0.000
	August	184	181.300	1.467
	September	199	197.500	0.754
	October	220	217.900	0.955
	November	206	207.400	0.680
	December	212	211.400	0.283
		MAPE		1.456

9. Predicting the number of emergency room patients using the TES method for the next period

The triple exponential smoothing method can only predict for one period ahead. Like some other methods, it cannot directly calculate the next five or ten periods in one step. It must be done gradually, one after another and use the previous prediction results as new inputs. Where the prediction results in the previous period are considered as historical data for the next period.

For example, to predict the number of emergency room patients in January 2025, the previous month's prediction result of December 2024 is used, which is 211.400. This value is then used as historical data for January 2025 for the next prediction. The results of this analysis are as follows:

Tabel 4. Prediction of the Number of Emergency Room Patients for the Next 24 Periods TES Method

No	Period	Data	Prediction
1	Jan-25	211.400	211.460
2	Feb-25	211.460	211.454
3	Mar-25	211.454	211.455
4	Apr-25	211.455	211.455
5	May-25	211.455	211.455
6	Jun-25	211.455	211.455
7	Jul-25	211.455	211.455
8	Aug-25	211.455	211.455
9	Sep-25	211.455	211.455
10	Oct-25	211.455	211.455
11	Nov-25	211.455	211.455
12	Dec-25	211.455	211.455
13	Jan-26	211.455	211.455
14	Feb-26	211.455	211.455
15	Mar-26	211.455	211.455
16	Apr-26	211.455	211.455
17	May-26	211.455	211.455
18	Jun-26	211.455	211.455
19	Jul-26	211.455	211.455
20	Aug-26	211.455	211.455
21	Sep-26	211.455	211.455
22	Oct-26	211.455	211.455
23	Nov-26	211.455	211.455
24	Dec-26	211.455	211.455

10. MAPE Results of Triple Exponential Smoothing Method for Number of Emergency Room Patients

Based on the MAPE value that has been obtained, the triple exponential smoothing method is able to provide an accuracy rate for the number of emergency room patients of 1.456%. MAPE which is below 10% indicates that the prediction quality is very good. Therefore, it can be concluded that the most appropriate method used to predict the number of patients per polyclinic at RSUD Dr. Fauziah Bireuen is the triple exponential smoothing method.

11. Garfik Results of Number of Emergency Room Patients Triple Exponential Smoothing Method

The following graph shows the prediction results using the triple exponential smoothing method, the resulting prediction results look much closer to the actual data. The pattern of the rise and fall of the number of emergency room patients can be followed quite well. The method also takes into account the trend component in the prediction process, so that it can produce more dynamic predictions and the method also looks more accurate and realistic when patient data increases or decreases sharply because the prediction line also follows these changes.

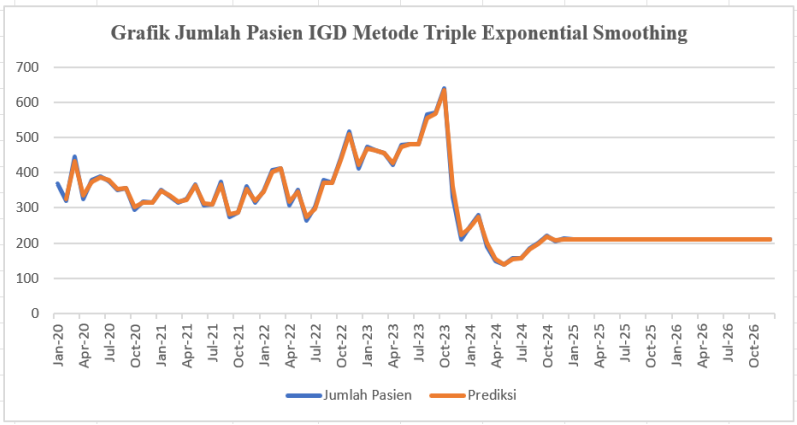

Fig 2. Graph of Number of Emergency Room Patients TES Method

B. System Implementation

1. Polyclinic List Page

The polyclinic list page displays information about all polyclinics that have been inputted by the admin. After the admin accesses this menu, the system will automatically display a table containing polyclinic list data. Through this page, the admin can also add new polyclinic data, as well as edit or delete existing data.

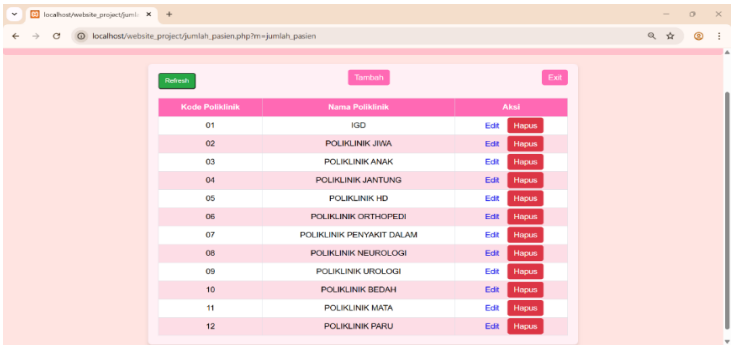

Fig 3. Polyclinic List Page

2. Period Page

The period page displays information about all periods that have been inputted by the admin. After the admin accesses this menu, the system will automatically display the period data table complete with the name of the polyclinic and the number of patients that have been inputted by the admin before. Through this page, the admin can also add new period data, as well as edit or delete existing data.

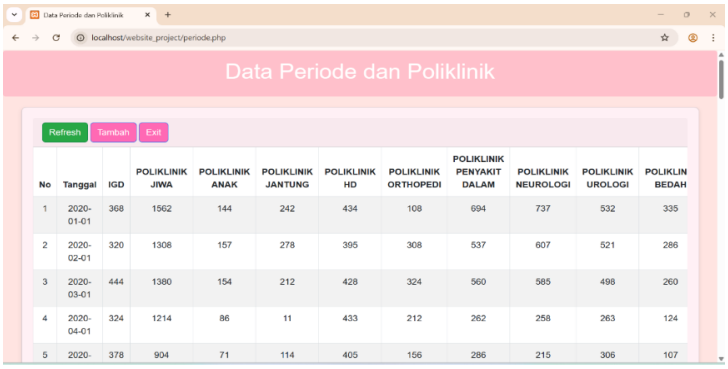

Fig 4. Period page

3. Triple Exponential Smoothing Page

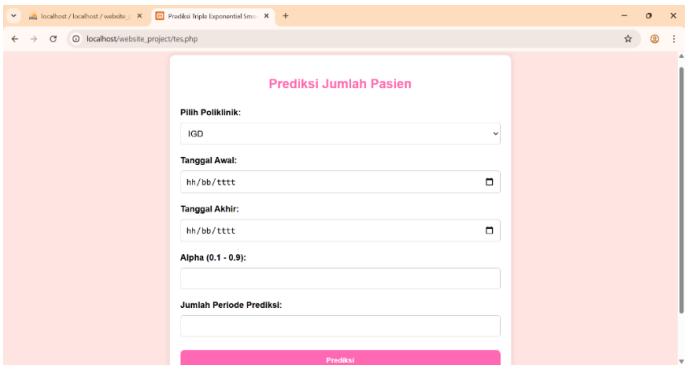

Fig 5. Triple Exponential Smoothing Calculation Page

After the input process is complete, the system will display the complete data calculation results, including predictions for the next period and the MAPE value of the number of patients at the selected polyclinic. The data can also be printed. In addition, the system also presents a visualization graph of the calculated prediction results. The following graph shows the prediction of the number of patients of the selected polyclinic using the Triple Exponential Smoothing method. This graph illustrates the trend of historical data and predictions for the next period. The horizontal axis (X) shows time and the vertical axis (Y) shows the number of patients.

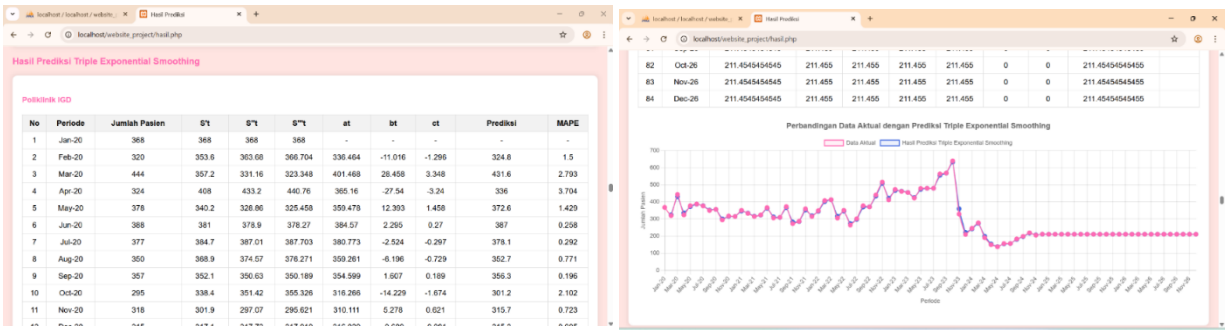

Fig 6. Triple Exponential Smoothing Prediction Final Results Page

IV. Conclusion

The application of the Triple Exponential Smoothing method can produce predictions of the number of patients per polyclinic at RSUD dr. Fauziah Bireuen for the coming period. This method shows the ability to identify patterns in historical data on the number of patients per polyclinic to provide more accurate predictions. By using the triple exponential smoothing method, the prediction

period for January 2025 is 211.460, February 2025 is 211.454, March 2025 to December 2026 is 211.455. Based on the results of the MAPE comparison on the number of emergency room patients, the Triple Exponential Smoothing method produces a MAPE value of 1.456%, which means it has an accuracy rate of around 98.544%. Based on the MAPE results on the number of emergency room patients, the most appropriate method used to predict the number of patients per polyclinic at RSUD Dr. Fauziah Bireuen is the Triple Exponential Smoothing method. Triple Exponential Smoothing is highly recommended for use in predicting the number of patients because it is able to provide more accurate results, which greatly helps the hospital in planning resource needs optimally.

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