ANALYSIS OF PHARMACEUTICAL LOGISTICS FORECASTING BY ACT CLASSIFICATION METHODS

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INFORMATION

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Keywords:
pharmaceutical logistics; forecasting; exponential smoothing; moving average; t-test

ABSTRACT

Objective: This study aims to evaluate the effectiveness and compare the accuracy of the Exponential Smoothing and Moving Average methods in forecasting pharmaceutical logistics needs at BB Hospital.

Methods: A quantitative approach with a descriptive-comparative design was used. The data analyzed were monthly pharmaceutical logistics needs over a 12-month period, categorized into solid, liquid, and topical dosage forms. Forecasting was performed using Exponential Smoothing and Moving Average methods. Statistical analysis was conducted using ANOVA and independent t-tests to examine the significance of differences in forecasting accuracy.

Results: Both methods showed satisfactory accuracy, as reflected in comparable values of Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE). The ANOVA test revealed a statistically significant difference between the methods (p = 0.000); however, the independent t-test showed a significance value of 0.756, indicating no significant difference in the average forecasting results between the two methods.

Conclusion: Both Exponential Smoothing and Moving Average methods are effective for forecasting pharmaceutical logistics needs. Since no significant difference was found in their average forecasting performance, either method can be applied flexibly based on the hospital's specific requirements. These findings provide practical insights for strategic decision-making in pharmaceutical inventory management.

INFORMASI	ABSTRAK
Korespondensi: embayhaqi@gmail.com **Kata kunci:** logistik farmasi; peramalan; exponential smoothing; moving average; uji t	Tujuan: Penelitian ini bertujuan untuk mengevaluasi efektivitas dan membandingkan akurasi metode Exponential Smoothing dan Moving Average dalam meramalkan kebutuhan logistik farmasi di Rumah Sakit BB. Metode: Penelitian ini menggunakan pendekatan kuantitatif dengan desain deskriptif-komparatif. Data yang dianalisis mencakup kebutuhan logistik farmasi selama 12 bulan, dikelompokkan berdasarkan bentuk sediaan padat, cair, dan topikal. Peramalan dilakukan dengan metode Exponential Smoothing dan Moving Average, disertai uji ANOVA dan independent t-test untuk menilai signifikansi perbedaan hasil. Hasil: Kedua metode menunjukkan akurasi yang baik, dengan nilai Mean Absolute Deviation (MAD), Mean Squared Error (MSE), dan Mean Absolute Percentage Error (MAPE) yang relatif kompetitif. Hasil uji ANOVA menunjukkan perbedaan signifikan antara metode (p = 0,000), namun uji t menghasilkan signifikansi 0,756, yang mengindikasikan tidak terdapat perbedaan signifikan pada rata-rata hasil peramalan. Kesimpulan: Baik metode Exponential Smoothing maupun Moving Average efektif digunakan dalam peramalan kebutuhan logistik farmasi. Karena tidak terdapat perbedaan signifikan di antara keduanya, maka keduanya dapat diterapkan secara fleksibel sesuai dengan kebutuhan rumah sakit. Hasil ini memberikan kontribusi praktis dalam pengambilan keputusan strategis manajemen persediaan.

INTRODUCTION

Bhayangkara B Hospital is a newly established healthcare facility operated by the Indonesian National Police, serving police personnel, their families, and the general public. As a hospital still in its development phase, pharmaceutical logistics management is a critical component that requires close attention. Ensuring the availability of appropriate drugs in adequate quantities and aligned with actual needs significantly affects the continuity and quality of healthcare services. However, the hospital still faces major challenges in planning drug procurement due to the lack of stable long-term demand data (Kepolisian RI, 2022).

Effective pharmaceutical logistics management is essential to support medical services. Inaccurate planning of pharmaceutical logistics needs often stems from fluctuating demand, budget constraints (Azhari et al., 2025), and deficiencies in forecasting systems. These issues may result in overstocking, drug shortages, or wastage due to expiration. Therefore, statistical forecasting methods are required to improve the accuracy of pharmaceutical logistics planning (Ilham et al., 2025).

Pharmaceutical supply chains have garnered increased attention amid rising healthcare service demands and uncertainties caused by crises such as the COVID-19 pandemic, geopolitical conflicts, and climate disruptions (Rizaldy et al., 2024). The World Health Organization (WHO) emphasizes the importance of adaptive, data-driven pharmaceutical logistics forecasting systems to ensure a sustainable drug supply in healthcare facilities (Sauvola et al., 2024). Both developed and developing countries have begun adopting quantitative analytical approaches such as Exponential Smoothing and Moving Average to improve drug demand planning, reduce stockouts, and prevent overstocking, thereby enhancing service efficiency and financial sustainability (Khajuria et al., 2024).

Exponential Smoothing and Moving Average are two commonly used forecasting techniques in logistics decision-making due to their simplicity and ability to identify trends in historical data (Sinaga et al., 2018). This study aims to apply both methods to forecast pharmaceutical logistics needs for the next 12 months at Hospital B. The data utilized are historical pharmaceutical logistics data over the past year, classified by dosage form (solid, liquid, injection) and pharmacological function (e.g., analgesics, antipyretics, antibiotics) (Azzahra et al., 2025).

The implementation of these forecasting methods is expected to improve the efficiency, precision, and responsiveness of drug procurement and distribution processes within the hospital. This study involves the pharmaceutical logistics and procurement units, with researchers actively participating in data analysis and application of forecasting methods. A comparative analysis will be conducted to determine the most accurate forecasting approach (Suryawan et al., 2024).

Accurate pharmaceutical logistics management relies heavily on robust information systems. The advancement of health information systems plays a pivotal role in enhancing the efficiency and quality of hospital services, especially in pharmaceutical logistics (Astuti, 2020). Effective pharmaceutical logistics will ensure timely drug availability and prevent stock imbalances that could compromise medical care. Hospital B, as a public service institution, faces significant challenges in aligning pharmaceutical supply with fluctuating demand and budgetary limitations (Suparyanto dan Rosad, 2020).

Several previous studies have explored the use of forecasting methods for pharmaceutical logistics in hospitals. A study by Lestari and Iskandar (2022) at Regional General Hospital X applied the Moving Average method to predict drug needs in the emergency unit (Marita & Darwati, 2022). While this method offered improved estimates compared to conventional approaches, it still struggled to accurately forecast long-term needs due to high demand volatility and data uncertainty. Additionally, Jauhari et al. (2025) implemented Exponential Smoothing at Hospital ABC to forecast drug demand based on five-year historical data. Their results indicated that Exponential Smoothing was more effective for sharp demand fluctuations but declined in accuracy over longer forecast horizons (Octiva et al., 2024).

Further research by Azhari et al. (2025) at Hospital XYZ compared various forecasting methods, including Exponential Smoothing and Moving Average. They concluded that Exponential Smoothing performed better in anticipating seasonal drug demand surges, while Moving Average excelled in identifying long-term stable trends. Wijayanti (2021) found that combining both methods resulted in more stable and reliable forecasts, especially when dealing with volatile drug consumption data (Jackson et al., 2024).

While previous studies have shown that quantitative methods such as Exponential Smoothing and Moving Average are effective for short- to medium-term pharmaceutical demand forecasting, most have focused solely on total logistics volume, overlooking distinctions by dosage form (solid, liquid, injection) or pharmacological function (e.g., analgesics, antibiotics, antihypertensives). This lack of detail limits their relevance to actual clinical needs (Handayani et al.,, 2021).

This research integrates Exponential Smoothing and Moving Average methods to project pharmaceutical logistics needs for the next 12 months, with a detailed classification based on dosage form and pharmacological function. Such an approach enhances procurement decision-making by ensuring alignment with clinical requirements (Azhari et al., 2025).

This study is highly relevant in providing a scientific foundation for pharmaceutical logistics planning, particularly for newly established or developing hospitals. By combining historical data with modern forecasting techniques, more accurate and systematic projections can be made (Odnoletkova et al., 2025). Classification by dosage form and pharmacological function offers a more contextual understanding of clinical needs. The findings are expected to offer strategic recommendations for Hospital BB to build an efficient and adaptive pharmaceutical logistics system and serve as a practical reference for other hospitals in early operational stages seeking to strengthen their logistics systems (Burinskiene, 2022; Handayany, 2021).

Hospital pharmaceutical logistics systems play a crucial role in ensuring the timely availability, quantity, and quality of medications. Dwiyanti et al. (2021) highlight that efficient logistics reduce the risk of surplus or shortages, affecting both budgets and service delivery. One useful planning tool is the Anatomical Therapeutic Chemical (ATC) classification system, which categorizes drugs based on target organs and therapeutic properties, thereby supporting clinically driven and rational procurement strategies (Ariska Putri et al., 2023; Azhari et al., 2025).

To forecast pharmaceutical needs, quantitative methods such as Exponential Smoothing and Moving Average are often employed for their simplicity and reliability with stable historical data (Burinskiene, 2022). Exponential Smoothing is effective for detecting short-term trends through weighted recent data, while Moving Average smooths fluctuations to identify general or seasonal patterns. Applying these methods enables hospitals to anticipate periodic drug requirements based on evidence (Ennajeh et al., 2025).

Table 1. Utilization of Pharmaceutical

No.	DRUG NAME	DOSAGE FORM	USAGE 2024- 2025					
			OCT	NOV	DEC	JAN	FEB	MAR
1	Antipyretic	Solid	31	33	34	36	44	40
2	Analgesic	Solid	25	27	28	30	10	30
3	Anti-inflammatory	Solid	9	11	12	14	10	40
4	Anti-influenza	Solid	35	37	38	40	70	110
5	Antitussive	Solid	15	17	18	20	20	70
6	Anti-asthma	Solid	9	11	12	14	0	0
7	Antihistamine	Solid	28	30	31	33	40	13
8	Corticosteroid	Solid	57	59	60	62	100	96
9	Antibiotic	Solid	38	40	41	43	3	40
10	Antiviral	Solid	0	0	0	0	40	70
11	Vitamin	Solid	204	206	207	209	17	196
12	Antacid	Solid	15	17	18	20	17	76
13	Antihypertensive	Solid	0	0	0	0	0	50
14	Cardiovascular Drug	Solid	0	0	0	0	5	0
15	Antihyperlipidemic	Solid	28	30	31	33	18	62
16	Antipyretic	Liquid	0	0	0	2	1	0
17	Anti-inflammatory	Liquid	0	0	0	1	2	0
18	Anti-influenza	Liquid	0	0	0	1	0	1
19	Antitussive	Liquid	0	0	0	0	4	0
20	Antihistamine	Liquid	0	0	1	3	7	0
21	Corticosteroid	Liquid	0	0	0	0	15	0
22	Antibiotic	Liquid	0	0	0	0	3	0
23	Vitamin	Liquid	3	5	6	8	17	8
24	Antacid	Liquid	5	7	8	10	17	1
25	Infusion	Liquid	24	26	27	29	21	21
26	Antiarrhythmic	Liquid	0	0	0	0	4	0
27	Topical Drug	Gel	0	0	1	3	1	2
28	Other Topical Drugs	Gel	0	2	3	5	2	4
29	Other Drugs	Gel/ Ointmen	115	117	118	120	211	26

METHODS

This study employed a descriptive quantitative approach aimed at analyzing pharmaceutical logistics needs based on the Anatomical Therapeutic Chemical (ATC) classification system using Exponential Smoothing and Moving Average forecasting methods. This approach was chosen to identify drug usage patterns and systematically project future needs based on historical data (Rotar et al., 2020).

1. Research Design

   The research design followed a systematic sequence, starting with the collection of historical data on pharmaceutical usage and stock levels from May 2024 to April 2025. The collected data were then categorized by dosage form and pharmacological function according to the ATC classification system. Subsequently, two time series forecasting methods—Single Exponential Smoothing and Simple Moving Average—were applied (Mac-seing et al., 2022). The forecasting outcomes were further analyzed to formulate strategic recommendations for pharmaceutical logistics management.

2. Population and Sample

The population in this study comprised all pharmaceutical logistics items used in the Pharmacy Installation of Bhayangkara B Hospital from May 2024 to April 2025. These included various dosage forms such as solid, liquid, and injectable drugs, classified according to the ATC system, covering categories such as analgesics, antibiotics, antihypertensives, and others (Khajuria et al., 2024). A total sampling technique was used, involving the entire population to ensure comprehensive and representative data coverage. This approach was selected to support the development of a robust and accurate forecasting model for evidence-based pharmaceutical logistics management (Duevel, 2020).

3. Data Collection Technique

Data were collected using a total sampling method from all available secondary data within the hospital's pharmaceutical information management system, particularly from the Pharmacy Installation. This method was chosen to ensure the completeness and accuracy of the data, considering that each pharmaceutical item exhibits unique characteristics and usage patterns. Collected data included the drug name, monthly usage and stock levels, dosage form (e.g., tablet, capsule, syrup, injection), and pharmacological category (e.g., analgesic, antibiotic, antihypertensive) used as the basis for the research (Ciceri et al., 2025).

4. Research Instruments

The primary tools used in this study included Microsoft Office Excel and IBM SPSS Statistics version 26 for analyzing linearity, normality, and performing t-tests (Balnaves & Caputi, 2011). Additionally, stock and usage records obtained from the hospital's pharmaceutical logistics system were utilized. Data classification was based on the ATC system to ensure the validity of pharmacological function categorization and to support a structured understanding of logistics needs in accordance with clinical applications (Bakker & Demerouti, 2021).

5. Data Analysis Techniques

   Data were analyzed using time series statistical methods with two main approaches: Single Exponential Smoothing and Simple Moving Average. The forecasting process projected pharmaceutical logistics needs for the next six months based on monthly historical data (Azhari et al., 2025). Three key error metrics were used to assess forecasting accuracy: Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD), and Mean Squared Error (MSE). MAPE evaluates deviation in percentage form, MAD calculates the average absolute difference between actual and predicted values, and MSE assesses squared errors to detect extreme deviations (Kosasih & Brintrup, 2024; Octiva et al., 2024).

   To assess the influence of time on pharmaceutical logistics needs, a simple linear regression analysis was performed, with time as the independent variable and logistics needs as the dependent variable. The significance of the regression coefficient was tested using a partial t-test at a 5% significance level. If the t-value exceeds the critical t-table value and the p-value is < 0.05, the influence of time is considered statistically significant. This regression analysis also aimed to reinforce the forecasting results by providing statistical evidence of demand trends over time (Odnoletkova et al., 2025).

6. Research Ethics

   This research has received ethical approval from the relevant institution, with the approval number SRk/003/X/Kes.23.2./2024/Rumkit.

RESULTS

The forecasting analysis of pharmaceutical logistics at BB Hospital using Exponential Smoothing and Moving Average revealed different responses to variations in drug demand. Exponential Smoothing was more adaptive to fluctuations, whereas Moving Average showed more stability but less responsiveness. These findings are crucial for effective and efficient stock management to support improved pharmaceutical service delivery.

1. Exponential Smoothing Forecasting

Table 2. Usage Forecasting Result of Ekponential Smoothing

No.	DRUGS NAME	USE NAME	FORECAST	MAD	MSE	MAPE
1	Antipyretic	Solid	215.9462	5.0112	25.11213	12.528
2	Analgesic	Solid	148.2662	6.6112	43.70797	22.03733
3	Anti-inflammatory	Solid	98.82624	29.4112	865.0187	73.528
4	Anti-influenza	Solid	340.2662	66.6112	4437.052	60.55564
5	Antitussive	Solid	167.4662	52.6112	2767.938	75.15886
6	Anti-asthma	Solid	41.22624	8.5888	73.76749	#DIV/0!
7	Antihistamine	Solid	168.1862	18.7888	353.019	144.5292
8	Corticosteroid	Solid	436.7462	29.0112	841.6497	30.22
9	Antibiotic	Solid	203.4662	7.6112	57.93037	19.028
10	Antiviral	Solid	122.4	62	3844	88.57143
11	Vitamin	Solid	1041.546	28.0112	784.6273	14.29143
12	Antacid	Solid	171.7862	59.2112	3505.966	77.90947
13	Antihypertensive	Solid	60	50	2500	100
14	Cardiovascular Drug	Solid	4.8	1	1	#DIV/0!
15	Antihyperlipidemic	Solid	205.8662	34.6112	1197.935	55.82452
16	Antipyretic	Liquid	2.496	0.52	0.2704	#DIV/0!
17	Anti-inflammatory	Liquid	2.688	0.56	0.3136	#DIV/0!
18	Anti-influenza	Liquid	1.968	0.84	0.7056	84
19	Antitussive	Liquid	3.84	0.8	0.64	#DIV/0!
20	Antihistamine	Liquid	9.6384	2.008	4.032064	#DIV/0!
21	Corticosteroid	Liquid	14.4	3	9	#DIV/0!
22	Antibiotic	Liquid	2.88	0.6	0.36	#DIV/0!
23	Vitamin	Liquid	44.10624	0.8112	0.658045	10.14
24	Antacid	Liquid	43.38624	7.7888	60.66541	778.88
25	Infusion	Liquid	144.1862	3.7888	14.35501	18.0419
26	Antiarrhythmic	Liquid	3.84	0.8	0.64	#DIV/0!
27	Topical Drug	Gel	6.2784	1.192	1.420864	59.6
28	Other Topical Drugs	Gel	13.38624	2.2112	4.889405	55.28
29	Other Drugs	Gel/ Ointment	682.0262	109.5888	12009.71	421.4954

The results of pharmaceutical logistics forecasting at BB Hospital using the Exponential Smoothing method revealed varied levels of accuracy across different drug types. Certain drugs, such as solid-form antipyretics, demonstrated low forecasting errors with a MAPE of approximately 12.5%, indicating relatively high model accuracy. However, other drugs—

particularly anti-inflammatory and antihistamine types—showed significantly high MAPE values, often exceeding 70%, which signals poor predictive performance. This inconsistency is primarily attributed to unstable demand patterns, which hinder the effectiveness of the Exponential Smoothing method for certain drug categories (Burinskiene, 2022).

2. Forecast Moving Avarage

Table 3. Usage Forecast result of Moving Avarage

NO.	DRUGS NAME	USE BNAME	FORECAST	MAD	MSE	MAPE
1	Antipyretic	Solid	231.2576	1.8213	3.3172	4.5533
2	Analgesic	Solid	157.5259	4.6821	21.922	15.607
3	Anti-inflammatory	Solid	152.5488	18.219	331.93	45.548
4	Anti-influenza	Solid	469.0198	39.788	1583	36.171
5	Antitussive	Solid	262.5640	32.799	1075.8	46.856
6	Anti-asthma	Solid	26.0930	5.436	29.551	#DIV/0!
7	Antihistamine	Solid	142.0297	13.34	177.94	102.61
8	Corticosteroid	Solid	503.0045	15.207	231.26	15.841
9	Antibiotic	Solid	208.1563	6.6341	44.011	16.585
10	Antiviral	Solid	242.2027	37.041	1372	52.916
11	Vitamin	Solid	1033.6396	29.658	879.62	15.132
12	Antacid	Solid	277.3513	37.218	1385.2	48.972
13	Antihypertensive	Solid	146.4558	31.988	1023.3	63.977
14	Cardiovascular Drug	Solid	4.6456	0.9678	0.9367	#DIV/0!
15	Antihyperlipidemic	Solid	265.1158	22.268	495.84	35.915
16	Antipyretic	Liquid	2.5207	0.5251	0.2758	#DIV/0!
17	Anti-inflammatory	Liquid	2.6540	0.5529	0.3057	#DIV/0!
18	Anti-influenza	Liquid	3.7249	0.474	0.2247	47.398
19	Antitussive	Liquid	3.7165	0.7743	0.5995	#DIV/0!
20	Antihistamine	Liquid	9.5314	1.9857	3.943	#DIV/0!
21	Corticosteroid	Liquid	13.9367	2.9035	8.4302	#DIV/0!
22	Antibiotic	Liquid	2.7873	0.5807	0.3372	#DIV/0!
23	Vitamin	Liquid	52.4703	0.9313	0.8673	11.641
24	Antacid	Liquid	36.2500	6.3021	39.716	630.21
25	Infusion	Liquid	139.2424	2.7588	7.6111	13.137
26	Antiarrhythmic	Liquid	3.7165	0.7743	0.5995	#DIV/0!
27	Topical Drug	Gel	9.8149	0.4552	0.2072	22.761
28	Other Topical Drugs	Gel	20.3918	0.7517	0.5651	18.793
29	Other Drugs	Gel/ Ointment	525.3209	76.942	5920	295.93

Pharmaceutical logistics forecasting at BB Hospital using the Moving Average method demonstrated good accuracy for several solid-form drugs such as antipyretics and vitamins (MAPE < 20%). However, the method was less accurate for drugs like anti-inflammatories and antitussives (MAPE > 45%). Several liquid and gel formulations also showed high error rates, particularly liquid antacids, which had a MAPE exceeding 600%. These findings indicate the need for more adaptive forecasting methods for drugs with highly variable demand.

3. Linear Regression Analysis

Linear regression analysis was conducted to examine the extent of the relationship between the two forecasting methods—Moving Average and Exponential Smoothing—in predicting pharmaceutical logistics needs. This approach allows for the measurement of the strength and direction of the linear relationship between the two variables, while also assessing the consistency of prediction results generated by each method.

The results of the linear regression analysis provide a robust statistical foundation for determining which forecasting method is more accurate and appropriate for use in the context of pharmaceutical logistics planning in hospitals.

Table 4. Result Exam ANOVA between Moving Average dan Exponential Smoothing

Resource	Summary Squared (SS)	df	Centra Squared (MS)	F Macth	Sig.
Between Groups					
(Combined)	1.459.236,052	25	58.369,442	350.216,652	0.00
- Linearity	1.376.023,050	1	1.376.023,050	8.256.138,300	0.00
- Deviation from Linearity	83.213,002	24	3.467,208	20.803,250	0.00
In Groups (Error)	0,500	3	0,167		

4. T-Test Analysis

A T-test analysis was conducted to determine whether there is a statistically significant difference between two independent data sets. In this study, the T-test was used to compare the forecasting results of pharmaceutical logistics needs generated by the Exponential Smoothing and Moving Average methods, aiming to assess whether the two methods produce significantly different estimates. This analysis is important to support the selection of the most accurate and effective forecasting method for managing drug inventories in hospitals.

Table 5. T-Test Results Between Moving Average and Exponential Smoothing

T-Test	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI Lower	95% CI Upper
Equal variances assumed	-0.313	56	0.756	-18.82	60.19	-139.39	101.75
Equal variances not assumed	-0.313	55.99	0.756	-18.82	60.19	-139.39	101.75

The T-test results indicated a significance value (Sig. 2-tailed) of 0.756, which is greater than the threshold of 0.05. This suggests that there is no statistically significant difference between the average forecasting results of pharmaceutical logistics needs using the Exponential Smoothing and Moving Average methods. Thus, both methods yielded relatively similar results in the context of this study.

DISCUSSION

1. Exponential Smoothing Forecasting

These substantial differences in forecast accuracy—for instance, the low error rate for solid-form antipyretics versus high MAPE in anti-inflammatory and antihistamine drugs—highlight the challenge of predicting highly fluctuating demand using basic forecasting techniques. In such cases, more advanced and adaptive forecasting models such as ARIMA, machine learning, or multivariate regression may be more appropriate to improve predictive reliability. Regular model evaluation and parameter adjustment are also essential to ensure forecasting accuracy keeps pace with evolving consumption patterns (Alfallah & Sumijan, 2025).

Improved pharmaceutical inventory management in hospitals can significantly reduce risks of stockouts or overstocking, ensuring timely drug availability aligned with patient needs (Hidayat et al., 2020). Previous studies (e.g., Nurmaesah et al., 2022) have highlighted that while Exponential Smoothing and Moving Average are effective in forecasting short-term stable consumption patterns, they tend to be less accurate in predicting demand with seasonal or erratic fluctuations. This aligns with findings from Suryawan et al. (2024 which emphasize the importance of selecting forecasting methods that are appropriate for the characteristics of the data, as well as the need for integrated information systems to enhance the accuracy of predictions in hospital logistics management.

Based on the findings presented, researchers conclude that effective pharmaceutical management particularly in inventory control based on accurate forecasting—can significantly improve the quality of services in healthcare facilities. According to Hidayat et al. (2020), proper drug stock management can reduce the risk of stockouts or overstocking, thereby ensuring timely availability of medications in line with patient needs. Other studies by Nurmaesah et al. (2022) and Suryawan et al. (2024) indicate that simple forecasting methods such as Exponential Smoothing and Moving Average are effective for stable drug consumption patterns but less accurate in predicting seasonal or fluctuating demand. This aligns with the findings of Alfallah and Sumijan (2025), who emphasize the importance of using more adaptive forecasting models such as ARIMA, machine learning, or multivariate regression to enhance prediction reliability. Therefore, selecting appropriate forecasting methods and utilizing integrated information systems in pharmaceutical management play a major role in improving logistics efficiency and the overall quality of patient care.

2. Forecast Moving Avarage

The Moving Average forecasting results revealed that drugs with stable consumption patterns—such as antipyretics, corticosteroids, and solid-form vitamins—had low MAPE values, indicating reasonably accurate predictions. This suggests that the method is effective for drugs with consistent demand over time and can be reliably used in pharmaceutical logistics planning (Ilham et al., 2025).

Conversely, for drugs with more volatile demand patterns—such as anti-inflammatories, antihistamines, and liquid antacids—MAPE values were extremely high, exceeding 600%. This indicates that the Moving Average method is less suitable for forecasting demand for such drugs. Therefore, more complex and adaptive forecasting techniques should be considered to improve prediction accuracy and inventory management efficiency in hospitals (Kurniawati et al., 2023).

The discrepancy in forecasting results for some drug types may also be influenced by the operational context of BB Hospital, which is relatively new and has not yet partnered with the Indonesian National Health Insurance (BPJS Kesehatan). This situation contributes to unstable demand patterns, as patient visit trends are still fluctuating and not yet reflected in representative historical data (Jauhari et al., 2025). Additionally, reliance on out-of-pocket payment affects the type and volume of medications consumed. Integrating demand data with local disease trend analysis and implementing adaptive information systems is critical for improving the accuracy of pharmaceutical logistics forecasting and overall inventory management efficiency (Subramanian et al., 2025).

Previous studies by (Burinskiene, 2022; Dwiyanti et al., 2021; Jackson et al., 2024) have extensively discussed the application of forecasting methods such as Moving Average and Exponential Smoothing in pharmaceutical logistics management. Their findings suggest that both methods are effective in identifying drug demand patterns based on historical data and can enhance stock prediction accuracy in hospitals. However, research by Burinskiene 2022) emphasizes that forecasting accuracy is heavily influenced by data characteristics and operational context, especially in newly established hospitals without BPJS affiliation, where drug demand patterns are often more volatile and unstable—necessitating a more adaptive and holistic forecasting approach.

3. Linear Regression Analysis

Based on the ANOVA results, an F-value of 350.216 with a significance level (Sig.) of 0.000 was obtained, indicating a highly significant difference between the Moving Average and Exponential Smoothing methods in forecasting pharmaceutical logistics needs. The correlation coefficient (R) of

0.971 and the coefficient of determination (R^2) of 0.943 suggest that 94.3% of the variation in forecasting results can be explained by the relationship between the two methods, indicating a very strong correlation.

Furthermore, the values of Eta and Eta Squared being 1.000 reinforce the existence of an extremely strong relationship and substantial effect between the forecasting methods and the predicted results. The significant Deviation from Linearity ($p = 0.000$) also indicates a lack of perfect linearity between the methods. Although both methods are strongly correlated, the nature of their relationship is not entirely linear. This highlights the importance of selecting a forecasting method that aligns with the specific data characteristics and the types of drugs being predicted (Sugiyono, 2020).

Based on the linear regression analysis, a very strong relationship between the Moving Average and Exponential Smoothing methods was observed, as evidenced by the R^2 value of 0.943. This indicates that 94.3% of the forecast variation can be attributed to the linear relationship between the two methods. Thus, the two methods exhibit highly similar and consistent forecasting patterns (Zhang et al., 2025). This significant correlation further supports the validity of using either method as a reference for forecasting pharmaceutical logistics needs, especially in newly established hospitals that have yet to collaborate with Health and Social Security Agency (*BPJS Kesehatan*), where prediction accuracy and efficiency are critical for inventory management (Ghannem et al., 2024).

4. T-Test Analysis

The absence of significant differences between the forecasting results of Exponential Smoothing and Moving Average suggests that both approaches are equally viable for projecting pharmaceutical logistics requirements in hospitals. These methods may serve as interchangeable alternatives, particularly in hospitals with relatively stable drug consumption patterns. However, the selection of a forecasting method should also consider additional factors such as ease of implementation and the availability of historical data (Odnoletkova et al., 2025).

Moreover, although statistically insignificant, small differences in means and forecasting errors may still have practical implications in inventory management especially for drugs with high demand fluctuations. Therefore, periodic performance evaluation and adjustment of forecasting parameters are necessary to ensure that predictions remain accurate and efficient over time (Handayany, 2021).

A study by Marita & Darwati 2022) also found that Exponential Smoothing and Moving Average produced statistically similar forecasting results in the context of pharmaceutical inventory management at a regional hospital. This reinforces the finding that both methods can be used interchangeably depending on data characteristics and availability.

CONCLUSION

Based on the analysis and statistical tests, both the Exponential Smoothing and Moving Average methods are effective for forecasting pharmaceutical logistics needs at BB Hospital, with no significant differences observed between the two. Therefore, either method can be applied flexibly depending on the characteristics of the data and hospital conditions. Regular evaluation and adjustment of forecasting parameters are crucial to maintaining prediction accuracy in line with changes in drug consumption patterns.

For newly established hospitals that have not yet collaborated with BPJS Kesehatan, it is recommended to develop an integrated logistics management system to anticipate dynamic drug needs and avoid issues of overstocking or stockouts. Additionally, strengthening human resource capacity in data management and forecasting technologies is essential to support more effective decision-making.

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