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# COMPARISON OF FORECASTING DRUG NEEDS USING TIME SERIES METHODS IN HEALTHCARE FACILITIES: A SYSTEMATIC REVIEW

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**ABSTRACT**
Drug planning is essential to ensure the fulfillment of the right type, amount, and time criteria. Forecasting can be utilized during the planning stage to predict future drug needs. Perfect forecasting is impossible due to uncertainties in various factors, necessitating selecting the best method. This study aimed to identify the optimal forecasting method for healthcare facilities based on the smallest Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Mean Absolute Percent Error (MAPE) values obtained from forecasting results using time series methods like Single Moving Average (SMA), Weight Moving Average (WMA), (Single Exponential Smoothing) SES, Double Exponential Smoothing (DES), and Triple Exponential Smoothing (TES). This research involved a descriptive observational study with retrospective data and adhered to PRISMA guidelines. PubMed, Google Scholar, and Garuda served as the data sources. Nine articles meeting the eligibility criteria were employed. The findings revealed that the SES, DES, and TES methods produced forecasts with MAPE values below 10%, indicating highly accurate forecasting. The MAPE values for the SMA and WMA methods were less than 50%, which is still acceptable. Therefore, the ES methods, particularly SES, are highly recommended for accurate drug planning. Forecasting accuracy factors include data stability, pattern consistency, and smoothing constants. The SES method emerged as the best forecasting method, generating the smallest MAD, MSE, and MAPE values compared to other methods, falling below 10%, reflecting highly accurate forecasting.

**Keywords:** Exponential smoothing; Forecasting; Healthcare facilities; Moving average

## 1. INTRODUCTION

The pharmaceutical service provider must ensure that the availability of pharmaceutical preparations, medical devices, and consumable medical materials are safe, of good quality, practical, and affordable. Planning drug needs and controlling drug supplies is a chain of drug governance that includes selection, planning of drug needs, procurement, receipt, distribution, destruction, withdrawal, administration, monitoring, and evaluation (Kemenkes, 2019). Drug planning is essential to fulfill the criteria of the right type, amount, and time (Laurensia et al., 2020). The planning stage can use forecasting to predict future drug needs. Forecasting is an attempt to predict future drug needs by considering and considering events or data from the past (Safitri et al., 2017).

Forecasting methods in healthcare facilities are critical, especially in analyzing drug management. Performing drug management using forecasting methods is essential in decision-

making, especially in estimating the number of drug needs in the future. In addition, it can avoid the occurrence of excess or shortage of drug stocks so that it can manage drug supplies more efficiently. Forecasting analysis is carried out using historical data on previous drug use so that it can project drug needs more accurately. Accurate forecasting can make better decisions regarding drug procurement to improve the quality of health services to patients (Aji et al., 2022). There are many forecasting methods, but the time series method is commonly used, which is based on a sequence of equally spaced data points in time (weekly, monthly, quarterly, and others) (Hernadewita et al., 2020). The time series method is a forecasting method using pattern analysis of the relationship between the variable to be estimated and the time variable. This method assumes that past data is a good indicator of the future. Commonly used time series methods are Single Moving Average (SMA), Weight Moving Average (WMA), Single Exponential Smoothing (SES), Double Exponential Smoothing (DES), and Triple Exponential Smoothing (TES). Some factors contain uncertainty, so it is impossible to do perfect forecasting, so it is necessary to find the best forecasting method. Various forecasting methods require criteria that can be used to compare and select models (Santiari & Rahayuda, 2021).

Model accuracy can be determined using several forecasting error measures, namely Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Mean Absolute Percent Error (MAPE). Forecasting results are calculated using Excel to obtain error measures, namely MAD, MSE, and MAPE. A small error value means that forecasting with the method used has a small error compared to the actual data. The smaller the error value, the smaller the deviation between accurate data and forecasting (Satibi, 2014). MAD is a method to evaluate forecasting by measuring the forecast accuracy through the absolute value of each error in the same unit as the original series. MSE is an approximation forecasting method that manages significant forecasting errors because the errors are squared. MAPE is calculated using the absolute error in each period divided by the real observed value and then averaging the absolute percentage error. This approach is functional when the size of the forecast variable is essential in evaluating forecast accuracy. MAPE indicates how much the error in forecasting is compared to the actual value (Ginantra & Anandita, 2019). The interpretation of the MAPE value is <10%, including very accurate forecasting; 10-20%, including good forecasting; 20-50%, including reasonable forecasting; and >50%, including inaccurate forecasting (Fajrul et al., 2022). The novelty of this systematic review is that there is no need to discuss further the best forecasting method that can be used to determine drug planning in healthcare facilities. Therefore, this systematic review aims to determine the best forecasting method based on the smallest MAD, MSE, and MAPE values from forecasting results using time series methods, namely SMA, WMA, SES, DES, and TES.

## 2. METHODS

This research is a descriptive systematic review with retrospective data, and the guidelines used to review this article are the PRISMA guidelines. In September 2023, a systematic review was conducted on forecasting drug planning using the time series method in healthcare facilities.

### 2.1. Search Strategy

A search was conducted across three databases: PubMed, Google Scholar, and Garuda. The search employed the keywords "exponential smoothing", "forecasting," “hospital”, and "moving average". Boolean operators "AND" and "OR" were used to combine keywords strategically.

### 2.2. Selection Criteria

Articles were selected based on the following search criteria: Indonesian and English, published between 2014-2023, available in full-text, and health care facilities in Indonesia. After applying the search based on the established criteria, the retrieved articles were evaluated for valid and relevant studies that met the inclusion criteria. The inclusion criteria in this systematic review were: a) discussing forecasting of drug demand planning in various health care facilities in

Indonesia; b) using the time series method; c) there are indicators of forecasting accuracy; and d) quantitative research journals. Exclusion criteria in this systematic review are: a) discussing forecasting outside the health sector; b) the year of publication of the article is not listed in the research article; c) proceedings; and d) theses and theses.

### 2.3. Quality Assessment

The quality assessment in this systematic review was conducted using an evaluation tool provided by the Joanna Briggs Institute (JBI). The quality assessment included analysis of various aspects, including research methodology, clarity of research questions, selection of participants, research design, data analysis, and interpretation and conclusion of results. This evaluation process aims to ensure that the research methodology used in this journal meets the quality standards JBI sets so that the research findings are trustworthy, reliable, and relevant. The assessment result is 6/8, indicating that the research meets most of the quality standards JBI sets. This score indicates that of the eight aspects assessed, six have been well met, while the other two aspects still need to meet the set criteria fully.

### 2.4. Data Analysis

Articles satisfying the inclusion criteria, particularly those about forecasting drug needs in healthcare facilities, were further analyzed to align with the objectives of this systematic review. Employing the PRISMA application approach, the review eventually included nine articles.

## 3. RESULTS AND DISCUSSION

### 3.1. Selection Study

A search was performed across three databases: PubMed (yielding 114 articles), Google Scholar (yielding 353 articles), and Garuda (yielding 253 articles). Duplicate studies were removed during the initial screening. Subsequently, the remaining articles were assessed based on the inclusion criteria, resulting in 35 articles. Further screening of abstracts narrowed the selection down to fourteen (14) potentially relevant articles. Finally, nine (9) articles met all the eligibility criteria for inclusion in the systematic review. PRISMA Flowchart Diagram can be seen in Figure 1.

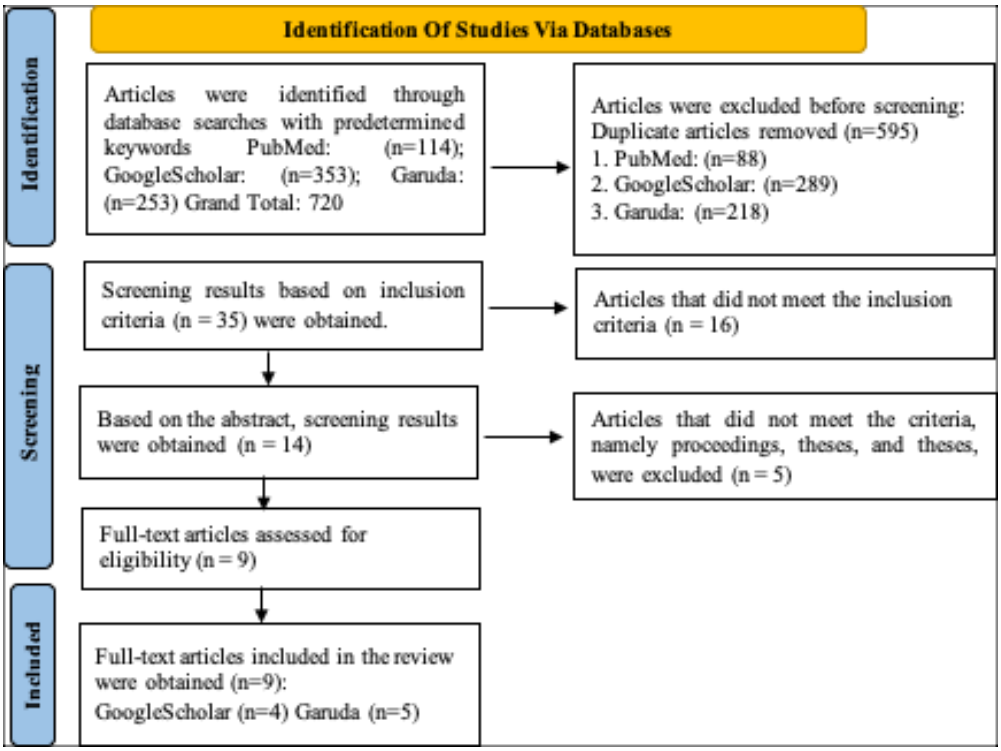


**Figure 1**. PRISMA flowchart diagram

### 3.2. Study Characteristics

Nine articles were identified in this study for quantitative assessment to determine the optimal forecasting method for drug demand planning in healthcare facilities. The publication years of the study used were between 2016-2022. The data used was retrospective data on previous drug usage. The study characteristics of each study can be seen in Table 1.

**Table 1.** Characteristics of forecasting methods

| No | Author Name and Year | Place | Data Type | Data Period |
|---|---|---|---|---|
| 1 | (Sesario et al., 2022) | Pharmacy | Retrospective | September 2021-August 2022 |
| 2 | (Sari et al., 2023) | Pharmacy | Retrospective | February 2020 -October 2022 |
| 3 | (Aji et al., 2022) | Clinic | Retrospective | January 2020-March 2022 |
| 4 | (Sabarina et al., 2021) | Hospital | Retrospective | Data for the 2018-2019 period |
| 5 | (Sophia et al., 2021) | Clinic | Retrospective | January 2018-December 2018 |
| 6 | (Nangi et al., 2018) | Hospital | Retrospective | January 2016-December 2016 |
| 7 | (Vimala & Nugroho, 2022) | Pharmacy | Retrospective | January 2019-December 2021 |
| 8 | (Puspitasari et al., 2022) | Hospital | Retrospective | January 2018-December 2020 |
| 9 | (Hendriani et al., 2016) | Community Health Center | Retrospective | October 2015-March 2016 |

### 3.3. Drug Planning Forecasting against Accuracy Indicators

The results of this systematic review are based on research at Sida Waras Farma Pharmacy and Simpang F Pharmacy; forecasting was carried out using the SES method, which resulted in highly accurate forecasting, namely a MAPE value of <10%. The MAPE value <10% is considered highly accurate forecasting because the lower the MAPE value produced, the less the forecasting error (Sari et al., 2023; Sesario et al., 2022). Sesario et al. (2022) conducted forecasting using the SES method with an alpha constant (α) of 0.1. At the same time, the forecasting conducted by Sari et al. (2023) used a constant alpha (α) of 0.22. The alpha constant value determined using a genetic algorithm (application) produces more accurate forecasting results than conventionally set values (Falani, 2018). The alpha constant is used as a smoothing parameter value or reduces the burden of forecasting error. The provisions for an excellent constant value for forecasting are $0 < \alpha < 1$ (Hudaningsih et al., 2020). The magnitude of the alpha value generated for each drug item does not indicate the forecasting quality but instead reflects the analyzed data pattern. α values close to 1 are used for random data, while α values close to zero are used for more stable data. A higher α value is given to more recent data so that the appropriate α parameter value will provide an optimal forecast with the smallest error value (Fachrurrazi, 2015).

Based on research at the Healthy Prayer Clinic by Aji et al. (2022), they conducted forecasting using the SMA, WMA, and ES methods. The SMA method aims to reduce random variations in demand over time and use the average value to forecast demand for the coming period (Satibi, 2014). The three forecasting methods used produce a MAPE value of <10%, which includes highly accurate forecasting. However, the ES method produces the smallest MAPE value of 0.90%, so it can be concluded that it is the best forecasting method (Aji et al., 2022). Research at Condong Catur Hospital by Sabrina et al. (2021) and Sofia Medika Clinic by Sophia et al. (2021) conducted forecasting using the DES method. DES is a forecaster whose data is not seasonal and patterned with up-and-down trends. The alpha constant used is 0.1. The forecasting results obtained are the MAPE value <10%, including highly accurate forecasting (Sabarina et al., 2021; Sophia et al., 2021). TES forecasting conducted by Nangi et al. (2018) at RSUD Kab. Muna and Apotek Mandiri Medika by Vimala and Nugroho (2022), with an alpha constant of 0.1, resulted in very accurate forecasting, namely the MAPE value <10%. The Triple Exponential Smoothing method is suitable for forecasting seasonal data with trends or fluctuating data (Kristianto et al., 2017). In addition, Vimala and Nugroho also conducted forecasting using the SES and DES methods. In this method, the MAPE values> 10% are 10.46% and 11.39%, which is included in good forecasting because they are in the range of 10-20% (Vimala & Nugroho, 2022). Forecasting drug demand planning using the SMA method at UGM Academic Hospital by

Puspitasari et al. (2022) resulted in a MAPE value < 50%, which ranged from 8-32%. MAPE values in the 20-50% range include reasonable forecasting. Based on research by Hendriani et al. (2016), drug planning forecasting is carried out using the Weighted Moving Average (WMA) method, resulting in a MAPE value = 15.298%, which is included in the excellent forecasting category because it is in the 10-20% range. Forecasting using the WMA method is intended for forecasting with horizontal or stationary data patterns that fluctuate around a constant and consistent average value over time. This method is used with a moving average model using several recent actual demand data to increase the value of demand forecasting in the future (Rizqi et al., 2021). Thus, the ES method, especially SES, produces the most accurate forecasting, as evidenced by the smallest MAPE value.

The effect of the SES method on the MAD value depends on the smoothing constant used. A smaller smoothing constant will give greater weight to the most recent data and make the forecast more responsive to recent changes in the data. This can lead to more significant fluctuations in the forecast and, in turn, increase the MAD value. If a larger smoothing constant is used, the weight given to the most recent data will be smaller, and the forecast will be smoother and less responsive to recent changes. This can reduce forecast fluctuations and result in a lower MAD value. The selection of an appropriate smoothing constant should be based on analysis of historical data and an understanding of the patterns and trends in the data. An optimal smoothing constant can result in a lower MAD value and more accurate forecasting, resulting in a small error value (Nu et al., 2024). The effect of the SES method on the MSE (Mean Squared Error) value is that the smaller the α value, the slower the method reacts to trends and fluctuations in historical data. Thus, if the α value is meager, the SES method gives almost equal weight to all historical data, which can lead to forecasting that is less responsive to actual changes in the data. If the α value is very high, the method will give a higher weight to the most recent data, so the forecast will react more quickly to trend changes or new fluctuations. However, using too high a value of α can also lead to instability in forecasting and overreaction to random fluctuations. Thus, if the resulting forecast is very close to the actual value, the MSE value will be lower, indicating better forecasting quality (Box et al., 2015). Forecasting interpretation results based on accuracy indicators can be seen in Table 2.

### 3.4. Advantages and Disadvantages of Forecasting Methods

The Single Moving Average (SMA) method is a forecast of future periods with historical data over a certain period. SMA is a forecasting method that is done by taking a group of observation values and finding the average value as a forecast for the coming period. The Weight Moving Average (WMA) method is a weighted moving average method that predicts by giving weight to the data of the previous n periods and then dividing it by the number of weights. The WMA method gives greater weight to the most recent data, making it more responsive to changes in recent drug demand trends (Aji et al., 2022). The Single Exponential Smoothing (SES) method is short-term forecasting with the assumption that the data fluctuates near a fixed mean value without trend data and fixed growth patterns. The SES method is a development of the simple moving average model. In the exponential smoothing method, the value of 1/n is replaced with α (Sesario et al., 2022). In this method, forecasting is done by repeating the calculation continuously using the latest data. Each data is given a weight, newer data is given a greater weight. This method is more suitable for forecasting things that fluctuate randomly or irregularly (Yuniarti, 2021). The Double Exponential Smoothing (DES) method is forecasting in the presence of a trend like simple smoothing except that two components must be updated each period level and trend. Level is a smoothed estimate of the data value at the end of each period. The trend is a smoothed estimate of the average growth at the end of each period (Sophia et al., 2021). The Triple Exponential Smoothing (TES) method is forecasting that uses trend and seasonal data forms that can be performed simultaneously (Vimala & Nugroho, 2022). Based on the review of these

results, the advantages and disadvantages of each forecasting method used in health facilities can be seen in Table 3.

**Table 2.** Forecasting interpretation results based on accuracy indicators

| No | Author Name and Year | Methods | Accuracy Indicator | | | Interpretation |
|---|---|---|---|---|---|---|
| | | | MAD | MSE | MAPE | |
| 1 | (Sesario et al., 2022) | *SES* | 21,4 | 710,4 | 7% | Highly accurate forecasting |
| 2 | (Sari et al., 2023) | *SES* | - | - | 4.61% | Highly accurate forecasting |
| 3 | (Aji et al., 2022) | *SMA* | 1.040 | 1.749.587 | 2.63% | Highly accurate forecasting. The ES method produces the smallest MAPE value so that the forecasting performed is the most accurate. |
| | | *WMA* | 1.028 | 1.628.449 | 2.27% | |
| | | *ES* | 883 | 1.341.137 | 0.90% | |
| 4 | (Sabarina et al., 2021) | *DES* | - | - | 9.89% | Highly accurate forecasting |
| 5 | (Sophia et al., 2021) | *DES* | 221.0 | 324.84 | 7.26% | Highly accurate forecasting |
| 6 | (Nangi et al., 2018) | *TES* | - | 48.21 | 4.25% | Highly accurate forecasting |
| 7 | (Vimala & Nugroho, 2022) | *SES* | - | 109.58 | 10.46% | Good Forecasting |
| | | *DES* | - | 129.82 | 11.39% | |
| | | *TES* | - | 91.84 | 9.58% | Highly accurate forecasting |
| 8 | (Puspitasari et al., 2022) | *SMA* | - | - | <50% which is between 8-32%. | Reasonable Forecasting |
| 9 | (Hendriani et al., 2016) | *WMA* | - | - | 15.29% | Good Forecasting |

**Single Moving Average* (SMA), *Weight Moving Average* (WMA), *Single Exponential Smoothing* (SES), *Double Exponential Smoothing* (DES), *Triple Exponential Smoothing* (TES), *Mean Absolute Deviation* (MAD), *Mean Square Error* (MSE), and *Mean Absolute Percent Error* (MAPE).

**Table 3.** Advantages and disadvantages of forecasting methods

| No | Methods | Advantages | Disadvantages |
|---|---|---|---|
| 1 | *SES* | Short-term forecasting, usually only one month ahead, considers the weight of previous data by assigning weights to each data period to distinguish priorities-better handling of outliers, more flexible parameters, and better data smoothing mechanisms (Lusiana & Yuliarty, 2020). | Not capable of long-term forecasting as this method is more suitable for short- or medium-term forecasting. This method tends to be less accurate for long-term forecasting, especially if there is a solid long-term trend (Lusiana & Yuliarty, 2020). |
| 2 | *DES* | This method can be used to solve trend-patterned data. Uses relatively little data. Fewer parameters and more accessible data management (no data transformation is required if the data is non-stationary and no autoregression analysis is used) in forecasting (Junita & Primandari, 2023). | Periodic maintenance and regular checks must be carried out by checking whether the data entered is correct. To get an accurate stock forecast, you must have a lot of sales data per month (Setyawan et al., 2021). |
| 3 | *TES* | It can use relatively little data when compared to other methods. The linear exponential and seasonal smoothing method is used for trend-and seasonal-patterned data. This method uses three parameters: α, β, and γ (Febriyanti & Rifai, 2022). | Dependence on historical data, i.e., if historical data varies significantly or suddenly changes, this method does not produce good forecasts. It is difficult for irregular or varying seasonal periods, so this method must be more accurate (Febriyanti & Rifai, 2022). |
| 4 | *SMA* | It is easy to calculate and simple. Each year's data is given equal weight, which means that both the earlier and more recent data are considered equal in their influence. This method is effective, simple and efficient (Dewi & Chamid, 2019). | This method requires a lot of historical data. It cannot follow drastic changes and is unsuitable for forecasting data with trend symptoms because the resulting forecast will be too late to follow the changes. Last year's data, which should be too small or too large, is just averaged to forecast the coming year (Dewi & Chamid, 2019). |
| 5 | *WMA* | Forecasting is more accurate because the data used is relevant and given a high weight. Each historical data set is given a different weight, and the latest data sets are given a higher weight, so forecasting will be more accurate (Sudarthio et al., 2020). | It requires historical data, needs to catch up with drastic changes, and is appropriate when forecasting data with a trend (Eris et al., 2014). |

*SMA (*Single Moving Average*), WMA (*Weight Moving Average*), SES (*Single Exponential Smoothing*), DES (*Double Exponential Smoothing*), TES (*Triple Exponential Smoothing*)

### 3.5. Relationship between Forecasting and Drug Planning

Forecasting is an essential tool in effective and efficient planning. A forecast is a prediction of what will happen in the future, while a plan is a determination of what will be done. There is a difference between a forecast and a plan. Forecasting is forecasting what will happen but is not necessarily implemented by the company (Saepulloh & Handoko, 2018). Forecasting shows an estimate of what will occur in a particular situation. In contrast, planning uses the forecast to help decision-makers choose the best alternative. In other words, forecasting is an approach to quantitatively estimating what will happen in the future based on related and relevant historical data. At the same time, planning is an effort by decision-makers to influence the results that will occur through various strategies based on actual information obtained from the past (Ahmad, 2020). Forecasting is essential in all aspects of business, but forecasting is only an estimate of demand until actual demand becomes known. Forecasting drives decisions in many areas. Demand forecasting will impact three activities: supply chain management, human resources, and capacity (Heizer & Render, 2016).

Based on the results of the systematic review, the forecasting method that produces highly accurate forecasts is the Single Exponential Smoothing (SES) method. Planning drug needs in healthcare facilities can be done using the Single Exponential Smoothing forecasting method because, in this method, short-term forecasting is carried out with data properties that fluctuate near a fixed mean value without trends and seasonality (Yuniarti, 2021). The SES method is a procedure that continuously improves estimates by averaging the past values of data in a decreasing (exponential) manner. This forecasting method is suitable for forecasting things that have random (irregular) fluctuations. Thus, this SES method can help plan and manage drugs in each health service facility to predict the amount of drugs needed in the future (Gustriansyah, 2017).

### 3.6. Factors that Affect Forecasting

Based on research conducted by Sesario et al. (2022) and Sari et al. (2023), they have resulted in highly accurate forecasting with a MAPE value of <10%. Some factors affect the accuracy of Single Exponential Smoothing forecasting with MAPE <10%, namely data stability, pattern consistency, and alpha (α) weighting strength. Forecasting tends to give accurate results if the historical data is relatively stable and has no significant fluctuations. If the historical data pattern shows a constant trend or regular seasonal pattern, then the Exponential Smoothing method can produce accurate forecasts (Romaita et al., 2019). The factors that cause forecasting to fall into a reasonable category, namely those carried out by Vimala and Nugorho (2022), are complex patterns, unexpected trends or patterns, unexpected seasonal changes, and the influence of extreme data. The resulting reasonable forecasting is with a MAPE value of 10.46% (Vimala & Nugroho, 2022). Meanwhile, the SMA method must effectively handle more complex data patterns, such as emerging trends or significant seasonal fluctuations. If the historical data has a clear trend or seasonal pattern, this method cannot capture it accurately, which can lead to a slightly higher MAPE value. If the historical data has irregular or unstable patterns, SMA forecasting cannot accurately process the data against changes. If the historical data is irregular and tends to have fluctuations or unexpected changes in the pattern, the SMA method cannot keep up well with the changes (Montgomery et al., 2015). Writing a systematic review has limitations. The literature on forecasting in each health service facility is minimal, so not much can be included in this systematic review in both Indonesian and English journals.

## 4. CONCLUSION

A systematic review based on the discussion that has been made regarding the comparison of forecasting drug needs using time series methods in healthcare facilities can conclude that the best forecasting method is the exponential smoothing method, especially single exponential smoothing. The MAD, MSE, and MAPE values of the Exponential Smoothing method produce

the smallest values when compared to other methods. The MAPE value in the Single Exponential Smoothing method is <10%, which is included in the highly accurate forecasting category. Furthermore, it is recommended that research be conducted in healthcare facilities related to forecasting drug demand planning using the Single Exponential Smoothing method.

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## 6. AUTHOR DECLARATION

### Authors' Contributions and Responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation, and discussion of results. The authors read and approved the final manuscript.

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### Availability of Data and Materials

All data are available from the authors.

### Competing Interests

The authors declare no competing interest.

### Additional Information

No additional information from the authors.

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