

## Analysis of medication demand forecasting using single exponential smoothing method based on consumption patterns at Bali Mandara Hospital, Indonesia

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### ABSTRACT

Effective medication demand forecasting typically requires an accurate method to determine the type and quantity of medications appropriately. Several studies have recommended the use of Single Exponential Smoothing (SES) method due to its high accuracy. Therefore, this study aims to determine the accuracy of SES method on 4 types of known patterns of drug consumption, including Smooth, Intermittent, Erratic, and Lumpy. The study procedures were carried out with a descriptive technique using drug consumption data from January to December 2023 at Bali Mandara Hospital, Indonesia. The sample population comprised 469 items of drugs grouped by similarity in active substance, strength and dosage form, which were grouped into 4 consumption patterns on the basis of CV<sup>2</sup> (Squared Coefficient of Variation) and ADI (Average Inter-Demand Interval) values. Subsequently, forecasting was carried out for each group using the SES method. The prediction results were then analyzed for accuracy using MAPE (Mean Absolute Percentage Error) parameters. MAPE values of <10, 10-20, 20-50, and >50 indicated highly accurate, good, reasonable, and inaccurate forecasting, respectively. The results showed that among the 469 items of drugs analyzed, 335 items had a smooth pattern, while 3 items, 50 items, and 81 items were categorized as intermittent, lumpy, and erratic. The level of accuracy for the smooth pattern category was highly accurate, good, reasonable, and inaccurate for 9 items (2.6%), 72 items (21.5%), 170 items (50.7%), and 84 items (25.2%), respectively. In the erratic consumption category, there were no highly accurate forecasts, while 1 item (1.2%), 7 items (8.6%), and 73 items (90.1%) were considered good, reasonable, and inaccurate, respectively. The results also showed that all items (100%) had reasonable accuracy in the intermittent pattern. In the lumpy pattern, 13 items (26%) had reasonable accuracy, while 37 items (74%) were inaccurate. Therefore, it can be concluded that the SES method provides a better level of accuracy for a smooth pattern of consumption compared to others.

### Keywords:

drugs forecasting; single exponential smoothing; consumption pattern; forecasting accuracy

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## INTRODUCTION

Good drugs inventory management often requires accurate demand forecasting. This is essential to avoid over procurement of drugs, which leads to overstocks, shortages, or expired goods.<sup>1</sup> Several studies have shown that planning for drug needs in hospitals is still suboptimal due to inaccuracies in the forecasting process for the number and type of drugs.<sup>2</sup> For example, the management of inventory in the pharmacy department of UPT Community Eye Hospital in East Java in 2015 was found to be inefficient, with 39% of drugs experiencing overstocking and 29% experiencing understocking.<sup>3</sup>

Bali Mandara District Hospital is a secondary referral hospital in Bali Province, Indonesia. This facility has been reported to face significant challenges in drug inventory management due to overstock and shortages, which affect the quality of healthcare services. Although the average consumption method has been used in the drug demand planning process, the forecast results are still inaccurate. Fluctuations in consumption caused by variations in disease incidence, unstable supply, and changing consumption trends often lead to low forecasting accuracy using average consumption data. Therefore, an accurate forecasting method is needed to assist inventory management in predicting the need for the right type and amount in the next period.<sup>4</sup>

Forecasting is the art and science of estimating future events, which serve as the basis for planning drug requirements in the short, medium, and long term. This method is also used to support planning, monitoring, and decision-making in inventory management.<sup>5,6</sup> Using historical data on usage, a forecast can be made to predict the future demand by patients. One of the most accurate forecasting methods is Single Exponential Smoothing (SES), which offers the advantages of simplicity and ease of implementation, making it

suitable for use without requiring high-level statistical expertise. This method supports work efficiency, specifically for hospital managers in dynamic environments, and is effective for short-term forecasting of time series data that is continuous, stable, or experiences linear changes.

In addition, it aims to produce forecasts that are more stable, accurate, and effective in supporting the planning of future requirements.<sup>7</sup> SES also improves prediction accuracy by adjusting historical values based on previous errors. Several studies have demonstrated its reliability in predicting emergency department visits and inpatient admissions, indicating high relevance to healthcare management. However, the SES method has various limitations, such as the inability to handle complex data patterns, including multiple cycles, trend interactions, or significant irregularities.<sup>8</sup>

According to previous studies, irregularity or variation in drug use can be described in terms of 4 patterns of consumption, namely smooth, intermittent, erratic, and lumpy<sup>9</sup>. Smooth and intermittent patterns have low variability in usage amounts, with stable and more significant interval variability, respectively. Meanwhile, erratic and lumpy patterns exhibit higher variability in usage amounts, where erratic patterns show stable intervals and lumpy patterns exhibit highly variable intervals.<sup>10</sup>

The accuracy of forecasts is typically measured by Mean Absolute Percentage Error (MAPE), which calculates the average absolute percentage error by dividing each absolute error by the actual value in the same period. MAPE provides a relative measure of error, enabling precise accuracy analysis by comparing errors to actual values.<sup>10,11</sup> MAPE values of <10, 10-20, 20-50, and >50 indicate highly accurate, good, reasonable, and inaccurate forecasting, respectively.<sup>12</sup> Several studies on

forecasting pharmaceuticals using the SES method have been conducted and have produced good results. Forecasting sales of pharmaceuticals and medical devices at Sida Waras Farma pharmacy using the SES method produced highly accurate forecasts with a MAPE value of 7%.<sup>13</sup> Drug utilization in hospitals tends to have a varied consumption pattern due to various factors. It is essential to implement a reliable forecasting method to effectively manage all types of drug consumption patterns in hospitals. This approach will optimize the procurement process, ensure drug availability, and prevent shortages or excess stock. Therefore, this study aims to determine the accuracy of SES method on 4 types of known patterns of drug consumption, including Smooth, Intermittent, Erratic, and Lumpy.

## METHODS

This study was carried out using a non-experimental descriptive method, with retrospective data obtained from Bali Mandara Hospital. The study clearance number was 054/EA/KEPK.RSBM.DISKES/2024, which was granted by the Health Study Ethics Committee of RSUD Bali Mandara Bali Province on May 20, 2024.

### *Study Materials and Study Subjects*

The study sample comprised all drug items available at Bali Mandara Hospital from January to December 2023, as obtained from the management information system of Bali Mandara Hospital. However, the data obtained were complete and reliable, and the inclusion criteria of this study encompassed all drug items used from January to December 2023, with analysis based on 12 periods, where each month was considered as one period. The exclusion criteria included drugs that the hospital had discontinued,

defined as those not used for at least 6 consecutive months without any data on repurchase or stock requests. The drugs were excluded from consideration due to insufficient data available for utilization, which included notably wide void intervals. This limitation can compromise the reliability of the MAPE value utilized as a metric for accuracy evaluation. The selection of drug usage data in 2023 was due to the nature of SES forecasting method, which is a short-term forecasting method covering periods of up to a year.<sup>8</sup>

The primary rationales for selecting Bali Mandara Hospital as a study site pertained to the completeness of the data, the efficiency of data retrieval from the hospital information system, and the hospital's willingness to serve as a study site. In essence, the results of this study could be extrapolated to other hospitals or medical centers, provided that the drug utilization data examined was both complete and reliable.

There were 743 names of drugs used in Bali Mandara Hospital in 2023 with various brand names, dosage forms, and strengths. Subsequently, the grouping of these drugs based on the similarity in the active substance or generic name, dosage form, and strength resulted in a total of 469 types of drugs. The rationale for grouping drugs based on generic name, dosage form, and strength was to eliminate variations in drug use that may have occurred due to supply shortages or changes in hospital formularies and national formularies.

### *Data Analysis*

The data obtained was secondary, and after the drug usage data was collected, drugs were grouped based on consumption patterns using  $CV^2$  (Squared Coefficient of Variation) and ADI (Average Inter-Demand Interval) parameters. The cut-off values for the  $CV^2$  and ADI parameters are essential for classifying drug consumption

patterns in a hospital setting. Drugs that fall into the smooth consumption pattern group are drugs with  $CV^2$  values  $\leq 0.49$  and ADI values  $\leq 1.32$ . Drugs that fall into the intermittent consumption pattern have  $CV^2$  values  $\leq 0.49$  and ADI values  $> 1.32$ . Drugs with  $CV^2$  values  $> 0.49$  and ADI values  $\leq 1.32$  are classified as having an erratic consumption pattern, while drugs with  $CV^2$  values  $> 0.49$  and ADI values  $> 1.32$  are designated as having a lumpy consumption pattern<sup>9</sup>. The calculation methods for ADI and  $CV^2$  values were as follows:

$$ADI = \frac{\text{Total Number of Periods of Drugs Use in a Year}}{\text{Number of Periods Drugs Use Occurred}}$$

$$CV^2 = \left( \frac{\text{Standard Deviation}}{\text{Average Use of Drugs}} \right)^2$$

The results of the consumption pattern grouping were then analyzed using the E-Views 12 application with the SES forecasting method. The SES method can be written with the following formula in the equation below<sup>6</sup>:

$$(F_{t+1} = \alpha \times X_t + (1 - \alpha) \times F_t)$$

Explanation:

$F_t$  = forecast for period  $t$

$\alpha$  = smoothing constant between 0 and 1 = actual value of the time series

$X_t + (1 - \alpha) F_{t+1}$  = forecast at time  $t + 1$

The range of alpha values used in this study was between 0.001 and 0.999. Forecasting accuracy was calculated using Microsoft Excel based on the MAPE value. The method for calculating the forecasting results using the MAPE indicator as follows:

$$MAPE = \frac{\sum (\text{actual-forecast})}{n} \times 100\%$$

The resulting MAPE value was then interpreted based on the following criteria: MAPE values less than 10% ( $<10\%$ ) indicate highly accurate forecasting and MAPE values ranging from 10% to 20%

(10%-20%) reflect good forecasting accuracy. MAPE values ranging from 20% to 50% (20%-50%) signify reasonable forecasting, and MAPE values greater than 50% ( $>50\%$ ) indicate inaccurate forecasting.<sup>12</sup> MAPE has issues with small actual values and is sensitive to extreme values, which may distort the accuracy evaluation. To improve the reliability of the accuracy results, this study excluded types of drugs with a very low level of consumption and a very long interval between zeroes. The types of drugs that were analyzed were those that had consistent or near-consistent consumption rates, and their utilization was not distributed uniformly across the entire dataset.

## RESULTS

This study used drug utilization data from Bali Mandara Hospital for the period January 2023 to December 2023. The analysis encompassed a total of 743 drug items available at the hospital, of which 469 items fulfilled the stipulated inclusion criteria. This subset consisted of 344 items of drugs included in the national formulary issued by the Indonesian Ministry of Health and 125 items of drugs not included. The drugs included in the national formulary were defined as essential medications that must be available in hospitals and were primarily used for patients with national health insurance (JKN). Conversely, the drugs that were not included in the national formulary were supplementary medications provided by the hospitals to address the diverse health services needed within the institution.

Consumption patterns were determined based on  $CV^2$  and ADI values calculated using the aforementioned formulas for each drug. Drug items that fell into the smooth consumption pattern group were items, with a  $CV^2$  value  $\leq 0.49$  and an ADI  $\leq 1.32$ . Drug items that fell into an intermittent consumption pattern had  $CV^2$

values  $\leq 0.49$  and ADI values  $> 1.32$ . Drug items with  $CV^2$  values  $> 0.49$  and ADI values  $\leq 1.32$  were classified as having an erratic consumption pattern, while drug items with  $CV^2$  values  $> 0.49$  and ADI values  $> 1.32$  were designated as having a lumpy consumption pattern.

The analysis of consumption data at Bali Mandara Hospital revealed the

existence of all consumption patterns in drug utilization, as illustrated in Table 1. This table shows that most of the drugs (335 drug items) at Bali Mandara Hospital fell into the smooth consumption pattern category, with an average  $CV^2$  value of 0.1706 and an average ADI value of 1.0091.

**Table 1.** Number of Drug Items,  $CV^2$ , and ADI Values for Each Consumption Pattern at Bali Mandara Hospital

No	Consumption Patterns	National Formulary Status		Total (n)	Average $CV^2$ value	Average ADI value
		Included (n)	Not Included (n)			
1.	Smooth	239	96	335	0.1706	1.0091
2.	Intermittent	3	0	3	0.4570	1.3333
3.	Lumpy	38	12	50	1.7864	1.4642
4.	Erratic	64	17	81	0.9679	1.0772

n : number of drug items

#### ***Accuracy Level of Smooth Consumption Pattern at Bali Mandara Hospital***

The utilization of these drugs exhibited minimal variability. Out of the 335 types of drugs with the same generic name, strength and dosage form included in the smooth consumption pattern, a consistent trend was maintained in 2023. Out of the 355 medicine items classified

into the smooth consumption pattern, there were 10 types of medicine with a high rate of consumption. Folic acid was the drug with the highest consumption rate, which will amount to 123.413 tablets in 2023. The following table 2 lists 10 types of drugs with the highest consumption in this pattern.

**Table 2.** Top 10 Most-used Drugs in Smooth Consumption Pattern in 2023

No	Drugs (in generic name)	Quantity of Consumption (Yearly)	Unit	National Formulary Status
1	Folic Acid 1 mg	123,413	Tablet	Included
2	Mecobalamin 500 mcg Injection	108,803	Ampoule	Not Included
3	Paracetamol 650 mg	103,076	Tablet	Not Included
4	Lansoprazole 30 mg	101,652	Tablet	Included
5	Paracetamol 500 mg	88,720	Tablet	Included
6	Sevoflurane 250 mL	88,436	Bottle	Included
7	Sodium Chloride (NaCl) 500 mL	63,495	Bottle	Included
8	Acetylcysteine 200 mg	59,882	Tablet	Included
9	Ondansetron 4 mg	56,471	Tablet	Included
10	Acetylsalicylic Acid 80 mg	51,771	Tablet	Included

By calculating MAPE values using the formula previously described, it was found that out of the 355 drug items included in the smooth consumption pattern category, most drugs (170 items or 51%) have MAPE values ranging from 20 to 50,

114 items of which were listed in Indonesia's national drug list, and 56 items were not. The distribution of MAPE rates for drugs that fell into the smooth consumption pattern category could be observed in Table 3 as follows:

**Table 3.** Number of Drug Items in the Smooth Consumption Pattern Based on MAPE Values Using the SES Forecasting Method

No	MAPE (%)	National Formulary Status		Total (n)	Percentage (%)
		Included (n)	Not Included (n)		
1	<10	6	3	9	3%
2	10-20	65	7	72	21%
3	20-50	114	56	170	51%
4	>50	54	30	84	25%

n : number of drug items

As Table 3 illustrates, the SES method demonstrated a range of forecasting accuracies for smooth consumption patterns. The majority (75%) exhibited a commendable level of accuracy, characterized as "very accurate" (MAPE <10), "good" (MAPE 10-20), or "reasonable" (MAPE 20-50), with 9 items (3%), 72 items (21%) and 170 items (51%), respectively.

#### ***Accuracy Level of Intermittent Consumption Pattern at Bali Mandara Hospital***

A total of 3 drug items were identified as following the intermittent

consumption pattern, which included rifampicin 450 mg, budesonide 0.5 mg/ml, and calcium carbonate 625 mg. All of the drug items were included in the national formulary. The use of these drugs tends to be less variable, however, in a few months of the year, there was no use of these drugs at all. The following table 4 shows that all drugs in the intermittent pattern category have MAPE values of 20-50 or "reasonable" accuracy and were all included in the national formulary of Indonesia.

**Table 4.** Number of Drug Items in the Intermittent Consumption Pattern Based on MAPE Values Using the SES Forecasting Method

No	MAPE (%)	National Formulary Status		Total (n)	Percentage (%)
		Included (n)	Not Included (n)		
1	<10	0	0	0	0%
2	10-20	0	0	0	0%
3	20-50	3	0	3	100%
4	>50	0	0	0	0%

n : number of drug items

#### ***Accuracy Level of Lumpy Consumption Pattern at Bali Mandara Hospital***

There were 50 drug items classified under the lumpy consumption pattern, of which 38 drug items were included in the

national formulary and 12 drug items were not included. The use of these drugs varied widely, and in some months of the year, there was no use of these drugs at all. Based on the highest consumption data for 2023, Rebamipide 100 mg was the most widely

used drug throughout 2023, with a total of 14,348 tablets, while Ethambutol 400 mg

was the drug with the lowest usage, with only 1,688 tablets, as shown in Table 5.

**Table 5.** Top 10 Most-used Drugs in Lumpy Consumption Pattern in 2023

No	Drugs (in generic name)	Quantity of Consumption (Yearly)	Unit	National Formulary Status
1	Rebamipide 100 mg	14,348	Tablet	Not included
2	Ranolazine 375 mg	7,105	Tablet	Not included
3	Codeine 10 mg	5,485	Tablet	Included
4	Anhydrous Theophylline 250 mg	4,447	Tablet	Not included
5	Tramadol 50 mg	4,425	Tablet	Included
6	Mesalazine 250 mg	3,203	Tablet	Included
7	Dolutegravir 50 mg	2,724	Tablet	Included
8	Glimepiride 1 mg	2,409	Tablet	Included
9	Mebhydrolin Napadisylate 50 mg	1,806	Tablet	Not included
10	Ethambutol 400 mg	1,688	Tablet	Included

Table 5 presents a list of the ten most frequently used drugs categorized under the lumpy consumption pattern. This pattern reflected highly irregular usage, characterized by significant fluctuations and periods of zero demand. These drugs represented a diverse range of therapeutic classes, with some included in the National Formulary and others not. This information was crucial for supporting the hospital's

efforts in optimizing drug inventory planning and ensuring more efficient resource allocation.

By calculating the MAPE values of the 50 drug items with lumpy consumption patterns, most drug items have MAPE values >50, while the rest (13 items) have MAPE values between 20 and 50, as shown in Table 6:

**Table 6.** Number of Drug Items in the Lumpy Consumption Pattern Based on MAPE Value Using SES Forecasting Method

No	MAPE (%)	National Formulary Status		Total (n)	Percentage (%)
		Included (n)	Not Included (n)		
1	<10	0	0	0	0%
2	10-20	0	0	0	0%
3	20-50	8	5	13	26%
4	>50	30	7	37	74%

n : number of drug items

Table 6 showed that the SES forecasting method had limitations in handling the lumpy consumption pattern at RSUD Bali Mandara. Only 13 drug items

(26%) fell into the reasonable forecast category, while the majority were categorized as inaccurate.

### ***Accuracy Level of Erratic Consumption Pattern at Bali Mandara Hospital***

There were 81 drug items with erratic consumption patterns, consisting of 64 drug items included in the national formulary and 17 drug items that were not included. Demand for these drugs could fluctuate very high in 2023, but it was never

discontinued entirely. Based on the highest consumption data in 2023, omeprazole 20 mg, was the most widely used throughout 2023, with a total of 35,525 tablets, while Vitamin B6 10 mg had the lowest usage, totaling 10,073 tablets, as shown in Table 7.

**Table 7.** Top 10 Most-used Drugs in the Erratic Consumption Pattern in 2023

No	Drugs (in generic name)	Quantity of consumption (Yearly)	Unit	National Formulary Status
1	Omeprazole 20 mg	32,525	Tablet	Included
2	Omeprazole 40 mg/mL	17,048	Vial	Included
3	Vitamin C 500 mg	14,832	Tablet	Not Included
4	Clopidogrel 75 mg	13,797	Tablet	Included
5	Trimetazidine HCl 35 mg	11,564	Tablet	Included
6	Silymarin phytosome 70 mg, Curcuminoid 20 mg, Echinacea extr. 150 mg, Choline bitartrate 150 mg, Vit.B6 2 mg	11,381	Tablet	Not Included
7	Vitamin B6 10 mg	10,073	Tablet	Included
8	Ketorolac 30 mg/mL	8,194	Ampoule	Included
9	Thiamazole 5 mg	8,136	Tablet	Included
10	Salbutamol Sulfate 2.5 mg	6,872	Tablet	Included

By calculating the MAPE values of the 81 drug items with erratic consumption patterns, most (90%, 73 items) have MAPE

values >50, 7 items have MAPE values of 20-50, and only 1 item had a MAPE value of 10-20, as shown in Table 8:

**Table 8.** Number of Drug Items in the Erratic Consumption Pattern Based on MAPE Values Using SES Forecasting Method

No	MAPE (%)	National Formulary Status		Total (n)	Percentage (%)
		Included (n)	Not Included (n)		
1	<10	0	0	0	0%
2	10-20	1	0	1	1%
3	20-50	4	3	7	9%
4	>50	59	14	73	90%

n : number of drug items

According to Table 8, the majority of drug items (90%) for erratic consumption pattern at RSUD Bali Mandara fell into the inaccurate forecast category. Only 1 item (1.23%) was considered good (MAPE 20-50), and 7

items (9%) were considered reasonable (MAPE 10-20). The high proportion of inaccurate forecasts indicated the limitations of SES method in handling erratic consumption patterns characterized by significant fluctuations in drug use.

## DISCUSSION

Drug management in hospitals requires good planning and procurement to avoid shortages or excess. Accurate forecasting of drug demand was key to the success of the procurement process. SES method was a forecasting method that was widely used for data with stable or horizontal fluctuation patterns that experienced ups and downs around a fixed value.<sup>14</sup> The value of "n," which usually referred to the number of historical data points used in the average calculation, was replaced by the " $\alpha$ " parameter, which could be set in the range of 0 to 1 to reduce errors or inaccuracies in forecasting.<sup>15</sup> The " $\alpha$ " parameter worked as a "smoothing factor" that made the forecasting method more sensitive or responsive to changes in the data used.<sup>16</sup>

This study, which was conducted at Bali Mandara Hospital, revealed that the trend of drug utilization in 2023 exhibited variability among different substances. In addition, it was imperative to note that not all drugs demonstrated a consumption pattern with stable fluctuations. Consequently, further analysis was necessary before the implementation of SES forecasting method at this hospital.

This study found that consumption patterns of 469 types of drugs used in 2023 at Bali Mandara Hospital were mostly (71.43%) in the smooth consumption pattern group, followed by 17.27% in the erratic consumption pattern, 10.66% in the lumpy consumption pattern and the rest (0.64%) was in the intermittent consumption pattern. Generally, most of the drugs fell into the smooth consumption pattern and were included in the national formulary of Indonesia, indicating that the essential drugs at Bali Mandara Hospital were quite steady in use with a smooth supply. Most of the patients in this hospital were JKN patients, and the large number of

national formulary drugs that fell into the smooth consumption pattern category was an indication of good drug availability. However, few drugs included in the national formulary were classified as having erratic or even lumpy consumption patterns. These drugs showed large fluctuations or uneven distribution of demand throughout the year. This was partly due to disruptions in drug supply, in addition to changing disease patterns. The supply of national formulary drugs was still an obstacle to the implementation of JKN in Indonesia.<sup>17</sup>

The results revealed that a smooth consumption pattern did not necessarily guarantee precise results based on MAPE value, a consequence of the instability of historical data, significant fluctuations in usage, or inconsistent usage patterns.<sup>18</sup> Consumption trend analysis of several drugs with MAPE > 50% or exhibiting inaccurate consumption patterns indicated a substantial decline in utilization over several months, though not reaching complete cessation. Inaccuracies in forecasting pantoprazole injection, for example, could be due to the possibility of a supply shortage of Pantoprazole Injection (40 mg) in July 2023, resulting in substitution with omeprazole 20 mg or lansoprazole 30 mg Injection. This shortage was a contributing factor to the observed variation in the utilization of these medications.

Drugs with consistent usage and steady supply in 2023, such as tamsulosin HCl 0.4 mg tablets, demonstrated high forecasting accuracy, with a MAPE value of 9.7%. The forecasting accuracy that fell into the good category (MAPE 10-20%) in smooth consumption pattern amounted to 72 drug items, including cefixime trihydrate tablet 200 mg with a MAPE value of 10.14%, acetylsalicylic acid tablet 80 mg with a MAPE value of 10.49%, and paracetamol tablet 500 mg with a MAPE

value of 12.46%. These drugs were used stably, although there were fluctuations in some months. The existence of other alternative drugs such as antibiotics, antiplatelet, or antipyretic analgesics along with fluctuations in infectious and cardiovascular cases were also factors supporting the trend of use of these drugs.

Drugs with reasonable levels of accuracy included several antibiotic drugs, such as azithromycin, several symptomatic drugs, and vaccines. The drug usage data demonstrated stability with slight fluctuations. In this pattern, a trend of correlation between  $CV^2$  value and the level of accuracy was also evident, therefore, a greater  $CV^2$  value corresponded to a lower level of accuracy.

The second most common consumption pattern was erratic, with 72 drugs showing consistent but highly variable usage. Only Ketorolac 30 mg tablets had good accuracy (MAPE 17.37%). Listed in the national formulary for postoperative pain, its variation stemmed from prescription fluctuations, with no stockouts in 2023. Alternative analgesics also contributed to usage variability. Drugs like cefepime 1g injection, vancomycin 500 mg injection, and methyl dopa 250 mg tablets had erratic patterns, likely due to case variations. A study limitation was the lack of disease pattern analysis at Bali Mandara Hospital. SES method showed low accuracy for erratic patterns, and struggled to predict high-fluctuation drugs.<sup>19</sup> Forecasting was reasonable for rebamipide 100 mg tablets, glimepiride 1 mg tablets, and others, but inaccurate for codeine 10 mg tablets. Prolonged drug shortages could contribute to inconsistencies and high variability in usage data.

Intermittent consumption pattern was characterized by inconsistent utilization across the analysis period, exhibiting minimal variability in the data. Drug use could fluctuate significantly, with periods of elevated use interspersed with

extended periods of absence, resulting in a pattern of variability.<sup>20</sup> Drugs with an intermittent consumption pattern had a higher risk of expiration or deterioration. A total of 3 in this category showed reasonable forecasting accuracy, namely Rifampicin 450 mg (MAPE 33%), Budesonide 0.5 mg/mL (MAPE 38.33%), and Multivitamin and Mineral drugs (MAPE 46.28%). The cause of utilization inconsistencies remained unclear due to limited data on disease patterns and drug shortages, posing a key study limitation.

The SES method has been demonstrated to produce high levels of accuracy in the context of smooth consumption patterns, contingent upon the presence of consistent consumption data. Inconsistent drug consumption data, attributable to drug shortages rather than the absence of related disease cases, can be further analyzed by examining the substitutions made by hospitals to replace the shortage of drugs. The combination of the drugs used as substitutes and the shortage of drugs has the potential to yield more consistent consumption data, thereby enhancing the accuracy of the SES method.

Accurate forecasting is essential for minimizing the risk of shortages or excessive stockpiling of drugs, thereby facilitating the determination of necessary drug procurement. This approach enhances the efficiency and effectiveness of drug management within healthcare facilities. Ensuring consistent drug availability is not only crucial for optimal patient care but also contributes to reducing drug-related problems and ensuring patient safety.

The results of this study generally showed that the SES forecasting method could still be applied at Bali Mandara Hospital, specifically for drugs with smooth consumption patterns with consistent use throughout the year and not too large variations in use. This was still necessary for analyzing the use of consumption data for other periods of the year. Furthermore, the disease pattern data

and drug shortage data before recommending the use of SES method to forecast drugs were needed at Bali Mandara Hospital.

## LIMITATION

In this study, other accuracy parameters, such as Root Mean Squared Error (RMSE), Mean Squared Error (MSE), Mean Absolute Error (MAE), or Mean Error were not utilized due to the absence of accuracy indicators that could be quantitatively and categorically grouped according to accuracy levels. However, it was generally accepted that a reduction in RMSE, MSE, MAE, or Mean Error values corresponded to increased forecasting accuracy. Further analysis is necessary to ascertain the relationship between MAPE and other accuracy parameters.

## RECOMMENDATION

The findings of this study indicated that the SES method holds considerable promise in the production of accurate forecasts, particularly in contexts characterized by smooth consumption patterns. It is recommended that Bali Mandara Hospital consider the implementation of this forecasting method to determine the quantity of drug demand before conducting the drug procurement process. However, further analysis was required to employ alternative forecasting methodologies and encompass additional periods of drug utilization to ascertain an accurate forecasting method for pharmaceutical demand in medical facilities. The prevalence of drug shortages warranted the attention of relevant stakeholders to determine the cause of the variation in the data. Adherence to established standards should be reinforced to mitigate variations in pharmaceutical utilization. Further studies were necessary

to investigate alternative forecasting methods, diverse consumption patterns, and the application of these methods in other healthcare settings.

## AUTHOR CONTRIBUTIONS

N.P.V.G.P.: Conceptualization, methodology, data curation, formal analysis, writing original draft. C.W.: Supervision, conceptualization, data curation, formal analysis, writing-review and editing. E.Y.: Supervision, conceptualization, data curation, formal analysis, writing-review and editing.

## ETHICAL CONSIDERATION

The study was approved by the Ethics Committee of the Health Research Ethics Committee of RSUD Bali Mandara, Bali Province (Approval No. 054/EA/KEPK.RSBM.DISKES/2024, approved on May 20, 2024).

## CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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