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Drug Stock Prediction at Dandy Primary Clinic Using the Single Moving Average Method

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Abstract

This study addresses the issue of ineffective drug stock management at Klinik Pratama Dandy, often resulting in shortages and surpluses due to manual recording and suboptimal planning. This study assesses the accuracy of the Single Moving Average (SMA) method for forecasting drug stock demand and its utility in pharmaceutical logistics planning. Utilizing 24 months of historical data (January 2023–December 2024), partitioned into 80% for training and 20% for testing, prediction accuracy was evaluated with the Mean Absolute Percentage Error (MAPE). The findings reveal that the SMA method performs with 'High Accuracy' (MAPE < 10%). A key insight is that the optimal forecasting period (n) is specific to each drug, as demonstrated with Paracetamol (n=5, MAPE 1.19%) and Hydrocortisone Ointment (n=2, MAPE 6.62%). Consequently, a web-based system was created to automate this forecasting process, serving as a practical instrument for more efficient and objective drug inventory management.

Keywords: *Drug Stock Prediction, Single Moving Average, Mean Absolute Percentage Error, Klinik Pratama Dandy*

1. INTRODUCTION

The availability of drugs in the right quantities and at the appropriate time is a fundamental aspect of healthcare delivery. This availability not only affects the quality of medical services but also has direct implications for patient safety. Ineffective drug stock management can lead to serious problems, including stock-outs that hinder the smoothness of therapy, and overstock which can potentially cause financial losses due to expired drugs or wasted storage space (Pramestutie et al., 2021; Rahayu & Rindarwati, 2021). These problems indicate that drug stock management is one of the important challenges that needs serious attention from various healthcare facilities.In Indonesia, constraints in drug stock management are still often encountered, especially in primary healthcare services such as clinics and community health centers (Puskesmas). One of the main causes is manual recording, which is prone to errors in recording transactions and distribution planning. Nurkholis and Oktora (2022) emphasize that manual recording methods often produce inaccurate data, leading to overall stock imbalances. A similar condition is also experienced by Klinik Pratama Dandy in Medan. Although drug demand tends to be stable every month, this clinic still faces difficulties in managing drug supplies optimally, so the risk of shortages or overstock remains.

Drug usage data at Klinik Pratama Dandy shows a relatively stable pattern, making it potentially predictable using simple forecasting methods. This study specifically highlights two types of drugs: Paracetamol and Hydrocortisone Ointment (Zalf). Paracetamol has a relatively constant monthly usage rate, ranging from 4,800 to 5,000 units. Meanwhile, Hydrocortisone Ointment has a smaller demand pattern, around 800 to 1,200 units per month. The characteristics of stable usage patterns with small fluctuations for both drugs indicate that simple forecasting methods have the potential to provide accurate prediction results.The Single Moving Average (SMA) method is one technique that can be used. It works by averaging data from the most recent several periods to forecast the next period. The advantage of SMA lies in its simplicity, ease of implementation, no requirement for complex statistical skills, and sufficient responsiveness to short-term changes. Thus, SMA is considered suitable for the data pattern of Klinik Pratama Dandy, which is relatively stable without significant seasonal trends (Apriliani et al., 2020; Hayuningtyas & Sari, 2021). Various previous studies support the application of SMA to demand data. Apriliani et al. (2020) showed that SMA could predict restaurant menu sales trends with adequate accuracy. Hayuningtyas and Sari (2021) proved the effectiveness of SMA in predicting medical equipment supplies, which have characteristics similar to drug needs. Irawan et al. (2021) successfully utilized SMA to predict palm oil production, while Hudaningsih et al. (2020) cautioned

that although SMA is simple, its accuracy is sometimes lower compared to other methods like Single Exponential Smoothing. More specifically, Nurkholis and Oktora (2022) applied Moving Average in drug supply prediction and found relevant results for the pharmaceutical context. This literature shows that SMA is worth considering, but its effectiveness in the context of a primary clinic needs further testing. Based on this description, there is a clear research gap. Most previous studies only emphasized manual prediction aspects or were limited to data simulations outside the clinic context. Not many studies have examined the effectiveness of SMA directly in drug stock management in primary clinics, let alone with the development of an automated web-based system. This study offers contributions in two main aspects. First, an academic contribution in the form of testing the effectiveness of the Single Moving Average method in predicting drug stock needs in primary services with real data from Klinik Pratama Dandy. Second, a practical contribution in the form of developing a web-based drug stock prediction system capable of automating the forecasting process, thereby supporting more objective and efficient pharmaceutical logistics decision-making.

2. LITERATURE REVIEW

The literature review serves to examine relevant previous research and provide a theoretical foundation for this study. This review not only presents the results of previous studies but also analyzes their strengths, limitations, and relevance to the research context. Thus, the literature review helps identify the research gap, which is then formulated into the conceptual framework. The Single Moving Average (SMA) method has been widely applied in various fields for forecasting based on historical data. Apriliani et al. (2020) used this method to predict restaurant menu sales trends. Their results showed that SMA could produce accurate predictions when applied to simple seasonal patterns. This finding is important because it proves that although simple, the SMA method can still provide reliable results in the context of stable inventory management. Irawan et al. (2021) utilized SMA to predict palm oil production levels. The results proved that this method can handle data with relatively high fluctuations. The relevance of this study to the pharmaceutical context lies in the similarity of data properties, namely the presence of seasonal variation and demand patterns that tend to repeat. Thus, these findings strengthen the argument that SMA also has the potential to be applied to predicting drug needs in clinics. The application of SMA in the health sector has also been researched previously. Hayuningtyas and Sari (2021) developed an application for predicting medical equipment supplies using SMA. This study found that SMA was quite accurate in estimating periodic stock, which has characteristics similar to drug stocks in pharmacies or clinics. The results of this study are relevant because they show that the SMA method can be used directly in a health context.

Furthermore, Nurkholis and Oktora (2022) researched a drug supply system using the Moving Average method combined with a Fixed Time Period with Safety Stock approach. This research is highly relevant as it directly addresses drug supply prediction. Their findings support the urgency of this study to test the accuracy of the SMA method specifically as a basis for pharmaceutical logistics decision-making at Klinik Pratama. However, the literature also shows the limitations of the SMA method. Hudaningsih et al. (2020) conducted a comparative study between the SMA method and Single Exponential Smoothing (SES) in predicting pharmaceutical product sales. The results showed that SMA had lower accuracy compared to SES. This criticism is important to note because it emphasizes that although SMA is simple, its effectiveness must still be evaluated empirically according to the research context. From these various studies, a common thread can be drawn that SMA is a simple, flexible method that can be adapted in various fields, including health. However, previous research still has limitations. First, most SMA applications were conducted more in general sales or agricultural production sectors, not in drug management in primary clinics. Second, research related to pharmaceuticals focused more on aspects of manual recording without integration into an automated web-based system. Third, no research has been found that specifically tests the effectiveness of SMA for predicting the needs of Paracetamol and Hydrocortisone Ointment in primary healthcare services.

Based on this gap, this study aims to test the effectiveness of the SMA method in the context of predicting drug needs at Klinik Pratama Dandy. The research focuses on two drugs, Paracetamol and Hydrocortisone Ointment, with 24 months of historical data. The accuracy of the prediction results is measured

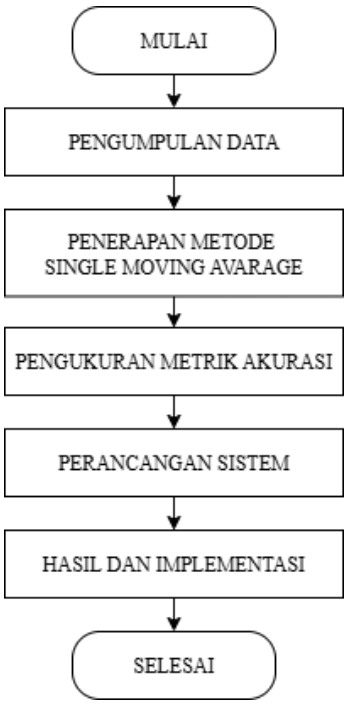
using the Mean Absolute Percentage Error (MAPE) indicator, while the prediction system is developed as a web-based application tested using the Black Box method.

The conceptual framework of this research is illustrated in a systematic flow starting from problem identification, followed by the collection of historical drug usage data. This data is analyzed using the SMA method to generate demand predictions. The accuracy of the prediction results is measured with MAPE to determine the level of accuracy of the method used. Furthermore, a web-based system is designed to automate the prediction process so that it can be used directly by the clinic. The research results are in the form of a practical, efficient drug stock prediction system implementation relevant for supporting pharmaceutical logistics decision-making.

3. RESEARCH METHOD

This research adopts a case study approach with quantitative data analysis. The case study was chosen to understand the problem of drug stock management at Klinik Pratama Dandy Medan in depth and measurably, focusing on the application of the Single Moving Average (SMA) method as a forecasting technique. Figure 1 shows the research framework of this study.

Picture 1. ReaserchDesain



.**3.1** Location, Population, and Sample

The research was conducted at Klinik Pratama Dandy Medan. The research population includes all 60 types of drugs managed by the clinic. From this population, two types of drugs were selected as research samples: Paracetamol and Hydrocortisone Ointment (Zalf). The selection was made because these two drugs have relatively stable consumption patterns, are important in medical services, and are representative for testing simple forecasting methods. The data used is secondary data in the form of historical records of monthly drug usage for 24 months (January 2023–December 2024). The data was obtained through documentation from the clinic's pharmacy department. The drug sample usage recap data can be seen in Table 1.

Tabel 1. Rekapitulasi Data Pemakaian Obat Klinik Dandy

Bulan / Tahun	*Paracetamol*	*Hydrocortisone Zalf*
Jan 2023	4.864	14
Feb 2023	4.538	16
Mar 2023	4.900	17
Apr 2023	5.060	17
Mei 2023	4.947	20
Jun 2023	4.882	21
Jul 2023	4.955	21
Agt 2023	4.833	20
Sep 2023	4.980	20
Okt 2023	4.904	19
Nov 2023	4.850	18
Des 2023	5.015	17
…	…	…
Des 2024	5.061	11

Sumber : Administrasi Farmasi Klinik Dandy Medan

3.3 Research Database

The database in this study was designed to support the management of drug data, transactions, and stock forecasting results at Klinik Pratama Dandy. The database consists of six main interconnected tables, including drug data, employees, suppliers, purchase transactions, sales transactions, and forecasting results. A summary of the database structure is presented in Table 2.

Tabel 2. Database

Nama Tabel	Jumlah Field
tbl_dataobat	10
tbl_pegawai	9
tbl_supplier	5
tbl_pembelian	8
tbl_penjualan	6
tbl_peramalan	7

3.4 Analysis Technique

The data analysis process in this study is based on the Single Moving Average approach. The SMA formula is shown in Equation (1).

$$F_{t+1} = \frac{Y_t + Y_{t-1} + \cdots + Y_{t-n+1}}{n} \quad \ldots\ldots\ldots(1)$$

Keterangan:

1. F_{t+1} = nilai peramalan periode berikutnya
2. Y_t = nilai aktual pada periode ke-t
3. n = jumlah periode moving average
   Prediction accuracy is measured using the Mean Absolute Percentage Error (MAPE), as shown in Equation (2).

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right| \times 100\% \quad \text{.....(2)}$$

Keterangan:

1. Y_t = data aktual
2. F_t = data hasil peramalan
3. n = jumlah data pengamatan
4. MAPE accuracy classification: <10% highly accurate, 10–20% good, 20–50% fair, >50% inaccurate.

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3.5 System Design and Testing

The drug stock prediction system was built as a web-based system using Python for the Single Moving Average calculation method and PHP for the user interface. Implementation was done in Visual Studio Code with MySQL database support. The system allows users to input data, process forecasts, and display results in tables and graphs. The testing process on this system was carried out using a Black Box Testing approach. This method focuses on testing application functionality from the user's side, such as input data validation, calculation accuracy, and display of forecast results, without reviewing the internal program code.

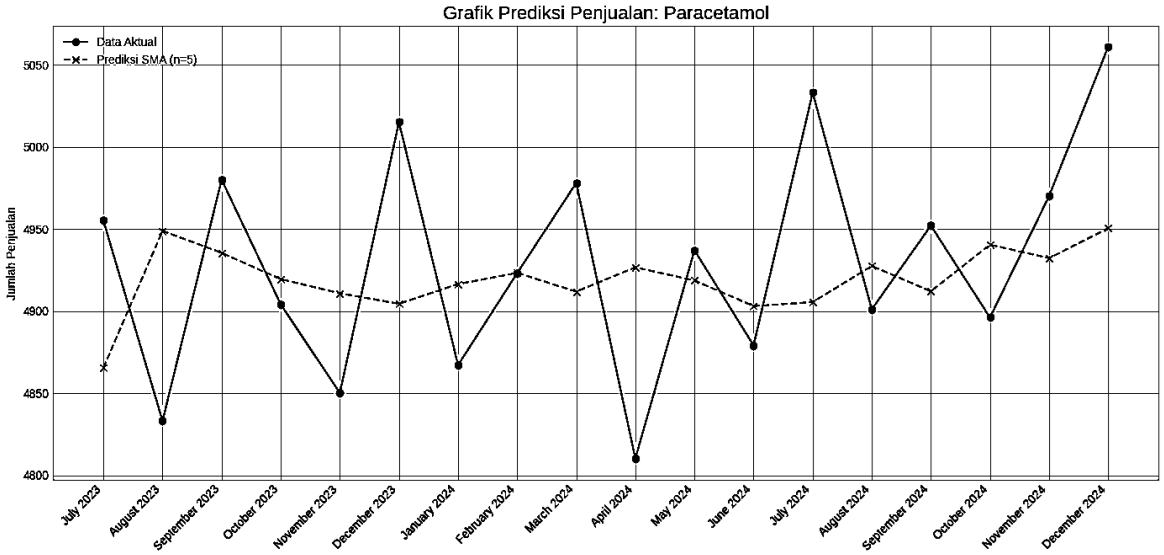
4. RESULTS AND DISCUSSION

The results and discussion of this research are presented comprehensively in the following section, starting from the application of the Single Moving Average (SMA) forecasting method, evaluation of model accuracy, to the implementation of the web-based system. Furthermore, the discussion section will delve deeper into these findings, relate them to the hypothesis, compare them with relevant literature, and highlight the novelty and contribution of this research in the context of pharmaceutical logistics management in primary healthcare facilities.

4.1 Forecasting Results Using Single Moving Average

Using historical drug usage data for Paracetamol and Hydrocortisone Ointment over 24 months (January 2023 – December 2024) as presented in the research methods section, the Single Moving Average method was applied. This process aimed to find the most accurate forecasting model by testing several different moving periods (n), namely n=2, 3, 4, 5, and 6. The calculation was automated using a Python script on 80% of the training data to ensure efficiency and accuracy. The period n with the smallest Mean Absolute Percentage Error (MAPE) value was then selected as the best forecasting model for each drug. For Paracetamol, the best period found was n=5, indicating that the average usage of the last five months provides the most accurate prediction for the next month. Meanwhile, for Hydrocortisone Ointment, the best period was n=2, suggesting that data from the last two months is more relevant for predicting its needs. These forecasting results were then validated by comparing them against the 20% test data. A visualization comparing the actual data and prediction results is presented in graph form in Figure 2 for Paracetamol.

Gambar 1. Grafik Paracetamol



The figure above shows that the actual data has significant monthly fluctuations. The SMA prediction line (n=5) successfully performs its function of "smoothing" this volatility, moving along the central trend of the data. Although it does not capture every peak and valley precisely, the prediction line consistently follows the general flow of the data, indicating that the model successfully identifies the basic demand pattern without overreacting to short-term random variations.

Similarly, the graph for Hydrocortisone Ointment can be seen in Figure 3.

Gambar 2. Grafik Hyrocortisone Zalf

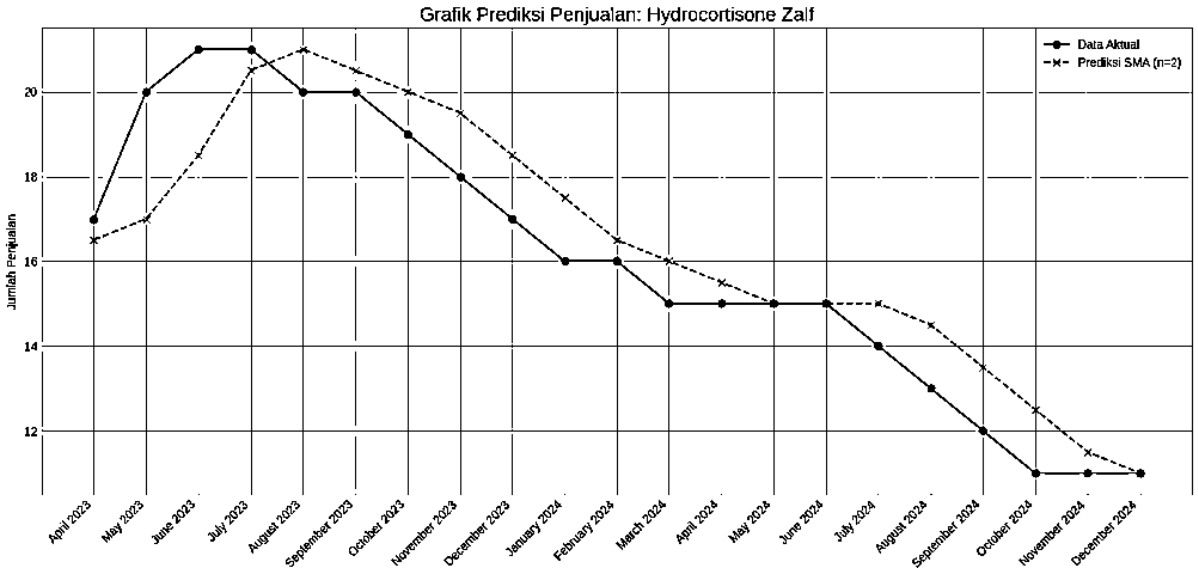


Figure 3 shows the SMA prediction line (n=2) which is able to follow the downward trend in usage in 2024 quite well. Although there are some discrepancies, especially at points of sharp trend change, the model can still provide estimates close to the true values.

4.2 Model Accuracy Evaluation

The accuracy of the forecasting model was measured using the Mean Absolute Percentage Error (MAPE) metric, which calculates the average percentage of absolute error between predicted and actual values. The advantage of MAPE is its ability to present the error level in an intuitive and easily understandable percentage format. Table 3 summarizes the accuracy evaluation results for the two sample drugs using the best period n.

Tabel 3. Summary of Forecasting Model Accuracy Evaluation Results

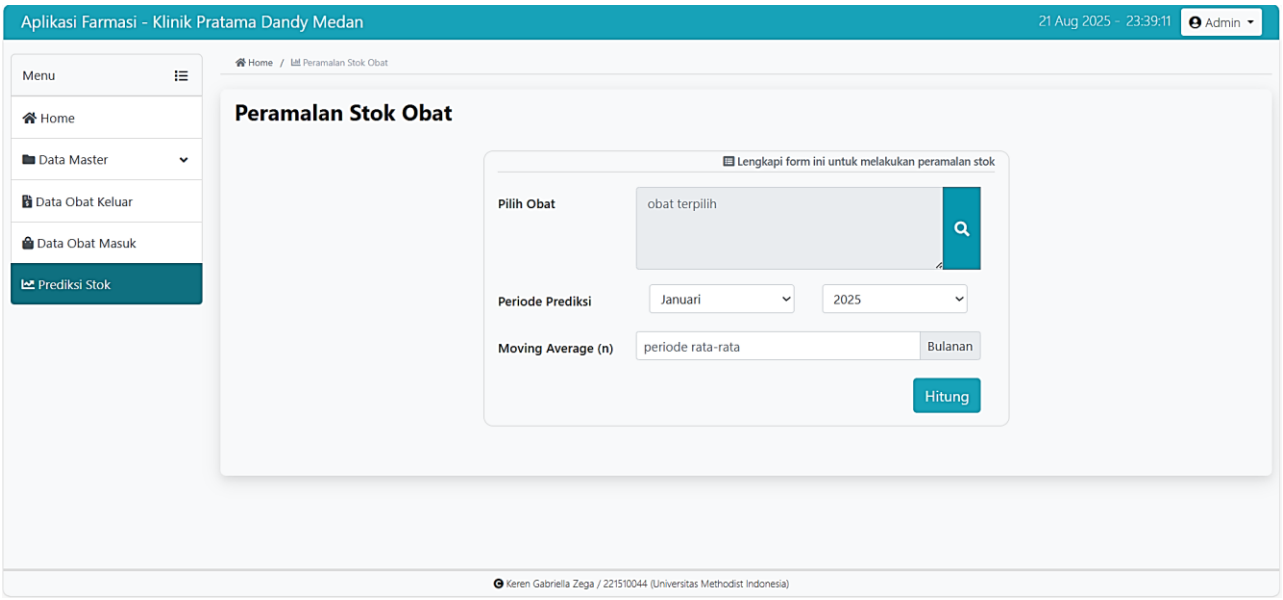
Nama Obat	Periode Terbaik (*n*)	Nilai MAPE	Kategori Akurasi
Paracetamol	5	1,19%	Sangat Akurat
Hydrocortisone Zalf	2	6,62%	Sangat Akurat

Based on the standard interpretation of MAPE (Khoiri, 2023), a MAPE value below 10% is categorized as "Highly Accurate". The research results show that both forecasting models meet this criterion. The model for Paracetamol yielded a MAPE of 1.19%, indicating a very high level of accuracy. This means, on average, the predicted usage of Paracetamol deviates by only about 1.19% from its actual usage. For Hydrocortisone Ointment, the MAPE value of 6.62% also shows very good performance, although its data pattern has slightly more variation. These results are in line with findings in the literature stating that the Single Moving Average method is very effective for data with stationary or stable patterns (Apriliani et al., 2020; Hayuningtyas & Sari, 2021). This high level of accuracy confirms the initial hypothesis that the Single Moving Average method is a reliable and relevant tool for predicting drug stock needs at Klinik Pratama Dandy.

4.3 Web-Based System Implementation

To translate the forecasting model into a practical tool that can be used by pharmacy staff, this research implemented a web-based information system. This system was developed by integrating two main technologies: Python to run the Single Moving Average calculation algorithm in the backend, and PHP to build an interactive and easily accessible user interface. The developed system has several core functionalities, including drug data management, recording of drug in and out transactions, and the main feature, namely the stock prediction module. Users (such as pharmacists or admins) can select the drug name and the time period to be forecasted, and the system will automatically display the prediction results in table and graph form. The interface display for this prediction feature is designed to be minimalist and functional, as shown in Figure 4.

Picture 3. Stock and Estimation



To ensure system reliability and functionality, testing was conducted using the Black Box Testing method. Test scenarios covered all main features, from the login process, data management (CRUD), to the execution of the forecasting function. The test results showed that all features worked as expected, with no bugs or functional errors found. Thus, this system is proven ready to be implemented as an operational tool at Klinik Pratama Dandy.

4.4 Discussion

This section discusses the research findings in more depth, connects them to the problem context at Klinik Pratama Dandy, and compares them with previous research to place the contribution of this study in a broader scientific landscape.

4.4.1 Interpretation and Analysis of Results

The very high level of accuracy (MAPE < 10%) achieved by the Single Moving Average method in this study can be attributed to the suitability of the method's characteristics with the drug usage data pattern at Klinik Pratama Dandy. The historical data, particularly for Paracetamol, shows a relatively stable pattern with small fluctuations from month to month. The Single Moving Average method, which essentially calculates a moving average, excels in handling such stationary data due to its ability to dampen "noise" or short-term random variations. By taking the average of the last several periods (n=5 for Paracetamol), the model successfully ignores momentary spikes or drops and focuses on the more fundamental consumption trend, resulting in consistent and accurate predictions. For Hydrocortisone Ointment, although the data shows a clearer downward trend in the second year, choosing a shorter period (n=2) allows the model to be more responsive to recent changes. This demonstrates the flexibility of the Single Moving Average method, where determining the right n value is key to optimizing prediction performance according to the unique characteristics of each item. This success directly addresses the problem at Klinik Pratama Dandy, where previous stock planning was often subjective and not data-based, risking stock-outs or overstock. These research results provide an objective quantitative basis for decision-making.

4.4.2 Comparison with Previous Studies

The findings of this study strengthen and complement the results of previous studies in the field of inventory forecasting. Research by Nurkholis & Oktora (2022), which also applied the Moving Average method for drug stock prediction, found that this method is effective for managing supplies. The results of this study align with that conclusion, and furthermore, show a very high level of accuracy in a specific case study in a primary healthcare facility. This strengthens the argument that computationally simple methods can provide very reliable results if applied to the right data context. On the other hand, research by Hudaningsih et al. (2020) compared Single Moving Average with Single Exponential Smoothing (SES) and found that SES had higher accuracy on their pharmaceutical product sales data. However, it is important to note that the superiority of a method often depends on the data pattern. Their findings do not negate the validity of Single Moving Average, but rather highlight the importance of selecting the appropriate method. In the case of Klinik Pratama Dandy, where the data does not show a strong long-term trend, the simplicity of SMA is its advantage. This study provides empirical evidence that for stable data, SMA is a choice that is not only accurate but also easier to implement and interpret by non-statistical practitioners.

4.4.3 Novelty and Contribution of the Research

The novelty of this research lies in several aspects. First, this study specifically applies and validates the Single Moving Average forecasting method in the context of a primary clinic or small-scale primary healthcare service. Most research often focuses on large hospitals or pharmaceutical distributors. By demonstrating the effectiveness of this method in an environment with potentially more limited resources, this study fills an important gap in the literature. Second, the novelty lies in the integration of the forecasting model into a functional and user-friendly web-based application system. This transforms a theoretical concept into a

practical solution that can be directly adopted. This system not only provides prediction results but also becomes an integrated inventory management tool, which is a significant added value for clinic operations. The main contribution of this research is twofold. Practically, this research provides a real and low-cost solution for Klinik Pratama Dandy to overcome stock management problems. Implementing this system has the potential to increase efficiency, reduce financial losses due to expired drugs or stock shortages, and ultimately improve the quality of service to patients. Theoretically, this study strengthens the existing literature by providing strong empirical evidence that classic forecasting methods like Single Moving Average are still very relevant and highly competitive in real-world contexts, especially when faced with stable data patterns. This research shows that complex solutions are not always better; sometimes, a simple approach, if applied correctly, can provide optimal results.

5. CONCLUSION AND SUGGESTIONS

5.1 Conclusion

This study conclusively answers the problem regarding the effectiveness of the Single Moving Average (SMA) method in supporting drug stock planning at Klinik Pratama Dandy, by showing that this method is capable of producing highly accurate predictions (MAPE < 10%). This success was achieved by determining the optimal and unique forecasting period (n) for each drug type, such as n=5 for Paracetamol (MAPE 1.19%) and n=2 for Hydrocortisone Ointment (MAPE 6.62%). These prediction results were then successfully implemented into a functional web-based application system that automates the forecasting process, providing an objective and efficient tool for clinic management. However, this study has limitations as it only focused on the SMA method without comparing it to other forecasting methods that might offer higher accuracy for certain data patterns. Therefore, further research can refine these findings by conducting a comparative analysis with other methods such as Exponential Smoothing and developing the system with more advanced features, such as automatic minimum stock notifications or a procurement module, to create a more comprehensive pharmaceutical logistics management solution.

5.2 Suggestions

Based on the research findings, several developments can be made for future research. First, it is suggested to conduct a comparative study by applying other forecasting methods, such as Single Exponential Smoothing or Double Exponential Smoothing, to identify the most optimal method for each drug data characteristic. Second, the application system that has been built can be further developed by adding more comprehensive functionality, such as a module for automatic notifications when stock reaches the minimum limit, integration with a procurement system, and features to generate managerial reports in PDF format, thereby enhancing its effectiveness as a comprehensive pharmaceutical logistics management tool.

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