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Evaluation of Different Stock Control Models for a Medium-Scale Pharmaceutical Drug Enterprise to Reduce Annual Inventory Related Cost

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Abstract: *Inventory control is a critical aspect in an operation of a pharmaceutical drugstore and an inefficient management of the enterprise's inventory might result to serious loss of firm's profit. Inventory control is a critical aspect in an operation of a pharmaceutical drugstore and an inefficient management of the enterprise's inventory might result to serious loss of firm's profit. Poor inventory management has greater impact on the operations of small to medium-scale enterprises and it is evident when the firm experiences stock outs and high volume of obsolete or expired drug items. The most common inventory control among small and medium-scale pharmaceutical drugstores is the eyeball system in which the firms are likely to have above normal level of inventory and chances of having shortages on other drug items. On the other hand, there are predetermined inventory control models which might help resolve these problems and to minimize the firm's annual inventory related cost. The firm's problem now is how to identify which inventory management models best fit to their operations and needs. The current study aims to develop a systematic way of managing numbers of drug items and at the same time minimizing the total annual inventory cost through evaluation of the effectiveness of existing stock control models to a medium scale pharmaceutical drugstore. This may serve as basis for policy making related to efficiently managing the inventory of drug items and an effective strategy in improving the firm's overall operations.*

Keywords: *Inventory Control, Operations Research, Drugstore, Inventory Models, Re-order Point*

1. INTRODUCTION

Inventory management and control have always been a big part of operations research. For the past decades, many cases in different industries and other firms were given the optimal solutions to complex inventory – related problems. Management scientists insist the need and importance of an excellent inventory management since it answers all necessary questions regarding the supply of materials, including as well all kinds of cost [1]. In a pharmaceutical drugstore setting, inventory decisions are so essential since no other asset has the potential to ravage the enterprise as much as appallingly controlled inventory. Moreover, a study made by Fredaric (2016) stated that pharmacy's inventory represents its single largest investment [2]. An efficient inventory management plays a vital role in the practice of any kinds of drugstore since it covers both financial and operational perspectives. Inventory decisions must involve a delicate balance since too much stock translates to too little cash and, oftentimes to less profitability. Conversely, too low inventory can mean lost sales [3].

Handling and managing numerous types of drug is a complex situation for pharmaceutical drugstores and often face multiple issues related to inventory control such as stock shortage and stock piling in which both cases have tremendous effect on the inventory cost of all drugs [4]. Also, poor inventory management may result to inefficient use of financial resources, shortage or overage of some medicines resulting in expiration and increase in holding cost, as well as decline in quality of service once the drug needed by a customer was not provided [5]. These situations may negatively influence productivity and customers' satisfaction.

Hence, the proponents conduct a system analysis on a community drugstore and develop a methodology for effective inventory management that can be applied to similar drug enterprises. The main purpose of the study is to minimize the costs involved in the inventory of over the counter drug items and prescription medicines.

Community Drugstore XYZ's inventory management uses eyeball system as standard control practice in handling inventory of pharmaceutical drug items. A weekly order is made for drug items that are needed by the drugstore to replenish the few remaining stock or for some instances, refill items with zero stock. Since it heavily relies on the actions of the workers, drug items are prone to stock out for some time before anyone notices. Laeiddee (2010) explained that shortage cost due to unavailability of drug items negatively strikes a pharmaceutical enterprise since it is the value of losing all customers' future purchases or, in the case of life-saving emergency drugs, of causing physical harm to the patient [6]. Likewise, difficulties involving expired medicines due to vast pile of drug items indicated the gravity of poor supervision and control related problem associated with the inventory cost. Due to the vagueness of the eyeball system, unnecessary costs are made since there is no definite framework with ordering guidelines leading to detrimental financial status. The table below shows the total annual inventory cost of present system excluding cost of obsolete drugs (see Table 1).

Table 1: *Margin specifications*

Particulars	***Cost (Php)***
Pharmaceutical Acquisition Cost	9,511,069.74
Ordering Cost	14, 040.00
Holding Cost	480,000.00
Total Annual Inventory Cost	10,005,109.74

Inventory of small to medium scale drugstore in the Philippines can be anywhere from Php100, 000.00 to Php10, 000,000.00 for a full stock yearly. Based on the stock report of the company using an eyeball system, it shows that approximately 94% of the medicine stocks equivalent to Php8, 941,503.87 are sold for the whole year and 4% holds for drug items that are still good for sale. On the other hand, 2% of the stocks amounting to Php188, 352.35 are considered obsolete drugs and are no longer good for sale. Mashishi (2015) stated that for a pharmaceutical enterprise, 0.05% would be the acceptable maximum value of drugs to expire in which the percentage of obsolete stock equivalent to 2% is above by 1.95% [7].

Drug store management should always ensure that medicines be supplied at the right time and at the same time avoiding wastage due to unwanted costs. This would be beneficial to Community Drugstore XYZ and other similar establishments since inventory of medicine is always on their top priority and managing innumerable types of drug seems to be a problem needing supplemental assistance. In addition, this will also benefit the consumers who are in need of proper medicines to be bestowed to them at the right time. Moreover, this research study is valuable since the Department of Health together with Philippine Pharmacists Association is striving to seek for advantageous inventory management practice since small to medium scale drugstores are growing in numbers and it covers 26% of the overall pharmaceutical enterprises [8]. This research aims to develop a methodology that can be adapted and can be generalized for all drugstore institutions in alignment with minimizing the total cost of drug inventory in which all pharmaceutical stores are aiming to along with providing quality service to all their customers.

In relation to this, this study generally aimed to analyze the cost involved in the stock management of over the counter and prescription drugs and with this given information develop a system of methods in line with minimizing the total annual cost of inventory. Specifically, the study intends to:

• Decrease the level of stock- outs and stockpile of pharmaceutical drug items

• Identify and assess the most appropriate inventory management practice

The subject of the study is a pharmaceutical drugstore providing a wide range of over the counter and prescription drugs. This research will cover all drugs in the community drugstore's database.

2. REVIEW OF RELATED LITERATURE

Acquiring inventory requires knowing the correct quality and amount to purchase, when to arrange, at what cost, and from what sources. Marx (2018) points that inventory control is essential to keep the right balance of stock in any establishments. When an establishment has control over the stocks, then it is can give better customer satisfaction [3]. Monitoring the amount spend of the company in stock can affect the financial aspects of the business.

A number of studies had shown interest concerning the inventory management of pharmaceutical drugs. An inventory grouping strategy namely the ABC- VED analysis had been widely used in different researches as to provide an in- depth understanding of which among the multitude of drugs require stringent control. A study made by Ceylan et al. (2017) in Istanbul, Turkey has implemented this drug categorization technique in able to classify the drugs based on economic and criticality as to determine which requires strict managerial control [9]. In like manner, several authors have adopted the same method in categorizing a mass of drugs into three (3) groups after combined matrix analysis [10][11] [12] [13][14]. Table 2 shows the collation of results involving the category of drugs under ABC and VED analysis in several literature studies. The summary includes the percentage of drugs concerning the total annual drug expenditure in the form of category A, B, & C as well as the descriptive assessment of drugs labeled as vital, essential, and desirable.

Table 2: *Total Annual Drug Expenditure (%) Summary in Several Literature Studies*

Analysis	Category	Literature Studies						
		Ceylan & Bulkan, 2017	Singh et al., 2015	Kumar & Chakravarty, 2015	Chhillar et al., 2013	Anard et al., 2013	Mahatme et al., 2012	Devnani et al., 2010
ABC Analysis	A	10.31	11.08	6.77	3.45	18.60	15.00	13.78
	B	21.78	22.16	19.27	6.49	24.00	30.00	21.85
	C	67.91	66.75	73.95	89.65	57.40	55.00	64.37
VED Analysis	V	10.76	12.40	13.14	32.41	13.20	14.55	12.11
	E	45.49	60.16	56.37	61.38	38.80	18.18	59.38
	D	43.75	27.44	30.49	6.20	48.00	67.27	28.51

Effective control cannot be accomplished by using only the combined matrix analysis of both grouping strategies and it is highly suggested for future researchers to consider other inventory models. A study made by Wang (2009) used a three-phase method involving the demand and forecast accuracy of the drugs, ABC grouping strategy, and the use of an inventory model. Some studies adopted the use of Economic Order Quantity (EOQ) as their means of identifying the optimal order quantity[15]. Trailokyanath et al. (2017) reported that the optimal cycle time and the optimal order quantity has been derived using this model [16]. Additionally, Agada et al. (2017) proved that this model can identify the optimal order needed for the inventory system [17]. Madhukar & Pankaj (2012) also pointed out that this model showed the optimal inventory cost for continuously deteriorating goods[18]. Likewise, a model based on the same theory as EOQ namely the Period Order Quantity (POQ) can be beneficial to minimize total cost of ordering and carrying inventory. In addition, Kalpana (2016) introduced four inventory control techniques namely the ABC analysis and Economic Order Quantity (EOQ), which were aforementioned a while ago, along with minimum safety stock and re-order point[19]. On the other hand, Bhathavala & Rathod (2012) utilized two formulas namely the retroactive holding cost decrease and stepwise holding cost decrease and results testified that these two formulas may be used to identify the minimum inventory holding cost [20]. Another study conducted by Kulkarni & Rajhans (2013) emphasized that Wagner-Whitin algorithm model gives minimum total annual inventory cost of drug items and the use of this technique proved to provide optimum results[21]. Discrete order quantity model is suitable in case of large holding costs and low ordering costs and this technique indicates that items are purchased in the exact quantities required for each period. The inventory project in pharmacy made by Academy for Excellence in Healthcare (2014), Pareto analysis had been used as the approach in improving the inventory management at Genesis Heath Care System Pharmacies[22]. Results of the study reported that among three thousand (3000) plus total number of drugs, twenty- six 26 drugs contributed to almost 50% of their spending and these drugs are primarily the highest-cost. The 80/20 approach reduced the inventory cost of about $346,000.

In line with improving inventory accuracy, some studies embraced the use of radio frequency identification (RFID). This method undeniably shows more accuracy compared to physical inventory of supplies and in effect reduced the inventory time and cost needed[23]. Conversely, Zhang et al. (2011) used the inventory visibility approach that could reduce error while doing manual inventory and improve the stocking system of supplies[24].

On the other hand, a study made by Kumar et al. (2015) wanted to improve medical stores management through automation and effective communication with the use of Iterative Six Step Quality Improvement (QI) [11]. This study revealed that as a result of effective communication, it lessens the expired medicines due to their communication between suppliers and pharmacy.

A study concerning all antibiotics crucial at intensive care units wherein an optimization model with re-order point was used to strictly place an order just in time. After the optimization process, drugs were monitored strictly and order events had taken place to satisfy the demand of all the set of antibiotics [25].

An analytical- cross sectional study was done to improve the re- order point of drug inventory at Ramathibodi Hospital. This study revealed that the total cost of drug accounts to more than two million Bath and the application of inventory model can improve the efficiency of drug purchasing in the said establishment [6].

In the Philippines, a study was carried out to enhance the pharmaceutical inventory control of Malijan Diabetes Center (MDC) using descriptive research design. The researchers incorporated the use of SWOT analysis and results revealed weaknesses of the current system. Close supervision with accounting forms of data is needed to improve the current inventory system of Malijan Diabetes Center [26].

3. METHODOLOGY

The study has a case study research design and focuses on the assessment and deter-mining the best inventory management and control model in order to reduce the total inventory cost. High inventory cost is mostly due to excess amount of obsolete medicines and the presence of opportunity lost in case of stock-out. The primary subject of the study is a Community Drugstore XYZ that caters different medicines listed on the Philippine National Formulary (PNF) by the pharmaceutical division of Department of Health.

3.1 Phase 1- Identifying Inventory Management and Control Model for Evaluation

The first phase involves reviewing related literature to find relevant models and in-struments with high reliability and validity for adaptation. This phase is essential in evaluating the strengths and weaknesses of each inventory models under different conditions. Inventory management and control models under evaluation are ABC-VED Analysis, Economic Order Quantity (EOQ), Period Order Quantity (POQ), Direct Order Quantity (DOQ), and Wagner-Whitin Algorithm.

3.2 Phase 2 – Data Gathering

The second phase involves data collection for different variables necessary to evaluate inventory models. These variables include demand (D), ordering cost (C_o), holding cost (H), lead-time (L), annual drug expenditure (A_e), criticality of drug (C_r) and number of order (N). All pertinent information and historical data of each medicine are collected through documentary analysis on the subject pharmaceutical drugstore.

3.3 Phase 3 – Matrix Analysis

Drug items are then analyzed using combined matrix analysis of both ABC and VEL grouping strategy. Table

3 shows the cross-tabulation of these two drug classification techniques.

Table 3. *Cross Tabulation of ABC and VEL Analysis*

ABC \ VEL	V	E	L
A	AV	AE	AL
B	BV	BE	BL
C	CV	CE	CL

The resultant combinations are classified into three categories. Category I are those drugs belonging to AV, AE, AL, BV, and CV in which these items require strict managerial control since these are either fast moving or vital. Meanwhile, category II is constituted by items under BE, CE, and BL and these drugs are medium moving essential and less essential items hence requiring control and supervision at the middle managerial level. The remaining CL subcategory is under category III and these drugs are either slow moving or less essential items.

3.4 Phase 4 – Application of Inventory Models

Data of all drug items are subjected to analysis to different inventory models in order to determine the information like the optimum quantity to be ordered. The results derived from different inventory management models help to identify recommendation for cost reduction of drug items management. Different assumptions in using probabilistic model are based on the historical data patterns in which the daily demand of pharmaceutical drug items are assumed to be variable and the lead time for each placement to receiving of orders are said to be constant. This phase calculate the quantity of each drug that would trigger the placement of an order for additional units whereas the enterprise can prevent stock outs and backorders incidents. Economical comparison of the results obtained from different inventory models provides the most appropriate inventory management model for a small-scale pharmaceutical drug store.

4. RESULTS AND DISCUSSION

Initially, the study identifies number of verified and validated inventory management tools that are used to control and monitor a vast quantity of pharmaceutical drug items. Examining the data accumulated using product management and control techniques involves both quantitative (cost) and qualitative (criticality) analysis of all pharmaceutical drug items. The figure below shows the diagram of the inventory management tool set.

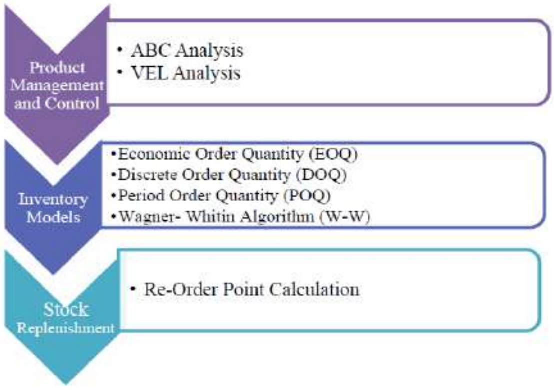

Figure 1. *Inventory Management Tools*

4.1 ABC Analysis

ABC analysis is a significant and well- known analytical tool in inventory management [9] [10] [11] 12] [13] [14]. This grouping strategy divides the item into three classes as A, B, and C that can be managed and controlled separately. Class A items consume the 70% of the annual drug expenditure of the company and needs to be under strict control of the higher management. On the other hand, Class B items are the interclass drug products which account the other 20% of the annual drug expenditure and the remaining 10% are included on Class C items.

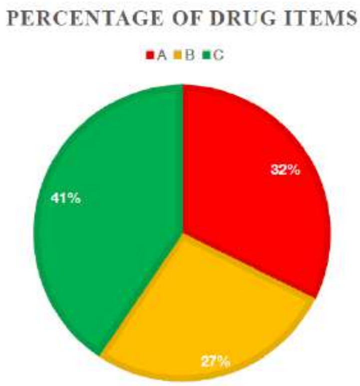

Figure 2. *ABC Analysis Results*

This inventory grouping strategy revealed that 32.29% of all the drug items are in Class A wherein these products require stringent managerial control since it compromises the 70% of annual drug outlay. Moreover, 96 Class B items constituted the other 20% of total annual drug expenses. Meanwhile, about 40.51% of the drug population is included in category C. All pharmaceutical drug items are grouped based on the price and purchased drug items for an entire year.

4.2 Vital, Essential and Less Essential (VEL) Analysis

The degree of criticality of each pharmaceutical drug items can be analyzed and classified upon their functional basis. This inventory grouping strategy is based on priority and importance and it divides the medicine list into three categories as Vital (V), Essential (E), and Less Essential (L). The Philippine National

Drug Formulary (PNDF) made a guideline for medicine classification (see Table 4) and the qualitative ratings for each medicine are founded on three (3) principal characteristics.

Table 4 *Benchmark for Drug Classification*

Attributes of Individual Drugs	Vital (V)	Essential (E)	Less Essential (L)
1. Occurrence of Target Conditions			
Persons affected (0% of population)	> 5%	1-5%	<1%
Persons Diagnosed (cases/ 100,000 pop/ year)	>100	50-100	<50
Persons Treated (frequency)	Moderate	Low	Very Low
2. Severity of Target Conditions			
Life threatening	Possibly	Infrequently	Rarely
Chronic	Possibly	Infrequently	Rarely
Disabling	Possibly	Infrequently	Rarely
Restricting	Frequently	Occasionally	Infrequently
3. Therapeutic Effects			
Drug Action	Prevention of Disease	Cure of Disease	Relief and/or mitigation of self-limited disease
	Cure of Disease	Prevention of complication	Palliative treatment of minor symptoms and complications
	Prevention of Complication		

(Philippine National Drug Formulary, 2017)

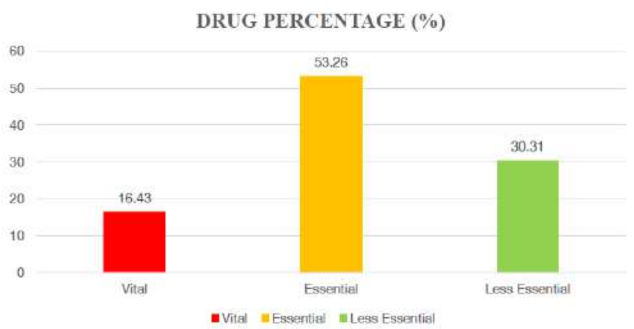

Figure 3. *VEL Analysis Result*

Figure 3 revealed that around 16.43% of the drug population consisted of prescription drugs used to prevent and cure diseases and complications like commonly known antibiotics, and tuberculosis drug items. In addition, about 53.26% of the total annual drug expenditure is spent on 188 types of drug which are mostly maintenance drugs and pain relievers that pairs up with some antibiotics thus it also includes anti- vertigo drugs. Lastly, the remaining 353 drug items constituted the 22.77% of the total annual medicine outlay in which these 30.31% of the overall pharmaceutical products are vitamins, food supplements, and over the counter drugs used to provide relief for coughs and colds (analgesics).

4.3Matrix Analysis

Cross-tabulating ABC and VEL inventory grouping resulted to different combinations and classifications into three categories which require distinct level of control. The next table below shows the results derived from the matrix analysis.

Table 5. *Matrix Analysis Result*

Inventory Classification Model		VEL Analysis V Quantity	V % of Drugs	E Quantity	E % of Drugs	L Quantity	L % of Drugs
ABC Analysis	A	24	6.80	62	17.56	28	7.93
	B	17	4.81	50	14.16	29	8.22
	C	17	4.81	76	21.53	50	14.16

The resultant combination of two inventory classification models will be grouped into three specific categories providing a valid approach in controlling a massive type of drug items. Category I drug items consist of five subcategories namely the AV, AE, AL, BV, and CV. These are drug salient drug items requiring strict managerial control since products under this bracket are either vital or fast moving wherein stock outs or medicine cache are inadmissible. Category II consists of interclass drugs requiring control and supervision by middle managerial level. Items under BE, CE, and BL are under this category. Lastly, all items under CL subcategory are drugs that are less essential and slow moving products and it can be supervised and controlled by lower level management. These products are commonly used to provide relief and mitigate self-limited diseases and collision is minimal with regards to criticality and economic perspective. After a thorough and comprehensive analysis, the study found out that the movement of each drug items extremely influenced the distribution per each class. Mostly, the expensive drugs are the fast moving items which are in contrast with the existing literature studies wherein the products that constituted the 70% of the total annual drug expenditure is spent on few slow moving goods which are composed of high- priced antibiotics used to treat severe health conditions. A column chart (see Figure 4) is provided to clearly visualize the values across the different categories.

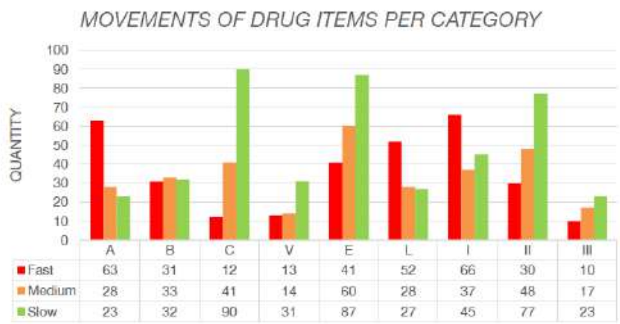

Figure 4. *Movement of Drug Items per Category*

This column chart revealed that 55.26% of the fast moving items are found in Class A wherein the pharmaceutical enterprise used up more than half of their finances on expensive drug products. Consequently, the distribution of drugs per category using matrix analysis are also affected which gave rise to the differences between the values.

4.4Application of Inventory Model

Utilizing the identified different stock management models helps the pharmaceutical drugstores in determining the optimum level of inventories that should be maintained to provide uninterrupted service to customers.

4.4.1Economic Order Quantity (EOQ)

This model is the most widely used and traditional means for determining how much to order in a continuous system. The main objective of this inventory model is to determine the optimal order size that minimizes total inventory costs. It is derived under a set of simplifying and restrictive assumptions, as follows:

- Demand is known with certainty and is constant over time;
- Constant lead time;
- Shortages are not allowed;
- Order quantity is received all at once.

In nature, demand of pharmaceutical drug items change from time to time and one good thing about this inventory model is that even if all the assumptions were not satisfied, it is fairly robust in practice. All 353 drug items were subjected to the model and the table below shows the summary of the total annual inventory cost.

Table 6. *Annual Inventory Cost using Economic Order Quantity (Php)*

	I	II	III
Pharmaceutical Acquisition Cost	6,723,115.52	2,080,327.94	368,502.67
Annual Inventory Cost	60,215.54	41,759.36	14,121.92
Total Annual Inventory Cost	6,783,331.07	2,122,087.30	382,624.59

The values of total inventory cost per month using Economic Order Quantity were obtained and the total annual inventory cost turned out to be Php 9,288,042.96. In order to clearly visualize the nature of the model, this table summarizes the order quantity per each drug item (see Table 7). One (1) drug item for each category was randomly selected for the purpose of conceptualizing the nature of the model.

Table 7. *Order Quantity per Drug Item (EOQ)*

Category	Drug Information	Order Quantity	Number of Orders Annually
AV	Clindamycin Brand A	116	5
AE	Methyldopa Brand A	552	5
AL	Mebendazole Brand A	93	5
BV	Augmentin Brand A	71	5
BE	Clonidine Brand A	231	5
BL	Sodium Ascorbate Brand A	575	5
CV	Hydroxyzine Brand A	93	5
CE	Cetirizine Brand A	48	5
CL	Lagundi Brand A	346	5

4.4.2Discrete Order Quantity (DOQ)

In this model, items are purchased in the exact quantities required for each period. This model is relatively straightforward and probably one of the simplest approaches in inventory management. This model is prone to stock outs but would be resolved when the idea of safety stock is incorporated. This model is widely used for items wherein the market fluctuates widely.

Table 8. *Total Annual Inventory Cost using Discrete Order Quantity (Php)*

	I	II	III
Pharmaceutical Acquisition Cost	6,723,115.52	2,080,327.94	368,502.67
Ordering Cost	1,680.48	1,165.41	394.11
Holding Cost	55,613.58	38,567.86	13,042.62
Total Inventory Cost	6,780,409.59	2,120,061.21	381,939.40

The values of total inventory cost per month using Discrete Order Quantity were acquired and the total annual inventory cost transpired to be Php9, 282, 410.20. In order to clearly visualize the ordering disposition of the model, this table summarizes the order quantity per each drug item.

Table 9. *Order Quantity per Drug Item (DOQ)*

Category	Drug Information	Order Quantity / Month (Q)											
		1	2	3	4	5	6	7	8	9	10	11	12
AV	Clindamycin	42	46	39	36	39	39	36	46	39	42	36	39
AE	Methyldopa	200	219	185	172	185	185	172	219	185	200	172	185
AL	Mebendazole	34	37	31	29	31	31	29	37	31	34	29	31
BV	Augmentin	25	28	24	22	24	24	22	28	24	25	22	24
BE	Clonidine	84	91	77	72	77	77	72	91	77	84	72	77
BL	Sodium Ascorbate	209	228	193	179	193	193	179	228	193	209	179	193
CV	Hydroxyzine	34	37	31	29	31	31	29	37	31	34	29	31
CE	Cetirizine	17	19	16	15	16	16	15	19	16	17	15	16
CL	Lagundi	125	137	116	108	116	116	108	137	116	125	108	116

In this model, it generates planned orders in quantities equal to the net requirements in each period that is why there is no extra on- hand inventory using this technique.

4.4.3Period Order Quantity (POQ)

The third model is based on the same theory as the economic order quantity. It uses the EOQ formula to calculate an economic time between orders. Instead of ordering the same quantity as EOQ, orders are placed to satisfy requirements for the calculated time interval[21]. The number of orders placed in a year is the same as for an economic order quantity, but the amount ordered each time varies. Thus, the ordering cost is the same but, because the order quantities are determined by actual demand, the carrying cost is reduced. The drug items are coded in the model and this table manifested the total inventory cost per month using POQ.

Table 10. *Total Annual Inventory Cost using Period Order Quantity (Php)*

	I	II	III
Pharmaceutical Acquisition Cost	6,723,115.52	2,080,327.94	368,502.67
Ordering Cost	560.16	388.47	131.37
Holding Cost	111,128.41	77,082.72	26,061.15
Total Inventory Cost	6,834,804.10	2,157,799.14	394,695.19

It can be seen that by using the Period Order Quantity, a total annual inventory cost of Php9, 387,298.43 were computed. Although this model is derived from the economic order quantity, there is a discrepancy between the two models with regards to financial concerns.

Table 11. *Order Quantity per Drug Item (POQ)*

Category	Drug Information	Order Quantity / Month (Q)											
		1	2	3	4	5	6	7	8	9	10	11	12
AV	Clindamycin	127			114			121			117		
AE	Methyldopa	604			542			576			557		
AL	Mebendazole	102			91			97			94		
BV	Augmentin	77			70			74			71		
BE	Clonidine	252			226			240			233		
BL	Sodium Ascorbate	630			565			600			581		
CV	Hydroxyzine	102			91			97			94		
CE	Cetirizine	52			47			50			48		
CL	Lagundi	378			340			361			349		

4.4.4 Wagner- Whitin Algorithm (W-W)

Wagner-Whitin algorithm is a method used for inventory modeling that is deterministic. It is formulated by Harvey M. Wagner and Thompson M. Whitin to which the purpose is to solve dynamic versions of economic lot size model. The algorithm minimizes the total setup and holding cost and assumes the following assumptions:

- Expected demand is known for N periods into the future
- Periods are equal in length
- No stock-out or backordering is allowed
- All forecast demand will be met
- Ordering cost A may vary from period to period
- Orders are places at the beginning of a period
- Order lead time is zero
- Inventory carrying cost is variable cost/unit/period and is charged at the beginning of a period for the units carried forward from the previous period[27].

The study used the first optimal property of the model which states that the replenishment of an item must only take place when the inventory level is zero. The total annual inventory cost using Wagner-Whitin Algorithm is Php10, 206, 177.14. The following tables show the annual inventory cost obtained using Wagner-Whitin Algorithm (see Table 12 and aid to clearly visualize the order quantity per drug item (see Table 13).

Table 12. *Annual Inventory Cost using Wagner-Whitin Algorithm*

	I	II	III
Pharmaceutical Acquisition Cost	6,723,115.52	2,080,327.94	368,502.67
Total Annual Inventory Cost	7,008,507.21	2,282,801.84	436,232.61

Table 13. *Order Quantity per Drug Item (W-W)*

Category	Drug Information	Order Quantity / Month (Q)											
		1	2	3	4	5	6	7	8	9	10	11	12
AV	Clindamycin	127			114			121			117		
AE	Methyldopa	604			542			576			557		
AL	Mebendazole	102			91			97			94		
BV	Augmentin	77			70			74			71		
BE	Clonidine	252			226			240			233		
BL	Sodium Ascorbate	630			565			600			581		
CV	Hydroxyzine	102			91			97			94		
CE	Cetirizine	52			47			50			48		
CL	Lagundi	378			340			361			349		

4.4.5 Re-order Point calculation (ROP)

This phase is very crucial in inventory management since it triggers an action to replenish the inventory stock once it reached that certain point of level. It ensures that the firm has the right amount of stock on-hand with safety stock to avoid the presence of stock outs. The disposition of Community Drugstore XYZ is that lead time is constant and that it is certain that it takes seven (7) days for their supplier to deliver the drugs once an order is placed. On the other hand, demand for each pharmaceutical drug items are continually varying. According to Management Sciences for Health (2012), a reasonable service level for pharmaceutical wholesalers is set at 95%, which implies a potential five percent (5%) stock- out at the drugstore facility [28]. In line with this, a value of 1.6449 was used as the number of standard deviation. The re-order points were calculated for each drug items based on 95% service level. The table below shows the total annual inventory cost along with the safety stock cost for every inventory models.

Table 14. *Re- Order Point Calculation*

Category	Drug Information	Re-order Point (pcs)
AV	Clindamycin	10
AE	Methyldopa	47
AL	Mebendazole	8
BV	Augmentin	6
BE	Clonidine	20
BL	Sodium Ascorbate	49
CV	Hydroxyzine	8
CE	Cetirizine	5
CL	Lagundi	30

An economical comparison of the results of each models shows that Period Order Quantity got the lowest inventory cost for Class I drug items compared to the three models left. Meanwhile, for Class II and III medicines, Discrete Order Quantity provided the most economical inventory cost.

Table 15. *Economical Comparison of Each Models*

Models	Class I	Class II	Class III
EOQ	Php6,901,804.31	Php2,192,420.73	Php402,818.14
DOQ	Php6,913,704.25	Php2,170,549.33	Php391,823.95
POQ	Php6,879,943.79	Php2,174,741.20	Php397,944.70
W-W	Php7,038,823.86	Php2,294,112.87	Php595,190.15

4.4.6 Summary of Findings

After thorough and extensive analysis of the secondary data collected in the pharmaceutical drugstore, the key findings are as follows:

- The total annual inventory cost of the present system is Php10, 005,109.74
- ABC analysis revealed that 32.29% of all the drug items are in A- class wherein these products require stringent managerial control since it compromises the 70% of annual drug outlay. Moreover, 96 B- class items constituted the other 20% of total annual drug expenses. Meanwhile, about 40.51% of the drug population is included in category C
- VEL analysis stated that 58 drug items in Class V constituted the 23.21% of the total annual drug expenditure. Around 16.43% of the drug population consisted of prescription drugs used to prevent and cure diseases and complications like commonly known antibiotics, and tuberculosis drug items
- Matrix analysis displayed that the 41.93% of the drug population under Category I constituted the 73.06 % of the annual expenditure of Community

Drugstore ABC. The remaining percentage comprises of Category II and III drug items

- Upon evaluating the multiple inventory management models, Period Order Quantity got the lowest inventory cost for Class I drug items compared to the three models left. Meanwhile, for Class II and III medicines, Discrete Order Quantity provided the most economical inventory cost
- Key findings are likely to change from time to time and annual changes must be done as to arrive with the minimum cost in managing the inventory of drug items

5. RECOMMENDATION

Inventory optimization tools have been gaining ground as drugstores seek to evaluate their entire system and determine the best inventory policy for their products. After careful analysis of the case problem, the researchers came up with a recommendation in line with solving inventory issues of the drugstore using this framework.

Class I Drug Items. These drugs are either vital or fast moving or around 41.92% of the overall medicine items are included in this category. To be able to achieve inventory cost reduction, the enterprise should acquire these products every three months with safety stocks included. This means that the drugstore should purchase drug items in the months of January, April, July, and October. The order quantity (Q) per medicine follows the calculated values using the Period Order Quantity wherein the idea behind this framework is to maximize cost savings by buying in bulk enough to cover the demand for three (3) months. The total cost annually would sum up to Php6, 879,943.79 for all Class I drug items.

Class II Drug Items. Class II consisted of medium moving essential and less essential drugs. For this class, the drugs should be purchased in exact quantities required for each month. The order quantity (Q) per medicine follows the calculated values using the Discrete Order Quantity with additional safety stock to safeguard the enterprise against stock outs but will not cause stockpile of medicines. The total cost annually for Class II drug items would amount to Php2, 170,549.33.

Class III Drug Items. This class constituted the 14.16% of the overall drug items in which the products under it are commonly used to provide relief and mitigate self-limited diseases and collision is minimal with regards to criticality and economic perspective since they are slow moving products. The drugstore should purchase these medicines in exact quantities required for each month wherein the order quantity follows the Discrete Order Quantity framework with additional safety stock same with the policy for Class II drug items. The total cost annually for Class III drug items would amount to Php391, 823.95.

6. CONCLUSION

The aim of this research has been to identify the most appropriate inventor management practice that will decrease the level of stock- outs and stockpile of pharmaceutical drug items as well as minimize the cost of inventory. It is clear after comprehensive analysis that applying the recommended inventory framework in Community Drugstore XYZ will lessen the cost of inventory by 5.63%. Moreover, since demand variability and replenishment framework were taken into consideration set at 95%, the occurrence of zero stock and overstock will subside. Lastly, utilizing this proposal will enable the drugstore to achieve its maximum potential in managing their largest asset, which is the product inventory. The implications for this proposal includes the combined qualitative and quantitative evaluation of each drugs using matrix analysis as to frame policy guidelines regarding control of items based on its cost and criticality. The research that has been undertaken for this study has highlighted a number of topics on which further research would be beneficial. In this study, different inventory management tools have been utilized to identify the most appropriate stock management model fit for the drugstore setting under a number of criteria. Considering the tools used, the researchers highly recommend to review other inventory management tools and spend a generous amount of time in literature review as to find the latest operations research tool that will suit the study providing an in- depth and thorough analysis of the data accumulated. Moreover, further researches are highly favorable for the technical construct of the tools like the Wagner-Whitin Algorithm since this dynamic lot size model has been updated from time to time due to its complex nature making its applicability in the real world attainable and practical. As the limitations of the study explained that the results of this study cannot be generalized for the same kind of establishment, readers should therefore approach the current findings and conclusions with caution. Considering the data collected, it is recommended to examine wider historical data as this will be advantageous for the research analysis and setting of recommendations. Lastly, continuous research has to be done to improve the inventory practice of the drugstore from time to time.

REFERENCES

[1] Jurado, I., Maestre, J., Rueda, P., Ocampo-Martinez, C., Fernandez, I., Tejera, B., et al. (2015). Stock Management in Hospital Pharmacy using Chance-Constrained Model Predictive Control. *Computers in Biology and Medicine*.

[2] Fredaric, P. (2016). Inventory Control in Pharmaceutical Supply Chain. Retrieved September 2018, from https://www.linkedin.com/pulse/inventory-control-pharmaceutical-supply-chain-pinto

[3] Marx, J. (2018). Business 2 Community. Retrieved September 2018, from What is Inventory Control?: https://www.business2community.com/product-management/what-is-inventory-control-02039271

[4] Saxena, R., Gokhale, C., & Kadam, D. (2017). ABC-VED Analysis of the Pharmacy of an Urban Health Care. *International Journal of Multidisciplinary Research and Development*, 233-236.

[5] Kokilam, M., Joshi, H., & Kamath, V. (2015). Assessment of Public Pharmaceutical Supply Management System at Rural Primary Health Centers in Udupi District, Karnataka. *Indian Journal of Pharmacy Practice*, 148-165.

[6] Laeiddee, C. (2010). Improvement of Re-order Point for Drug Inventory Management at Ramathibodi Hospital. Bangkok: Mahidol University.

[7] Mashishi, K. (2015). ULSpace Home. Retrieved September 2018, from Expiration of Drugs in Public Hospital Pharmacies of Sekhukhune District, Limpopo Province, South Africa: http://hdl.handle.net/10386/1350

[8] Picazo, O. (2012). Review of the Cheaper Medicines Program of the Philippines. *Medicine, Business*.

[9] Ceylan, Z., & Bulkan, S. (2017). Drug Inventory Management of a Pharmacy using ABC and VED Analysis . *Eurasian Journal of Health Technology Assessment*.

[10] Singh, V., Singh, H., & Singh, S. (2015). Drug Inventory Management of A Pharmacy Store by Combined ABC-VED Analysis. *International Journal on Mechanical Engineeringand Robotics*, 19-22.

[11] Kumar, S., & Brig, C. (2015). ABC-VED Analysis of Expendable Medical Stores at a Tertiary Care Hospital. *Medical Journal Armed Forces India*.

[12] Mahatme, M., Dakhale, G., Hiware, S., Shinde, A., & Salve, A. (2012). Medical Store Management: An Integrated Economic Analysis of a Tertiary Care Hospital in Central India. *PubMed*.

[13] Devnani, M., Gupta, A., & Nigah, R. (2010). ABC and VED Analysis of the Pharmacy Store of a Tertiary Care Teaching Research and Referral Healthcare Institute of India. *PubMed*.

[14] Khurana, S., Chhillar, N., Gautam, S., & Kumar, V. (2013). Inventory Control Techniques in Medical Stores of a Tertiary Care Neuropsychiatry Hospital in Delhi. *Health*, 8-13.

[15] Wang, X. (2010). Inventory Management in a Pharmaceutical Company: Minimizing Discard Practices. *MIT Libraries DSpace@MIT*, 63.

[16] Trailokyanath, S., & Jagatananda Mishra, P. (2017). An Optimal Policy for Deteriorating Items with Timeproportional Deterioration Rate and Constant and Time-dependent Linear Demand Rate. *Journal of Industrial Engineering International*, 455-463.

[17] Agada, P., & Ogwuche, E. (2017). A Probabilistic Economic Order Quantity (EOQ) Model for Inventory Management of Drugs and Hospital Consumables. *FUW Trends in Science & Technology Journal*, 737-742.

[18] Madhukar, N., & Pankaj, D. (2012). Continuous Review Model for Perishable Products with Inventory Dependent Demand. *IMECS*.

[19] Kalpana, R. (2016). Methods and Techniques of Inventory Control. *Business Management Ideas*.

[20] Bhathavala, P., & Rathod, K. (2012). Inventory Model with Stock-level Dependent Demand Rate and Quantity Based Holding Cost. *International Journal of Engineering Research & Technology (IJERT)*, 1-6.

[21] Samak-Kulkarni, S., & Rajhans, N. (2013). Determination of Optimum Inventory Model for Minimizing Total Inventory Cost. *Procedia Engineering 51*, 803-809.

[22] Adams, C., & Pennington, M. (2014). Academy for Excellence in HealthCare . Retrieved September 2018, from Pharmacy Inventory Project: Improving Inventory Management at Genesis Healthcare System Pharmacies: https://nanopdf.com/download/5b05b29ca7af9_pdf

[23] Hardgrave, B., Aloysius, J., & Goyal, S. (2009). Does RFID improve inventory accuracy? A preliminary analysis. *International Journal of RF Technology Research and Applications*, 44-56.

[24] Zhang, A. (2011). Conceptual Modelling for Supply Chain Inventory Visibility. *International Journal of Production Economics*, 578-585.

[25] Cappanera, P. (2017). Health Care System Engineering. Florence, Italy.

[26] Diva, P., & Trinidad, M. (2011). Enhancement of Pharmacy Inventory Control System for Malijan Diabetes Center (MDC). *Philippines E-Journals*.

[27] Omitaomu, O., Jeong, M., & Badiru, A. (2011). On-line support vector regression with varying parameters for time-dependent data. *IEEE transactions on Systems, Man and Cybernetics: Part A-Systems and Humans*, 191-197.

[28] Management Sciences for Health. (2012). Retrieved September 2018, from *Inventory Management: Service Level and Safety Stock*: https://www.msh.org/sites/msh.org/files/mds3-ch23-inventorymgmt-mar2012.pdf

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