Jurnal Manajemen dan Pelayanan Farmasi (JMPF)
(Journal of Management and Pharmacy Practice)
ISSN-p : 2088-8139 | ISSN-e : 2443-2946

Efficiency of Drug Inventory Control in Hospitals in Indonesia Using the Minimum-Maximum Stock Level: A Systematic Review

Putu Hediarta Widiana Putra[1], Satibi[2*], Susi Ari Kristina[2]

1. Master's Program in Pharmacy Management, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta, Indonesia
2. Department of Pharmaceutics, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta, Indonesia

ARTICLE INFO
Submitted : 08-05-2025
Revised : 20-04-2026
Accepted : 05-05-2026
Published : 30-06-2026

Corresponding Author:
Satibi

Corresponding Author Email:
satibi@ugm.ac.id

ABSTRACT

Background: Efficient drug inventory management in hospitals is crucial for ensuring the availability of necessary medications while avoiding excessive costs and storage challenges. In developing countries, pharmaceuticals account for 40–50% of total hospital expenditures, highlighting the importance of inventory control. The Minimum-Maximum Stock Level (MMSL) method is a straightforward approach to managing hospital drug inventory that prevents overstocking and causes reorders to avoid shortages.

Objectives: This study aims to evaluate the impact of the MMSL method on drug inventory control efficiency in hospitals in Indonesia.

Methods: This systematic review was conducted following the PRISMA Statement guidelines. Articles were identified from PubMed, Scopus, Garuda, and Google Scholar databases. Studies conducted in hospitals in Indonesia that evaluated the implementation of the MMSL and reported efficiency indicators such as inventory value, Inventory Turnover Ratio (ITOR), stockout, and dead stock were included. The methodological quality of the selected studies was assessed using the JBI critical appraisal tools.

Results: A total of seven reviewed articles showed that the MMSL method positively influenced the efficiency of drug inventory control in hospitals, as evidenced by reductions in drug inventory values, increases in ITOR, decreases in stockout frequency and value, and a reduction in dead stock. In another study, ITOR decreased at a government hospital, although it remained within the ideal value range.

Conclusion: The MMSL method enhances the efficiency of drug inventory management and can be implemented in hospitals in Indonesia.

Keywords: Dead Stock; Drug Inventory; Inventory Turnover Ratio; Minimum-Maximum Stock Level; Stockout.

INTRODUCTION

Hospital pharmacists play a crucial role in enhancing the quality of healthcare services for the community. Managing pharmaceutical supplies, medical devices, and consumable medical supplies (CMS) is one of the standards of pharmaceutical services in hospitals. It encompasses a series of processes, including selection, drug planning, procurement, receipt, storage, disposal, recall, control, and administration[1]. The overall success of management depends on efficient drug management. This management aims to ensure that drugs are available in the appropriate quantity, type, and time, and used rationally to ensure that the available funds are allocated optimally and sustainably to meet the needs of hospital patients[2].

In many developing countries, hospital drug expenditures can reach 40-50% of the total hospital budget[3]. Although pharmaceutical supply procurement is costly, especially for drugs, pharmaceutical services also constitute a major source of revenue. This is because pharmaceutical supply management contributes approximately 30-50% of the hospital's total annual revenue[4]. Improper and poorly managed drug management in hospitals can lead to excessive inventory, increasing financial burdens through inventory and storage costs.

The risk of expiration is increased when many drugs become dead stock. Conversely, insufficient inventories may result in drug shortages, hindering the hospital's ability to meet patient needs. From a budgeting perspective, precise drug inventory management facilitates the planning of inventory budgets. Therefore, control measures are needed to manage drug inventories efficiently[5].

The goal of drug inventory control is to establish a balance between supply and demand. The success parameters for inventory control can be evaluated through efficiency indicators related to the applied inventory control method. Efficiency indicators include the accuracy of planning, which is assessed by the alignment between planning and actual usage; drug adequacy, which reflects the number of months covered by available stock; overstock, defined as to drug stocks exceeding 18 months' adequacy; dead stock, referring to drug stock that remain unused for three months or more; stockouts, defined as the final stock being zero; and TOR (Turnover Ratio), defined as the rate of capital turnover within a year[6]. Currently, many hospitals have implemented their inventory control methods; however, they still face challenges in achieving effective inventory management. The classic problem in inventory control is balancing inventory arrangements with the associated costs. In making inventory decisions, both the quantity and timing of orders must be carefully considered, taking into account variable costs, including holding or carrying costs, order costs, setup costs, and stockout or shortage costs[6].

The hospital pharmacy unit can use various methods for drug inventory control to ensure an efficient and available supply of medicines. Commonly used approaches include ABC analysis, which classifies drugs based on their consumption value; the Economic Order Quantity (EOQ) method, which determines optimal order quantities by balancing ordering and holding costs; and consumption-based methods, which estimate future needs based on historical usage data[6]. While these methods are effective, they often require complex calculations, continuous data monitoring, or integration with forecasting systems. In this context, the Minimum-Maximum Stock Level (MMSL) method is considered a simple and practical alternative for hospital settings. MMSL is a pharmaceutical inventory control method used for a scheduled procurement system, where fixed ordering intervals are used[7]. With this approach, the maximum stock for each drug item is theoretically defined as sufficient stock to prevent over-procurement. Meanwhile, the minimum stock serves as a reorder point to prevent stockout conditions[8]. Compared to other methods, MMSL offers several practical advantages, particularly in hospital settings with limited resources. It is relatively simple to implement, does not require complex mathematical modeling, and is well aligned with routine procurement systems. Furthermore, the method directly incorporates safety stock and reorder points, making it effective in minimizing both stockout and overstock conditions[6].

However, to the best of our knowledge, no systematic review has specifically examined the effectiveness of the MMSL method in managing drug and consumable medical supply inventories in hospitals. Therefore, this study addresses this gap by providing a comprehensive synthesis of available evidence on MMSL implementation. This review focuses on hospitals in Indonesia, considering high proportion of pharmaceutical expenditures in hospital budgets and the ongoing challenges in inventory management, including stockouts, overstocking, and dead stock[3,4]. Moreover, Indonesia, as a developing country, requires efficient inventory control to optimize limited healthcare resources. Thus, this study aims to provide context-specific evidence to support hospital management and policymakers in improving drug inventory control practices.

This study aims to examine the impact of implementing the MMSL method for drug inventory control, focusing on its efficiency indicators. This study can provide new insights for pharmaceutical logistics managers on more effective and efficient strategies to ensure the timely availability of medicines and consumable medication supplies, meet demand appropriately, and reduce the risk of shortages or overstocking.

METHODS

Study design

This study was a systematic review of the impact of the MMSL (Minimum-Maximum Stock Level) method on drug inventory control efficiency, conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Search strategy

Articles were systematically searched from several databases, including PubMed, Scopus, Garuda, and Google Scholar. The keywords used to search the articles included "drug", "medicine", "inventory", "inventory control", and "minimum-maximum stock level". These terms were combined using Boolean operators as follows: ("drug" OR "medicine") AND ("inventory" OR "inventory control") AND ("minimum-maximum stock level").

Additionally, reference lists of the included studies were manually screened to identify relevant articles. The study selection process was conducted in two stages, including title and abstract screening followed by full-text assessment.

Eligibility criteria

The inclusion criteria were original, open-access articles published between 2014 and 2024, conducted in hospital settings, and evaluating the implementation of the MMSL method for drug inventory control using efficiency indicators. Articles written in both English and Indonesian were included to ensure comprehensive coverage of relevant studies. Articles were excluded if they did not meet the criteria of original studies, were not conducted in hospital settings, or had insufficient data on the outcomes of interest.

Data Extraction

One hundred and twelve articles were identified using keywords. Duplicate articles were removed and screened based on their titles and abstracts. Ninety-eight screened articles were excluded for not meeting the eligibility criteria, such as being non-original, irrelevant to the research topic, or conducted outside hospitals. Subsequently, of the 19 articles that met the criteria, two were closed-access and could not be reviewed. Finally, from 17 full articles that had been reassessed, articles with insufficient data, those not specifically evaluating drug control efficiency indicators, and those with data duplication in other articles were excluded. Ultimately, seven articles met the final inclusion criteria for review.

Data Analysis

The process of identifying relevant literature is illustrated in a detailed flowchart in Figure 1. Data from the selected studies were extracted and analyzed narratively. The extracted data included study characteristics (author, year, and hospital setting), study design, number and type of drugs, intervention details related to the implementation of the MMSL method, and outcome measures such as inventory value, Inventory Turnover Ratio (ITOR), stockout value and frequency, and dead stock value.

The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) critical appraisal tools. The JBI checklist for quasi-experimental studies was used for interventional studies, while the JBI checklist for analytical cross-sectional studies was applied for observational studies.

The extracted data were then compared and synthesized to assess the impact of the MMSL method on the efficiency of drug inventory control across the included studies.

RESULTS AND DISCUSSION

The Quality of Individual Studies

The study was conducted across various hospitals in Indonesia and published on different publication platforms. Variations in publication years were also identified among the included studies, with all research conducted within the past six years (2019–2024). Despite the broader search period, only seven studies met the inclusion criteria. This limited number reflects the review's specific focus on the implementation of the Minimum-Maximum Stock Level (MMSL) method in hospital settings and the requirement that studies report defined efficiency indicators. Furthermore, the application of the MMSL method in hospital settings is relatively recent in Indonesia, with one of the earlier studies conducted by Indarti et al. (2019), which has subsequently been referenced by several later studies[9]. As a result, the number of studies evaluating MMSL remains limited.

A total of seven articles were reviewed, six were quasi-experimental studies without a control group, and their evaluation was conducted using the JBI Checklist for Quasi-Experimental Studies[10]. All included studies demonstrate good reporting quality, with the number of "YES" responses exceeding other responses, as shown in Table I. This indicates that, despite methodological limitations, the included studies generally followed appropriate reporting standards. In addition, the consistency of outcome measures across studies allows for a more reliable synthesis of the effects of MMSL. These articles evaluated the implementation of the MMSL method as the intervention, measuring outcomes such as inventory value, Inventory Turnover Ratio (ITOR) value, stockout value and frequency, and dead stock value, measured before and after the intervention. The study design lacked a control group, which limits the causal strength of the findings. However, the studies used retrospective data as an indirect "control" for comparison with prospective data following the implementation of the MMSL method. While this approach has limitations (e.g., the inability to control external factors), it remains commonly used when a control group is not feasible[11].

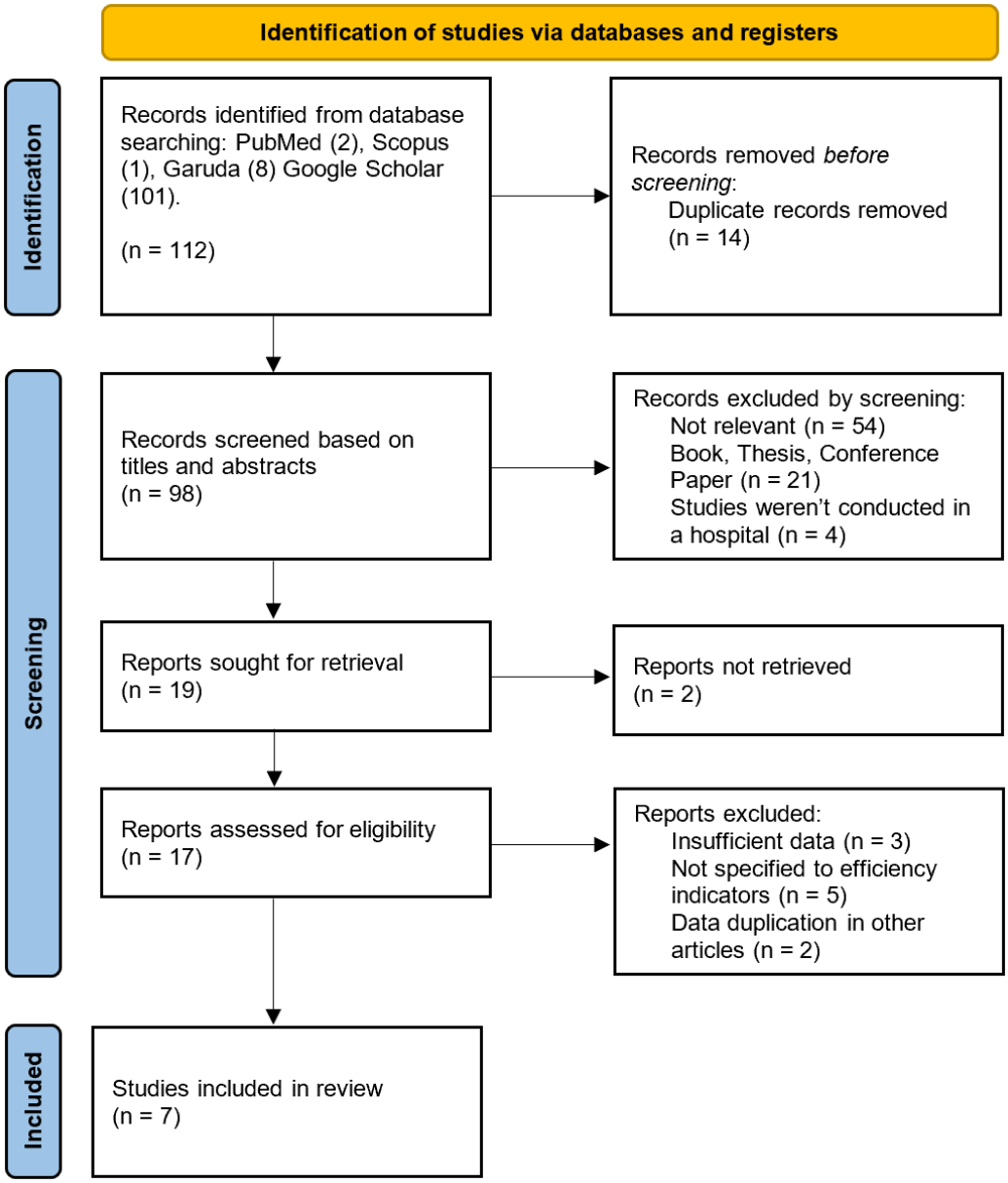

Figure 1. PRISMA Diagram for Retrieved Studies

The reviewed articles provided limited information regarding whether external factors, such as policy changes, procurement regulations, or shifts in management practices, remained constant during the study period. This lack of clarity may influence the interpretation of the observed outcomes, as changes in these external conditions could potentially affect inventory performance independently of the MMSL method. Despite this, all reported outcomes, including inventory value, ITOR, stockout value and frequency, and dead stock value, were measured using relatively consistent procedures across the included studies. Data collection was generally based on hospital pharmacy records and inventory management systems, ensuring comparability of indicators before and after the intervention. Furthermore, the data were analyzed using appropriate statistical methods, including the Wilcoxon Signed Rank Test and McNemar Test, which are nonparametric tests suitable for non-normally distributed data[12]. The use of these statistical approaches strengthens the reliability of the findings by enabling valid comparisons between pre- and post-intervention outcomes, thereby supporting the overall interpretation of MMSL effectiveness in improving drug inventory control. Moreover, the consistency of analytical methods across studies enhances the robustness of the synthesized evidence in this review.

Table I. Quality of Study Using the JBI Critical Appraisal Tool for Quasi-Experimental Studies

Internal Validity	Relevance to Study (Yes/No/Unclear/NA)					
	Sofia et al., 2024	Paramesthi et al., 2024	Agustina et al., 2024	Pranata et al., 2022	Darmawati et al., 2023	Indarti et al., 2019
Bias related to temporal precedence						
Is it clear in the study what the " cause " is and what the "effect" is (i.e., there is no confusion about which variable comes first)?	Yes	Yes	Yes	Yes	Yes	Yes
Bias related to selection and allocation						
Was there a control group?	No	No	No	No	No	No
Bias related to confounding factors						
Were participants included in any similar comparisons?	NA	NA	NA	NA	NA	NA
Bias related to the administration of the intervention/exposure						
Were participants included in any comparison groups receiving similar treatment or care, other than the exposure or intervention of interest?	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
Bias related to the assessment, detection, and measurement of the outcome						
Were there multiple measurements of the outcome, both pre- and post-intervention/exposure?	Yes	Yes	Yes	Yes	Yes	Yes
▪ Inventory Value	Yes	Yes	Yes	Yes	Yes	Yes
▪ Inventory Turnover Ratio	Yes	Yes	NA	Yes	NA	Yes
▪ Stockout Value	Yes	Yes	NA	NA	NA	Yes
▪ Stockout Incidence	NA	Yes	NA	Yes	NA	Yes
▪ Dead Stok Value	Yes	NA	NA	NA	NA	NA
Were the outcomes of participants included in any comparisons measured in the same way?						
▪ Inventory Value	Yes	Yes	Yes	Yes	Yes	Yes
▪ Inventory Turnover Ratio	Yes	Yes	NA	Yes	NA	Yes
▪ Stockout Value	Yes	Yes	NA	NA	NA	Yes
▪ Stockout Incidence	NA	Yes	NA	Yes	NA	Yes
▪ Dead Stok Value	Yes	NA	NA	NA	NA	NA
Were outcomes measured in a reliable way?						
▪ Inventory Value	Yes	Yes	Yes	Yes	Yes	Yes
▪ Inventory Turnover Ratio	Yes	Yes	NA	Yes	NA	Yes
▪ Stockout Value	Yes	Yes	NA	NA	NA	Yes
▪ Stockout Incidence	NA	Yes	NA	Yes	NA	Yes
▪ Dead Stok Value	Yes	NA	NA	NA	NA	NA
Bias related to participant retention						
Was the follow-up complete, and if not, were differences between groups in terms of their follow-up adequately described and analyzed?						
▪ Inventory Value	NA	NA	NA	NA	NA	NA
▪ Inventory Turnover Ratio	NA	NA	NA	NA	NA	NA
▪ Stockout Value	NA	NA	NA	NA	NA	NA
▪ Stockout Incidence	NA	NA	NA	NA	NA	NA
▪ Dead Stok Value	NA	NA	NA	NA	NA	NA

Internal Validity	Relevance to Study (Yes/No/Unclear/NA)					
	Sofia et al., 2024	Paramesthi et al., 2024	Agustina et al., 2024	Pranata et al., 2022	Darmawati et al., 2023	Indarti et al., 2019
Statistical Conclusion Validity						
Was an appropriate statistical analysis used?						
▪ Inventory Value	Yes	Yes	Yes	Yes	Yes	Yes
▪ Inventory Turnover Ratio	Yes	Yes	NA	Yes	NA	Yes
▪ Stockout Value	Yes	Yes	NA	NA	NA	Yes
▪ Stockout Incidence	NA	Yes	NA	Yes	NA	Yes
▪ Dead Stok Value	Yes	NA	NA	NA	NA	NA

The remaining article was an observational analytic study that used antibiotic logistics data collected over one year, without grouping by exposure. This study compared existing data between two inventory management methods, namely the consumption method and the MMSL method, and was evaluated using the JBI Checklist for Cross-Sectional Studies[13]. The assessment found that the study by Wijayanto et al. (2021) was suitable for inclusion in the review, as most checklist items received "YES" responses, as shown in Table II. The article clearly described the inclusion criteria for samples, detailed the research subjects and settings, and provided precise measurements for both methods (consumption and MMSL) using valid indicators, including inventory value, Inventory Turnover Ratio (ITOR), stockout value and frequency, and dead stock value.

Table II. Quality of Study Using the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies

Questions	Relevant to Study Wijayanto et al., (2021)			
	Yes	No	Unclear	NA
1. Were the criteria for inclusion in the sample clearly defined?	✓			
2. Were the study subjects and the setting described in detail?	✓			
3. Was the exposure measured in a valid and reliable way?	✓			
4. Were objective, standard criteria used for measurement of the condition?	✓			
5. Were confounding factors identified?		✓		
6. Were strategies to address confounding factors stated?		✓		
7. Were the outcomes measured in a valid and reliable way?	✓			
8. Was an appropriate statistical analysis used?	✓			

However, the study did not explicitly identify potential confounding factors or describe strategies to control for bias, which may influence the validity of the observed differences between methods. In addition, the absence of exposure grouping limits the ability to attribute observed effects solely to the MMSL method. The Mann-Whitney U test was applied to compare outcomes between the consumption and MMSL methods. This statistical test is appropriate for continuous data that do not follow a normal distribution and supports a valid comparison between independent groups. The use of nonparametric analysis further strengthens the robustness of the findings, particularly for skewed or nonhomogeneous data distributions. Therefore, despite certain methodological limitations, the study provides valuable comparative insights into MMSL's performance relative to conventional inventory control methods.

Details of Selected Studies

The selected studies comprised six articles that used a quasi-experimental design without a control group and used the MMSL (Minimum-Maximum Stock Level) method as the intervention. Additionally, one article was

an analytical observational study comparing the consumption method previously used by the hospitals with the MMSL method, which was intended to be implemented through simulation. Before applying the MMSL method, all reviewed articles conducted retrospective data collection as an initial analysis to categorize drugs into A, B, and C categories. The ABC analysis is an inventory analysis based on Pareto's principle, identifying types of drugs that require the highest cost or budget due to high usage or high prices through categorization[14]. This analysis was used to establish drug criteria, including high-volume, high-cost, and clinically critical drugs, and excluded drug criteria, including category B and C drugs and drugs with unstable supply, as detailed in Table III.

The MMSL (Minimum-Maximum Stock Level) Method

The MMSL method represents a simple and practical inventory control strategy for hospital pharmacy installations[6]. In implementing the MMSL ordering method, data on drug types and lead time (the number of days from the order to the receipt date) are required. This data is then used to calculate the safety stock, minimum stock, and maximum stock levels based on the average consumption. The formulas used for these calculations are as follows[6]:

$$Safety\ Stock = Lead\ Time \times Consumption\ Average$$

$$Minimum\ Stock = (Lead\ Time \times Consumption\ Average) + Safety\ Stock = 2 \times Safety\ Stock$$

$$Maximum\ Stock = Minimum\ Stock + (Procurement\ Period \times Consumption\ Average)$$

In another article, it is explained that determining minimum stock is equivalent to calculating the reorder point (ROP) using the formula[6,15]:

$ROP = (d \times L) + SS$, where d = daily demand; L = waiting time (lead time); SS = safety stock.

The Influence of the MMSL Method on the Efficiency of Drug Inventory Control

Table IV presents data on indicators of efficiency indicators in drug inventory control using the consumption method (pre-intervention) and the MMSL method (post-intervention). The indicators used to assess the method's efficiency include inventory value, the Inventory Turnover Ratio (ITOR), the stockout value and frequency, and the dead stock value[6].

The inventory value is determined by multiplying the remaining drug stock by the unit price of each drug. The comparison of inventory values between methods is based on the average inventory value. Studies by Sofia et al. (2024), Agustina et al. (2024), Darmawati et al. (2021), Indarti et al. (2019), and Wijayanto et al. (2021) demonstrated a significant decrease ($p < 0.05$) in inventory value after implementing the MMSL method compared to the previous consumption method[9,16–19]. Similarly, Pranata et al. (2022) reported a 13.48% reduction in inventory value, although it was not statistically significant[20]. This reduction in inventory value is attributed to adjusting purchasing quantities to align with the maximum stock, making it a critical factor in inventory control to prevent overstocking[9]. However, the findings from Paramesthi et al. (2024) on IVF medications differ from those of other studies. In their research, the inventory value increased following the MMSL intervention. The low inventory value before the intervention was due to frequent stockouts of IVF medications, with 50% of items experiencing stockouts by the end of the observation period. In this case, the low inventory value indicated the hospital pharmacy's inability to meet the high demand for IVF medications. After implementing the MMSL method, the inventory value for IVF medications increased as the hospital sought to reduce stockout events during this period, adhering to the minimum stock formula[21]. Ideally, IVF medications with a high stockout frequency should be excluded from the sample based on the exclusion criteria due to their unstable supply, as their inclusion could introduce bias into the study results. Unlike IVF medications, the CMS sample from the embryology laboratory demonstrated a decrease in inventory value, consistent with other studies. Most studies indicate that the MMSL method positively impacts the efficiency of hospital drug inventory management. Optimal inventory values play a crucial role in reducing storage costs, including expenses for storage space, security measures, logistics management, and the potential risk of expired drugs caused by overstocking, which could lead to financial losses for the hospital[18].

Table III. Characteristics of Selected Studies

Author and Year	Setting	Type of Study	Number of Drugs (n)	Drug Criteria	Duration of Intervention
Sofia et al., 2024	Muhammadiyah Siti Aminah Bumiayu General Hospital, a private hospital in Central Java, Indonesia	Quasi-experimental with the MMSL method as an intervention, without a control group	499	Category A, B, and C drugs with a stable supply	3 months (March-May 2023)
Paramesthi et al., 2024	Type C Specialized Hospital in Semarang, Central Java, Indonesia	Quasi-experimental with the MMSL method as an intervention, without a control group	68	IVF medications and CMS of the embryology laboratory with a stable supply	3 months (January-March 2024)
Agustina et al., 2024	PKU Muhammadiyah Gamping Hospital, a private hospital in Yogyakarta, Indonesia	Quasi-experimental with the MMSL method as an intervention, without a control group	23	Category A antibiotic drugs with stable supply	2 months (April-May 2020)
Pranata et al., 2022	Sentra Medika Sanggau General Hospital, a private hospital in West Kalimantan, Indonesia	Quasi-experimental with the MMSL method as an intervention, without a control group	22	Category A antibiotic drugs with stable supply	3 months (October-December 2021)
Darmawati et al., 2023	PKU Muhammadiyah Gamping Hospital, a private hospital in Yogyakarta, Indonesia	Quasi-experimental with the MMSL method as an intervention, without a control group	49	Category A Pharmaceutical Inventory of Central Surgical Installation	2 months (February-March 2021)
Indarti et al., 2019	Dr. Sardjito General Hospital, a government referral hospital in Yogyakarta, Indonesia	Quasi-experimental with the MMSL method as an intervention, without a control group	35	High-cost, high-volume, and clinically crucial Category A drugs with stable supply	5 months (August-December 2018)
Wijayanto et al., 2021	Aisyiyah Hospital Bojonegoro, a private hospital in East Java, Indonesia	An analytical observational comparing the consumption and MMSL method	17	High-cost, high-volume, and clinically crucial Category A antibiotic drugs with stable supply	Simulation study using 12 months of data (January-December 2020)

CMS = Consumable Medical Supplies; IVF = In Vitro Fertilization; MMSL = Minimum-Maximum Stock Level

Table IV. Efficiency Output of Drug Inventory Control from Selected Studies

Author and Year	Intervention	Inventory Value (IDR)	ITOR	Stockout Value (IDR)	Stockout Incidence	Dead Stock Value (IDR)
Sofia et al., 2024	Before MMSL**	289,756,421	8.74 times	141,841,056	NA	331,892
	After MMSL	184,725,126	13.21 times	122,248,245		185,233
	Statistical test result (p-Value)	0.002*	0.010*	0.027*		0.002*
Paramesthi et al., 2024 (a)**	Before MMSL**	21,514,537	1.89 times	11,656,679	6 times	NA
	After MMSL	49,635,116	1.41 times	7,464,448	2 times	
	Statistical test result (p-Value)	0.043*	0.075	0.917	0.125	
Paramesthi et al., 2024 (b)**	Before MMSL**	117,421,528	0.82 times	8,032,202	12 times	NA
	After MMSL	105,318,804	0.84 times	7,994,754	9 times	
	Statistical test result (p-Value)	0.005*	0.032*	0.600	0.375	
Agustina et al., 2024	Before MMSL**	15,175,340	NA	NA	NA	NA
	After MMSL	11,864,748				
	Statistical test result (p-Value)	0.000*				
Pranata et al., 2022	Before MMSL**	62,497,441	13.73 times	NA	2.87 times	NA
	After MMSL	54,072,358	19.16 times		2.03 times	
	Statistical test result (p-Value)	0.236	0.006*		0.021*	
Darmawati et al., 2023	Before MMSL**	244,588,361	NA	NA	NA	NA
	After MMSL	135,852,139				
	Statistical test result (p-Value)	0.004*				
Indarti et al., 2019	Before MMSL**	5,009,221,204	20.78 times	75,569,317	8 times	NA
	After MMSL	2,871,879,269	8.49 times	46,346,300	2 times	
	Statistical test result (p-Value)	0.007*	0.003*	0.068	0.031*	
Wijayanto et al., 2021	Consumption method	13,460,159	15.02 times	242,894,573	7 times	115,321,292
	MMSL method	503,938	32.40 times	-	-	42,071,519
	Statistical test result (p-Value)	0.000*	0.030*	0.004*	0.004*	0.048*

*Significant at $p < 0.05$ level; **Before MMSL indicates that all pre-intervention methods were consumption-based methods; *** (a) = In vitro fertilization medications; (b) = Consumable medication supplies of the embryology laboratory; IDR = Indonesian Rupiah; ITOR= Inventory Turnover Ratio; MMSL = Minimum-Maximum Stock Level

The efficiency of inventory control is also measured by the value of the Inventory Turnover Ratio (ITOR), calculated using the formula[6]:

$$ITOR = \frac{Cost\ of\ Goods\ Sold}{Average\ Inventory\ Value}$$

Where:

$$Cost\ of\ Goods\ Sold = Usage\ Quantity \times Base\ Price$$

$$Average\ Inventory\ Value = \left(\frac{Beginning\ Inventory + Ending\ Inventory}{2}\right) \times Base\ Price$$

A higher ITOR value indicates more efficient drug inventory management[9]. Among the reviewed studies, four studies reported a significant increase in ITOR values ($p < 0.05$) after implementing the MMSL method[16,19–21]. While the MMSL method led to only a modest change in the ITOR for the embryology laboratory CMS in Paramesthi et al.'s study, the significance of the p-value highlights its potential to optimize inventory procurement for greater efficiency. Hospitals should perform thorough risk analyses and manage inventory strategically to maximize its positive impact on financial performance[21]. Two studies did not measure ITOR values, while one study by Indarti et al. (2019) showed a significant decrease in ITOR ($p < 0.05$)[9]. A lower ITOR value suggests unsold inventory, which can hinder cash flow and impact profitability[8]. The decrease in ITOR observed in Indarti et al.'s study may be attributed to the procurement schedule at Dr. Sardjito General Hospital, a government hospital operating on a fixed three-month (90-day) procurement cycle. This schedule led to the absence of drug procurement activities during the study period (December 2018). Scheduled procurement prevents over-ordering, requires moderate funding, and provides more accurate drug usage forecasting[9]. This aligns with the theory that public sector organizations, such as government hospitals, typically have annual, quarterly, or semi-annual procurement schedules, resulting in lower ITOR values compared to private sector counterparts[22]. Another factor influencing ITOR reductions is the shifting patterns of drug usage and disease trends over specific periods in hospitals[15]. Although the ITOR value in Indarti et al.'s study declined, it remains within the normal range of 8–12, specifically at 8.49. This suggests that the efficiency of drug inventory control was maintained despite the decrease[23].

The efficiency of inventory control is assessed by reductions in stockout value and frequency, as well as decreases in dead stock value. The study by Sofia et al. (2024) reported a significant decrease in stockout value following the implementation of the MMSL method ($p < 0.05$)[16]. Similarly, Paramesthi et al. (2024) observed a decrease in stockout value and frequency for IVF medications and the CMS of the embryology laboratory, although these changes were not statistically significant[21]. Three other studies demonstrated significant decreases in stockout value and frequency ($p < 0.05$), indicating the positive impact of the MMSL method on the efficiency of drug inventory control[9,19,20]. Stockout frequencies often occur when drug procurement exceeds planned requirements, with minimum and maximum stock levels not clearly defined[24]. This finding aligns with Mellen et al. (2013), who noted that stockout incidents are also caused by inadequate procurement planning, floor stock, and insufficient staff for inventory activities. The financial losses hospitals incur due to stockouts are accounted for as the losses of opportunity costs[25]. However, stockout value does not significantly affect hospital revenue or economic losses as long as the stockout drugs can be substituted with other branded alternatives[9]. Nevertheless, hospitals should strive to minimize stockout rates and occurrences to ensure patients consistently have access to the medications they need. This supports continuity of care and enhances patient satisfaction with healthcare services. The MMSL method effectively reduces stockout value and frequency, as supported by Dewi et al. (2019). In their research, the MMSL method resulted in a smaller opportunity loss due to drug shortages (IDR 41,318,057) than the consumption method (IDR 55,164,308)[26]. These findings underscore the MMSL method's role in improving inventory control efficiency and reducing the adverse impact of drug shortages.

Among the seven studies that were reviewed as part of this study, only two specifically assessed and quantified the value of dead stock. Sofia et al. (2024) documented a significant decrease in the value of dead stock, from IDR 331,892 to IDR 185,233, following the implementation of the MMSL method intervention. Similarly, Wijayanto et al. (2021) found that the value of dead stock under the MMSL method was IDR 42,071,519, lower than the IDR 115,321,292 observed with the consumption method. Both studies demonstrated that the

MMSL method positively impacts drug inventory control by significantly reducing dead stock value ($p < 0.05$) compared to the consumption method[16,19]. Deadstock refers to drugs that remain unused for over three months. Factors contributing to dead stock include changes in prescribing patterns, leading to the accumulation of unused drugs in inventory. The associated losses include prolonged storage, resulting in expired drugs and poor cash flow[6]. Better coordination between prescribing doctors and pharmacy departments is essential to prevent dead stock, particularly regarding changes in prescribing patterns. Optimizing the combination of morbidity- and consumption-based drug planning methods can enhance the accuracy of pharmaceutical inventory planning[27]. The MMSL method helps reduce dead stock value by considering the minimum and maximum stock levels for drugs in inventory, thereby reducing potential hospital losses from stagnant drugs. This finding is supported by Dewi et al. (2019), who found that the MMSL method yielded the lowest opportunity loss from stagnant drugs compared with the consumption method and the Economic Order Quantity (EOQ) method. Specifically, the opportunity loss from stagnant drugs under the MMSL method was IDR 25,510,891, compared to IDR 473,733,147 for the consumption method and IDR 31,301,702 for the EOQ method[26].

Our review found that, overall, the MMSL method positively influences the efficiency of drug inventory control in hospitals. This is evidenced by reductions in drug inventory levels, increases in ITOR, decreases in stockout frequency and value, and a reduction in dead stock after implementing the MMSL method, compared to the consumption method, which is still commonly used in hospitals today. One study showed that the MMSL method increased the inventory value of IVF medications, due to high bias in the sample, specifically medications with unstable supply. However, the MMSL method positively impacted the significant reduction in stockout incidents in that study[21]. In another study, there was a decrease in ITOR in a government hospital, although it remained within the ideal value range[9].

Various inventory control methods have been widely applied in hospital pharmacy settings, including ABC analysis, EOQ, and consumption-based methods. ABC analysis is useful for prioritizing high-cost and high-impact items; however, it does not determine optimal stock levels or reorder points. EOQ provides a quantitative approach to optimize order quantities by minimizing total inventory costs, but it requires stable demand assumptions and more complex calculations. Meanwhile, consumption-based methods are simple and commonly used in hospitals, yet they rely heavily on historical usage data and may not adequately account for fluctuations in demand and lead time[28,29]. Compared to these methods, MMSL offers several practical advantages, particularly in hospital settings. The method integrates minimum and maximum stock levels with fixed ordering intervals, enabling better inventory control without requiring complex mathematical modeling. This makes MMSL more feasible in healthcare facilities with limited resources and information systems. Furthermore, MMSL directly incorporates safety stock and reorder points, contributing to the reduction of both stockout and overstock conditions observed across the included studies[22].

From a practical perspective, these findings have important implications for hospital pharmacy management, particularly in developing countries such as Indonesia. The consistent improvements in efficiency indicators suggest that MMSL can be adopted as a standardized inventory control method in hospital settings, especially in facilities that still rely on conventional or consumption-based approaches. Its simplicity enables easier integration into routine procurement systems and supports regular monitoring of stock levels without requiring advanced forecasting tools[22]. Therefore, the adoption of MMSL may help hospital managers optimize pharmaceutical budgets, reduce wastage due to overstock, and ensure the continuous availability of essential medicines. Ultimately, this contributes to improving the quality of healthcare services and to more efficient resource utilization within hospital systems[15].

This review has several limitations that should be acknowledged. First, the number of included studies was relatively limited, reflecting the relatively recent adoption of the MMSL method in hospital settings, particularly in Indonesia. Second, most of the included studies employed quasi-experimental designs without control groups, which may limit the strength of causal inference and restrict the generalizability of the findings. Third, variations in study settings, sample characteristics, and intervention duration may affect the comparability of results across studies. In addition, limited reporting on external factors, such as policy changes, supply chain conditions, and management practices, may influence the interpretation of the findings.

Nevertheless, this review provides valuable insights into the implementation of the MMSL method and its potential to improve drug inventory management efficiency. From a practical perspective, MMSL can be integrated into the Hospital Management Information System (HMIS) to support hospital pharmacists in inventory control, thereby enhancing operational efficiency and optimizing resource utilization within hospital settings[9,19,26].

Future research is recommended to address these limitations by conducting more rigorous studies, such as controlled or randomized studies, and involving multiple hospital settings to improve the generalizability of the findings. Further studies could also explore integrating MMSL with digital inventory systems or hospital information systems to enhance real-time monitoring and decision-making. In addition, evaluating the cost-effectiveness and long-term sustainability of MMSL implementation would provide more comprehensive evidence for its adoption in hospital pharmacy practice.

CONCLUSION

Our review concludes that the MMSL method positively impacts drug inventory control in hospitals, as demonstrated by reductions in drug inventory value, improvements in ITOR, reductions in stockout value and frequency, and decreases in dead stock value. This method also helps increase the value of medications with unstable supply and reduce ITOR in government hospitals, while still maintaining values within the expected normal range. The MMSL method can be implemented by hospitals to enhance drug inventory efficiency, thereby preventing both stockouts and overstocking.

ACKNOWLEDGEMENT

None.

REFERENCES

1. Kementerian Kesehatan Republik Indonesia. *Peraturan Menteri Kesehatan Republik Indonesia Nomor 72 Tahun 2016 Tentang Standar Pelayanan Kefarmasian Di Rumah Sakit*. 2016.
2. Kumalasari A, Rochmah TN. Pengendalian Persediaan Obat Generik dengan Metode MMSL (Minimum-Maximum Stock Level) di Unit Farmasi Rumah Sakit Islam Surabaya. *Jurnal Manajemen Kesehatan STIKES Yayasan RS Dr Soetomo*. 2016;2(2):143-152. doi:10.29241/jmk.v2i2.60
3. Prabowo P, Satibi, Pamudji W G. Analisis Faktor-faktor yang Mempengaruhi Ketersediaan Obat di Era JKN pada Rumah Sakit Umum Daerah. *Jurnal Manajemen dan Pelayanan Farmasi*. 2016;6(3):213-218. doi:10.22146/jmpf.348
4. Suciati S, Adisasmito WBB. Analisis Perencanaan Obat Berdasarkan ABC Indeks Kritis di Instalasi Farmasi. *Jurnal Manajemen Pelayanan Kesehatan*. 2006;9(1):19-26. doi:10.22146/jmpk.v9i01.2729
5. Tie A, Panjaitan F, Manullang RR. Analisis Perencanaan dan Pengendalian Persediaan Obat BPJS Fast Moving Berdasarkan Metode Konsumsi Dikombinasikan dengan Analisis ABC dan Reorder Point. *Jurnal Akuntansi Bisnis dan Keuangan*. 2019;6(2):1-8. https://e-jurnal.stie-ibek.ac.id/index.php/JABK/article/view/80
6. Satibi. *Manajemen Obat Di Rumah Sakit*. Gadjah Mada University Press; 2017.
7. Quick JD, [et al.]. *Managing Drug Supply: The Selection, Procurement, Distribution, and Use of Pharmaceuticals*. 2nd ed. Kumarian Press; 1997.
8. Dampung VM, Maidin A, Mardiana Y. R. Penerapan Metode Konsumsi dengan Peramalan EOQ, MMSL, dan Analisis ABC-VEN dalam Manajemen Perbekalan Farmasi di Rumah Sakit Pelamonia Makassar. *Media Farmasi*. 2018;16(1):97-104. doi:10.32382/mf.v14i1.144
9. Indarti TR, Satibi, Yuniarti E. Pengendalian Persediaan Obat dengan Minimum-Maximum Stock Level di Instalasi Farmasi RSUP Dr. Sardjito Yogyakarta. *Jurnal Manajemen dan Pelayanan Farmasi*. 2019;9(3):192-202. doi:10.22146/jmpf.45295
10. JBI. *JBI Critical Appraisal Tool: JBI Checklist For Quasi-Experimental Studies 2023*. 2023.
11. Hastjarjo TD. Rancangan Eksperimen-Kuasi. *Buletin Psikologi*. 2019;27(2):187-203. doi:10.22146/buletinpsikologi.38619
12. Heryana A. *Uji McNemar Dan Uji Wilcoxon (Uji Hipotesa Non-Parametrik Dua Sampel Berpasangan)*. 2020. doi:10.13140/RG.2.2.17682.48325
13. JBI. *Checklist for Analytical Cross Sectional Studies: Critical Appraisal Tools for Use in JBI Systematic Reviews*. 2020.
14. Fatimah SAG, Siregar CA. Pengendalian Persediaan Obat dengan Metode ABC, VEN dan EOQ di Apotek Medina Lhokseumawe. *Industrial Engineering Journal*. 2022;11(1):1-7. doi:10.53912/iej.v11i1.722
15. Heizer J, Render B, Munson C. *Operations Management Sustainability and Supply Chain Management*. 13th ed. Pearson Education Inc.; 2020.

16. Sofia A, Peranginangin JM, Herdwiani W. Analysis of Efficient Drug Supply Control at Muhammadiyah Siti Aminah Bumiayu Hospital Using the MMSL Method (Minimum-Maximum Stock Level) Period March – May 2023. *Formosa Journal of Science and Technology*. 2024;3(8):1783-1796. doi:10.55927/fjst.v3i8.10886
17. Agustina P, Utami AW, Suprapti S. Pengaruh Penerapan Metode Minimum-Maximum Stock Level (MMSL) pada Obat Generik Paretto A di Instalasi Farmasi Rawat Jalan PKU Muhammadiyah Gamping, Sleman, D.I. Yogyakarta. *Jurnal Ilmu Keperawatan*. 2024;13(1):78-85. doi:10.35328/keperawatan.v13i1.2625
18. Darmawati M, Saputra YD, Dhirisma F. Pengendalian Obat dan Alat Kesehatan Pareto A dengan Metode MMSL (Minimum-Maximum Stock Level) di Instalasi Bedah RS PKU Muhammadiyah Gamping Periode Februari-Maret 2021. *Indonesian Journal of Pharmaceutical Sciences and Clinical Research*. 2023;1(1):1-14. Accessed December 17, 2024. https://journal.upy.ac.id/index.php/ijpscr/article/view/3783
19. Wijayanto PA, Sriatmi A, Jati SP. Comparative Analysis of Consumption Methods and Minimum Maximum Stock Level (MMSL) in Improving the Efficiency and Effectiveness Inventory of Antibiotic Drugs at Aisyiyah Hospital Bojonegoro. *Jurnal Aisyah: Jurnal Ilmu Kesehatan*. 2021;6(4):623-630. doi:10.30604/jika.v6i4.812
20. Pranata Y, Banun A, Hilmy MR. Pengendalian Antibiotik Berdasar Metode Konsumsi ABC dengan Penerapan Minimum-Maximum Stock Level terhadap Efisiensi Persediaan Farmasi Rumah Sakit. *Jurnal Health Sains*. 2022;3(9):1429-1442. doi:10.47007/.v6i01.5807
21. Paramesthi P, Jati SP, Suryoputro A. Hospital Pharmaceutical Inventory Control in In-Vitro Fertilization Services Using Minimum-Maximum Stock Level. *Jurnal Medicoeticolegal dan Manajemen Rumah Sakit*. 2024;13(2):181-198. doi:10.18196/jmmr.v13i2.421
22. Quick JD, [et al.]. *Managing Access to Medicines and Health Technologies*. Management Sciences for Health, Inc.; 2012.
23. Doso T, Sunarni T, Herdwiani W. Analisa Pengendalian Persediaan dengan Metode EOQ, JIT dan MMSL di Instalasi Farmasi Rumah Sakit XXX Kota Mojokerto. *Journal of Pharmacy Science and Practice*. 2020;7(2):81-85. doi:10.33508/jfst.v7i2.2793
24. Febreani SH, Chalidyanto D. Pengelolaan Sediaan Obat pada Logistik Farmasi Rumah Sakit Umum Tipe B di Jawa Timur. *Jurnal Administrasi Kesehatan Indonesia*. 2016;4(2):136-145. doi:10.20473/jaki.v4i2.2016.136-145
25. Mellen RC, Pugjiraharjo WJ. Faktor Penyebab dan Kerugian Akibat Stockout dan Stagnant Obat di Unit Logistik RSU Haji Surabaya. *Jurnal Administrasi Kesehatan Indonesia*. 2013;1(1):99-107. https://journal.unair.ac.id/download-fullpapers-10.%20Renie%20Cuyno_JAKIv1n1.pdf
26. Dewi EK, Dahlui M, Chalidyanto D, Rochmah TN. Achieving Cost-Efficient Management of Drug Supply via Economic Order Quantity and Minimum-Maximum Stock Level. *Expert Rev Pharmacoecon Outcomes Res*. 2019;20(3):289-294. doi:10.1080/14737167.2019.1633308
27. Ayuningtyas A, Nurcahyani D, Eladisa G. L. Penyebab Obat Kedaluarsa, Obat Rusak dan Dead Stock (Stok Mati) di Gudang Perbekalan Farmasi Rumah Sakit X Surabaya. *Jurnal Riset Kefarmasian Indonesia*. 2023;5(1):194-203. doi:10.33759/jrki.v5i1.353
28. Jacobs FR, Chase RB. *Operations and Supply Chain Management*. 15th ed. McGraw-Hill Education; 2018.
29. Silver EA, Pyke DF, Thomas DJ. *Inventory and Production Management in Supply Chains*. 4th ed. Taylor & Francis Group; 2017.