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Application of ABC-VED Matrix Analysis to Control the Inventory of a Central Pharmacy in a Public Hospital: A Case Study

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Abstract: ***The hospital's drug pharmacy is the most important facility in a hospital where large financial resources are allocated for the purchase of drugs that support therapy of patients. In order to direct these resources efficiently and effectively, it is essential to apply inventory models to manage the drug inventory in pharmacies. The main objective of this research is to conduct a systematic classification for the drugs in a central pharmacy inventory of a public hospital. The necessary data about the 138 drugs dispensed were gathered for the period between 1/1/2018 – 31/12/2018. The ABC (Always, Better, Control), VED (Valuable, Essential, Desirable), and ABC-VED Matrix analysis were used to group the different types of drugs into three categories, I, II, and III. Data analysis was conducted by Microsoft Office Excel 2013 and by statistical methods. The VED analysis revealed that (81% of the Annual Drug Expenditure, (ADE) were allocated to Essential drugs, while categorizing the drugs indicated that (71.47 % of ADE) should be allocated to category I which includes AV,AE, AD, BV, and CV drug groups. This research concluded that top management should exert high supervision and control to drugs that fall in category I, then category II, and last category III. This research work is significant because it augments our knowledge about inventory control in general, and pharmacy inventory control systems in specific.***

Keywords: ABC, VED, ABC-VED Matrix Analysis, Pharmacy Inventory Management

1. Introduction

In response to the development of medical technology and the increased attention paid to the health of citizens, the number of public and private hospitals and clinics in Iraq has somewhat increased in the last decade. Meanwhile, the expenditures of health care delivery has increased disproportionally when compared to the financial resources allocated by the central government to the health care delivery system.

Therefore, the pharmacy in a public hospital can be considered as the most important working facility. It is also observed that the pharmacy inventory management is not well researched in Iraq, which has motivated the researchers to delve into this neglected area. To achieve efficiency and effectiveness in managing the hospital's pharmacy, any public or private hospital's administration should make sure that the inventory of all required drugs is available when needed. Therefore, a close supervision on vital drugs, prevention of shortages or stock outs, and prioritizing of purchasing orders is deemed very important, for it could bring great savings in a pharmacy store budget. Many pharmacy inventory management models have been proposed in the literature, however, the ABC-VED Matrix analysis is one of the most applied pharmacy inventory management model in the world. The ABC model, which is based on the Pareto principle, classifies pharmacy inventory according to their annual consumption, while the VED relies on the functional importance of medicines in classifying the pharmacy inventory. The ABC-VED Matrix considers both the medicine's cost and its functional importance in managing the pharmacy inventory.

The present study is conducted in a central pharmacy of a public hospital located in one of the provinces in Iraq. The field observation revealed multiple issues such as stock outs of vital medicines, spoilage, expiry, and repetitive purchases from local pharmacies. It is believed that applying inventory management models such as the ABC-VED Matrix analysis would improve and sustain the quality of health care delivered to patients, and should optimize the inventory cost of the drug store of the hospital.

2. Literature Review

Ravinder & Misra (2014) argue that the ABC analysis (which is based on the Pareto Principle) has proved to be a good tool to determine which inventory items require close control. The authors claim that the ABC analysis is myopic since it depends on the dollar volume criterion which is no longer adequate for today's businesses to survive. Global businesses should operate to provide customers with the right products in the right time, quantity, and quality. The authors reviewed a large body of research and literature and have concluded that in order for ABC analysis to be more effective, it should be coupled with other approaches such as: Data Envelopment Analysis, Analytical Hierarchy Process, Genetic Algorithms, and Neural Networks. Shah et al. (2015) stated that the main principle of inventory control is the ABC which is based on cost criteria, while the VED that is based on the criticality of drug items. The authors claim that mismanagement in drug categorization and expenditures negatively affect the community health. The study applied the ABC-VED matrix, and the study sample included six health centers and lasted from December 2012 to December 2013. The authors grouped drugs in each health

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center by ABC, VED, and then coupled the two methods to result into the ABC-VED matrix. The analysis revealed that more financial resources were allocated to less important and desirable drugs, while less money were allocated to vital and A type drugs. The results of this study should draw the attention of top management in allocating financial resources in the future to realize best drug control. Santhi & Karthikeyan (2016) indicated that the inventory planning and control systems perform a significant role in the pharmaceutical industry, because managing inventory is so essential regardless of whether it is domestic or international, small or big. Given that raw materials in a pharmaceutical industry have expiry date, the authors claim that such factories keep a minimum of safety stock to help track their orders smoothly. In their article, the authors presented a comprehensive review of pharmaceutical inventory literature since 1968 along with the relative models that the literature has offered. The review concluded that there are two objectives for pharmacy inventory control, the first is to keep medications available in stock, not expired, when needed, the second is to reduce medications cost as low as possible. We believe that profit should be a third goal, since a pharmacy must make profit to survive and to serve its customers, as well as achieving a return on its investment. Pund et al. (2016) suggest that significant improvements may be achieved in any hospital's inventory and expenditures by applying inventory planning and control tools. The authors attempted to categorize drugs according to two criteria: cost and criticality, these two criteria were used to identify the drugs that need strict management control. The tools employed were: ABC, VED and ABC-VED Matrix analysis. The study was conducted for a drug store of GMCH, Aurangabad, India, for the period between April 2014 to March 2015. The sample study consisted of 119 drug items used by the medical store. The analysis categorized drugs into three groups: group I requires top management control, while groups II and III require lower managerial control by middle and lower management. Ahlawat. et al. (2016), mentioned that approximately one-third of a hospital budget is spent on buying different materials and supplies including medicines, which requires an effective and efficient drug inventory planning and control system to supervise important drugs, to prevent wastage, and to set priorities for the purchase and the distribution of drugs. The authors claim that analysis of medicine expenditures is rarely done in Ayurveda hospitals since it is not required for the annual evaluation. The ABC study analysis was conducted in a pharmacy of an Ayurveda Institute. The analysis revealed that group A requires close day-to-day control, and that the cost factor should be taken into consideration especially for group A. The study recommended the use of ABC analysis as a tool which can help the hospital management in the coming year to allocate financial resources, in addition it can inform management in advance about the provisions required in the future such that a sound future decision is made on real economic data. In their research Ceylan & Bulkan (2017) stated that a pharmacy is one of the most significant facilities in a hospital in which extensive money resources are allocated, and therefore it is considered as a difficult facility to manage due to the various types of drugs stored into it. Despite that, the drugs must be made available and valid and priorities should be set as to when to buy and to distribute them. In this study the authors attempted to properly manage the drug inventory in a pharmacy to create a balance between inventory costs and drug levels to satisfy patients' needs. In this research, three inventory techniques were applied which are: ABC analysis, VED analysis, and ABC-VED matrix analysis. The study concluded that applying ABC analysis of drug inventory or VED independently does not work properly, because an inexpensive drug may be life saving and vise-versa, therefore analyzing drug inventory by the ABC-VED Matrix can lead to optimal budget allocation and provides better patient care, as well as preventing medicine shortages in the pharmacy. Gunergoren and Dagdeviren (2017) mentioned that hospitals should keep stocks of medicines and supplies in valid and sufficient quantities to support the services offered to patients without interruption. They added that hospitals must keep drugs according to their importance and cost to minimize the total annual inventory cost. The authors conducted their research to determine the significance of medications in a hospital's pharmacy using ABC, VED, and ABC-VED analysis. Based on the analysis, the order quantities were determined using the Economic Order Quantity technique. Due to the huge number of drugs, the authors devoted an Excel-based model to perform the analysis quickly and efficiently. The searchers concluded that grouping drugs according their cost and importance should improve the inventory planning and control decisions, and is capable of achieving potential costs savings. Saxena, Gokhale, & Kadam (2017), stated that efficient inventory management for a pharmacy involves the procurement of the right drug, at the right time, in the right amount, and at the right cost. The authors believe that ABC-VED analysis is an effective tool to control the drug inventory of a pharmacy through identifying the drugs that require strict control and the drugs whose purchase may be postponed. The study included a sample of 145 drugs from a tertiary care hospital. The drugs, their annual consumption, and the unit cost of the drugs were determined by a expert pharmacist. An ABC-VED analysis was conducted by the authors. The analysis revealed potential cost saving and service level improvement. The authors concluded that ABC-VED analysis is very essential to reduce excessive inventory cost and is an effective tool for drug inventory control. In a recent study, Pokhariya, & Mathur (2018), consider the pharmacy as the most important facility in the healthcare system where huge amounts of capital is spent on purchasing various types drugs. The authors believe that an efficient inventory management system should be applied to control essential drugs and to set priorities to purchase them, and to achieve better patient care and optimal use of resources. Three inventory control methods where reviewed and analyzed in the study: ABC, VED, and ABC-VED. The review revealed that drug inventory analysis plays an essential role in the management of pharmacies, and that the techniques reviewed in this article can contribute to the improvement of patient care, customer relationships, and improves financial allocation. Therefore, pharmacists can improve the pharmacy performance by planning, designing and organizing medical stores and inventory.

Taddele et al. (2019) conducted their study to analyze Arbaminch Hospital (Ethiopia) inventories by implementing the ABC-VED matrix. The sample study consisted of 218 drugs, and the study covered the period between 2013-2015.

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The authors were able to classify drugs into three categories: I, II, and III. Accordingly, items that fall into category I require strict management control, while items that belong to category II and III should be controlled by middle and lower management. The study concluded that ABC-VED analysis should be implemented to manipulate resources more efficiently and effectively, to reduce wastages, and drug inventory shortages in health care facility studied in this research. Other authors such as Gupta & Nigah (2010), Mani et al. (2014), Singh (2015), Kumar et al. (2016) and Hazrati et al. (2018) have conducted similar researches but in different locations, while other researchers have associated ABC method with more sophisticated techniques such as coupling ABC with the Analytical Hierarchy Process (Partovi & Burton,1993), ABC with the Weighted Linear Optimization (Ramanathan, 2006), and ABC with the Artificial Intellegence (Yu, 2011).

From the previous review, it could be concluded that the interest in the ABC-VED used alone or integrated with other methodologies in inventory management of pharmacies is increasing due to the possible benefits that could be harvested such as: cost savings, healthcare improvements, service-level improvements, wastages and shortages reductions, better patient-pharmacy relationships, and improving the community healthcare.

3. Theoretical Background

Inventory is any item stocked in an organization for future use or consumption. Inventory consists of six groups which are: Raw Materials, Work-in-Process, Finished Goods, Maintenance and Repair, Decoupling Inventory, and Pipeline Inventory. We shall describe each type briefly as follows:

- Raw Materials refer to any item used to manufacture components or finished products for sale or consumption. Raw materials may be purchased by the organization or extracted by it.
- Work-in Process inventory is created through the manufacturing process, and it refers to items that are unfinished yet. Some of these unfinished inventory may be sold as finished components such a car carburetors that is sold for replacement , or used to assemble a car.
- Finished Goods refer to items that have gone through the production process and are ready for sale or use.
- Maintenance and Repair Inventory consists of items that are used to maintain the production facilities running. The consumption of such items depends on machine breakdown incidents, or planned maintenance schedules.
- Decoupling Inventory refers to the inventory used to maintain the operation of the production process uninterrupted.
- Pipeline Inventory, refers to the inventory on its way to the customer. The customer could be internal or external.

According to Pokhariya and Mathur (2018), the inventory performs several functions which are:

- Meeting anticipated customer demand which refers to inventory held to satisfy expected or anticipated demand.
- Meeting production requirements, manufacturing companies often built inventories during off-season to satisfy demand during high demand seasons.
- Decoupling operations refers to holding inventories or buffer inventory to help operations to continue until the production problems are solved elsewhere in the manufacturing process.
- Protection against stock-outs, unexpected increase in demand increase the risk of shortages, therefore safety stock can reduce the risk of stock-outs.
- Protecting from price increase, holding extra inventories can help the organization from price increases or inflation. The organization must make sure that the stocks are stored under the right condition to maintain their quality.

In general, inventory costs are grouped into three categories: Ordering costs, Holding or Carrying cost, and Stock out cost.

- **Ordering Cost**: This cost is incurred when a purchase or manufacturing order is issued. The ordering cost increases when the number of orders increases and vice-versa. The order size should be balanced economically, since ordering excess inventory shall result in an increase in holding costs, while ordering less than required results in shortage or stock out costs. The elements of ordering cost include: cost of order preparation and forwarding, inspection cost, payment cost, staff cost, cost of order acceleration, and communication cost.
- **Holding or Carrying Cost**: This cost is due to stocking inventory items inside or outside the organization, and it consists of the following elements: cost of capital, stocking cost, spoilage cost, obsolescence cost, insurance cost, material handling equipments, and IT software applications.
- **Stock out Cost:** This cost is also referred to as the shortage cost which is a result of not having the inventory item when needed. The shortage of some inventory items may be tolerable sometimes, however the shortages may result in severe losses for the organization and it may damage its credibility. In the case of pharmaceutical drugs, the shortage may cost the life of a patient.

4. Pharmacy Inventory Management Models

According to Santhi & Karthikeyan (2016), the role of an inventory system is very much significant in the management of pharmacies regardless of the size of the pharmacy or whether it functions within a hospital or it is independent. Every pharmacy faces two challenges: the first is to keep medicine in a vital state and in a sufficient quality and quantity, and the second is to keep the inventory costs at minimum. Since these two objectives are not easy to achieve, researchers in this field (since 1968) were motivated to device pharmacy inventory models to deal with this issue. In this research, we shall enumerate the models only. However, the interested reader can view them in Santhi & Karthikeyan. These models are:

- Models for Pharmaceutical inventory with RFID (Radio Frequency Identification) technology.
- Models for Pharmaceutical inventory with drug pharmacy.
- Models for Pharmaceutical inventory with blood pharmacy.
- Models for inventory with perishable pharmaceuticals.
- Models for inventory management of pharmaceutical inside hospitals.

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Another classification of inventory management models is presented by Ahlawat et al. (2016) and is depicted in Figure (1). With respect to ABC, VED, and ABC-VED Matrix analysis, we shall present them in detail later in this research. For the rest of the models, we shall provide a brief description as follows:

- **FSN**: Fast moving, Slow moving and Nonmoving. It is based on issues from stores.
- **SDE**: Scarce, Difficult, Easy to obtain classification based on availability of items.
- **HML**: High, Medium and Low based on unit price.
- **XYZ**: Based on value analysis. Used in analysis of slow moving items.
- **SOS**: Season Off Season. Based on seasonal requirement.

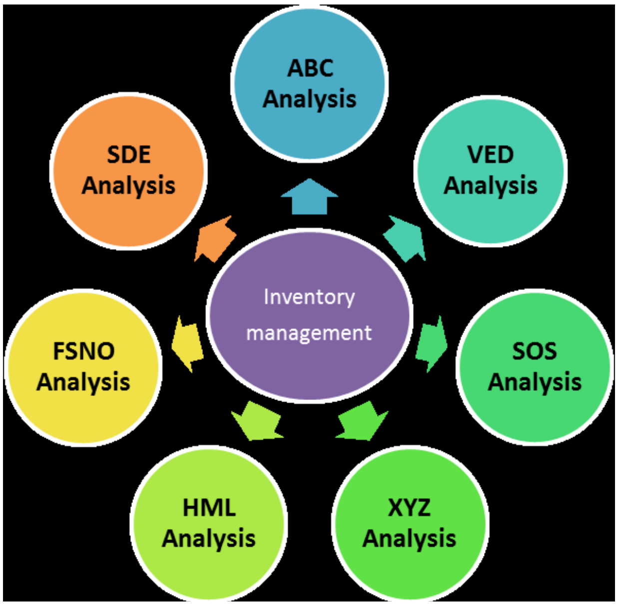

Figure 1: Classification of Inventory Models
Source: Ahlawat et al., 2016, p. 425.

4.1 ABC Analysis

The ABC analysis is one of many tools used for inventory control. This analysis is known as the Pareto principle which is proposed by the Italian Economist Velfredo Pareto (1906) who argued that 80% of a nation's wealth is owned by 20% of the population, and 20% of the nation's wealth is owned by 80% of the population. This principle is also referred to as the 20:80 ratio. In the 1940's, the Pareto principle was advanced by Joseph Juran who is an American engineer credited as being the father of quality control. Juran was the first quality guru who decided to call the 20:80 ratio as the "Pareto Principle". The principle was applied in many business metrics to separate between the "vital few" (20%) from the "trivial many" (80%). Based on this principle, the ABC analysis was developed in the 1950s to help managers to distinguish among the vital few of inventory items (referred to A items), from the trivial many (referred to C items), while the B items are referred to as interclass items. The A items constitute about 10% of inventory items, yet its annual consumption amounts to 70%-80%, the B items constitute 20% of all the inventory items and amount to 10%-15% of total annual inventory consumption, while C items constitute 70% of total inventory items and amount to 5%-10% of total annual consumption (Ceylan & Bulkan, 2016, Ravinder & Misra, 2016). Figure (2) depicts a schematic representation of ABC analysis, while Table (1) presents some characteristic of the ABC analysis. The advantages of ABC analysis may be summarized as follows: it reduces unnecessary investment in inventory, improves inventory control, saves time spent on inventory control, and it requires less staff to control all items stocked. Despite these advantages, the main drawback of the ABC analysis is that it relies on the consumption value, i.e. it depends on the cost criterion only.

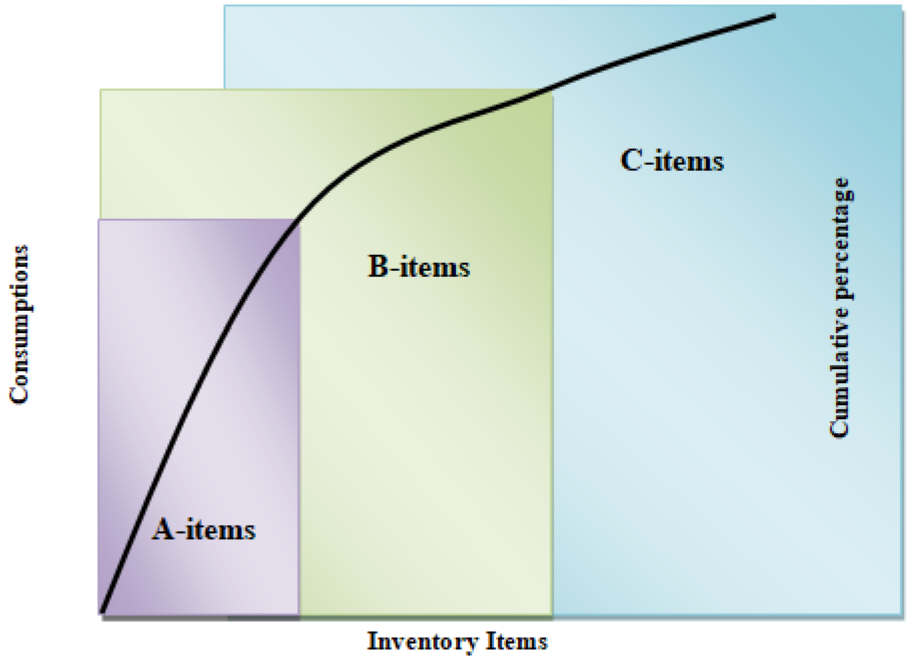

Figure 2: ABC Graphical Representation

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Table 1: Some Characteristics of ABC Analysis

Item Category	A	B	C
Quantity (approx.)	10%	20%	70%
Consumption Value (approx.)	75%	20%	5%
Control	Strict	Normal	Low
Supervision	Top Management	Middle Management	Clerical Staff
Safety Stock	Low	Medium	High
Purchase Authority	Centralized	Centralized /Decentralized	Decentralized
Lead time	short	Medium	Long

Source: https://www.blogger.com/profile/15521318744913553315

4.2 The VED Analysis

According to Devnani et al. (2010), Gupta el al. (2007) the VED analysis is based on the drug's functional importance and priority to the patient's health. As a consequence the drug items are divided into three categories or groups: Vital (V), Essential (E), and Desirable (D). The V class drugs are considered to have high functional importance such as life saving drugs whose non-availability cannot be tolerated. Examples of such drugs include: vaccines, serums, insulin, antibiotic, diogxin , etc., these drugs should continuously be available in the pharmacy.

The E class drugs are supposed to have lower severity (but still useful for serious diseases) and are used for less life threatening cases. The non-availability of this category can be tolerated for 2-3 days because alternative drugs may be used. Examples of such medicines are: ranitidine, phenytoin, chloroquine, etc., and such items are stocked in medium quantities. In addition the purchase of the E drugs should be based on rigid requirements and strict control.

The D class drugs have lowest importance and are used for therapy of slight diseases, examples of such drugs are: vitamins, aspirin, metformin, paracetamol, sun screen lotions, etc. The absence of such drugs could be tolerated for a longer time. Drugs falling in this category are stocked in small quantities, and the purchase quantities are based on usage forecast.

4.3 The ABC-VED Matrix Analysis

As we mentioned earlier in this work, when ABC analysis and VED analysis are used independently they do not lead to effective and efficient drug inventory control. Therefore, researchers in this field (Vaz, et al., 2008, Khurana, et al.,2013, Pund et al., 2016) have attempted to couple both methods to achieve better results in managing drug inventory. The combination of these two tools results in a 3x3 matrix as depicted in Table (2). By cross tabulating this table, it is possible to obtain 9 subclasses: AV, AE, AD, BV, BE, BD, CV, CE, CD. Furthermore, these nine subclasses are grouped into three categories: I, II, and III. Category I includes items AV, AE, AD, BV, CV. Category II is comprised of items: BE, BD, CE. While category III includes items CD.

Table 2: ABC-VED Matrix

ABC \ VED	V	E	D
A	AV	AE	AD
B	BV	BE	BD
C	CV	CE	CD

5. Research Methodology

5.1. Research Problem

The frequent field observations conducted by the authors revealed multiple issues such as stock outs of vital medicines, spoilage, expiry, and repetitive purchases from local pharmacies, in addition to the absence of applying a defined inventory model in the management of the central pharmacy.

5.2. Research Objectives

The analysis conducted in this research attempts to achieve the following objectives:

- Provide a systematic classification for the drugs in the central pharmacy inventory using the ABC, VED, and ABC-VED Matrix analysis.
- Improve the health delivery systems of the hospital.
- Direct the attention of hospital's management to the necessity of reducing shortages, spoilage, and repetitive purchases of drugs.
- Shed the light on the possibility of improving the Central Pharmacy's performance through the use of pharmacy inventory models presented in this research.

5.3. Materials and Methods

The present research was conducted at a central pharmacy of a public hospital. By the aid of our co-author (the pharmacist), the data collected (quantities, costs, and VED classification) belong to the period between 1/1/2018 to 31/12/2018. The total number of the drugs dispensed amounted to 138 drugs throughout the study period. The ABC, VED, and ABC-VED Matrix were used as to study the inventory of the central pharmacy. All the analysis performed in this research was conducted using Microsoft Office Excel 2013, and by some statistical methods.

5.4. Research Significance

This research work is significant because it could assist the hospital's administration to improve the central pharmacy inventory management system. The research may augment our knowledge about inventory control in general, and pharmacy inventory control in specific. From the results realized in this research, top management can allocate budget resources to drugs that fall in category I in the first place, then for drugs in the less important categories. The results achieved here could suggest standards to improve the performance of the central pharmacy by planning assessment and by prioritizing the acquisition of medicines to increase the efficiency of using the hospital's financial resources, and to improve the healthcare delivery system.

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6. Analysis, Results, and Discussion

In the first step of analysis, the annual drugs dispensed throughout the period of study (1/1/2018 – 31/12/2018) were obtained from the hospital's central pharmacy along with the corresponding costs of each drug type. The drug population consisted of 138 drugs. In the second step, the cost of each drug was multiplied by the quantity of drugs dispensed to obtain the annual consumption cost or the ADE. In the third step, ADE were arranged in a descending order (i.e. from highest to lowest). In the fourth step, the drugs were classified as A, B, or C according to their ADE and following the Pareto classification 70%, 20%, and 10%. It can be observed from Table (3) that ADE is about 1,461 millions ID/year (about 1.2 million US Dollars). Table (3) also reveals that 9.4% (13 drug items) fall into Class A with ADE of 996 million ID, and amount to 68.18% of annual drug consumption. While the drugs that fell into group B constituted 15.3% (21 drug items) with ADE 365 million ID, and amounted to 24.98% of annual consumption. Finally class C constituted 75.3% (104 drug items) with ADE of 100 million ID and amounted to 6.84% of annual consumption. Figure (3) presents a schematic representation of the ABC analysis conducted here. Due to its significance, class A items requires strict top management control, low safety stock, centralized purchase authority, and short lead times. Class B items require normal control, middle management supervision, medium safety stock, decentralized purchase authority, and medium lead time. Despite their high number, class C (104 drug items), they require low control, clerical staff supervision, high safety stock, decentralized purchase authority, and long lead times.

Table 3: Results of ABC Analysis

Group	No. of Items In the Group	Percentage of items approximately	ADE in Milli 100ons	ADE Percentage	Cumulative ADE Percentage
A	13	9.4%	996	68.18%	68.18%
B	21	15.3%	365	24.98%	93.16%
C	104	75.3%	100	6.84%	100%
Total	138	100%	1,461	100%	

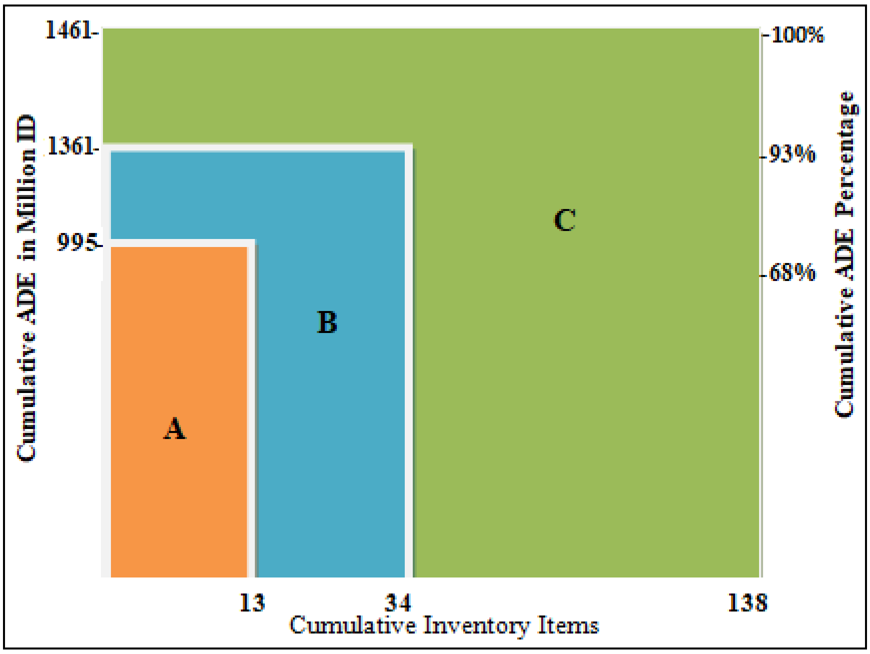

Figure 3: Schematic Representation of ABC Result Analysis

As it was mentioned earlier in this research, the ABC analysis depends only on the cost value of the drugs dispensed, and it does not consider the functional importance of the drugs. The functional importance of the drugs should be taken into consideration to augment the health service delivered to patients. Therefore, we took our analysis one step further by classifying drugs as Vital, Essential, and Desirable. By the aid of our co-author, the pharmacist, the drugs were classified according to their functional importance as it is presented in Table (4). This classification revealed that 8.69% (12 drug items) are vital and constitute 264,572,776 ID and their corresponding percentage of the ADE is 18.1% , 66.68% (92 drug items) belong to class E and their share of the annual consumption was 1,183,962,932 ID and constituted 81% of the ADE. The remaining 24.63% (34 drug items) belong to class D, the annual consumption of this class amounted to 12,665,539 ID and makes 0.9% of the ADE.

Table 4: VED Result Analysis

Drug Type	Quantity	% of Drug	ADE (ID)	% of ADE
V	12	8.69	264,572,776	18.1
E	92	66.68	1,183,962,932	81.0
D	34	24.63	12,665,539	0.9
Total	138	100.00	1,461,201,247	100.0

By associating ABC analysis (Table 3) with VED analysis (Table 4), we obtained the ABC-VED Matrix as depicted in Table (5), and Table (6) provides more details. From Table (5) we observe that nine subclasses could be derived from this association: AV, AE, AD, BV, BE, BD, CV, CE, and CD. Based on the categorization presented in Table (2), these nine subclasses are grouped into three major categories: I, II, and III as provided in Table (7).

Category I includes subclasses AV, AE, AD, BV, and CV. This category contains 23 drugs and represents 16.67% of

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the drugs population studied, and its ADE was 1, 044, 366, 767 ID which accounts to 71.47% of the total ADE. Category II consisted of 58.69% (81 drugs) and its annual consumption was 404,314,694 ID which represents 27.67% of the total ADE. The third category 24.64% (34 drugs) totaled 12,519,786 ID and represent 0.86% of the ADE.

The items in category I (23 drugs) should strictly be controlled by top management, safety stock levels, and consumption should, also, be monitored continuously. On one side, any shortages in this category can harm the health delivery service system, because these items have high functional importance whose non-availability cannot be tolerated. On the other side this category consumes 71.47% of the ADE and should be given high priority by top management.

The drugs in category II (83 drugs) are considered to be essential and their cost is average. Although this category has lower severity and is used for serious diseases, it still requires moderate control by middle level management to be exercised on it. The absence of drugs in this category can be tolerated for few days only, through using alternative drugs.

The drugs in category III are desirable, inexpensive, and have lowest importance. These drugs are used for therapy of slight diseases. Orders should be done on periodical basis, and the absence of such drugs could be tolerated for longer time. Lower level management should be in charge of drugs in this category since its share of the ADE is less than 1%. Figure (4) presents the distribution of the three categories schematically. Furthermore, Table (8) provides the distribution of the ADE according to the three models investigated in this research. From this table it could be inferred that classifying drugs into three categories offers a better financial resources to the drugs grouped into these categories vis-à-vis the other models, increases the service level (i.e. drug availability), and improves the health delivery system.

In order to assess the results of this research, the authors have compared the results attained in this work with the results of the most recent studies as it is presented in Table (9). The authors conducted one step which is different from previous studies and that by computing the Coefficient of Correlation for the results of this study with the average results of the previous studies for each class or category. The Coefficients of Correlation for the ABC, VED, and category I, II, III were 0.998, 0.977, and 0.801 respectively. Using statistical methods, the authors tested the coefficients of correlation for significance at $n=6$, $s.l.= 0.05$, and $d.f.= 4$ to assist or to deny the hypothesis that the results of this research are correlated significantly with the results of the previous studies cited in Table (9). The results of the tests assisted the hypothesis.

Table 5: Results of ABC-VED Matrix Analysis

Classification	V	E	D	Total
A	2	11	0	13
B	1	20	0	21
C	9	61	34	104
Total	12	92	34	138

Table 6: ABC-VED Result Analysis

Classification	V		E		D		Total
	Qtty	%	Qtty	%	Qtty	%	
A	2	1.45	11	7.97	0	0	13
B	1	0.72	20	14.5	0	0	21
C	9	6.52	61	44.20	34	24.64	104
Total	12		92		34		138

Table 7: Results Analysis of Drugs' Categories

Category	Quantity of Drugs	% of Drugs	ADE	% ADE
I	23 (AV,AE,AD,BV,CV)	16.67	1,044,366,767	71.47
II	81 (BE,BD,CE)	58.69	404,314,694	27.67
III	34 (CD)	24.64	12,519,786	0.86
Total	138	100.00	1,461,201,247	100.00

Table 8: Distribution of ADE (*in millions ID**) According to the Models Studied

ABC Analysis			VED Analysis			ABC-VED Categories		
Class	Qtty.	ADE	Class	Qtty.	ADE	Categ.	Qtty.	ADE
A	13	996	V	12	265	I	23	1,044
B	21	365	E	92	1,183	II	81	404
C	104	100	D	34	13	III	34	13
Total	*138*	*1,461*		*138*	*1,461*		*138*	*1,461*

- *1 USD=1,215 ID*

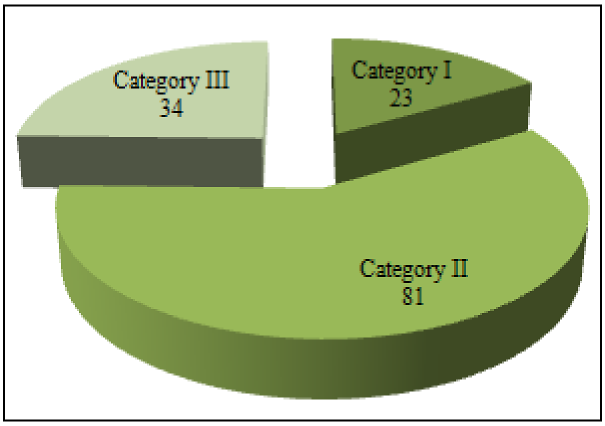

Figure 4: Distribution of Drugs' Categories

Table 9: Comparison Results of Previous Studies with Present Study

Class or Category	Devnani et al. 2010	Taddele et al. 2019	Singh et al. 2015	Saxina et al. 2017	Pund et al. 2016	Hazrati et al. 2018	Guner Goren 2017	Cylan & Bulkan 2017	Total	Average	Present Study	Coefficient of Correlation
A	13.78	15.14	11.23	15.2	16.8	5.7	10	10.31	98.16	12.27	9.4	
B	21.85	22.47	24.6	23.4	21.8	11.2	23	21.78	170.1	21.26	15.3	0.998
C	64.37	62.39	75.4	61.4	61.8	83.1	67	67.91	543.37	67.92	75.3	
V	12.11	31.19	12.3	3	35.3	10.55	24.2	23.31	151.96	19.00	8.6	
E	59.38	67.43	61.5	59	50.4	19.43	14.01	55.15	386.3	48.29	66.68	0.977
D	28.51	1.38	26.2	38	14.3	70	61.78	20.84	261.01	32.63	24.63	

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I	22.09	39.91	21.38	19	47.9	83.76	29.94	75.25	339.23	42.40	71.47	
II	54.63	59.17	58.27	58	43.7	13.54	24.84	22.18	334.33	41.79	27.67	0.801
III	23.28	0.92	20.32	23	8.4	2.7	45.22	2.57	126.41	15.80	0.86	

7. Conclusions

In this research we have demonstrated that the inventory analysis has a significant role in controlling the drugs inventory in pharmacies. The better use of inventory models improves: the health delivery system in the hospital, patient-hospital relationship, and the allocation of financial resources of the hospital. The present study examined three inventory control models: ABC, VED, and ABC-VED Matrix. The ABC model is based on the Pareto principle and is widely used in the world. It classifies drugs according to their cost in a descending order where few items consume the majority of the pharmacy's budget. The analysis revealed that 13 drugs account for 68.18% of the ADE, but no mention about the functional importance of these drugs. To overcome this issue, it was necessary to apply the VED analysis because it considers the functional importance of the drug. Here, the analysis revealed that 92 drugs were essential and account for 81% of the ADE, which means that the majority of the financial resources are allocated to this class of drugs. To harvest the advantages of the ABC and the VED models, the ABC-VED matrix analysis was conducted to classify the drugs into three categories. From this analysis Category I contained five drug groups (AV, AE, AD, BV, and CV), 23 drugs, and account for 71.47% of the ADE, therefore it requires strict top management supervision and control. Category II included three drug groups drugs, and account for 27.67% of the ADE, and should be controlled by middle management. Category III included the CD group only, and accounted for 0.86% of the ADE, and should be controlled by lower level management. By comparing the ADE from Table (8) allocated by the different models studied we conclude that the hospital's management should exert its most attention to category I, and to categories II, and III with lesser degrees. In addition, we suggest that the hospital should follow the categorization of drugs derived in this research to control the central pharmacy's drugs, to realize optimal allocation of budget, and avoiding stock outs cases in the central pharmacy. We, also, emphasize that top management should always consider drug pharmacies as a significant facility and requires planning, designing an organization of its activities to sustain the health delivery system in the hospital. The results of the analysis conducted in this research were found to coincide with previous researches and are statistically significant.

References

[1] Ahlawat, S. et al.,(2016), ABC Analysis of Pharmacy Store of an Ayurveda Institute, *International Journal of Pharmacy and Pharmaceutical Research*, Vol. 7, No. 3, pp. 423-435.

[2] Ceylan, Z. and Bulkan, S., (2017), Drug Inventory Management of a Pharmacy using ABC and VED Analysis, *Eurasian Journal of Health Technology Assessment*, Vol. 2, No. 1, pp. 13-18.

[3] Gunergoren, H. and Dagdeviren, O., (2017), An Excel-Based Inventory Control System Based on ABC and VED Analyses for Pharmacy: A Case Study, *Galore International Journal of Health Sciences and Research.* Vol.2, No.1. pp.11-17.

[4] Gupta, M. & Nigah, R., (2010), ABC and VED Analysis of the Pharmacy Store of a Tertiary Care Teaching, Research and Referral Healthcare Institute of India. *Journal of Young Pharmacists*, Vol. 2, No. 2. pp. 201-205.

[5] Gupta, R., Gupta, K., Jain, R. & Garg, K., (2007), ABC and VED Analysis in Medical Stores Inventory Control, *Medical Journal Armed Forces India*, Vol. 63, pp. 325–327.

[6] Hazrati, E., Paknejad, B., Azarashk, A. and Taheri, M., (2018), ABC and VED Analysis of Imam Reza Educational Hospital Pharmacy, *Annual Military Health Science Research*., Vol. 16, No. 3, pp. 1-5. DOI:10.5812/amh.86183..

[7] Khurana, S., Chillar, N., & Gautam, K., (2013), Inventory Control Techniques in Medical Stores of a Tertiary Care Neuropsychiatry Hospital in Delhi, *Health*, Vol. 5, pp. 8-13.

[8] Kumar Y., Lilhare A., Sahu, A., Lal, B. and Khaperde Y., (2016), ABC Analysis for Inventory Management-Case Study of Sponge Iron Plant, *International Journal for Research in Applied Science & Engineering*, Vol.4, No. 4, pp. 32-36.

[9] Mani, G., Annadurai K., Danasekaran, R & Ramasamy J., (2014), Drug Inventory Control Analysis in a Primary Level Health Care Facility in Rural Tamil Nadu, India, *Healthline*. Vol. 5, No.2, pp. 36-40.

[10] Partovi, F. & Burton, J., (1993), Using the analytic hierarchy process for ABC analysis, *International Journal of Operations & Production Management*, Vol. 13, No. 9, pp. 29-44.

[11] Pokhariya, U. and Mathur P., (2018), Review on: Inventory Management, *Indo American Journal of Pharmaceutical Sciences*, V0l. 5, No. 4, pp. 3124-3131.

[12] Pund, S., Kuril B., Hashmi J., Doibale, K. and Doifode M., (2016), ABC-VED Matrix Analysis of Government Medical College, Aurangabad Drug Store, *International Journal of Community Medicine and Public Health*, Vol. 3, No.2, pp. 469-472. DOI:10.18203/2394-6040.

[13] Ramanathan, R., (2006), ABC Inventory Classification with Multiple-Criteria Using Weighted Linear Optimization, *Computers & Operations Research*, Vol. 33, No.3, pp. 695-700.

[14] Ravinder, H. and Misra, R., (2014), ABC Analysis For Inventory Management: Bridging The Gap Between Research And Classroom , *American Journal Of Business Education*. Vol. 7, No. 3, pp. 257-264.

[15] Santhi, G. and Karthikeyan, K., (2016), Recent Review Article on Pharmaceutical Inventory Models, *International Journal of PharmTech Research*,Vol.9, No.5, pp 435-443.

[16] Saxena R, Gokhale C, and Kadam D., (2017), ABC-VED Analysis of the Pharmacy of an Urban Health Centre, *International Journal of Multidisciplinary Research and Development*, Vol. 4, No.8., pp. 233-236.

[17] Shah, A., Girish, A., Davda, K., Sonal B., Parikh, and Bala V., (2015), Always Better Control-Vital Essential

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Desirable Analysis of the Drugs Used in Health Centers of Ahmedabad District, *International Journal of Basic & Clinical Pharmacology*, Vol. 4, No. 4, pp.749-752. DOI: 10.18203/2319-2003.

[18] Singh, S., Gupta, K., Latika, M.,(2015), ABC and VED Analysis of the Pharmacy Store of a Tertiary Care, Academic Institute of the Northern India to Identify the Categories of Drugs Needing Strict Management Control, *Journal of Young Pharmacists* Vol. 7, No. 2, pp. 76-80. DOI:10.5530/jyp.2015.2.4.

[19] Taddele, W., Wondimagegn, A., Asaro, A., Sorato, M., Gedayi, G. and Hailesilase, A., (2019), ABC-VEN Matrix Analysis of the Pharmacy Store in a Secondary Level Health Care Facility in Arbaminch Town, Southern Ethiopia, *Journal of Young Pharmacists*, Vol. 11, No. 2, pp. 182-185. DOI: 10.5530/jyp.2019.11.38.

[20] Vaz, S., Ferreira, M., Kulkarni, S., Motghare, D., & Pereira-Antao, I., (2008), A study of Drug Expenditure at a Tertiary Care Hospital: An ABC-VED analysis, *Journal of Health Management*, Vol. 10, pp. 119-127.

[21] Yu, M. C. (2011), Multi-Criteria ABC Analysis Using Artificial-Intelligence-Based Classification Techniques, *Expert Systems with Applications*, Vol. 38, No. 4, pp. 3416-3421.

[22] *https://www.blogger.com/profile/15521318744913553315*

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