e-ISSN 3027-0537
p-ISSN 3027-0375

Check for updates

Business Management
Gph-International Journal
www.gphjournal.org

10.5281/zenodo.10700678 Vol. 07 Issue 01 Jan - 2024 Manuscript ID: #1231

A Data-Driven Approach to Inventory Control under Uncertain Demand for Pharmaceutical Products using Continuous Review Policy

By

Abdur Razzak Chowdhury[1], Asif Mohammad Mithu[2], Shibbir Ahmad[3], A.B.M Abdul Malek[3]
[1]Department of Industrial Engineering, Lamar University, Beaumont TX-77710, USA
[2]Department of Electrical and Computer Engi, South Dakota School of Mines and Technology, Rapid City, SD 57701
[3]Department of IPE, Shah Jalal University of Science and Technology, Sylhet-3100, Bangladesh.

Corresponding author: ahmadjerin@gmail.com

ABSTRACT:

With the continuous growth of Bangladesh's GDP, healthcare expenditure has been steadily increasing, highlighting the importance of efficient resource management in healthcare facilities. Pharmacy, being a significant contributor to overall operational costs, plays a crucial role in ensuring high-quality patient care. Proper inventory management of pharmaceutical products is essential to meet patient demands while minimizing costs. This research focuses on analyzing pharmaceutical inventory management practices at Sylhet Women's Medical College Hospital, a tertiary healthcare facility, and their impact on customer service levels.

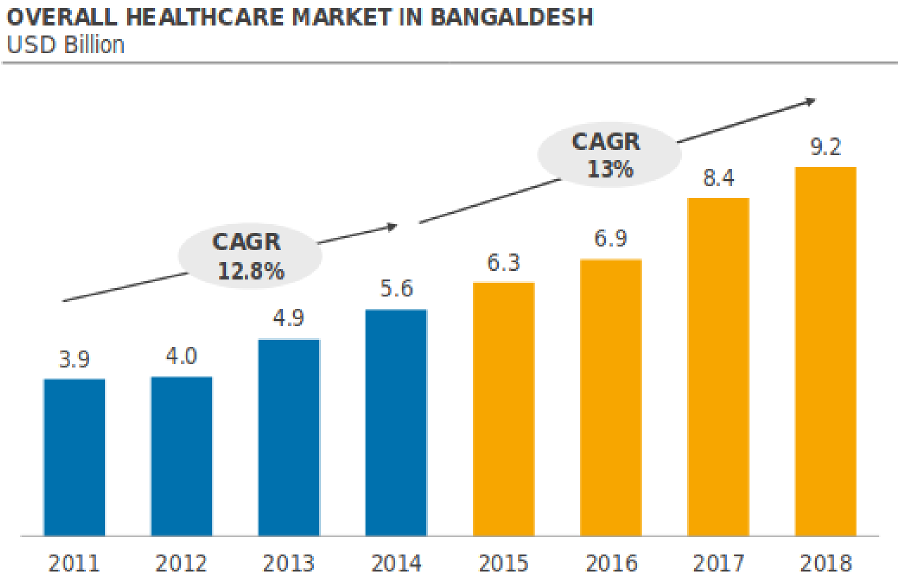
Secondary data from January 2016 to March 2018 was collected to assess the current inventory management practices. Through a comparison of actual inventory levels with ideal scenarios, a continuous review policy was implemented to optimize inventory levels. Additionally, cycle counting based on ABC classification was utilized to enhance inventory record accuracy and minimize waste. The analysis revealed that a significant portion of pharmaceutical items at the hospital were overstocked. Implementation of a continuous review process has the potential to yield substantial cost savings, estimated at BDT 2,815,482 (39% of total inventory value).

KEYWORDS:

Healthcare Inventory Management, Continuous Review Policy, Pharmaceutical Inventory Optimization, ABC Classification, Cost Reduction in Healthcare.

1. INTRODUCTION

The healthcare spending in Bangladesh has been growing consistently along with the increase in the country's Gross Domestic Product. According to Business Monitor International (2018), the healthcare spending in Bangladesh accounts for almost 3.7% of its GDP and has been growing at a 13% Compounded Annual Growth Rate (CAGR) in the last five years. Pharmacy plays a vital role in most of Bangladesh's hospitals, as it contributes a large portion of the total hospital expenditure. By 2022, the market size of the healthcare sector is expected to more than double to $4.44 billion from $2.02 billion.



Almost 80% of the total hospital pharmacy expenditure goes towards pharmaceutical products, with the remaining 20% being spent on personnel and other expenses (Edwards, 2011). Hospital pharmacy plays a crucial role in procuring, storing, handling, and distributing the correct medicines in the correct dosage, to the correct patient at the correct time. Effective and efficient management of the pharmacy is crucial to help the hospital in reducing its total expenditure while maintaining its customer service level(Pedersen, 2009).

Inventory management has become an important aspect in healthcare institutions, including hospital pharmacies. A company can optimize its return on investment and minimize its business risk by effectively managing its inventory. Inventory management involves balancing the costs of holding inventory against the benefits of having goods available as required. Inventory becomes the largest single part of an investment, accounting for 20-30% of the total assets, and must be managed effectively to achieve better financial performance (Shardeo, 2015).

In most pharmacy practices, customer demand is uncertain, making it challenging to predict inventory requirements(Dias, 2011). To address this issue, pharmacies may end up holding more inventory, which can result in room space problems, increasing waste due to expired medicine, and higher holding costs (Hafnika, 2016).

The objective of this research is to develop an effective approach to determine optimal inventory policies in a hospital pharmacy by analyzing moving items in inventory. The research aims to reduce inventory cost and to determine an optimal order quantity, re-order point, and safety stock to minimize total inventory costs under uncertain demand. The study also aims to estimate savings using continuous review inventory management systems compared to the current inventory system. The results of this research can be applied to other inventory management scenarios, not just in pharmacy, to optimize inventory cost and identify unnecessary costs related to moving inventory items.

2. RESEARCH METHODOLOGY

To explore the state of the art of pharmaceutical inventory practice in Bangladesh, we have followed the exploratory data analysis(Saunders, 2007), a comparison of secondary literature review, and empirical data set for the quantitative analysis which showed the data validity and relevant approaches that justify the continuous review policy. For the case study or empirical data set, we have collected pharmaceutical inventory where try to find out overstock and under-stock in the pharmacy of Sylhet Women's Medical College Hospital, Bangladesh. For analyzing the forecast and validations of our method we have tried figure out our solutions with the previous literature.

In recent years, no estimations have been made, and Bangladesh has made very little progress in terms of research. We believe this research is comparatively a new in recent time and there is limited research has been completed, eventually we found the research area is completely an embryonic stage in Bangladesh that we have examined and measured the pharmaceutical product inventory management at a private hospital in Sylhet City.

A Comparison of Current Inventory Management in Pharmaceutical Industry:

Publication Reference/Year	Covered Area	Capacity Analysis	Ideal Method Finding	Barrier and Challenges	Demand Forecast	Stock Monitoring	Cost Analysis	ABC Analysis
2016	inventory control vs stockout	X	√	X		√	X	√
2012	inventory control vs stockout		√	X	X	√	X	√
2016	barriers and challenges	√	X	√	X	X	X	√
2016	Point of sale system	X	X	X	X	√	X	X
2016	Cost analysis	X	X	X	X	X	√	√
2018	Inventory control techniques, performance evaluation	X	√	X	√	X	√	X
2016	Performance evaluation between inventory management practices	X	√	X	X	√	X	X
Our Manuscript	Performance evaluation of inventor control techniques	√	√	√	√	√	√	√

Table:- 01

Pharmaceutical inventories are unique from other types of inventories in that they need a significant budget and amount of planning to guarantee that essential items are kept at the ideal quantities. In order to properly manage inventory levels, the setup cost and holding cost must be balanced with service levels.

Several methods, including economic order quantity, reorder point, replenishment policy, safety stock, and average inventory level, are employed to maintain inventory stocks. The continuous review policy and the periodic review policy are used to further describe the replenishment policy. While the periodic review policy checks inventory at regular intervals and places an order to lower inventory levels, the continuous review policy tracks inventory continuously and places an order when it reaches the reorder point(Ma, 2013).

The research adopts a positivist philosophy and a deductive approach. The data collected consists of primary data from an interview with a pharmaceutical logistic manager and secondary data from the hospital's records. The data analysis uses economic order quantity, reorder point, safety stock, average inventory level, ABC analysis, and cycle counting techniques. The authors aim to evaluate the current inventory management system and provide recommendations to improve it.

One of an organization's primary problems is inventory management. Many authors have conducted numerous research on the inventory management system, many of which focus on pharmaceutical products. Unfortunately, Bangladesh has only seen a relatively small number of research studies.

3. DATA ANALYSIS

This chapter presents the analysis and findings of the study which has been conducted in the selected hospital pharmacy. The data was collected through questionnaires and pharmacy database, and it was found that the pharmacy carries 400 pharmaceutical products, with 304 product data collected. The pharmacy does not follow a strict ROP and does not have optimal order quantity calculation. The authors first evaluated the current inventory management system in place by analyzing the average inventory levels of pharmaceutical products at the Sylhet Women's Medical College Hospital Pharmacy from January 2018 to March 2018. This was calculated by using the month-end stock data and averaging the values.Next, the authors determined the optimal average inventory level by using a proposed inventory management system which utilized a continuous review policy. This system used an economic order quantity equation to determine the optimal order quantity and a percentage of customer service level to determine safety stock, reorder point, and average inventory level.In the third stage, the authors compared the average inventory levels under the current and proposed inventory management systems for all pharmaceutical products. This comparison helped determine the inventory status for each product, whether it was understocked, overstocked, acceptable, deadstock, or a discontinued item. The authors then calculated the total difference in average inventory level values between the actual and ideal conditions and determined the saving potential for the Sylhet Women's Medical College Hospital Pharmacy.Finally, the authors recommended an appropriate inventory control strategy to be implemented by the hospital pharmacy to increase productivity and efficiency while minimizing total expenditure. This included ensuring high accuracy in the inventory recording process by using the Cycle Counting technique and determining the ABC Classification for each product. Based on the classification, the authors suggested a certain number of pharmaceutical products to be checked daily.

Table 02 : Fixed variable of procurement process in Sylhet Women's Medical College Hospital Pharmacy

Lead Time	1 Day
Holding Cost	25% of unit price
Setup Cost	BDT 1000
Service Level	95%

Lead time among all types of pharmaceutical products in this hospital are quite different, but because lack of data resource, Pharmaceutical Logistic Manager assumed that lead time is only one day based on average. While the holding cost of inventory is assumed as 25% of unitprice, which consists of keeping cost, room space cost, and spoilage cost. Setup costis assumed to be BDT 1000 per order, which consists of telecommunication cost andtransaction cost. Service level is expected to be 95%, which means that managementoptimizes that in the 95% cases, hospital pharmacy can fulfill patient's demand forspecific medication from inventory availability in the warehouse. It is based on theconsideration that 95% customer service level is good enough for, Sylhet Women's Medical College Hospital Pharmacy since the higher the customer service level, means that, Sylhet Women's Medical College Hospital Pharmacy should carry more several number of safety stock, thus itcan impact to the total value of average inventory level.

The authors used weekly sales data from January 2018 to March 2018 to analyze the demand average for all pharmaceutical products and found that the demand average was rounded up based on the calculation of the average demand over a 13-week period.

Based on the weekly sales data, when we round up the average weekly demand for each product and in the analysis of current inventory management system, we can calculate the average inventory level for each product, in Bangladesh Taka, to show the amount of hospital capital tied up in inventory. The higher the average inventory level, the more hospital capital tied up in inventory. Products with no demand, like VIRUX 500MG INJ, have no average inventory level. Those products might be categorized as item or discontinued item depend on its average inventory level value.

4. ANALYSIS OF THE PROPOSED INVENTORY MANAGEMENT SYSTEM

According to (Chopra, 2013), in continuous review policy, inventory is continuously tracked, and an order is placed when inventory depletes to the reorder point (ROP). In this scenario, size of an order does not change between the orders, but the time between orders may fluctuate due to demand variability. Therefore, several steps of calculation should be done to get the amount. The first step is calculating Economic Order Quantity, then Reorder Point, Safety Stock, and Average Inventory Level. From the calculation, average inventory level in ideal condition is obtained. All equations in this section are collected from(Chopra, 2013).

4.5.1 Economic Order Quantity Calculation

EOQ aims at balancing annual order cost and annual holding cost, thus minimizing total cost. Below are the equations related to economic order quantity:Q*: optimal order quantity (unit/order)

D: annual demand of product (unit/period), S: setup cost (price/order), h: holding cost as a fraction of product cost (price/unit period), C: product cost (price/unit), Q: lot size (unit/order).

In EOQ technique, product cost is not depending on the size of an order, so the material cost is formulated:

Annual Material Cost = C × D…………………………… (4.1)

Given annual demand (D) and lot size (Q), we can calculate number of orders that must be put by company in one year that formulated using Equation 2.

Number of Orders per Year = $\frac{D}{Q}$……….…………….. (4.2)

In EOQ technique, setup cost is incurred whenever company put an order, so the annual ordering cost is formulated.

Annual Ordering Cost = $\frac{D}{Q} \times S$…………….…….. (4.3)

Because lot size is denoted as Q, so the average inventory level that hold by pharmacy is Q/2 unit. While, the annual holding cost is the cost of keeping the inventory in the warehouse for one year. The keeping cost is usually stated as portion of unit cost, so the annual holding cost is formulated:

Annual Holding Cost = $\frac{Q}{2} \times h \times C$ ……………………… (4.4)

Then, annual total cost is the sum of annual material cost, annual ordering cost, and annual holding cost. The formula is shown below:

Annual Total Cost = $CD + \frac{D}{Q}s + \frac{Q}{2}hc$ ……………………. (4.5)

Optimal lot size is found when annual setup cost equals with annual holding cost:

$\frac{D}{Q}s = \frac{Q}{2}hc$ ……...…………………………………..…….. (4.6)

By taking Q to the left side, thus we get Q* as the optimal lot size:

Q* = $\sqrt{\frac{2DS}{hc}}$……………………..……………………… (4.7)

Table 03: Example of economic order quantity calculation for ten products

ITEM	Annual Average Demand (unit)	Price per Unit (BDT)	EOQ Result Calculation (Round Up)
AMBROX 15MG	488	40.43	311
MUCOSOL	1092	40	468
VIRUX 500MG INJ	Inactive	60	inactive
AMBOLYT 15MG	1840	40	607
BACTROCIN	1236	140	266
MONTENE 10	504	8	710
ASYNTA	1088	125.37	264
TICAMET	320	595	66
LYTEX 15MG	1640	50	513
BICOZIN I	556	50.2	298

4.5.2 Reorder Point (ROP) and Safety Stock Calculation

In the continues review policy, when inventory level in the warehouse already reach ROP, company should order a new lot size as much quantity result from EOQ. In the presence of demand uncertainty, management should consider safety stock, thus ROP is formulated as follow:

ROP = dL + SS ………………………………. (4.8)

Where,d: average demand per week (unit), L: lead time (period), SS: safety stock (unit).

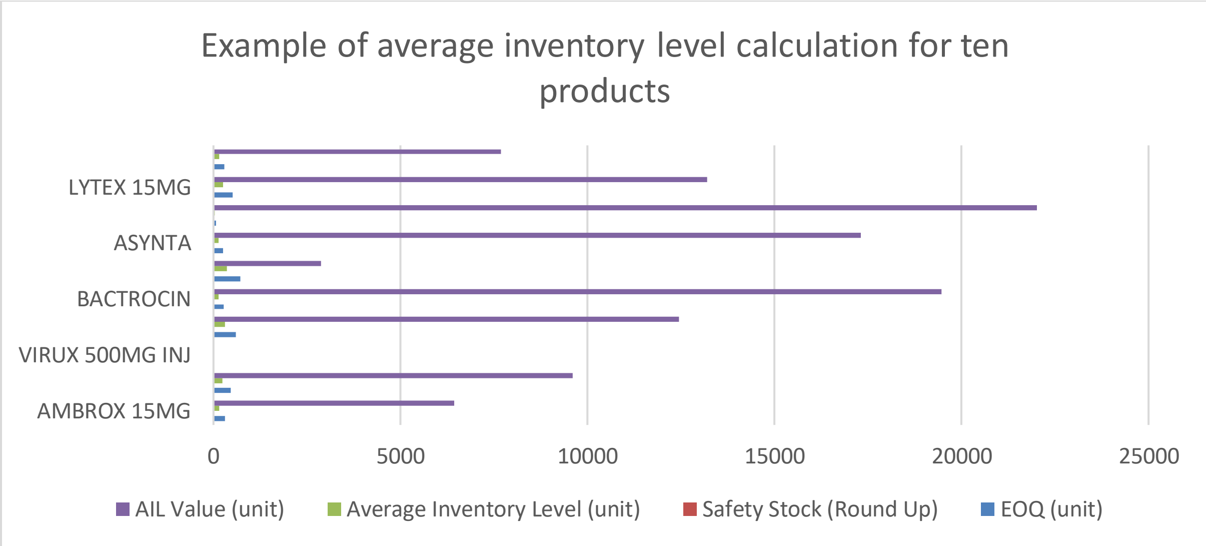
Then, safety stock is found by SS = $\sigma d \times \sqrt{L} \times z$ …………….…………….. (4.9)

Where, σ is standard deviation of demand, L is lead time, and Z is service level constant. To find Z, the authors need to determine how much customer service level (CSL), then applying ‘NORMSINV’ formula in excel to the CSL. Then, Safety Stock formula can be restated as:

SS = $\sigma d \times \sqrt{L} \times' NORMSINV'(CSL)$ ..…….. (4.10)

Average Inventory Level = $\frac{Q*}{2} + SS$………………. (4.11)

While, if it is stated in value BDT, so the formula is:Value AIL = AIL × Price per unit ……….……… (4.12)

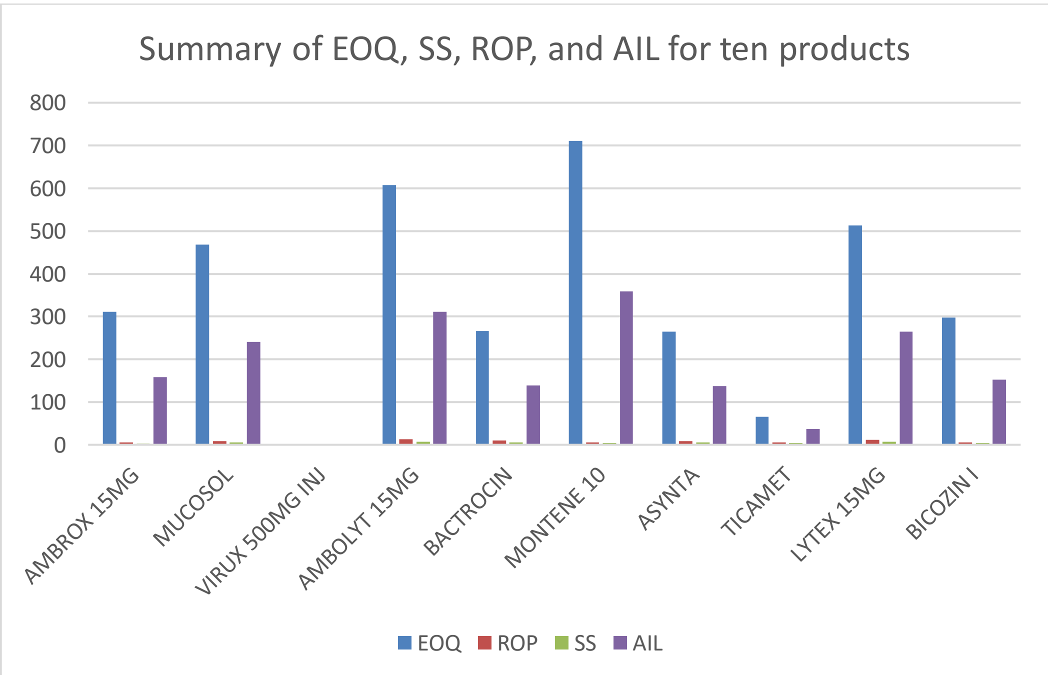


Graph: 01 Example of average inventory level calculation for ten products

We can see that some medicines have an EOQ and safety stock, while others are marked as inactive, indicating that they are not currently being ordered or stocked. The medicines with higher EOQ values generally have a higher AIL value, indicating that holding more inventory of these medicines will result in higher inventory holding costs.

For example, Ambrox 15mg has an EOQ of 311 units and an AIL value of 6428.37 per unit. This means that the optimal order quantity for Ambrox 15mg is 311 units and holding one unit of Ambrox 15mg in inventory for a year costs 6428.37 units. Similarly, Ticamet has a very low EOQ of only 66 units but has a high AIL value of 22015 units, which means that holding even a small quantity of Ticamet in inventory will result in high inventory holding costs.

Summary of EOQ, SS, ROP, and AIL calculation for ten products



Graph: 02: Summary of EOQ, SS, ROP, and AIL for ten products

After analyzing the outcome of the EOQ, SS, ROP and AIL, we have seen there is lowest amount of data in ROP and SS which consecutively from 5 to 13 highest value and 3 to 7 for SS.AIL holds the inventory in terms of money and changes when EOQ and SS change. Inaccurate EOQ, SS and ROP will result in higher AIL and cash flow tied up in the inventory. The inventory manager can effectively balance inventory costs with the risk of stockouts to ensure that an adequate level of inventory is maintained for each medicine. Effective inventory management can help ensure that the medicine is available when needed, while minimizing inventory holding costs and the risk of stockouts.

4.6 COMPARISON BETWEEN CURRENT INVENTORY MANAGEMENT SYSTEM AND PROPOSED INVENTORY MANAGEMENT SYSTEM

An item is considered understock if its inventory level is below the ideal level, overstock if it's above the ideal level, and acceptable if the difference is between 0-10%. A product is considered discontinued if there's no demand and inventory value.(Shim, 2007)

Table 4. 1: Comparison of ail value between current inventory policy with proposed inventory policy for ten products

ITEM	AIL Actual (BDT)	AIL Ideal (BDT)	GAP (BDT)	% GAP	Categories
AMBROX 15MG	16802	6428.37	10373.63	62%	Overstock
MUCOSOL	36697	9600	2389	74%	Overstock
VIRUX 500MG INJ	inactive	inactive	inactive	inactive	Discontinued
AMBOLYT 15MG	19299	12440	6859	36%	Overstock
BACTROCIN	10221	19460	-9239	-91%	Understock
MONTENE 10	2960	2872	4263	3%	Acceptable
ASYNTA	16631	17301.06	-670.06	-5%	Understock
TICAMET	66403	22015	4352	67%	Overstock
LYTEX 15MG	18854	13200	5654	30%	Overstock
BICOZIN I	1348	7680.6	-6332.6	-470%	Understock

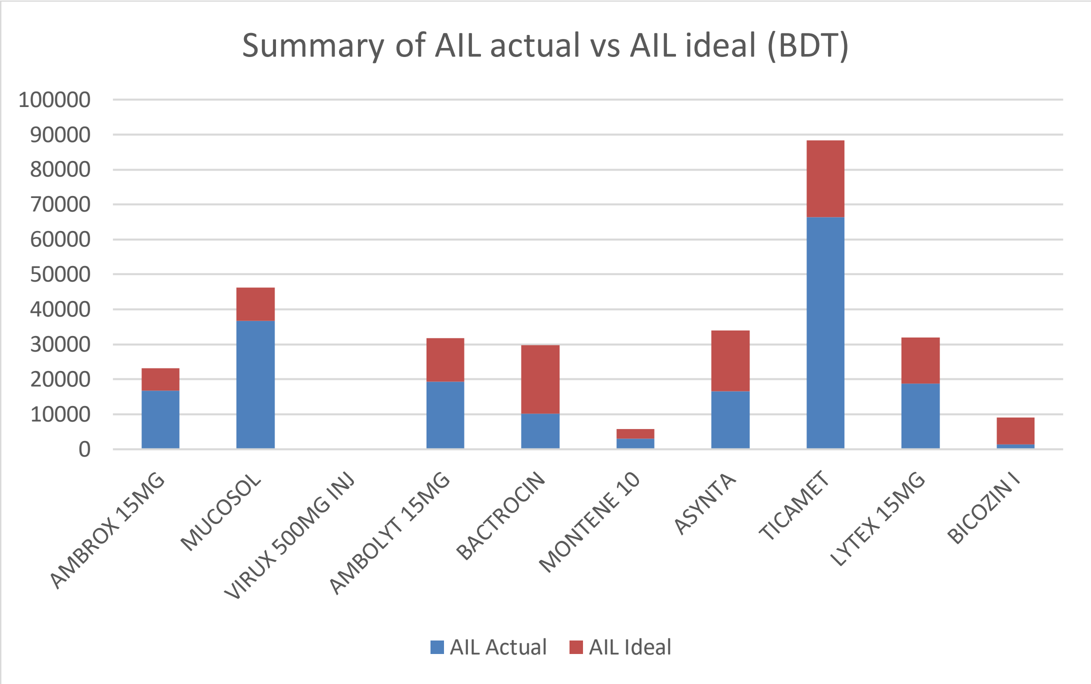


Fig: Summary of AIL actual vs AIL ideal (BDT)

The graph shows the inventory levels of various medicines in terms of their Average Inventory Level (AIL) in units and their corresponding values in Bangladeshi Taka (BDT). The AIL values for each item have been compared to their Ideal AIL values to identify whether the inventory is Overstock, Understock or Acceptable.The analysis of the table reveals that Ambrox 15mg and Mucosol have an Overstock situation, as their actual AIL values in BDT are significantly higher than their ideal AIL values, with percentage gaps of 62% and 74%, respectively. On the other hand, Bactrocin and Bicozin I are experiencing Understock situations, as their actual AIL values are lower than their ideal AIL values, with percentage gaps of -91% and -470%, respectively. As for Asynta and Montene 10, their actual AIL values are slightly lower than their ideal AIL values, with percentage gaps of -5% and 3%, respectively, indicating an Understock situation for Asynta and an Acceptable situation for Montene 10.Ticamet and Lytex 15mg have a slightly higher inventory level than ideal, with percentage gaps of 67% and 30%, respectively, which suggests an Overstock situation. Moreover, the medicine VIRUX 500MG INJ has been identified as discontinued, as all its inventory-related columns have been marked as inactive.In conclusion, the analysis of the medicine inventory table indicates that the ideal inventory levels have not been met for all medicines, which can result in financial losses due to Overstock or Understock situations. Therefore, appropriate inventory management strategies should be adopted to maintain optimal inventory levels for each item, and prevent any future losses.

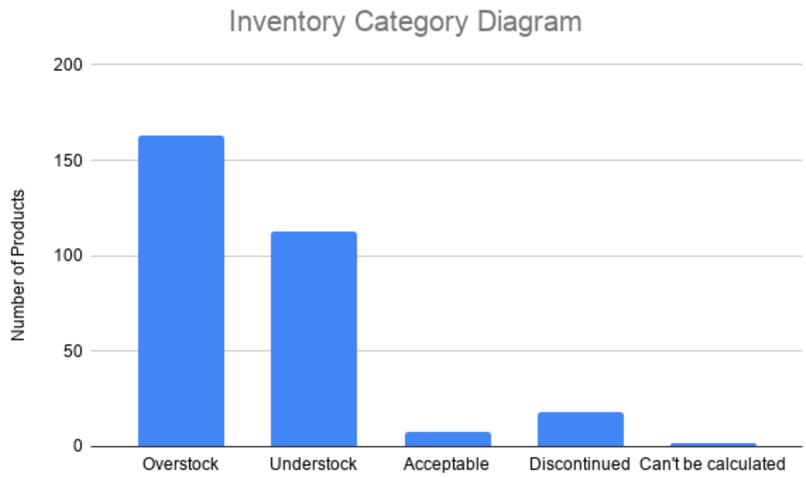


Figure 4. 1 : Inventory category diagram

Under current inventory management system, Sylhet Women's Medical College Hospital Pharmacy spent as much BDT 3,642,950 in the form of inventory. This value is excluded from 'cannot be calculated' inventory. But, in the ideal condition, hospital is expected to have inventory value in the warehouse as much BDT 3,398,991. Based on comparison of average inventory level, Sylhet Women's Medical College Hospital Pharmacy has money saving potential as much BDT 1,407,741 or (39%) Of the total actual inventory value from overstock item can be allocated to understock item that currently suffer shortage inventory as much BDT 1,168,580. Detail comparison is presented in Table 4.9

Table 4. 2 : Comparison of AIL value between actual and ideal condition based on inventory category

Categories	AIL (BDT)		
	Actual	Ideal	Gap
Overstock	2432179	1024438	1407741
Understock	1128173	2296752.58	-1168579.58
Acceptable	82598	77800.18	4797.82
Discontinued	-	-	-
Total AIL	3642950	3398990.76	243959.24

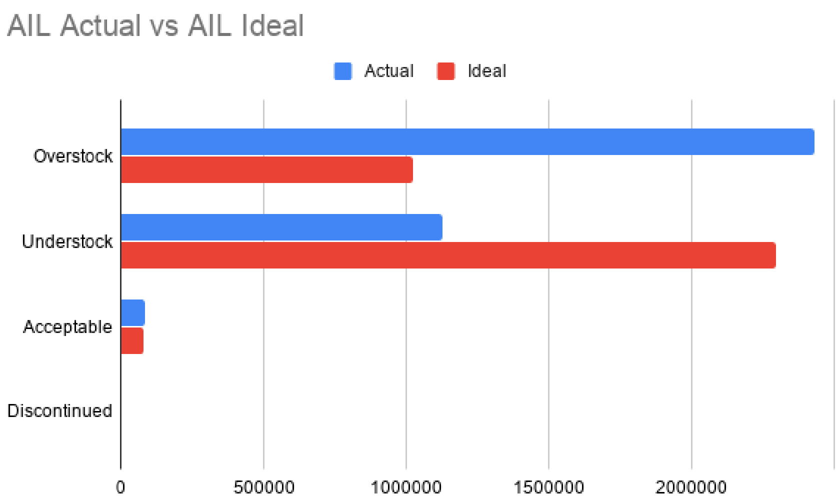


Figure 4. 2 : Value of money comparison based on inventory category

5. RESULTS AND DISCUSSIONS

We categorized inventory items into different types and showed the existing condition of the inventory items. We have sorted out the most valuable items and proposed an optimal level of inventory for the spare parts of the pharmacy.

Inventory Overstock, Understock, Discontinued, Applicable etc. items and their percentages are depicted in figure below.

5.1 CATEGORY OF ITEMS

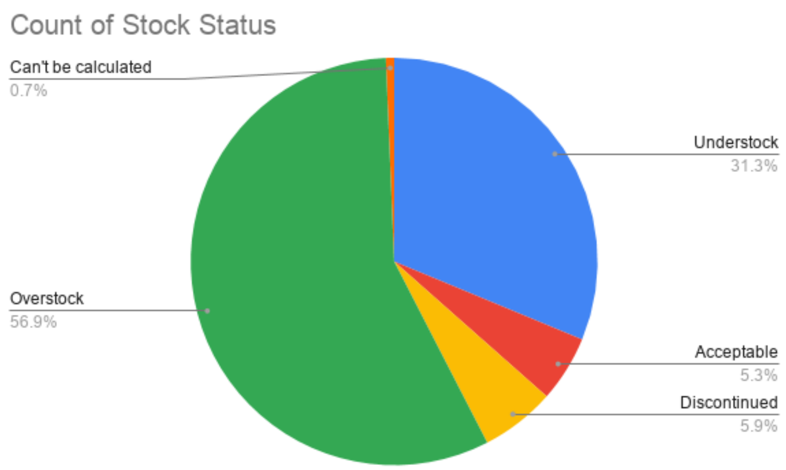


Figure 5. 1 : Percentages of product categories

Figure indicates that the main problem of Sylhet Women's Medical College Hospital Pharmacy is overstock. It means that this hospital is carrying too many inventories in the warehouse.

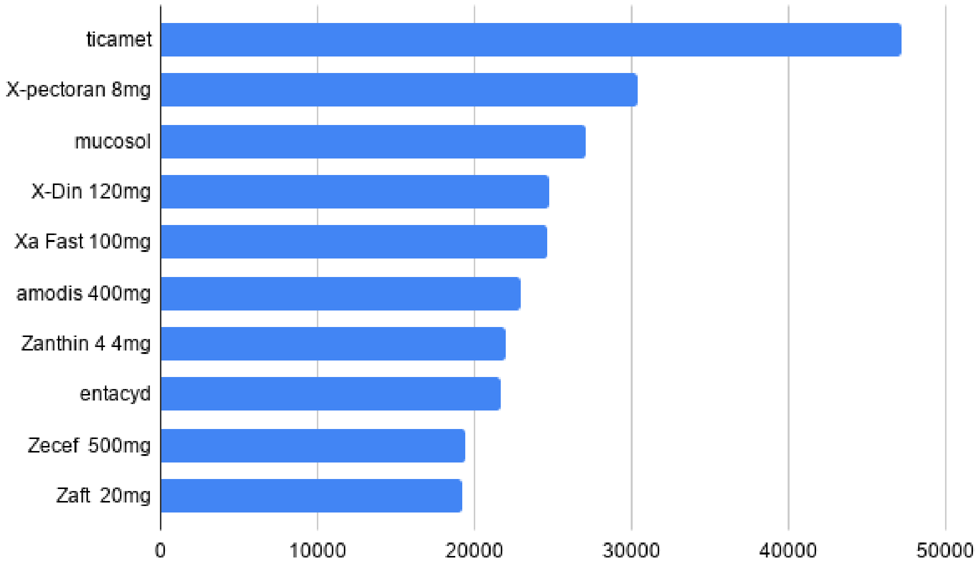


Figure 5. 2 : Ten highest gap of overstock value

The Figure represents the top ten pharmaceutical products with the highest gap in overstock average inventory level (AIL) between the actual condition and the ideal condition in Sylhet Women's Medical College Hospital Pharmacy. The inventory gaps indicate the excess stock value held for each product.

The product with the highest gap is TICAMET, which holds an excess inventory value of BDT 47,158. Following TICAMET is X-PECTORAN 8MG with an excess inventory value of BDT 27,097. Subsequently, MUCOSOL has an excess inventory value of BDT 24,704, X-DIN 120MG has an excess inventory value of BDT 24,643, and XA FAST 100MG has an excess inventory value of BDT 22,975.4.

Further down the list, AMODIS 400MG has an excess inventory value of BDT 22,012, ZANTHIN 4 4MG has an excess inventory value of BDT 21,667, ENTACYD has an excess inventory value of BDT 19,372.5, ZECEF 500MG has an excess inventory value of BDT 19,254, and ZAFT 20MG has an excess inventory value of BDT 19,085.

These findings suggest potential areas for improvement in inventory management to optimize stock levels and reduce excess inventory costs.

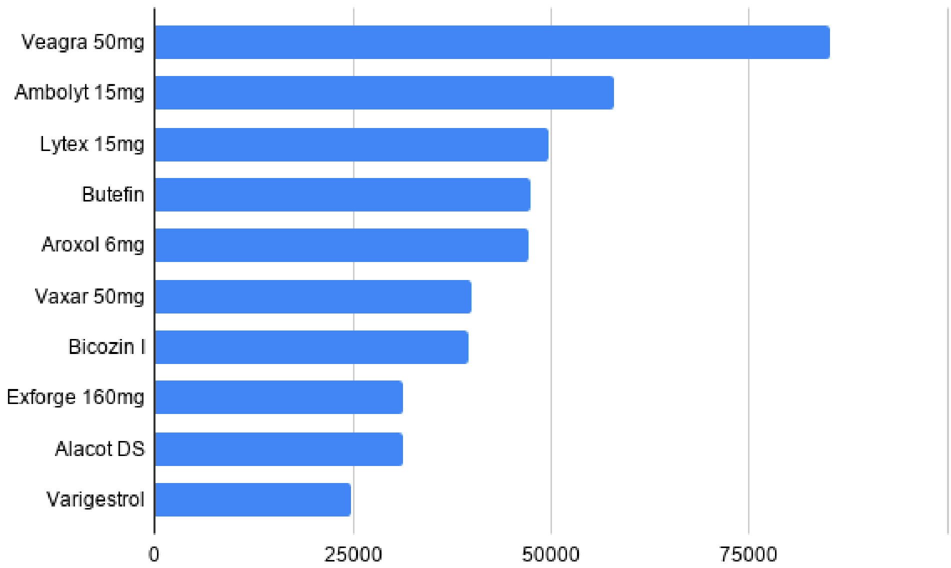


Figure 5. 3 : Ten highest gap of understock value

The Figure illustrates the top ten pharmaceutical products with the highest gap in understock average inventory level (AIL) between the actual condition and ideal condition at Sylhet Women's Medical College Hospital Pharmacy. The inventory gaps indicate the deficiency in stock value for each product.

The product with the highest understock gap is VEAGRA 50mg, which holds a deficit inventory value of -BDT 85,164 in the warehouse. Following VEAGRA 50mg is AMBOLYTE 15MG with a deficit inventory value of -BDT 57,975. Subsequently, LYTEX 15MG has a deficit inventory value of -BDT 49,595, BUTEFIN has a deficit inventory value of -BDT 47,393, and AROXOL 6MG has a deficit inventory value of -BDT 47,150.

Further down the list, VAXAR 50MG has a deficit inventory value of -BDT 39,907, BICOZIN I has a deficit inventory value of -BDT 39,470.45, EXFORGE 160MG has a deficit inventory value of -BDT 31,358, ALACOT DS has a deficit inventory value of -BDT 31,224, and VARIGESTROL has a deficit inventory value of -BDT 24,707.

5.2 ABC ANALYSIS

This technique categorizes pharmaceutical products into class A, B, or C based on their value. Class A products carry high value but low volume, class B products carry medium value and volume, and class C products carry low value but high volume. The authors use the actual average inventory level data for 304 pharmaceutical products and categorize them based on their inventory value. Class A should hold 80% of the total inventory value, class B should hold 15%, and class C should hold 5%.

Inventory Value = % of each class × Total Inventory Value ….………….(5.1)

The result of the ABC Classification based on inventory value is presented in Table 4.11.

Table 5. 1 : ABC classification based on inventory value

Class	Number of Items	Inventory Value (BDT)
A	43	26351178
B	100	6927643
C	141	385292

5.3 DEMAND FORECAST ON CATEGORY-A ITEMS

Table 5. 2 : Forecasts by applying selected methods

Week	Actual demand	Simple moving average (k=3)	Simple moving average (k=5)	Simple moving average (k=7)	Exponential smoothing for 0.3	Exponential smoothing for 0.5	Exponential smoothing for 0.8
1	177						
2	174				177	177	177
3	181				176.1	175.5	174.6
4	50	177.3333333			177.57	178.25	179.72

Week	Actual demand	Simple moving average (k=3)	Simple moving average (k=5)	Simple moving average (k=7)	Exponential smoothing for 0.3	Exponential smoothing for 0.5	Exponential smoothing for 0.8
5	174	135			139.299	114.125	75.944
6	195	135	151.2		149.7093	144.0625	154.3888
7	55	139.6666667	154.8		163.29651	169.53125	186.87776
8	185	141.3333333	131	143.7142857	130.807557	112.265625	81.375552
9	166	145	131.8	144.8571429	147.0652899	148.6328125	164.2751104
10	191	135.3333333	155	143.7142857	152.7457029	157.3164063	165.6550221
11	31	180.6666667	158.4	145.1428571	164.2219921	174.1582031	185.9310044
12	169	129.3333333	125.6	142.4285714	124.2553944	102.5791016	61.98620088
13	157	130.3333333	148.4	141.7142857	137.6787761	135.7895508	147.5972402

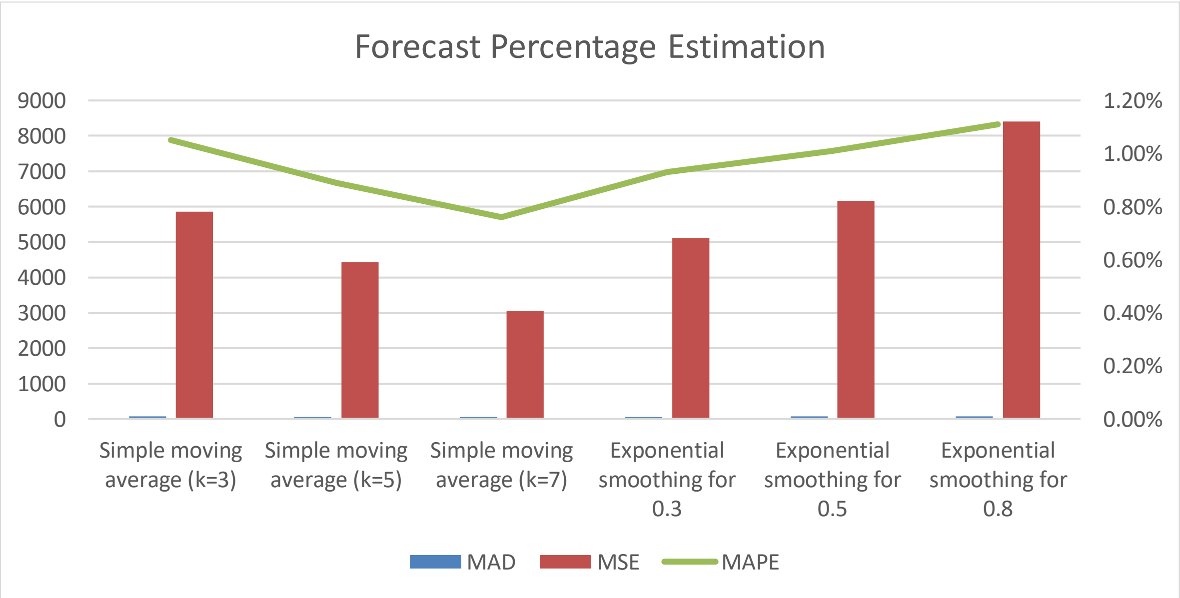


Fig: Forecast percentage error estimation

The methods considered are the simple moving average with three window sizes (k=3, k=5, k=7) and exponential smoothing with three smoothing factors (alpha=0.3, alpha=0.5, alpha=0.8).

The study uses a figure to visualize the forecast errors resulting from each method. Among the three-error metrics, MAD measures the average difference between the forecasted and actual values, regardless of direction. MSE calculates the average of the squared differences between the forecasted and actual values, while MAPE measures the average percentage difference between the forecasted and actual values.

After analyzing the forecast errors, it is observed that the simple moving average method with a window size of 7 exhibits the lowest MAD value of 44.29, indicating the highest accuracy among the methods. Similarly, the simple moving average with a window size of 5 demonstrates the lowest MSE value of 3059.29 and the lowest MAPE value of 0.76%, further supporting its superior accuracy.

In conclusion, based on the evaluation of these three-error metrics, the simple moving average method with a window size of 5 emerges as the most accurate approach for forecasting medicine inventory. This finding suggests that healthcare professionals and inventory managers can rely on this method to make more precise predictions, enabling effective inventory management and supply chain optimization.

The figure shows the forecast errors for a medicine inventory using different methods. The methods used are the simple moving average for three different window sizes (k=3, k=5, k=7) and exponential smoothing for three different smoothing factors (alpha=0.3, alpha=0.5, alpha=0.8). The forecast errors are measured using three metrics: Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE). MAD measures the average difference between the forecasted values and the actual values, regardless of direction. The smaller the MAD value, the more accurate the forecast. In this case, the simple moving average with a window size of 7 has the lowest MAD value of 44.29, indicating that it is the most accurate method.

MSE measures the average of the squared differences between the forecasted values and the actual values. The smaller the MSE value, the more accurate the forecast. In this case, the simple moving average with a window size of 5 has the lowest MSE value of 3059.29, indicating that it is the most accurate method.MAPE measures the average percentage difference between the forecasted values and the actual values. The smaller the MAPE value, the more accurate the forecast. In this case, the simple moving average with a window size of 5 has the lowest MAPE value of 0.76%, indicating that it is the most accurate method.Overall, the simple moving average method with a window size of 5 is the most accurate for this medicine inventory forecast, based on the three-error metrics used.

5.4 CYCLE COUNTING

When it comes to maintaining accurate inventory records, companies can employ two techniques: annual physical inventory and Cycle Counting(Associates, 1999). According to existing literature, Cycle Counting is a more favorable approach compared to annual physical inventory control. One of the primary reasons for this preference is that Cycle Counting utilizes an automated recording process, resulting in higher accuracy. To determine the counting schedule throughout the year, Cycle Counting employs the ABC Classification method.

The ABC Classification method categorizes pharmaceutical products into three classes: A, B, and C. Each class requires a different level of attention and control, based on inventory value and item quantity.

- Class A: Pharmaceutical products falling into this category possess high inventory value but have a smaller number of items. Consequently, these items require heightened regulation and control from management. Regular inventory checks are recommended, such as once a month, to ensure accuracy in record-keeping.
- Class B: Products in Class B do not possess as much inventory value as those in Class A, and the number of items is also relatively higher. Therefore, management should provide moderate attention and control to Class B items. Inventory checks can be conducted less frequently, such as once a quarter.
- Class C: Pharmaceutical products in Class C have low inventory value but are present in large quantities. As a result, management should exercise flexible regulation and control over these items. Inventory checks can be less frequent, perhaps once per semester.

Table 5. 3 : Cycle counting for ABC classification based on inventory value

Item Class	Quantity	Scheduling Policy	Daily Checked Item (Round Up)
A	43	Each month (25 working days)	2
B	100	Each quarter (75 working days)	2
C	141	Each semester (150 working days)	1

6. CONCLUSION

6.1 Conclusion

The study identified a prevalent issue of excess inventory in the pharmacy, primarily attributed to the absence of a reliable inventory control policy. In light of these findings, the authors propose several recommendations for improving inventory management within the pharmaceutical logistics division. These recommendations include the implementation of a continuous review policy, utilization of the Cycle Counting record accuracy technique, adjustment of optimal order quantities in the presence of minimum order quantities, and provision of training for the pharmaceutical logistics division to enhance their inventory management skills. It is important to note that the scope of this research is limited to pharmaceutical products and consumable items within the specified time frame and data availability.

The analyses conducted yielded the following noteworthy points: Firstly, out of the total 304 types of pharmaceutical products examined, 163 (53.6%) were found to have excessive inventory, while 113 (37.20%) experienced shortages. Additionally, 8 (2.6%) products were classified as acceptable, 18 (5.90%) were discontinued, and 2 (0.7%) could not be classified. Secondly, the proposed inventory policy, namely the continuous review policy, was found to have significant cost-saving potential for Sylhet Women's Medical College Hospital Pharmacy, estimated at BDT 28525203. Finally, to enhance productivity and efficiency, the pharmacy is advised to prioritize record accuracy in its inventory control processes. Maintaining highly accurate inventory records can yield various positive impacts, including improved customer service levels, reduced costs, and increased productivity. In light of the research findings, the authors suggest that Sylhet Women's Medical College Hospital Pharmacy adopts Cycle Counting as their preferred inventory record accuracy technique, as it has been evaluated by REM Associates (1999) as the most efficient method in this regard.

6.2 LIMITATIONS

This research specifically focuses on analyzing pharmaceutical products and consumable items within the inventory of Sylhet Women's Medical College Hospital Pharmacy. The scope of the study is as follows:

1. Pharmaceutical products are defined as drugs, medicines, or other substances utilized by physicians or medical professionals to cure, treat, and heal patients from diseases or injuries.
2. Consumable medical equipment refers to non-durable supplies, equipment, and items that are disposable in nature and cannot be reused by more than one individual. These items primarily serve medical purposes and can be ordered and prescribed by physicians.
3. The research does not take into account the minimum order quantity and quantity discount factors when calculating the optimal order quantity. This omission is due to limited data resources availability.
4. Data collection was conducted within a limited timeframe, specifically from January 2018 to March 2018. This timeframe was determined based on the data provided by Sylhet Women's Medical College Hospital Pharmacy.

Furthermore, in accordance with Chopra and Meindl (2013), the economic order quantity model suggests that the total costs incurred within the supply chain remain relatively stable. As a result, companies may place orders for quantities that are slightly different from the exact calculation of the economic order quantity. Consequently, significant variations in demand for patient-specific medications over the course of a year have a limited impact on the total cost derived from the economic order quantity calculation.

6.3 RECOMMENDATIONS

In order to optimize inventory management and enhance the customer service level, the authors propose several recommendations for Sylhet Women's Medical College Hospital Pharmacy based on the findings of this study. These recommendations are as follows:

1. Replacing the current inventory management system with a continuous review policy: The implementation of a continuous review policy allows for a more proactive approach to inventory management, enabling the pharmacy to monitor stock levels and reorder as necessary, thereby achieving a better balance between inventory investment and customer service.
2. Adjusting the optimal order quantity in the presence of a minimum order quantity: When a minimum order quantity is applicable, it is suggested that Sylhet Women's Medical College Hospital Pharmacy has the flexibility to modify the optimal order quantity derived from the economic order quantity (EOQ) calculation. This adjustment can be made based on the understanding that, according to the economic order quantity model, the total cost incurred in the supply chain tends to remain relatively stable.
3. Utilizing the Cycle Counting record accuracy technique: By employing the Cycle Counting technique, the pharmacy can enhance the accuracy of its inventory records. This involves checking pharmaceutical products on a daily basis to avoid inaccuracies in the recording process.
4. Conducting training programs for personnel in the pharmaceutical logistics division: It is recommended that the pharmacy organizes training sessions to improve the inventory management skills of individuals working in the pharmaceutical logistics division. This training program aims to enhance their knowledge and capabilities in effectively managing pharmaceutical products inventory.

These recommendations serve as valuable feedback for Sylhet Women's Medical College Hospital Pharmacy, aiding them in better managing their inventory and achieving the desired balance between inventory investment and customer service level.

References

Aspden, P., Wolcott, J. A., Bootman, J. L., & Cronenwett, L. R. (2006). Preventing Medication Errors: Quality Chasm Series. Washington DC: Institute of Medicine.

Burns, L. (2002). The Healthcare Value Chain. San Fransisco: Jossey-Bass.

Capkun, V., Hameri, A., & Weiss, a. L. (2009). On the Relationship Between Inventory and Financial Performance in Manufacturing Companies. International Journal of Operations & Production Management, 29 (8), 789- 806.

Chambers, D., & Lacey, N. (2011). Modern Corporate Finance, Sixth Edition. Michigan: Hayden McNeil Publishing.

Chen, M., Frank, M., & Wu, O. (2005). What Actually Happened to the Inventories of American Companies Between 1981 and 2000? Management Science.

Chopra, S., & Meindl, P. (2013). Supply Chain Management: Strategy, Planning, and Operation. London: Pearson.

Desselle, S., & Zgarrick, D. (2009). Purchasing and Inventory Management. New York: McGraw-Hill.

Dias, V. (2011). Inventory Management. In I. Management Sciences for Health. Managing Access to Medicines and Health Technologies, 1-24.

Edwards, R. (2011). In Struggle to Cut Expenses, Hospitals Eye the Pharmacy. Hospitals & Health Networks, 28-32.

Federal Accounting Standard Board. (1993). Accounting for Inventory and Related Property. Washington DC: Office of Management and Budget.

Gebicki, M., Mooney, E., Chen, S.-J., & Mazur, L. M. (2013). Evaluation of Hospital Medication Inventory Policies. Health Care Management Science, 17: 215– 229.

Gonzales, J., & Gonzales, D. (2010). Analysis of an Economic Order Quantity and Reorder Point Inventory Control Model for Company. Working Paper.

Gupta, S., & Gupta, S. (2012). Effective Inventory Visibility- Its Impact on Profitability. International Indexed & Referred Research Journal, 4 (39), 59- 60.

Hafnika, F., Farmaciawaty, D. A., Adhiutama, A., & Basri, M. H. (2016). Improvement of Inventory Control Using Continuous Review Policy in A Local Hospital at Bandung City, Indonesia. The Asian Journal of Technology Management, 2: 109-119.

Institute of Medicine. (2005). Building a Better Delivery System: a New Engineering/Heath Care Partnership. Washington DC.

International Pharmaceutical Federation. (2012). Good Pharmacy Practice. Netherland.

Kamani, P. (2004). Hospital Supply Chain Savings. San Francisco: Montgomery Research Inc.

Kim, D. (2005). An Integrated Supply Chain Management System: a Case Study in Healthcare Sector. International Conference on Electronic Commerce and Web Technologies.

Kontus, E. (2014). Management of Inventory in a Company. Business and Management, 245-256.

Kotler, P. (2000). Marketing Management Millenium Edition. Boston: Prentice-Hall Inc.

Little, J., & Coughlan, B. (2008). Optimal Inventory Policy within Hospital Space Constraints . Health Care Management Science, 11(2); 177 –183.

Ma, J., & Lei, T. (2013). EOQ-based Inventory Control Policies for Perishable Items: The Case of Blood Plasma Inventory Management. Industrial and Systems Engineering Research Conference.

McKone-Sweet, K., Hamilton, P., & Willis, S. (2005). The Ailing Healthcare Supply Chain: a Prescription for Change. Supply Chain Management, 41: 4-17.

Mittal, S., Mittal, R., Gagandeep, S., & Gupta, S. (2014). Inventory Management in Fertilizer Industry of India: An Empirical Analysis . Journal of Management Research and Innovation, 291–303.

O'Neal, B., Worden, J., & Couldry, R. (2007). "Innovations in Chemotherapy Preparation Safety: Use of Telepharmacy and Barcode Technology in the IV Admixture Area". Heallth-System Pharmacy.

Pedersen, C., Schneider, P., & Scheckelhoff, D. (2009). ASHP National Survey of Pharmacy Practice in Hospital Settings: Dispensing and Administration— 2008. Am J Health-Syst Pharm 66.

Phelan, B., & Pons, M. (2005). Maximizing your Profits with Pharmacy Control Strategies. Economics/Practice Management, 498-500.

Rachmania, I. N., & Basri, M. H. (2013). Pharmaceutical Inventory Management Issues in Hospital Supply Chains. Management, 1: 1-5.

REM Associates. (1999). Inventory Cycle Counting. Princeton.

Romero, A. (2013). Managing Medicines in the Hospital Pharmacy: Logistics Inefficiencies. World Congress on Engineering and Computer Science. San Francisco, USA.

Rossetti, M. D. (2008). Inventory Management Issues in Health Care Supply Chains.

Saunders, M., Lewis, P., & Thornhill, A. (2007). Research Methods for Business Students: Fourth Edition. London: Pearson Education.

Shardeo, V. (2015). Impact of Inventory Management on the Financial Performance of the firm. Business and Management, 1-12.

Shim, J., & Siegel, J. (2007). Financial Management. New York: McGraw Hill.

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2002). Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies. Burr Ridge: McGraw-Hill.

Zipkin, P. (2000). Foundations of Inventory Management. New York: McGraw Hill.