Eduvest – Journal of Universal Studies
Volume 4 Number 11, November, 2024
p- ISSN 2775-3735- e-ISSN 2775-3727

FACTORS AFFECTING THE EFFICIENCY AND EFFECTIVENESS OF PHARMACEUTICAL INVENTORY CONTROL OF IVF SERVICES USING THE MINIMUM-MAXIMUM STOCK LEVEL (MMSL) METHOD

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ABSTRACT

Good control of the supply of drugs and consumables (BMHP) by Hospital Pharmaceutical Installations (IFRS) can avoid shortages or overstocks in pharmaceutical warehouses. The Type C "X" Special Hospital in Semarang City experienced a stockout of IVF drugs and embryo laboratory BMHP which resulted in delays in medical procedures and a decrease in the quality of service. The purpose of this study is to determine the factors that affect the efficiency and effectiveness of pharmaceutical preparations using the MMSL method. This study is a quasi-experimental non-equivalent without control group, samples were taken purposively using retrospective data from October – December 2023 with a stable supply and the research was applied prospectively from January – March 2024. Twelve types of IVF drugs and 56 types of BMHP embryo laboratories were used as research samples. The statistical test used cross-tabulation between efficiency variables (inventory value, inventory turnover ratio [ITOR], stockout value) and effectiveness (number of stockout events). The test results showed that the lower the price of IVF drugs and BMHP in embryo laboratories led to lower inventory values. The more expensive the BMHP price of embryo laboratories results in higher ITOR. The faster the lead time supplier BMHP embryo laboratory, the smaller the stockout will occur. The larger the Smin, Smax, and BMHP safety stock of the embryo laboratory, the lower the incidence of stockout. This study provides an insight into the factors that support the application of MMSL to inventory control in IFRS "X".

KEYWORDS *Pharmaceutical management, Hospital management, Inventory control, IVF, MMSL*

How to cite: Prasasya Parameshthi et al. (2024). Factors Affecting The Efficiency And Effectiveness Of Pharmaceutical Inventory Control Of Ivf Services Using The Minimum-Maximum Stock Level (MMSL) Method. Journal Eduvest. *4*(11): 10332-10342
E-ISSN: 2775-3727

INTRODUCTION

Hospital pharmacy has a very important role in the aspects of management and service and is interrelated in the integrated system of services in hospitals. The main task of the Hospital Pharmacy Installation (IFRS) is management starting from planning, procurement, storage, preparation, compounding, direct service to patients to controlling all health preparations circulating and used in the hospital both for inpatient, outpatient, and for all units including hospital polyclinics. In relation to such management, IFRS must provide optimal drug therapy for all patients and ensure the highest quality and most beneficial services at minimal cost (Siregar & Amalia, 2004).

Determining the need for pharmaceutical preparations, medical devices and medical consumables is a serious challenge that must be faced by pharmaceutical personnel in hospitals, because the problem of vacancy or excess can occur. With the coordination and planning process for the procurement of pharmaceutical preparations, medical devices and consumable medical materials (BMHP) in an integrated manner, it is hoped that the planned pharmaceutical preparations, medical devices and consumable medical materials can be of the right type, in the right quantity, on time and available when needed.

Control of pharmaceutical preparations including distribution is the responsibility of IFRS. IFRS is responsible for developing a broad and well-coordinated pharmaceutical service, to meet the needs of various departments/units throughout the hospital for the benefit of better patient service. Therefore, adequate control guidelines are mandatory to be developed and implemented (Ali, 2011).

Type C "X" Special Hospital in Semarang City is a private hospital that pioneered IVF services since 2021. Due to the unstable number of patients handled at the IVF Installation and the lack of implementation of the inventory control method at IFRS, there was a stockout of IVF drugs and BMHP in embryo laboratories in early 2023, resulting in delays in medical treatment and reduced service quality to patients. Previous research has found that the Minimum-Maximum Stock Level (MMSL) method is a method that can significantly improve the efficiency and effectiveness of controlling the supply of IVF and embryo laboratory BMHP (Martinez Carreño et al., 2021). This study aims to analyze the factors affecting the efficiency and effectiveness of pharmaceutical inventory control of IVF services using the MMSL method in Hospital "X".

RESEARCH METHODS

The design of this study is a quasi-experimental with a non-equivalent without control group design by applying the method studied, namely MMSL. The research samples are all IVF drugs and embryo laboratory BMHP with a stable supply in October – December 2023. The research was conducted prospectively in January – March 2024. The research sample is in the form of secondary data according to the Hospital Information System (HIS) RS "X". The variables used were efficiency assessed by a decrease in inventory value, a decrease in inventory turn over ratio (ITOR), and stockout value, as well as effectiveness assessed by a decrease in the number of stockout events. This study analyzed the relationship between variables in IVF drugs and embryo

laboratory BMHP using a cross-tabulation test. The formula used to calculate MMSL is as follows:

$$Consumption\ average\ = \frac{Total\ consumption}{Procurement\ period}$$

$$Safety\ stock = Lead\ time\ \times Consumption\ average$$

$$Minimum\ stock = 2\ \times Safety\ stock$$

$$= (Lead\ time\ \times Average\ Consumption) + Safety\ stock$$

$$Maximum\ stock = Minimum\ stock + (Procurement\ period \times Consumption\ average)$$

$$Cost\ of\ goods\ sold = Total\ consumption\ \times Cost\ per\ unit$$

$$Inventory\ turnover\ ratio = \frac{Cost\ of\ goods\ sold}{Average\ inventory\ value}$$

$$Inventory\ Value = \frac{(Initial\ inventory\ value + Final\ inventory\ value)}{2} \times Cost\ per\ unit$$

RESULT AND DISCUSSION

Calculation of Safety Stock, Minimum Stock, and Maximum Stock

The calculation of safety stock, minimum stock, and maximum stock of IVF drugs and BMHP embryo laboratories are presented in Tables 1a and 1b.

Table 1a. Calculation of safety stock, minimum stock, and maximum stock of IVF drugs

No	Drug Name	Units (per Unit)	*Lead Time* (Days)	*Consumption Average* (Unit)	*Safety Stock* (Unit)	*Minimum Stock* (Unit)	*Procurement Period* (Days)	*Maximum Stock* (Unit)
			x	**and**	**xy**	**2xy**	**xi**	**2xy+(xi*y)**
1	Gonal-f inj 75 IU	vial	8	0,50	4	8	90	53
2	Gonal-f inj 150 IU	vial	8	0,23	1,84	3,68	90	24,38
3	Gonal-f inj 300 IU	vial	8	0,93	7,44	14,88	90	98,58
4	Pergoveris inj 150/75 IU	vial	7	1,20	8,40	16,80	90	124,80
5	Menopur 75 IU	vial	15	0,01	0,15	0,30	90	1,20
6	Rekovelle inj 12 mcg/0.36 mL prefilled syringe	vial	20	0,03	0,60	0,42	90	3,12
7	Rekovelle inj 36 mcg/1.08 mL prefilled syringe	vial	20	0,07	1,40	0,98	90	7,28
8	Rekovelle inj 72 mcg/2.16 mL prefilled syringe	vial	20	0,03	0,60	0,42	90	3,12
9	Ovidrel inj 250 mcg/0.5 mL prefilled syringe	vial	10	0,73	7,30	14,60	90	80,30
10	Cetrotide inj 0.25 mg	vial	12	0,07	0.84	1,68	90	7,98
11	Saizen inj 3.33 mg	vial	21	0,01	0,21	0,42	90	1,32
12	Wounds table 50 mg	tablet	4	7,70	30,8	61,6	90	754,60

Table 1b. Calculation of safety stock, minimum stock, and maximum stock of embryo laboratory BMHP

No	BMHP Name	Units (per Unit)	*Lead Time* (Days)	*Consumption Average* (Unit)	*Safety Stock* (Unit)	*Minimum Stock* (Unit)	*Procurement Period* (Days)	*Maximum Stock* (Unit)
			x	**and**	**xy**	**2xy**	**xi**	**2xy+(xi*y)**
1	Blade	fruit	1	0,01	0,01	0,02	90	1,02
2	BRAND Pasteur Pipettes	fruit	3	0,33	1,00	2,00	90	32,00
3	Sterican Heparin, Tuberculin	fruit	3	0,23	0,70	1,40	90	22,40
4	Cover glass	fruit	1	0,03	0,03	0,07	90	3,07
5	CryoCane alumunium canes	fruit	9	0,01	0,10	0,20	90	1,20
6	7X cleaning solution	braid	9	0,03	0,30	0,60	90	3,60
7	Terumo Needle no. 21	fruit	1	0,07	0,07	0,13	90	6,13
8	Terumo Syringe 1 cc tuberculin	fruit	1	0,03	0,03	0,07	90	3,07
9	Falcon cell strainer	fruit	4	0,01	0,04	0,09	90	1,09
10	Falcon container	fruit	4	0,07	0,27	0,53	90	6,53
11	Falcon center well organ culture dish	fruit	4	0,80	3,20	6,40	90	78,40
12	Falcon cell culture flask 50 mL	fruit	4	0,03	0,13	0,27	90	3,27
13	Falcon serological pipets 10 mL	fruit	4	0,87	3,47	6,93	90	84,93
14	Falcon serological pipets 1 mL Pcs	fruit	4	0,77	3,07	6,13	90	75,13
15	Falcon transfer pipette 3 mL	fruit	4	0,23	0,93	1,87	90	22,87
16	Falcon test tube 14mL	fruit	4	0,40	1,60	3,20	90	39,20
17	Falcon test tube 5mL	fruit	4	1,23	4,93	9,87	90	120,87
18	Flat Cassette	fruit	9	0,03	0,30	0,60	90	3,60
19	Guardia access embryo transfer catheter	fruit	10	0,23	2,33	4,67	90	25,67
20	Inviclot inj 5.000 IU/mL, 5 mL	vial	2	0,10	0,20	0,40	90	9,40
21	The Name of the Lemak	then	1	0,01	0,01	0,02	90	1,02
22	Kitazato cryotop green	fruit	16	0,03	0,53	1,07	90	4,07
23	Kitazato cryotop yellow	fruit	16	0,03	0,53	1,07	90	4,07
24	Kitazato cryotop red	fruit	16	0,07	1,07	2,13	90	8,13
25	Kitazato sperm freeze	kit	16	0,01	0,18	0,36	90	1,36
26	Kitazato thawing kit	kit	16	0,03	0,53	1,07	90	4,07
27	Kitazato vitrification kit	fruit	16	0,03	0,53	1,07	90	4,07

28	3M Micropore surgical tape	fruit	1	0,03	0,03	0,07	90	3,07
29	Nunc conical centrifuge tube 15 mL	fruit	8	0,10	0,80	1,60	90	10,60
30	Nunc cryogenic tube 1,8mL	fruit	8	0,37	2,93	5,87	90	38,87
31	Nunc petri dish	fruit	8	0,80	6,40	12,80	90	84,80
32	Nunc IVF ICSI dish	fruit	8	0,10	0,80	1,60	90	10,60
33	Nunc 4-well dishes for IVF	fruit	8	0,07	0,53	1,07	90	7,07
34	Nunc OPU	fruit	8	0,07	0,53	1,07	90	7,07
35	Object glass	fruit	1	0,20	0,20	0,40	90	18,40
36	Oosafe hood and incubator disinfectant	fruit	15	0,03	0,50	1,00	90	4,00
37	Oosafe filter	fruit	15	0,01	0,17	0,33	90	1,33
38	Oosafe surface and floor disinfectant	fruit	15	0,01	0,17	0,33	90	1,33
39	ORIGIO flushing medium	bottle	11	0,03	0,37	0,73	90	3,73
40	ORIGIO hyaluronidase	bottle	11	0,10	1,10	2,20	90	11,20
41	ORIGIO liquid paraffin	bottle	11	3,07	33,73	67,47	90	343,47
42	ORIGIO universal IVF medium	bottle	11	0,30	3,30	6,60	90	33,60
43	ORIGIIO UTM	bottle	11	0,20	2,20	4,40	90	22,40
44	ORIGIO SAGE 1-Step	bottle	11	0,57	6,23	12,47	90	63,47
45	Parafilm	fruit	3	0,01	0,03	0,07	90	1,07
46	Cook precision holding pipette	fruit	7	0,03	0,23	0,47	90	3,47
47	ORIGIO micropipettes	fruit	11	0,01	0,12	0,24	90	1,24
48	Cook precision micro-injection pipette	fruit	7	0,10	0,70	1,40	90	10,40
49	STRIPPER tip 150	fruit	8	0,27	2,13	4,27	90	28,27
50	STRIPPER tip 270	fruit	8	0,10	0,80	1,60	90	10,60
51	Eppendorf tip 2-200 µL	fruit	7	1,53	10,73	21,47	90	159,47
52	Eppendorf tip 0,1 - 10 µL	fruit	7	0,01	0,08	0,16	90	1,16
53	Vitrolife SpermGrad	bottle	10	0,53	5,33	10,67	90	58,67
54	Vitrolife ICSI	fruit	10	0,03	0,33	0,67	90	3,67
55	Vitrolife SpermRinse	bottle	10	1,43	14,33	28,67	90	157,67
56	IUI catheter	fruit	11	0,40	4,40	8,80	90	44,80

Results of cross-tabulation of inventory control using the Minimum-Maximum Stock Level method.

Table 2a. Cross-tabulation between price and IVF supply value after MMSL intervention

		Inventory Value After Intervention		
		≤ Rp 1.179.840,00	> Rp 1.179.840,00	Total
Price	≤ Rp 67.641,67	17	11	28
	> Rp 67.641,67	11	17	28
	Total	28	28	56

Table 2a shows the cross-tabulation between the median price of IVF drugs (Rp 2,176,410.50) and the median inventory value after the intervention (Rp 4,591,138.00). The table shows that the price of IVF drugs has an impact on the value of supplies after the intervention. The lower the price of IVF drugs, the smaller the value of the inventory at the end of the procurement period, and vice versa. It is the same with Table 2b which shows the cross-tabulation between the median price of embryonic laboratory BMHP (Rp 67,641.67) and the median value of inventory after intervention (Rp 1,179,840.00). The table shows that the price of embryo laboratory BMHP has an impact on the value of inventory after the intervention. The lower the price of embryo laboratory BMHP, the lower the value of the inventory after the procurement period, and vice versa. Thus, it can be concluded that the lower price of IVF drugs and laboratory BMHP will be more beneficial to hospitals because it will cause a lower inventory value at the end of the procurement period. This can be an input for hospitals to further increase the sales or use of IVF drugs and BMHP embryo laboratories which have cheaper prices. By selling more items that have low prices, it will reduce the value of inventory at the end of the procurement period, thereby circumventing the liquidity of hospital cash so that it continues to run smoothly. The value of pharmaceutical supplies should be able to help determine the value of the unsold merchandise stored (Sukasih et al., 2020). The value of inventory must also take into account other factors such as tax costs, transportation costs, storage costs, devaluation costs of pharmaceutical preparations, and the cost of destroying unsold goods.

Table 3a. Cross-tabulation between price and ITOR of IVF after MMSL intervention

		ITOR After Intervention		
		≤ 1,655 times/procurement period	> 1,655 times/procurement period	Total
Price	≤ Rp 2.176.410,50	3	3	6
	> Rp 2.176.410,50	3	3	6
	Total	6	6	12

Table 3b. Results of cross-tabulation between price and ITOR BMHP embryo laboratory after intervention

		ITOR After Intervention		
		≤ 0.55 times/procurement period	> 0.55 times/procurement period	Total
Price	≤ Rp 67.641,67	21	7	28
	> Rp 67.641,67	7	21	28
Total		28	28	56

Table 3a shows the cross-tabulation between the median IVF drug price (Rp 2,176,410.50) and the median ITOR after MMSL intervention (1,655 times/procurement period). The table shows that the price of IVF drugs has no impact on ITOR after the intervention. In contrast to Table 3b which shows the cross-tabulation between the median price of embryonic laboratory BMHP (Rp 67,641.67) and the median ITOR after the intervention (0.55 times/procurement period). The table shows that the price of embryonic laboratory BMHP has an impact on ITOR after the intervention. The lower the price of embryo laboratory BMHP, the lower the ITOR after the procurement period, and vice versa. Thus, it can be concluded that the higher the price of embryonic laboratory BMHP, the more profitable it will be for hospitals because it causes a higher ITOR at the end of the procurement period. This can be an input for hospitals to further increase the sales or use of embryo laboratory BMHP which has a higher price. By selling more items that have a high price, it will increase ITOR at the end of the procurement period, thus ensuring a smooth turnover of capital in pharmaceutical installations.

The procurement period set by the Head of IFRS "X", i.e. scheduled purchasing every 30 days, affects the results of the ITOR value. This scheduled order prevents overbooking, the funds provided are not too large and the estimated use of drugs is more precise. The ITOR standard for hospitals is 8 – 12 times per year. A low ITOR can be interpreted as too much stock in pharmaceutical warehouses. [9]

Table 4a. Cross-tabulation between supplier lead time and the number of IVF stockout events after MMSL intervention

		Number of Stockout Incidents After Intervention		
		No *Stockout*	Stockout Occurs	Total
Supplier Lead Time	≤ 10 days	5	1	6
	> 10 days	5	1	6
Total		10	2	12

Table 4b. Results of cross-tabulation between *supplier lead time* and the number of *occurrences of embryonic* laboratory BMHP stockouts after MMSL intervention

		Number of Stockout Incidents After Intervention		
		No *Stockout*	Stockout Occurs	Total
Supplier Lead Time	≤ 8 days	29	3	32
	> 8 days	18	6	24
Total		47	9	56

Table 5a. Cross-tabulation between Smin and the number of IVF *stockout* events after MMSL intervention

		Number of Stockout Incidents After Intervention		
		No *Stockout*	Stockout Occurs	Total
Smin	≤ 2.68	5	1	6
	> 2.68	5	1	6
Total		10	2	12

Table 5b. Results of cross-tabulation between Smin and the number of occurrences of *embryonic* laboratory BMHP stockouts after MMSL intervention

		Number of Stockout Incidents After Intervention		
		No *Stockout*	Stockout Occurs	Total
Smin	≤ 1.07	22	8	30
	> 1.07	25	1	26
Total		47	9	56

Table 6a. Cross-tabulation between Smax and the number of IVF *stockout* events after MMSL intervention

		Number of Stockout Incidents After Intervention		
		No *Stockout*	Stockout Occurs	Total
Smax	≤ 16.18	5	1	6
	> 16.18	5	1	6
Total		10	2	12

Table 6b. Results of cross-tabulation between Smax and the number of occurrences of *stockout* of embryonic laboratory BMHP after MMSL intervention

		Number of Stockout Incidents After Intervention		
		No *Stockout*	Stockout Occurs	Total
Smax	≤ 7.60	21	7	28
	> 7,60	26	2	28

Total	47	9	56

Table 7a. Cross-tabulation between *safety stock* and the number of IVF *stockout* events after MMSL intervention

		Number of Stockout Incidents After Intervention		
		No *Stockout*	Stockout Occurs	Total
Safety	≤ 1.84	5	1	6
Stock	> 1.84	5	1	6
Total		10	2	12

Table 7b. Results of cross-tabulation between *safety stock* and the number of occurrences *of stockout* of embryonic laboratory BMHP after MMSL intervention

		Number of Stockout Incidents After Intervention		
		No *Stockout*	Stockout Occurs	Total
Safety	≤ 0.53	22	8	30
Stock	> 0,53	25	1	26
Total		47	9	56

Table 4a shows the cross-tabulation between the median supplier lead time of IVF drugs (10 days) and the incidence of stockout after the intervention. The table shows that the lead time of IVF drug suppliers has no impact on the incidence of stockout after the intervention. In contrast to Table 4b which shows the cross-tabulation between the median supplier lead time of embryonic laboratory BMHP (9 days) and the incidence of stockout after the intervention. The table shows that the lead time of embryo laboratory BMHP suppliers has an impact on the incidence of stockout after the intervention. The faster the BMHP supplier lead time of the embryo laboratory, the lower the incidence of stockout after the procurement period, and vice versa.

Table 5a shows the cross-tabulation between the median Smin of IVF drugs (2.68) and the incidence of stockout after the intervention. The table shows that Smin IVF medication has no impact on the incidence of stockout after the intervention. In contrast to Table 5b which shows the cross-tabulation between the median Smin BMHP of embryonic laboratories (1.07) and the incidence of stockout after the intervention. The table shows that Smin BMHP of embryo laboratories has an impact on the incidence of stockout after the intervention. The higher the Smin BMHP of the embryo laboratory, the lower the incidence of stockout after the procurement period, and vice versa.

Table 6a shows the cross-tabulation between the median Smax of IVF drugs (16.18) and the incidence of stockout after the intervention. The table shows that Smin IVF medication has no impact on the incidence of stockout after the intervention. In contrast to Table 6b which shows the cross-tabulation between the median Smax BMHP of embryo laboratories (7.60) and the incidence of stockout

after the intervention. The table shows that embryonic laboratory BMHP Smax has an impact on the incidence of stockout after the intervention. The higher the Smax BMHP of the embryo laboratory, the lower the incidence of stockout after the procurement period, and vice versa.

Table 7a shows the cross-tabulation between the median safety stock of IVF drugs (1.84) and the incidence of stockout after the intervention. The table shows that the safety stock of IVF drugs has no impact on the incidence of stockout after the intervention. In contrast to Table 7b which shows the cross-tabulation between the median safety stock of embryonic laboratory BMHP (0.53) and the incidence of stockout after the intervention. The table shows that the safety stock of embryonic laboratory BMHP has an impact on the incidence of stockout after the intervention. The higher the safety stock of the embryo laboratory's BMHP, the lower the incidence of stockout after the procurement period, and vice versa.

It can be concluded that the faster the lead time of the BMHP supplier of the embryo laboratory, the more profitable it will be for the hospital because it causes a lower possibility of stockout. The recommended supplier lead time in this study was less than or equal to nine days. Second, the number of embryo laboratory BMHP is recommended to have safety stock characteristics of >0.53, Smin >1.07, and Smax >7.60 to minimize the occurrence of stockouts. This can be an input for hospitals to choose suppliers who can commit to sending embryonic laboratory BMHP orders less than or equal to nine days after the order is placed and ensure that the embryonic laboratory BMHP stock adapts to the cut-off point to minimize the occurrence of stockouts. A study reports that pricing policies, ordering, promised lead times, and optimal supplier selection are logistics inventory procurement priorities (Noori-Daryan et al., 2019). Embryonic laboratory BMHP alternatives are recommended to be replaced or substituted with other embryonic laboratory BMHP that fall into the above criteria. Replacing empty pharmaceutical preparations with pharmaceutical preparations that have the same active substances can avoid drug stockouts that can interfere with the quality of patient service (Zuma, 2022). Calculate the optimal safety stock by analyzing past demand fluctuations and considering the anticipation of disruptions in the supply chain. Safety stock functions as a protective measure against unexpected changes in demand or disruptions in the supply chain, thereby avoiding stock shortages and ensuring the quality of hospital services (Gebicki et al., 2014).

CONCLUSION

Based on the results of the research and analysis that has been presented, it can be concluded that several factors, such as price and supplier lead time, can affect the efficiency and effectiveness of controlling the supply of IVF drugs and embryonic laboratory BMHP using the MMSL method. Further research can apply other inventory control methods to calculate the most efficient and effective method that can be applied in IFRS X.

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