

Inventory Control of Medicine with Minimum-Maximum Stock Level at Ibu Fatmawati Soekarno Hospital Surakarta in 2023

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ABSTRACT

Background: Inventory control prevents overstock and stockouts by monitoring availability, usage, while managing loss, damage, and expiration. Many hospitals struggle to manage inventory efficiently. Therefore, it is crucial to categorize drug supplies based on usage and investment values to balance supply and demand.

Objectives: The study aims to categorize drug supplies based on their usage and investment values and then calculate the minimum and maximum stocks.

Methods: This is a descriptive non-experimental study using cross-sectional data collected descriptively and retrospectively. Secondary data was used from drug information on SIM in 2023 and primary data from interviews. The results will be categorized using ABC categories, and inventory will be managed using the MMSL method. Additionally, the study will calculate the minimum and maximum stock as part of the investment process.

Results: The ABC analysis of usage shows the percentage of drug items in groups A consists of 8.17% of items accounting for 70.06% of total usage, group B with 12.03% accounting for 20.41%, and group C with 79.80% accounting for 9.53%. Similarly, for investment value, group A accounts for 70.35%, group B for 20.16%, and group C for 9.50%. The MMSL method resulted in optimal safe, minimum, and maximum stock levels for each drug item.

Conclusion: Grouping drugs into A, B, and C categories based on usage value and investment value can help to prioritize a drug, and inventory control with the MMSL method has a positive impact where there is a decrease in the number of purchases and purchase costs after the MMSL method.

Keywords: ABC; inventory control; MMSL

INTRODUCTION

Inventory control is an activity designed to ensure proper distribution of available medications. The aim of inventory control is to prevent excess stock or stock outs in hospitals. Monitoring medication availability, usage, and managing loss, damage, and expiration are key activities in inventory control. In many developing countries, drug budgets account for approximately 40-50% of total hospital costs, highlighting the need for efficient inventory management to maintain quality and control costs. Although inventory management plays an important role, many hospitals face inefficiencies that lead to stockouts or overstocks, thereby affecting service quality and operational cost.^{1,2}

Excess drug inventory leads to higher carrying costs, including capital costs and potential damage. In addition to storage costs, other factors such as demand costs, reorder costs, and the number of drugs ordered will affect inventory control.³ Insufficient supplies can result in unfilled prescriptions, which negatively impacts the quality of hospital services.

Overcoming these challenges requires systematic approaches such as ABC analysis and the Minimum-Maximum Stock Level (MMSL) method. ABC analysis, also called Pareto analysis, categorizes drugs based on usage value and investment costs. Group A consists of 10-20% of drug items, representing 65-70% of total drug use. Group B contains 10-20% other drugs, accounting for 15-20% of use. Group C includes 60-80% of the types

of drugs, but only 5-10% of them are used.⁴ Therefore, ABC analysis compares the use and costs of items in a particular category, providing information about similar drugs and their costs, while projecting overall cost savings by using less expensive alternatives.⁵

This MMSL method is critical for hospitals to anticipate or estimate when to stock up, ensure they do not overstock, and help determine the minimum inventory needed to avoid stockouts. MMSL sets minimum and maximum stock levels taking into account lead time, average consumption, safety stock and procurement period.⁷

Based on previous research by Indarti et al⁸, with the title of Inventory Control of Medicine with Minimum-Maximum Stock Level Method in Dr. Sardjito Hospital Pharmacy Yogyakarta, it was found that the MMSL method had a positive effect on the productivity of drug inventory, specifically by reducing the frequency rate from 8 interventions to 2 interventions. From this research, the MMSL method can be used in drug stock control.

Currently, literature and practices on inventory management still reveal gaps particularly in type C hospitals like Ibu Fatmawati Soekarno General Hospital. Most existing research focuses on the high-level hospitals with some studying specific drug categories, leaving the exploration of stock control methods in mid-level facilities relatively overlooked. Further examples include stock shortage, wastage, resource misallocation, among many occurring challenges that would require extensive and context-specific investigation. It proposes a study that fills the gap in literature that compares ABC analysis and MMSL on the classification of drug stocks with respect to the use and amount invested in stock. Moreover, it aims to determine the optimum minimum and maximum stock levels to improve the efficiency of inventory management at Ibu Fatmawati Soekarno Hospital, Surakarta, and thus contribute to improved medicine availability and cost management.

METHODS

Study design

The research is a descriptive non-experimental study using retrospective cross-sectional data collection methods. The primary data source consists of quantitative data obtained from hospital inventory records. In addition, qualitative data from interviews with pharmacy staff are used to support and complement the quantitative findings.

Population and samples

The population in this research is the entire drug inventory obtained from the Pharmacy Department of Ibu Fatmawati Soekarno Surakarta General Hospital in 2023. The inclusion criteria include active drug items listed in the 2023 inventory system with complete data on usage and investment value. The exclusion criteria were expired, discontinued, or obsolete drugs during the period of the study, and incomplete records or missing inventory of drug items. The sampling methods used for this research were total sampling and interviews. Total sampling allows all drug items lying within the criteria of inclusion, to be included as samples, while the interviews provided added information to that of the method of inventory management from key pharmacy staff members.

Study instruments

The study collects data from the drug inventory that was logged into the Hospital Management Information System (*Sistem Informasi Manajemen* – SIM) at Ibu Fatmawati Soekarno Surakarta General Hospital in 2023. SIM constitutes an integrated management information system employed by health facilities to manage varieties of operations, such as inventory management, procurement, and distribution.

Additional primary data were obtained through structured interviews with the key informants, which included the head of the Pharmacy Department and the warehouse coordinator. These interviews delved deeper into the inventory management practices and the challenges faced at the facility, which were complemented by the quantitative SIM data.

Data collection

This study employs retro and descriptive techniques of data collection which uses both secondary and primary sources. The 2023 secondary data was taken from the SIM system at the Health Service Unit of Ibu Fatmawati Soekarno Surakarta General Hospital. This data comprises complete records of drug use, procurement, and inventory details which are very valuable in analyzing drug utilization and value investments.

Meanwhile, the primary data were acquired through structured interviews with two key informants, the Head of the Pharmacy Installation and the Pharmacy Warehouse Coordinator at Ibu Fatmawati Soekarno

Surakarta General Hospital. The interviews give one good understanding of how they practice inventory management, the challenges they face, some applications of different inventory techniques such as ABC analysis and the MMSL approach. Integration of the two data sources guarantees a very strong as well as comprehensive analysis-with quantitative evidence from secondary data and contextual depth in findings through primary data.

Data Analysis

ABC analysis based on usage value

The ABC analysis categorizes drugs into three groups based on their usage value, helping prioritize drug management. The formula used is:

$$\% \text{ Usage} = \frac{\text{Total Drug Usage (JP)}}{\text{Total Drug Usage Over a Year (JTP)}} \times 100\%$$

The identification of Groups A, B, and C as critical items for closer monitoring and more efficient resource allocation can thus reduce the risk of overstocking and stockouts.

ABC analysis based on investment value

This method categorizes drugs based on their contribution to total inventory costs, linking cost management to supply chain decisions. The formula used is:

$$\text{Cost of Drug Usage (JBP)} = \text{Total Usage (JP)} \times \text{Price (H)} \quad \% \text{ usage cost} = \frac{\text{JBP}}{\text{Total Cost of Usage Over a Year (JTBP)}} \times 100\%$$

This analysis would help assess which high-cost drugs (Groups A, B, and C) should be prioritized for tighter control measures and financial efficiency.

Minimum-maximum stock level (MMSL)

The formula used to calculate the minimum-maximum stock level (MMSL) method is as follows:

$$\begin{aligned} \text{Safety stock (SS)} &= \text{Lead Time (LT)} \times \text{Average Daily Consumption (CA)} \\ \text{Smin (Minimum stock)} &= (\text{LT} \times \text{CA}) + \text{SS} = 2 \text{ SS} \\ \text{Smak (Maximum stock)} &= \text{Smin} + (\text{Procurement Period (PP)} \times \text{CA}) \end{aligned}$$

This method minimizes the possibility of overstocks or shortages by keeping inventory within calculated thresholds. The combination of ABC and MMSL methods offers a comprehensive strategy for inventory control. Through classifying the medicines and determining the otherwise sufficient stock levels, hospitals will use resources effectively, minimize waste and guarantee continued availability of the medicines to improve patient care.

RESULTS AND DISCUSSION

ABC analysis based on usage value

In 2023, at Ibu Fatmawati Soekarno Surakarta General Hospital, there were 698 drug items. Table I presents the results of the ABC analysis based on drug usage at Ibu Fatmawati Soekarno Surakarta General Hospital in 2023.

In this analysis, drug items are categorized into three groups: A, B, and C. Group A consists of drugs with high prices and high usage volumes. It also includes drugs with moderate prices but exceptionally high usage. Group B encompasses drugs with moderate usage and either high prices or moderate prices. Lastly, Group C includes drugs with low prices but high usage, as well as drugs with high prices but low usage frequency.⁹

Table I. ABC analysis based on usage value

Year	Group	Drug items	Percentage (%)	Drug uses (item)	Percentage (%)
2023	A	57	8.17	3,826,691	70.06
	B	84	12.03	1,114,821	20.41
	C	557	79.80	520,615	9.53
Total		698	100.00	5,462,127	100.00

This classification that belongs to the Pareto Principle. The principle indicates that a small percentage of items usually accounts for a large majority of usage. Hospitals can thus finally manage their inventories according to this. Group A requires closer and more frequent ordering; Group B requires a moderate frequency of replenishment, and Group C requires minimal effort in management.⁸

ABC analysis based on the value of drug usage at Ibu Fatmawati Soekarno Surakarta General Hospital in 2023, group A got a percentage of drug items of 8.17% with a percentage of the total drug usage of 70.06%, group B got a percentage of drug items of 12.03% with a percentage of the total drug usage of 20.41%, and group C got a percentage of drug items of 79.80% with a total drug usage of 9.53%.

The results of ABC analysis research based on the value of drug usage at Ibu Fatmawati Soekarno Surakarta General Hospital in 2023 are in line with the research of Putri et al¹⁰, that the percentage of the number of drug items must be inversely proportional to the percentage of the amount of usage where drug items with a small amount have a high usage value and this is in line with the Pareto principle, namely that drug item with a small amount have a high value. Then further procurement activities can be controlled by determining the frequency of orders, where items included in group A are ordered carefully, as often as possible and the amount ordered is less to reduce procurement costs and low safety stock. Drug items included in group B are controlled with the optimum frequency and amount of procurement and drug items included in group C have the minimum control effort.¹¹

ABC analysis based on investment value

In 2023, Ibu Fatmawati Soekarno Surakarta General Hospital had 698 drug items. The results of the ABC grouping based on the investment value at the hospital in 2023 are presented in Table II.

Table II. ABC analysis based on investment value

Year	Group	Drug items	Percentage (%)	Cost (IDR)	Percentage (%)
2023	A	90	12.89	7,120,240,293.68	70.35
	B	156	22.35	2,040,182,631.07	20.16
	C	452	64.76	961,416,837.55	9.50
Total		698	100.00	10,121,839,762.29	100.00

IDR = Indonesian Rupiahs

In this research, the ABC analysis method is used to categorize drug items based on their investment value to determine the priority level of stock management. Group A is that group, which comprises drug items accounting for 70% of the total investment value while representing around 10-20% of total drug items. Group B consists of drugs covering 20% of the investment value but only 10-20% of the items. While C represents the remaining 10% investment value but 60-80% of the total items. The report subsequently points out the drugs with a need for frequent checks and controls to optimize costs and minimize stock-outs.

ABC analysis based on the investment value of drugs at Ibu Fatmawati Soekarno Surakarta General Hospital in 2023, group A absorbs the highest number of usage costs amounting to IDR7,120,240,293.68 with the percentage of drug items 12.89% and the percentage of total drug usage costs 70.35%. Group B absorbed costs of IDR2,040,182,631.07 with a percentage of drug items of 22.35% and a percentage of total drug costs of 20.16%. Group C absorbed costs of IDR961,416,837.55 with a percentage of drug items of 64.76% and a percentage of total drug costs of 9.50%.

With high risk, drug items in Group A require strict inventory control, accurate record-keeping, and physical monitoring at least once a month to prevent overstocking and shortages. Group B, with moderate usage costs, also requires attention, while Group C demands less oversight but still needs expiry monitoring to avoid hospital losses. Additionally, to prevent drug shortages, it is crucial to maintain stock levels for all groups, especially critical drugs, ensuring a continuous supply and avoiding service disruptions.^{4,12}

The results of the ABC analysis based on the medicines investment value per the Ibu Fatmawati Soekarno Surakarta General Hospital show in 2023 that Groups A and C are in line with theory. An example of Groups A consists of several drug items but has a higher investment value because it is expected to be higher when compared with Groups B and C. It is in sum because, according to theory, approximately 10-20% of the items fall under this group but 70-80% come from the total investment. In Group B, a little bit above that level exists under the theoretical provisions, where percentage drug items in Group B should fall under 10-20%, but the result is

shown as 22.35%. This gap could be due to fast moving drugs in Group B. Group B positioned at the intersection of A and C scores a medium number of items with a medium value of investment. Finally, Group C has many types of drugs but has an overall low investment value, according to theory.

Metode Minimum-Maximum Stock Level (MMSL)

Following the completion of the ABC analysis and the categorization of the drugs into three groups A, B, and C, the subsequent stage is the implementation of a minimum-maximum stock level (MMSL) calculation to oversee inventory control. To apply this method, it is necessary to consider three key parameters: the average usage per month, the procurement period (PP), and the safety stock (SS). Table III presents data on the ten drugs with the highest usage values, demonstrating the application of the minimum-maximum stock level (MMSL) method for inventory control.

Table III. Top 10 drug items with a large usage value with inventory control using the MMSL (Minimum-Maximum Stock Level) Method.

No	Drug Name	Lead time (Month)	Usage	Average Usage in 1 Month	SS	Smin	PP (Month)	Smax
		X		Y			Xi	2xy+(xi*y)
1	Metformin tab 500 mg tab	0.13	278,642	23,220	3,096	6,192	3	75,853
2	Simvastatin tab 10 mg	0.13	167,124	13,927	1,857	3,714	3	45,495
3	Candesartan tab 16 mg	0.10	164,804	13,734	1,373	2,747	3	43,948
4	Lansoprazole cap 30 mg	0.07	160,372	13,364	891	1,782	1	15,146
5	Miniaspi tab 80 mg/aspilet	0.13	135,701	11,308	1,508	3,016	1	14,324
6	Amlodipin tab 10 mg	0.10	128,118	10,677	1,068	2,135	3	34,165
7	Guaifenesin 100 mg tab/gregorix	0.07	124,819	10,402	693	1,387	1	11,788
8	Furosemide tab 40 mg/farsiretic	0.10	110,040	9,170	917	1,834	1	11,004
9	Salbutamol tab 2 mg	0.13	107,719	8,977	1,197	2,394	3	29,324
10	Gabapentin capsule 100 mg/Alpentin 100 mg	0.10	97,456	8,121	812	1,624	3	25,988

The Minimum-Maximum Stock Level (MMSL) method is utilized to efficiently manage drug inventory, ensuring the prevention of overstocking or shortages. This method involves determining the minimum and maximum stock levels for each drug item by considering three key parameters: average monthly usage, procurement period (PP), and safety stock (SS).¹⁴ Based on an interview with the head of the Pharmaceutical Supplies Room of Ibu Fatmawati Soekarno General Hospital, it is known that the lead time results for each drug are different. The difference in lead time is determined by the drug category based on e-catalog and regular ordering. For e-catalog drugs, the lead time is 2-5 days and the regular lead time is 2-3 days. Furthermore, the existing lead times are then averaged and the results are obtained for e-catalog 3 and 4 days or 0.13 and 0.10 months, while for regular 2 and 3 days or 0.10 and 0.07 months. The drug procurement period at Ibu Fatmawati Soekarno Surakarta General Hospital is differentiated based on 2 drug categories, namely chronic and non-chronic drugs where for the chronic drug category the drug procurement period is 90 days or every 3 months while for the non-chronic drug category, the drug procurement is 30 days or once a month.

Safety stock is a reliable inventory stock that protects against potential fluctuations in demand or supply uncertainty.¹⁵ The quantity of safety stock required for each drug item is determined through the application of a formula, specifically, the lead time multiplied by the average monthly usage. Once the safety stock value has been determined, the subsequent step is to calculate the minimum and maximum stock values for each drug item to maintain a stable drug supply, free from shortages, excesses, and deficiencies. The minimum stock is determined by multiplying the lead time by the average monthly usage and adding this figure to the safety stock.

$$S_{\min} (\text{Minimum stock}) = (LT \times CA) + SS = 2 \text{ SS}$$

Moreover, the maximum stock is determined by calculating the minimum stock and adding it to the procurement time, which is then multiplied by the average usage per month.

$$\text{Smax (Maximum stock)} = \text{Smin} + (\text{Procurement Period (PP)} \times \text{CA})$$

The requisite quantity of orders can be calculated by subtracting the maximum stock level from the minimum stock level.

$$\text{Order Quantity} = \text{Smax} - \text{Smin}$$

These formulas ensure that stock levels are maintained within optimal limits, preventing overstock or stockouts.^{7,16}

A comparison of the average remaining stock in the hospital and the average purchase in the hospital is necessary to ascertain the suitability of the MMSL method in calculating stock levels. This comparison is essential to determine whether the MMSL method produces results that are consistent with existing data in the hospital.

The results presented in Table IV highlights the differences between hospital procurement practices and the MMSL method, analyzing procurement period (PP), average monthly usage, purchases, and calculated stock levels (Smin and Smax). Higher-usage drugs require shorter procurement periods to avoid stockouts. Average usage determines stock levels, while purchases reflect current strategies compared to MMSL optimization. Smin ensures availability, and Smax prevents overstocking, demonstrating MMSL's efficiency in inventory management.

Table IV presents the procurement calculation of metformin 500 mg tablets for the hospital. This drug is ordered when the remaining stock is 22,800 items, and 70,000 items are purchased. The Minimum-Maximum Stock Level (MMSL) method indicates that the minimum stock of metformin is 6,192 items and the maximum is 75,853 items. Procurement is within this range to ensure that the Ibu Fatmawati Soekarno Surakarta General Hospital has provisions of adequate supplies of the drugs and to avoid shortages or over-stocked supply.

As illustrated in Table IV, 100 mg gabapentin was procured at a stock level of 4773 and procured 27593 more. The Minimum-Maximum Stock Level (MMSL) calculation indicated a minimum stock of 1624 items and an upper ceiling of 25988 items. The amount of the purchase exceeded, in this case, the maximum stock value determined using the MMSL method. Going beyond this point can lead to an exceedingly high inventory, resulting in medication pile-up, damage, or expiration of medicines. It should be noted with seriousness that maximum stock thresholds are maintained in order to prevent excess stocks inventory and promote effective management of inventory.

Table IV. Results of hospital procurement calculations and calculations using the MMSL (Minimum-Maximum Stock Level) method.

No	Drug Name	PP	Average Usage (Month)	Average Purchase (Month)	Smin	Smax
1	Metformin tab 500 mg	3	22,800	70,000	6,192	75,853
2	Simvastatin tab 10 mg	3	15,488	44,968	3,714	45,495
3	Candesartan tab 16 mg	3	10,200	43,500	2,747	43,948
4	Lansoprazole cap 30mg	1	6,623	13,333	1,782	15,146
5	Miniaspi tab 80 mg/aspilet	1	3,354	12,500	3,016	14,324
6	Amlodipin tab 10 mg	3	16,875	30,000	2,135	34,165
7	Guaifenesin 100 mg tab/gregorix	1	4,992	10,417	1,387	11,788
8	Furosemide tab 40 mg/farsiretic	1	3,292	10,558	1,834	11,004
9	Salbutamol tab 2 mg	3	12,975	24,575	2,394	29,324
10	Gabapentin cap 100 mg/alpentin	3	4,773	27,593	1,624	25,988

A comparison of the value of drug purchases before and after the implementation of an inventory control system, utilizing the Minimum-Maximum Stock Level (MMSL) method, is presented in Table V.

Table V illustrates that the number of pharmaceutical acquisitions before the application of the Minimum-Maximum Stock Level (MMSL) methodology was 5,521,888 items, whereas, after the implementation of the MMSL approach, the figure was 5,462,127 items, representing a discrepancy of 59,761 items. Furthermore, the cost of purchasing drugs before the Minimum-Maximum Stock Level (MMSL) calculation was IDR

10,247,702,614.46, while after controlling for the MMSL calculation, the cost was IDR 10,121,839,762.29. This represents a cost difference of IDR 125,862,852.17.

Table V. The data set has been analyzed using the minimum-maximum stock level (MMSL) method.

	Before	After	Difference
Purchase	5,521,888 item	5,462,127 item	59,761 item
Cost	IDR 10,247,702,614.46	IDR 10,121,839,762.29	IDR 125,862,852.17

The Minimum-Maximum Stock Level (MMSL) method has been demonstrated to have a positive impact on efficiency in drug items where there is a decrease in inventory value, as evidenced by the results. This finding aligns with the conclusions of Wijayanto et al¹⁷, who demonstrated that the MMSL method has a positive impact on the efficiency of category A antibiotic supply, particularly in instances where there is a decrease in inventory value, an increase in inventory turnover ratio value, a decrease in dead stock value, and a reduction in stock-outs. In a separate study, Hartinah et al¹⁸ demonstrated that the application of the MMSL method to inventory control yielded optimal prediction results. A reduction in inventory value will result in a corresponding decrease in incurred costs, thereby ensuring the cost budget is efficiently managed.

CONCLUSION

The classification of drug items at Ibu Fatmawati Soekarno Surakarta General Hospital with the method of ABC analysis based on both usage values and investment values in 2023 shows that Group A comprises 8.17% of drug items with a total usage of 70.06%. Group B includes 12.03% of drug items and contributes to 20.41% of usage, while Group C whose total item counts for percentage 79.80 with only 9.53% of usage. In terms of investment limit, the value of items classified in Group A accounts for 12.89%, with 70.35% of total investments being allocated to it, while Group B constitutes 22.35% of drug items, consuming 20.16% of investments, and Group C accounts for 64.76% of the items and includes just 9.50% of the investments.

Inventory Control using MMSL (Minimum-Maximum Stock Level) showed some positive results. In the assessment of applications of the MMSL, the hospital is experiencing reductions in the frequencies of sale and purchase costs, thus proving the method effective in optimizing drug inventory management.

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STATEMENT OF ETHICS

This study was approved with ethical clearance approval obtained from Dr. Moewardi Surakarta Hospital with number 651/III/HREC/2024 on March 4, 2024.

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