Purchasing planning for pharmaceuticals inventory: a case study of drug warehouse in hospital

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ABSTRACT

Lack of purchasing planning and proper demand forecasting causes hospitals to suffer from drug inventory mismatches with actual demand; in other words, the inventory management cost is high if the quantity exceeds or less the demand. Therefore, this research aimed to plan an appropriate inventory purchase to reduce inventory costs and effectively meet the hospital's pharmaceutical inventory needs in a case study: i) demand forecasting for 29 AV drugs using Minitab 19, ii) economic order quantity (EOQ) and Newsboy form when drug demand is stable and non-steady, respectively, and iii) design a ready-made program using Excel program to help control, make purchase decisions and be easy to use. There were 5 forecasting methods used. Each drug forecasting method was selected from the one with the slightest error. Twenty-four drugs and five drugs were determined using EOQ and Newsboy forms for re-order point (ROP), safety stock (SS), and total costs. The total cost of drug inventory management per year was 1,780,336.98 baht; compared with the current method, it reduced the cost by 506,569.10 baht per year or a 22.15% reduction.

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1. INTRODUCTION

Health is the foundation of people's whole growth in today's society, and health care affects the happiness of thousands of families. Drug inventory management is essential in disease control for public health programs. Previous studies of pharmaceutical management have focused primarily on drug inventory systems implemented for national programs to manage inventory at local health clinics [1]. In order to successfully control and satisfy consumer requirements, drug inventory management accounts for a large share of the costs in the health care system, particularly in the hospital supply chain [2]. Additionally, suppose the pharmacy runs out of drug stock. In that case, the healing process and lives of the patients are at risk, necessitating a high level of service for managing drug inventory carried out by pharmacy installations. If something like a medicine shortage occurs and the hospital needs to make last-minute supplies, the overall costs will be costly [3]. It is, therefore, essential to plan the right amount of drug inventory to avoid making false predictions. This leads to problems, such as an oversupply of drug inventory, which leads to high storage costs. Also, medicines are deteriorating due to expiration dates, or the amount of medicine in the inventory is not enough to meet the needs of patients. These problems result in hospitals incurring unnecessary costs [4].

Order planning is an important activity in inventory management. It is managing inventory items since collection, keeping a record of incoming and outgoing products, controlling the right amount of inventories, and maintaining and storing resources in the present or future to run smoothly [5]. Inventory management consists of four types of costs: purchasing costs, ordering costs, carrying costs, and shortage costs [6]. The planning of the purchase must know the needs of the product or service in advance. It can be obtained from the demand forecast. Forecasts are predictions about the nature or trends of interest that will happen in the future to use as information for decision-making [7]. Quantitative forecasting is a forecast that uses a mathematical model by using historical data or trends in forecasting [8]. Quantitative forecasting techniques used in various researches are linear regression analysis, moving average, exponential smoothing, seasonal method, and Holt Winters seasoning [9]. The recent literature reviews carried out by Restyana *et al*. [10] focus on forecasting medicine using single moving averages and single exponential smoothing methods. Wettermark *et al*. [11] focus on linear regression analysis to aggregate sales data on hospital sales and dispensed drugs in ambulatory care. Rushton *et al*. [12] forecasted pharmaceutical stock inventory using linear regression, exponential smoothing, and Holt Winters seasoning. additionally, moving average, exponential smoothing, and Holt Winter seasoning were forecasted for the medicine of the new medical center hospital [13]. Satrio *et al*. [14] uses linear regression, moving average, and simple exponential smoothing to forecast household appliances.

Forecasting techniques are chosen based on forecasts with high accuracy or low tolerances. Tolerance measurement methods include: mean absolute deviation (MAD), mean squared error (MSE), and mean absolute percent error (MAPE) [7]. The MAD and MSE were used in [10], [14], [15]. The best forecasting method of spare parts is chosen based on MSE, MAD, and MAPE the smallest [16].

Optimal order quantity analysis has a method for testing the variability of the demand rate by determining the variability coefficient (VC). If the VC value≤0.25, the demand for the product is constant. economic order quantity (EOQ) will be used. It is to find the order quantity that brings the lowest total cost of each order [17]. EOQ model has been to reduce the number of orders placed each month of the dairy company [8]. Boonlorm *et al*. [18] design and analysis of the appropriate order quantity of drug dispensing for a hospital using EOQ. Thirugnanasambandam and Sivan [19] provided the EOQ in wellness industries. The EOQ model was applied to plan computer spare parts [20]. The EOQ method can cut the cost of inventory of safety glass in the automotive industry [21] The retail company can reduce overstocking of the household appliance using the EOQ method [22]. The EOQ cost management model is used for the inventory control of spare parts [23]. Inventory control of raw materials can lower costs by using the EOQ method [24] The drug inventory is within the management of the EOQ [4], [25], [26].

If the VC value>0.25, the demand for the product is not stable or uneven. Orders are placed on a dynamic lot-sizing basis to avoid overstocking and understocking. Other methods, such as Newsboys, will be used to find the order quantity.The silver-meal and the least unit cost (LUC) method takes into account the demand for each period in advance. LUC method uses the average cost per piece, while the Silver-Meal uses the average cost per installment [27].

The order quantity in Newsboy method is an order for inventory more than average demand to prevent shortages from variability. The principle consists of ordering the average inventory demand for the cycle and adding any inventory variance compared to the average quantity [28]. Based on assigned service levels, inventory orders will be larger than the average quantity. Newsboy method was applied for cleanroom equipment [29], reusable, and imperfect items [30]. Brzeczek [31] considered the discrete Newsboy problem of risk optimization and merchandise planning. The Newsboy model was developed by Slama *et al*. [32] to determine the total lease cost of the disassembly order.

Time to purchase inventory is another essential factor in inventory control by taking into account the order period, lead time, including safety stock (SS). It is the amount of inventory that is reserved to prevent shortages when the product is used, and the quantity decreases to the reorder point, which is a warning point for the next order when demand exceeds stored inventory. It is to prevent the product from being a shortage in advance [27], [33], [34].

From the related research above, quite a few studies use the Newsboy method in drug purchasing planning. Moreover, studies using the EOQ and Newsboy methods have yet to be conducted. Therefore, it is a challenge in this study to forecast the optimal demand for each drug together with order quantity calculation in both stable and non-steady demand cases by EOQ and Newsboy methods, respectively. Furthermore, it is to make the drug inventory sufficient to meet the demand under the reasonable cost of the hospital pharmaceutical inventory; a case study, which is a hospital that provides services to patients in Nakhon Ratchasima Province covering the lower northeastern region [35] by analyzing the appropriate forecasting model of each drug item. Calculate the optimal order quantity, predict drug demand, and choose the best forecasting method for each drug from the minor tolerances with Minitab 19 due to different medicines and needs. In the list of medicines in constant demand, the EOQ method is used to determine the purchased quantity. On the other hand, the Newsboy method is used to determine the purchased quantity for drug items with unstable demand to prevent shortages caused by variance. Besides, it is a method that uses the average demand per unit to calculate, which is suitable with the drug demand data of the pharmaceutical warehouse, to find the minimum SS, reorder point (ROP), and total cost to plan and manage the drug inventory. In addition, ready-made programs that display the results on the computer screen with the Excel program in the part of Solver and Macro functions to help in ordering medicines are written. Therefore, purchasing planning in this research can be applied to warehouses with similar needs, such as hospital pharmacy warehouses, pharmacies, warehouses with different products and needs.

The remainder of the paper is structured as shown: section 2 presents the methods involved in the EOQ and Newsboy method. Followed by section 3 where the results and discussion are presented. Finally, section 4 presents conclusions.

2. METHOD

2.1. Data collection

The current drug ordering information of the case study hospital's drug inventory, the AV drug data obtained from research by ABC-VED matrix [36] were used as a sample group to be used for data analysis. It was found that the pharmaceutical department of the case study hospital faced problems in managing the drug inventory. The relationship between cause and problem can be shown with the Why-Why-Why analysis chart, as shown in Figure 1.

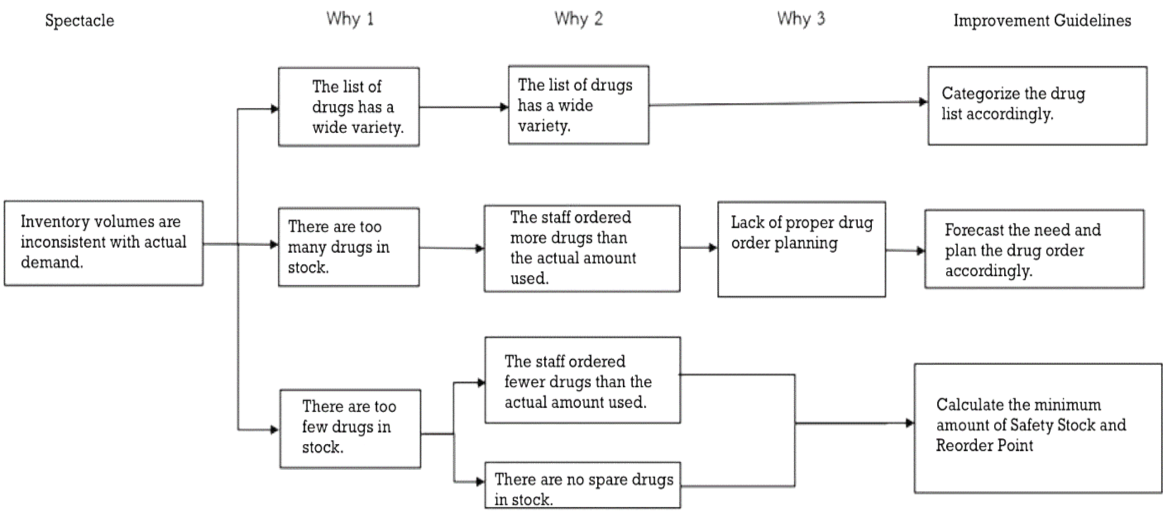

Figure 1. Why-Why-Why analysis chart

From Figure 1, it was found that the drug inventory was too high or too low due to a lack of proper forecasting and order planning, resulting in improper ordering quantity and reorder point. In addition, the unstable rate of drug use was caused by an increase or decrease in the number of cases or epidemics. It led to purchasing medicines in stock that did not meet demand. Excess drug inventory led to high storage costs. There was drug deterioration due to the expiration date, or the number of drugs in the inventory was too low. Therefore, it was insufficient to meet the needs of patients receiving services. As a result, the hospital wasted unnecessary expenses.

This research, therefore, collected drug use data from the drug warehouse from July 2019-September 2021. It included drug list data, unit price, order quantity and monthly discharged amount for the past two years, order cost information, expenses incurred in ordering activities such as labor costs, telephone charges, and document costs related to the purchase order. It also included storage costs, such as utilities, water, and electricity, which were the cost of ordering 726,475.00 Baht per year. As a result, there were 185 orders, representing an order cost of 3,926.89 Baht per time, an average drug inventory value of 144,000,000 Baht per year, and electricity costs of 292,654.69 Baht per year.

2.2. Analysis of drug demand characteristics

Analysis of drug demand characteristics was conducted by using historical drug dosage information to forecast future demand. Historical data is employed to create a trend forecast graph with the Minitab 19 program. There are five forecasting techniques, namely linear regression analysis, moving average, exponential smoothing, double exponential smoothing, and Winters' method [9].

2.3. Verify forecasting accuracy

Validation was performed by calculating forecast error. There are three methods: MAD, MSE and MAPE. The appropriate forecasting method was chosen from the method with the lowest error.

2.4. Find the variability coefficient

The variability coefficient (VC) value was considered to determine whether the demand information for each drug was stable or not. The VC value could be obtained from (1), (2) and (3). If VC is less than or equal to 0.25, the EOQ method [18] will be used to calculate order quantity. If VC is greater than 0.25, the Newsboy method will be used for order quantity, as mentioned:

$$VC = Est.varD/(\bar{d})^2 \tag{1}$$

where

$$Est.varD = \frac{1}{n}\left(\sum_{i=0}^{n} \bar{d}_i^2\right) - \left(\bar{d}^2\right) \tag{2}$$

$$\bar{d} = \frac{1}{n}\left(\sum_{i=0}^{n} d_i\right) \tag{3}$$

when

d_i=Estimate the need for medication at each time interval.

n=Study period.

2.5. Calculate order quantity, SS and ROP

Find order quantity by using EOQ and Newsboy method. Find the re-order point and SS in case of variable demand rates and fixed order cycle times. Order quantity for fixed demand with EOQ method can be obtained from (4). Order quantity in case of unstable demand with the Newsboy method can be obtained from (5). Suppose the demand rate of the product fluctuates, and the order cycle is fixed. In that case, the reorder point is calculated as shown in (6), and the minimum inventory reserve as in (7).

$$Q^* = \sqrt{\frac{2DP}{IC}} \tag{4}$$

Where

Q^*=EOQ unit

D=Average demand of medicine items case study (unit/month)

P=Purchasing cost (unit/time)

I=Inventory cost (Baht/unit/year)

C=Drug price (Unit cost) (Baht/Unit)

$$Q* = \mu + Z\sigma \tag{5}$$

where

Q*=Appropriate order quantity each time (units)

μ=Average demand (unit)

σ=Standard deviation of demand

z=The standard value for normal distribution at the service level is 95 % because the drug is essential to the patient's life

$$ROP = (d \times \bar{L}) + z\sqrt{L}\sigma \tag{6}$$

$$SS = z\sqrt{L}\sigma \tag{7}$$

Where
d=Average demand (Unit)
$\overline{L}$=Lead time (Month)
z=The standard value for Normal Distribution at the service level of 95%
σ= Standard Deviation of Demand

2.6. Create a ready-made program

Create a ready-made program and check the correctness of the program for planning drug purchase inventory by using Microsoft Excel. This program has been produced to calculate the number of drug orders, the number of times to order, the minimum inventory of medicines, and reorder point by showing the results of the calculations on the computer screen. This package has been created to simplify the process and make it easier for users.

3. RESULTS AND DISCUSSION

The information on current drug order management was collected in the hospital drug inventory case study. The AV drug data obtained from research by ABC-VED Matrix [36] was used as a sample for data analysis. The results were as shown in next sub sections.

3.1. Forecast results of drug demand

Using the drug dosage data to create a forecast curve and determine the error value using the Minitab 19 program, the forecast method suitable for each drug giving the slightest error was chosen. Examples of a prognosis for Trustiva (TDF/FTC/EFV) 300/200/600 mg were shown in Figures 2 and 3. Examples of tolerances for each method and each forecast for Trustiva (TDF/FTC/EFV) 300/200/600 mg are shown in Table 1. From the four methods of forecasting above, it was found that there were still some drugs with high tolerances. However, the most suitable forecasting method could not be found. Therefore, this list of drugs was predicted using Winters' method. The smoothing constants level (α), trend (γ), and seasonal (δ) were used to find the answer, and the smoothing values α, γ, and δ were selected with the lowest tolerance to be used in forecasting. A summary of the optimal forecasting methods and predictive values for each AV drug is shown in Table 2. An example of one year's advanced prediction of Trustiva (TDF/FTC/EFV) 300/200/600 mg by linear regression method is shown in Figure 4.

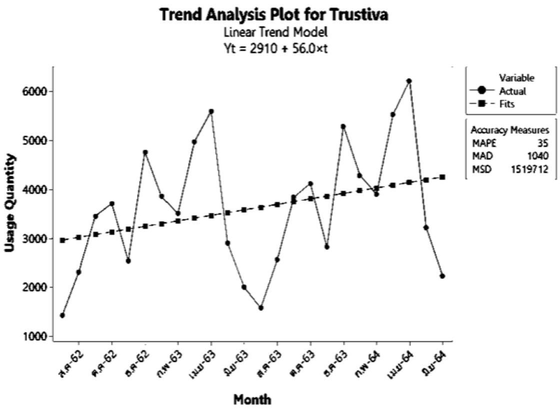

Figure 2. Prognosis of Trustiva (TDF/FTC/EFV) 300/200/600 mg with linear regression method

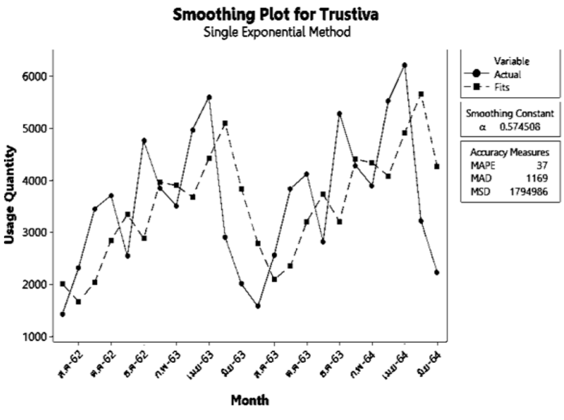

Figure 3. Predicted results of drug demand quantity Trustiva (TDF/FTC/EFV) 300/200/600 mg with single exponential smoothing method

Table 1. Examples of tolerances values from various forecasting methods and their methods

Drug Item	Error	Forecasting Method				Forecasting
		Linear regression	Moving average	Single exponential smoothing	Double exponential smoothing	
Meropenem 1 g inj.	MAPE	26.40	37.00	24.10	27.30	Single exponential smoothing
	MAD	203.50	292.00	186.50	204.80	
	MSD	51,843.70	102,491.00	63,014.00	70,210.10	
Trustiva (TDF/FTC/EFV) 300/200/600 mg	MAPE	35.00	41.00	37.00	36.00	Linear regression

Table 2. The optimal forecasting methods and predictive values for each AV drug

No.	Drug	Unit	Forecasting method	Forecasting (Unit)
1	Meropenem 1 g inj.	Vial	Single exponential smoothing	13,277.36
2	Trustiva (TDF/FTC/EFV) 300/200/600 mg	Tablet	Linear regression	55,416.18
3	Ceftazidime 1 g inj. (Fortum_L)	Vial	Linear regression	19,676.54
4	20% Human albumin 50 mL inj.	Bottle	Single exponential smoothing	1,081.46
5	NSS IV 100 mL	Bag	Linear regression	79,669.10
6	Piperacillin 4 g/Tazobactam 0.5 g inj. (Tazocin_L)	Vial	Winter’s method (Multiplicative)	14,125.35
7	NSS IV 1000 mL	Bag	Moving average	30,288.00
8	Sterile water for injection (SWFI) 10 mL inj.	ampules	Linear regression	144,005.70
9	Enoxaparin 60 mg/0.6 mL inj. (Clexane)	Pre-filled Syringe	Winter’s method (Multiplicative)	13,411.27
10	5% Human albumin 250 mL inj.	Bottle	Moving average	408.00
11	Amoxicillin 875 mg/Clavulanic acid 125 mg tablets (AMK 1 g)	Tablet	Linear regression	68,904.85
12	Enoxaparin 40 mg/0.4 mL inj. (Clexane)	Pre-filled Syringe	Linear regression	2,931.29
13	Entecavir 0.5 mg tablets (Baraclude)	Tablet	Winter’s method	15,407.91
14	Levofloxacin 750 mg/150 mL inj.	Vial	Winter’s method	1,256.65
15	Clindamycin 600 mg/4 mL inj.	Vial	Linear regression	10,648.13
16	Cefixime 100 mg capsules (Cefspan)	Capsules	Single exponential smoothing	15,750.24
17	Metronidazole 400 mg tablets	Vial	Linear regression	34,212.27
18	D5N/2 IV 1000 mL	Bag	Linear regression	14,498.45
19	Inactivated quadrivalent influenza vaccine (split virion) 0.5 mL inj. (Vaxigrip Tetra)	Syringe	Winter’s method (Multiplicative)	2,795.62
20	Norepinephrine 4 mg/4 mL inj. (Levophed_L)	Capsules	Winter’s method (Multiplicative)	2,980.18
21	Acyclovir 500 mg inj.	Vial	Winter’s method (Multiplicative)	957.60
22	Acetated Ringer's solution IV 1000 mL (Acetar)	Bag	Linear regression	9,905.18
23	Cefazolin 1 g inj.	Vial	Winter’s method (Multiplicative)	4,666.18
24	Amoxicillin 500 mg capsules	Capsules	Moving average	105,867.96
25	SWFI piggy bag 100 mL	Bag	Winter’s method (Multiplicative)	17,876.24
26	Ertapenem 1 g inj. (Invanz)	Vial	Winter’s method (Multiplicative)	13,500.00
27	Cefdinir 100 mg capsules (Omnicef)	ampules	Winter’s method (Multiplicative)	22,612.38
28	NSS 5 mL inj.	ampules	Linear regression	37,547.78
29	Tenofovir disoproxil fumarate (TDF) 300 mg	Tablet	Winter’s method (Additive)	41,834.97

Trend Analysis for Trustiva (TDF/FTC/EFV) 300/200/600

Method

Model type	Linear Trend Model
Data	Trustiva (TDF/FTC/EFV) 300/200/
Length	24
NMissing	0

Fitted Trend Equation

$Y_t = 2910 + 56.0 \times t$

Accuracy Measures

MAPE	35
MAD	1040
MSD	1519712

Forecasts

Period	Forecast	Period	Forecast
25	4309.93	31	4646.02
26	4365.95	32	4702.04
27	4421.96	33	4758.05
28	4477.98	34	4814.07
29	4533.99	35	4870.08
30	4590.01	36	4926.10

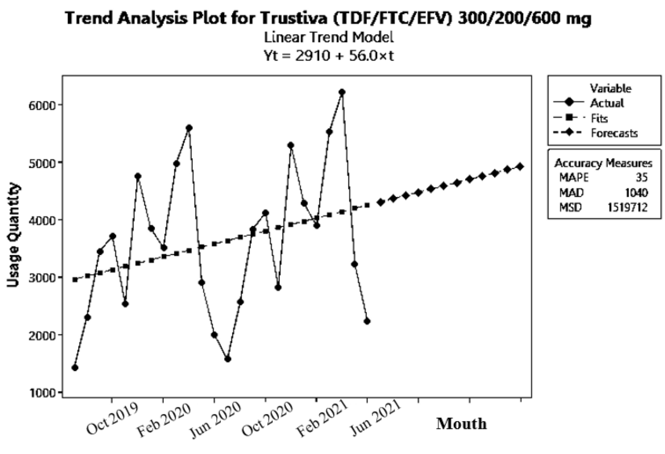

Figure 4. One year's advanced prediction of Trustiva (TDF/FTC/EFV) 300/200/600 mg by linear regression

3.2. The result of checking the variability coefficient

29 AV drug dosage data items were used to determine the coefficient of variance from (1). If VC was≤0.25, drug demand was constant. The EOQ method was quantified, and the drug demand was not stable if the VC value was>0.25. The Newsboy method was quantified using the Newsboy method as described in 3.4. The results showed that there were 24 drugs with VC≤0.25 and 5 drugs with VC>0.25.

3.3. The result of calculating the order quantity of SS and ROP

3.3.1. The result of calculating the order quantity by EOQ SS and ROP method

Based on the VC determination in step 3.2, there were 24 AV drugs with VC≤0.25. Finding the optimal order quantity by the EOQ method, the cost of ordering was 3,926.89 Baht per time and storage cost 0.002 Baht/unit/year. Optimal order volume with EOQ SS and ROP method; the results are shown in Table 3.

Table 3. Optimal order quantity by EOQ SS and ROP method

No.	Item	Unit	VC	Q* (Unit)	No. of purchasing (time/Year)	Safety stock: SS (Unit)	Re-order point: ROP (Unit)
1	Meropenem 1 g inj.	Vial	0.00	4,128	4	0	1,103
2	Trustiva (TDF/FTC/EFV) 300/200/600 mg	Tablet	0.00	18,893	5	396	5,015
3	Ceftazidime 1 g inj. (Fortum_L)	Vial	0.00	7,456	5	127	1,767
4	20% Human albumin 50 ml inj.	Bottle	0.00	539	6	0	91
5	NSS IV 100 mL	Bag	0.00	35,821	6	450	7,091
6	Piperacillin 4 g/Tazobactam 0.5 g inj. (Tazocin_L)	Vial	0.11	5,916	6	783	1,961
7	NSS IV 1000 mL	Bag	0.00	15,616	7	0	2,524
8	Sterile water for injection (SWFI) 10 ml inj.	ampules	0.00	68,100	6	981	12,982
9	Enoxaparin 60 mg/0.6 mL inj. (Clexane)	Pre-filled syringe	0.15	3,827	4	892	2,010
10	5% Human albumin 250 mL inj.	Bottle	0.00	268	8	0	34
11	Amoxicillin 875 mg/Clavulanic acid 125 mg tablets (AMK 1 g)	Tablet	0.00	43,002	8	358	6,101
12	Enoxaparin 40 mg/0.4 mL inj. (Clexane)	Pre-filled syringe	0.00	1,963	9	14	259
13	Levofloxacin 750 mg/150 mL inj.	Vial	0.15	718	7	84	189
14	Clindamycin 600 mg/4 mL inj.	Vial	0.00	8,282	10	16	904
15	Cefixime 100 mg capsules (Cefspan)	Capsules	0.00	13,003	10	16	904
16	Metronidazole 400 mg tablets	Vial	0.00	60,602	22	163	3,015
17	D5N/2 IV 1000 mL	Bag	0.00	10,942	10	61	1,270
18	Inactivated quadrivalent influenza vaccine (split virion) 0.5 mL inj.(Vaxigrip Tetra)	Syringe	0.21	1,520	7	217	450
19	Acetated Ringer's solution IV 1000 mL (Acetar)	Bag	0.00	7,616	10	115	941
20	Amoxicillin 500 mg capsules	Capsules	0.00	106,605	13	0	8,823
21	SWFI piggy bag 100 mL	Bag	0.05	16,966	12	701	2,191
22	Cefdinir 100 mg capsules (Omnicef)	Capsules	0.14	15,580	9	1,449	3,334
23	NSS 5 mL inj.	Capsules	0.00	34,774	12	293	3,422
24	Tenofovir disoproxil fumarate (TDF) 300 mg tablets	Tablet	0.02	25,955	8	1,083	4,570

From Table 3, the most frequently ordered drugs 1, 2, and 3 were Metronidazole 400 mg tablets, Amoxicillin 500 mg capsules, SWFI piggy bag 100 mL, and NSS 5 mL inj., respectively. All three drugs are antibiotic drugs used in various treatments and have high consumption. The least commonly prescribed drug was Enoxaparin 60 mg/0.6 mL inj. (Clexane), as it is a topical drug and is used in different concentrations.

3.3.2. The result of calculating the order quantity using newsboy, SS and ROP method

The optimal purchase volume was determined using the Newsboy method for five AV drugs with a VC value>0.25. The minimum inventory and reorder point results are shown in Table 4. From Tables 3 and 4, the top three drug reserves were Entecavir 0.5 mg tablets (Baraclude), Cefdinir 100 mg capsules (Omnicef), and Tenofovir disoproxil fumarate (TDF) 300 mg tablets, respectively, because it is an antiviral drug for common diseases. Drugs with minimal inventory or no need for stockpile were Meropenem 1 g inj., 20% Human albumin 50 mL inj., NSS IV 1000 ml, 5% Human albumin 250 mL inj., and Amoxicillin. 500 mg capsules, as this is a contraindication drug and has possible side effects. Dosage and duration of use were at the discretion of the treating physician and pharmacist. In comparison, the drugs with the highest inventory at the point of the purchase were SWFI 10 ml inj., Amoxicillin 500 mg capsules, and NSS IV 100 ml, respectively. Since it is a solution and disinfectant used to treat many symptoms, it has a high volume of usage that must always be prepared and ready to use. Whereas the drugs with the lowest inventory at the point of the purchase were Ertapenem 1 g inj. (Invanz), 5% Human albumin 250 mL inj. and 20% Human albumin 50 mL inj., respectively. Because it is a topical medication and the solution is used in different concentrations, other drugs must be used as directed by the physician.

Table 4. Optimal order quantity by Newsboy, SS and ROP

No.	Item	Unit	VC	Q* (Unit)	No. of Purchasing (time/Year)	Safety Stock (Unit)	Re-Order Point (Unit)
1	Entecavir 0.5 mg tablets (Baraclude)	Tablet	0.35	2,832	3	1548	2,832
2	Norepinephrine 4 mg/4 mL inj. (Levophed_L)	Ampules	0.31	531	3	282	351
3	Acyclovir 500 mg inj.	Vial	0.40	184	3	104	184
4	Cefazolin 1 g inj.	Vial	0.33	845	3		
5	Ertapenem 1 g inj. (Invanz)	Vial	0.46	27	3	16	28

3.4. Total cost calculation result

The total cost of ordering comprised the average drug inventory value, cost of storage, and cost of ordering. The calculation results are shown in Table 5. From Table 5, it was found that the average drug inventory was 918,481.00 Baht, storage costs 1,866.65 Baht, and purchase costs 859,989.32 Baht, which accounted for a total cost of 1,780,336.98 Baht. It was found that the cost could be reduced from 2,286,906.08 Baht by 506,569.10 Baht, or a decrease of 22.15%. Furthermore, it showed that when using EOQ and Newsboys methods to calculate the inventory of AV drugs, the cost of purchasing and storage of medicines could be reduced. It also made available drugs to meet the needs of the case study drug inventory.

Table 5. Drug ordering costs

No.	Item description	Cost (Baht)			
		Inventory cost (Baht)	Carrying cost (Baht)	Ordering cost (Baht)	Total cost (Baht)
1	Meropenem 1 g inj.	0.00	0.00	15,707.57	15,707.57
2	Trustiva (TDF/FTC/EFV) 300/200/600 mg	19,800.00	40.24	19,634.46	39,474.70
3	Ceftazidime 1 g inj. (Fortum_L)	14,478.00	29.42	19,634.46	34,141.88
4	20% Human albumin 50 mL inj.	0.00	0.00	23,561.35	23,561.35
5	NSS IV 100 mL	9,000.00	18.29	23,561.35	32,579.64
6	Piperacillin 4 g/Tazobactam 0.5 g inj. (Tazocin_L)	101,790.00	206.87	23,561.35	125,558.22
7	NSS IV 1000 mL	0.00	0.00	27,488.24	27,488.24
8	SWFI 10 mL inj.	9,810.00	19.94	23,561.35	33,391.29
9	Enoxaparin 60 mg/0.6 mL inj. (Clexane)	263,140.00	534.79	15,707.57	279,382.35
10	5% Human albumin 250 mL inj.	0.00	0.00	31,415.14	31,415.14
11	Amoxicillin 875 mg/Clavulanic acid 125 mg tablets (AMK 1 g)	4,296.00	8.73	31,415.14	35,719.87
12	Enoxaparin 40 mg/0.4 mL inj. (Clexane)	3,430.00	6.97	35,342.03	38,779.00
13	Entecavir 0.5 mg tablets (Baraclude)	100,620.00	204.49	11,780.68	112,605.17
14	Levofloxacin 750 mg/150 mL inj.	65,940.00	134.01	27,488.24	93,562.25
15	Clindamycin 600 mg/4 mL inj.	800.00	1.63	39,268.92	40,070.54
16	Cefixime 100 mg capsules (Cefspan)	30.00	0.06	39,268.92	39,298.98
17	Metronidazole 400 mg tablets	489.00	0.99	86,391.62	86,881.62
18	D5N/2 IV 1000 mL	2,379.00	4.83	39,268.92	41,652.75
19	Inactivated quadrivalent influenza vaccine (split virion) 0.5 mL inj. (Vaxigrip Tetra)	84,630.00	172.00	27,488.24	112,290.24
20	Norepinephrine 4 mg/4 mL inj. (Levophed_L)	42,300.00	85.97	11,780.68	54,166.64
21	Acyclovir 500 mg inj.	60,944.00	123.86	11,780.68	72,848.53
22	Acetated Ringer's solution IV 1000 mL (Acetar)	6,325.00	12.85	39,268.92	45,606.77
23	Cefazolin 1 g inj.	15,960.00	32.44	11,780.68	27,773.11
24	Amoxicillin 500 mg capsules	0.00	0.00	51,049.59	51,049.59
25	SWFI piggy bag 100 mL	14,020.00	28.49	47,122.70	61,171.20
26	Ertapenem 1 g inj. (Invanz)	30,240.00	61.46	11,780.68	42,082.13
27	Cefdinir 100 mg capsules (Omnicef)	43,470.00	88.35	35,342.03	78,900.37
28	NSS 5 mL inj.	2,930.00	5.95	47,122.70	50,058.66
29	Tenofovir disoproxil fumarate (TDF) 300 mg	21,660.00	44.02	31,415.14	53,119.16
		918,481.00	1,866.65	859,989.32	1,780,336.98

3.5. The result of creating a successful program with Excel

Excel created the ready-made program to plan the purchase of medicine inventory in the part of Input, drug list, the quantity of demand, and VC value. The output section showed the order method by EOQ or Newsboy method to calculate the number of orders per year, re-order point, order quantity per time, and SS, as shown in Figure 5. The researcher's program can be modified and expanded to make it more user-friendly and practical.

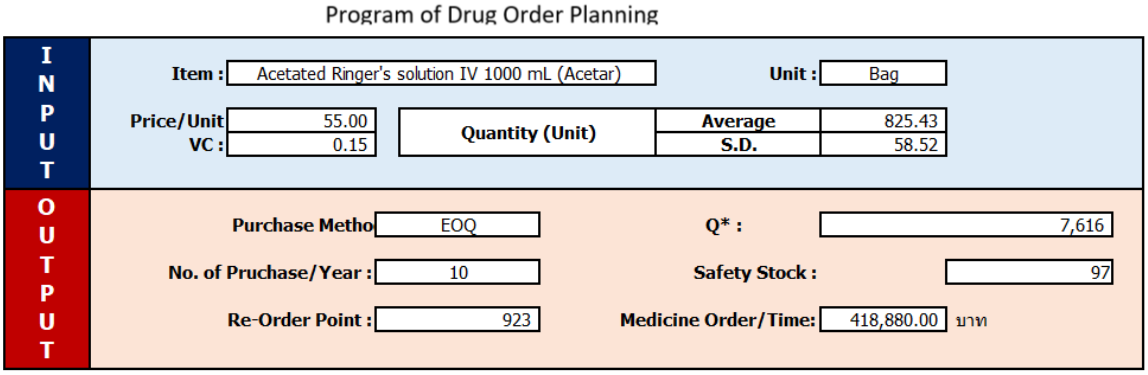

Figure 5. Display the results of the order planning

4. CONCLUSION

From the research, it was concluded that a method for forecasting the optimal drug demand dose for each drug of 29 from case study drug inventory samples was obtained by selecting the method with the least error as follows: MAD, MSE, MAPE. When taking the predicted drug demand predictions to check the VC values, it was found that there were 24 drugs with constant demand. Quantified purchases were found by the EOQ method, and five drugs were with variable demand. Quantified purchases were found using the Newsboy method to calculate the quantity of SS, ROP, and total cost. The proposed drug order planning management model could reduce the total cost of managing the annual drug inventory from 2,286,906.08 Baht to 1,780,336.98 Baht, a decrease of 506,569.10 Baht, or a decrease of 22.15%. It showed that when using this method in calculating the quantity of AV drug purchase inventory, the cost could be reduced, and had sufficient quantities of drugs to meet the needs of the hospital drug inventory in the case study. Furthermore, it could apply the principles of this research to be applied in planning the orders of other agencies that were similar. It is due to government agencies must comply with the regulations of the Prime Minister's Office on the parcel of the year 2535, which cannot be ordered in too frequent quantities. In addition, the results obtained from the VC calculation should be regularly compared with the actual drug demand behavior to conclude whether it is suitable for that method or not. Besides, the annual demand for medicines is uncertain. Therefore, the appropriate order quantity should continually be reviewed to avoid making mistakes in ordering medicines.

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