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Multi-Criteria Inventory Classification of Pharmaceuticals for Inventory Management Optimization: The Case of Public Hospitals in Addis Ababa, Ethiopia.

By

Mesay Mekonnen (B. Pharm)

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Multi-Criteria Inventory Classification of Pharmaceuticals for Inventory Management Optimization: The Case of Public Hospitals in Addis Ababa, Ethiopia.

Under the supervision of: Mr. Zelalem Tilahun (B.Pharm, MSc, Ass. Prof.)

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This is to certify that the thesis prepared by Mesay Mekonnen, entitled *multi-criteria inventory classification of pharmaceuticals for inventory management optimization: the case of public hospitals in Addis Ababa, Ethiopia,* and submitted to the department of pharmaceutics and social pharmacy, school of pharmacy for the partial fulfillment of the Degree of Master of science in health supply chain management obeys with the regulation of the university and meets the accepted standards with respect to creativity and excellence.

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External Examiner…….		……..	……
Internal Examiner……...		……..	…….
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Declaration

I **Mesay Mekonnen** under signed, declare that this study entitled "*multi-criteria inventory classification of pharmaceuticals for inventory management optimization: the case of public hospitals in Addis Ababa, Ethiopia*" is my original work has not been presented any other university, and all source in the study have been fully acknowledged.

Student Name: Mesay Mekonnen

Signature: ……..

Date of submission: ……..

Table of Contents

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List of tables

List of Figures

List of Acronyms and Abbreviations

ALERT - All Africa Leprosy Rehabilitation and Training Center

ABC - Always, Better, Control

AACHAB – Addis Ababa City Administration Health Bureau

ADE – Annual Drug Expenditure

EFY – Ethiopian Fiscal Year

EPSS – Ethiopian Pharmaceutical Supply Service

FMOH – Federal Ministry of Health

FSN – Fast Moving, Slow Moving, Non- Movable

HCMIS – Health Commodity Management Information System

IPLS – Integrated Pharmaceutical Logistics System

LIAT - Logistics Indicator Assessment Tool

LMIS – Logistics Management Information System

LSAT – Logistics System Assessment Tool

MCIC – Multi Criteria Inventory Classification

RDF – Revolving Drug Fund

SPHMMC – St. Paoul Hospital Millennium Medical College

TPE – Total pharmaceutical expenditure

VED - Vital, Essential, Desirable

Abstract

Background: Inventory management is the heart of the pharmaceutical supply chain system. Effective and efficient management of medical stores requires close monitoring of important drugs, prevention of the pilferage and priority in purchase and distribution of drugs that would help to optimize use of resources and eventually help to improve patient care, by ensuring the availability of essential stocks and preventing stock-outs. Implementation of different types of products' classification and categorization for inventory optimization is critical to minimize the inventory cost and maximize inventory efficiency.

Objective: To describe multi-criteria inventory classification of pharmaceuticals for inventory management optimization in Addis Ababa public hospitals.

Methods: Facility-based descriptive cross-sectional study design with mixed research approach was conducted to retrospectively review logistic data from the digital health commodity management information system (HCMIS) and manual records of 2012-2013 EFY. The quantitative data was analyzed using Microsoft excel spreadsheet and SPSS version 20, while the qualitative data was analyzed thematically.

Result: The ABC – VED matrix analysis revealed that 264 (33.67%) of category (AV, AE, AD, BV, CV) items account for 84.65 % of total pharmaceutical expenditure (TPE), of which the highest amount (32.54%) & (31.17%) was AE & AD items 30 (3.83%) & 50 (6.38%) respectively. From FSN – XYZ matrix analysis Category I consists (FX, FY, FZ, SX & NX) that hold 30.35% of items with 68.12% of total pharmaceutical expenditure (TPE) and 40.21% of items were category II (SY, SZ & NY) holds 11.1% of TPE. The remaining 22.44% of items accounted 21.2% of TPE were grouped under category III (NZ) in 2012. On the other hand Category I holds 36.29% of items that accounted 90.64% of TPE, category II and category III holds 51.87% &11.83% of items that accounted 9.05% & 0.31% of TPE in 2013, respectively.

Conclusion: ABC-VED matrix analysis of present study showed that category I pharmaceuticals holds large amount (84.65%) of budget that needs greater attention for control which avoids wasting extra funds on the purchase of drugs that are not really necessary. Category I consumed 68.12% and 90.64% of total consumption in 2012 and 2013, respectively, according to the FSN-XYZ matrix study. According to this finding, NZ class products spent more budgets (21.2%) in 2012 than 2013 (0.3%). which are non-moving and have low closing values, which creates an issue with a lack of available space and a high rate of waste. In 2013, Category I consumed 90.64% of all pharmaceutical spending and required tight manager supervision.

This study also examined the inventory management practices with in public hospitals, and the findings indicated that while ABC-VED analysis is used in these facilities, it is not updated yearly. FSN-XYZ analysis is not used in any of the hospitals. To reduce overstock and stock out, the hospitals used different inventory control techniques, such as minimum/maximum, routine physical inventory, bin cards, and stock cards**.**

Keywords: Multi-criteria classification, ABC-VED Analysis, FSN-XYZ Analysis, inventory management optimization.

1. Introduction

Inventory is defined as a stock of physical commodity required to meet the future demand having economic value which includes stock of raw materials, finished and/or semi – finished products. In an industrial system, various materials of the right quality in the right quantity are required at the right place and the right time which needs planning using scientific material management (Kushal Kumar, 2019).

Nowadays, in any industry inventory optimization is a critical issue (Aregawi Yemane, 2021). Excess and Shortage of inventory in all levels of the supply chain can affect the availability of products and/or services to consumers (Dr.Y.Lokeswara, 2013). Karthikeyan and his colleague stated that effective and efficient management of medical stores requires close monitoring of important drugs, prevention of the pilferage and priority in purchase and distribution of drugs that would help the optimize use of resources and eventually help to improve patient care, by ensuring the availability of essential stocks and preventing stock-outs (K.Karthikeyan, 2016). In order to meet customer demand at the lowest possible cost and with minimum investment ,inventory control is very important (Ilma Nurul Rachmania, 2013).

There are different types of products' classification and categorizations available for inventory optimization including ABC, XYZ, FSN, SDE, VED, HML (Dr.Y.Lokeswara, 2013). Each of these methods are useful in controlling inventory on their own, however when implementing an efficient inventory management system it is better to use a combination of all available methods to establish a customized system that best meets the needs of a specific pharmaceutical environment (Dr. Babu Krishnaraj R, 2017).

Among all inventory control methods and techniques ABC analysis is the most widely used and the analysis is based on Pareto's Principle of 80,20 rule (Z.Farrukh, 2015). Even if it is simple and easy to use, it is not a very good classification method for inventory informed decisions. Qamar Iqbal (2017) suggested that criteria's other than consumption value is best for classifying inventories. This inventory classification considers more than one factor that can impact on inventory classification, including cost of the item, lead time, criticality, obsolescence, durability, stock ability, order size requirement, commonality, substitutability, and reparability.

In today's world, a moderate-size company must deal with thousands of inventory items, and inventory classification decisions may become challenging (Iqbal et al., 2017). Ng. (2007) declared that a number of methodologies have been proposed in the literature for the multi-criteria inventory classification problem (MCIC). Having the proper amount of materials in the right location at the right time for the lowest price is the goal of inventory management (Geetha Mani, 2014). So the main purpose of this study is to analyze how to optimize inventory management by classifying pharmaceuticals using ABC-VEN matrix and FSN-XYZ matrix analysis.

2. Statement of problem

According to Render. (2011) one of many firms' most expensive assets, inventory can account for up to 50% of total invested capital. Globally, operation managers have known for a long time how important effective inventory management is. One way a company might cut costs is by decreasing inventory. When an item is out of stock, however, production can stop and customers might become dissatisfied. Since the goal of inventory management is to establish a balance between customer service and inventory investment.

Health care institutions across the globe are in search of methods that will prove effective in improving the efficiency of operations, that is inventory management, while reducing expenditures that will in no way affect medical care and services (Tarek Abu Zwaida, 2021). One of the crucial elements that affect the efficiency of the downward supply chain of pharmaceuticals and a potential area for efficiency increases is good inventory management procedures in hospitals (John Charles Okiria, 2016). Moreover, the success of the health care supply chain will be maintained by eliminating wastage, optimizing the usefulness of inventory, and fulfilling the consumer needs (Laquanda Leaven, 2017). In addition to these hospitals should have been accurate and current records of stock for proper management, which are the sources of information used to calculate the needs and inaccurate records produce inaccurate demand estimations which bring about problems of stock outs and expiry (Abdelmonim Ahmed et al., 2019).

Governments spend a significant amount of money on the purchase of medications; somewhere between 40 and 60 percent of the total public health budget of any nation is allocated to this purpose. Despite such significant expenditures, only one-third of the world's population lacks access to basic healthcare, and this number actually rises to one-half in Asia and Africa (Qamar Iqbal, 2017). The mismanagement of available resources is a major contributor to this unfavorable condition, and it is estimated that up to 70% of resources are squandered globally owing to inadequate medication management systems (R. Khembhavi, 2019).

Pharmacy department is one of the most consumers of the hospital budget and one of the few areas where a large amount of money is spent on buying medicines and drugs that ensure smooth supply of the required stock to ensure uninterrupted supply. This calls for the effective and efficient inventory management of pharmacy stock by keeping a close supervision on important drugs, prevention of pilferage, and priority setting in purchase and distribution of drugs (Dorothy Oballah, 2015). To optimize the inventory, it is the most suitable to use available resources according to the importance of inventory items (Z.Farrukh, 2015).

Thus, effective priority setting, decision-making about the acquisition and distribution of specific pharmaceuticals, close monitoring of drugs falling under critical categories, and theft prevention are all dependent on drug and inventory management (Sameer Mehrotra, 2015).

Naidu. (2020) described that the two most significant issues with an inefficient inventory control system are overstocking and shortages. These two issues are often conflicting. On one hand, keeping the inventory level high to avoid stock-outs leads to more storage space requirements, higher management costs, deterioration of products and financial loss. On the other hand, keeping the cost of inventories low, the status of stock-outs in terms of health facilities in particular will cause negative consequences such as delay in the production of health care services, possible loss of income caused by delay, disability or death and related penal practices. In addition to this inadequate availability and access to essential health commodities are major barriers to the delivery of essential health care in developing countries (Adzimah., 2014).

Yu-Tso Chen and Hao-Yun Chang. (2017) stated that the three main challenges hospitals face when managing their pharmaceutical inventory are the absence of a well-designed information system, the challenge of managing the medicine stock while taking the issue of drug expiration into account, and the challenge of finding the right space for storing the medicine. Moreover, an assessment of Pharmaceuticals Inventory Management Performance and Challenges in selected Health Facilities in West Shewa Zone, Oromia Region, showed that, low inventory accuracy rate, high wastage rate and lower storage condition resulted due to poor pharmaceutical inventory management performance (Bekele., 2020).

Though, the inadequate inventory control systems in healthcare facilities in developing nations, like Ethiopia, become a driver for inadequate and excess pharmaceuticals, resulting in stock reduction or expiration and inefficient budget spending (Yohannes et al., 2022). The ABC-VED matrix analysis done in Ethiopia, showed that a significant amount of the annual budget (84.7%) was spent on very few (26.6%) pharmaceutical products and unexpected amount of budget (20%) was dispersed on high cost non-moving (XN) pharmaceuticals based on FSN-XYZ matrix analysis (Jobira et al., 2021). Moreover the study done by Teka. (2018) described that overstocking is another issue that affects the supply of medications. It's possible that institutions ordered more than they needed because of worries about stock shortages. Overall, this causes the supply chain to be inefficient since resources are used to store huge amounts of goods in vast storage facilities, which requires risk of product expiration and slow-moving inventory. So the hospital supply system should ensure adequate stock of all the required items to maintain uninterrupted supply. This necessitates the effective and efficient inventory management of pharmacy store by keeping a close supervision on important drugs, prevention of pilferage, and priority setting in purchase and distribution of drugs (Surabhi Dwivedi, 2012).

However just a few research on the use of multiple criterion categorization in inventory control practices in particular regions of Ethiopia have been done. Most of them conduct only ABC-VED matrix in single health facility (Mohammed and Workneh, 2020, Legese., 2017, Abat, 2017) and the study done by using additional criteria (consumption frequency & stock value) to enhance the inventory management practices were done in regions (Yohannes et al., 2022, Jobira et al., 2021). There hasn't been any research done in Addis Ababa despite variations in the regional leadership.

3. Research questions

- How to classified pharmaceuticals using ABC-VEN matrix analysis in the hospitals?
- How to classified pharmaceuticals using FSN-XYZ matrix analysis in the hospitals?
- How is the practice of pharmaceutical inventory management optimization in public hospitals?

4. Objectives

4.1. General objective

To describe multi-criteria inventory classification of pharmaceuticals for inventory management optimization in Addis Ababa public hospitals.

4.2. Specific objective

- To conduct pharmaceuticals ABC-VEN matrix analysis for inventory management optimization.
- To conduct pharmaceuticals FSN-XYZ matrix analysis for inventory management optimization.
- To assess pharmaceutical inventory management optimization practice in public hospitals.

4.3 Significance of the research

Inventory management optimization is the major challenge which directly affects the clinical services given by hospitals. Good inventory control system within the hospitals enables to maintain a tradeoff between carrying costs and ordering costs which results in minimization of the total cost of inventory, maintaining adequate inventory for sustainable supply of products, avoiding stock out problems, losses, damages and misuses.

This study conducted different inventory control techniques and assessed pharmaceutical inventory management optimization practice within Addis Ababa public hospitals. This study may help the hospitals, EPSS, Federal Ministry of Health and Addis Ababa City Administration

Health Bureau to understand the current situation related to multi-criteria classification of pharmaceuticals for inventory management optimization and plan for future course of action to minimize shortage of pharmaceuticals, stock out, wastage rate, inventory cost and strengthen the overall drug supply management system. Moreover, the study can support researchers to carry out more research on multi-criteria inventory classification.

5. Literature review

This section covers theoretical review on inventory management optimization that includes inventory classification methods along with the empirical study conducted on these areas and conceptual framework.

5.1. Theoretical Literature Review

5.1.1. Inventory

According to Tom Jose V (2013) "Inventory" means physical stock of goods, which is kept in hands for smooth and efficient running of future affairs of an organization at the minimum cost of funds blocked in inventories. The main reason for carrying inventory is that it is physically impossible and economically impractical for each stock item to arrive, exactly when it is needed.

In pharmacy operations, inventory is referred to the stock of pharmaceutical products retained to meet future demand. Inventory represents the largest current asset, as well as liquid asset in pharmacy practice and its value continues to rise because of the growth in variety and cost of pharmaceutical products (Ayad K. Ali, 2011).

The importance of inventory described by Farida (2019) are; storing resources to provide good service to customers, buffer inventory to anticipate inventory shortages and inventory stock out, transit inventory, to anticipate price fluctuations every year, for quantity discount and seasonal inventory.

5.1.2 Inventory management

Inventory management is the process of monitoring and controlling inventory level and ensuring adequate replenishment in order to meet customer demand. Determining the appropriate inventory level is crucial since inventory ties up money and affects performance. Holding too much inventory reduces the working capital and impacts the company's liquidity. On the other hand, holding too little inventory leads to stock outs and missed sales which lead to less profit. Therefore management attention should be focused on keeping inventory level somewhere in between, striving for increased customer satisfaction and minimum stock outs while keeping inventory costs as low as possible (G Priniotakis and P. Argyropoulos, 2019).

Moreover, R. Khembhavi (2019) defined as inventory management is the continuing "process of planning, organizing and controlling inventory" that aims at minimizing the investment in inventory while maintaining a sound balance between holding costs, on the one arm, and purchasing and shortage costs, on the other hand also stresses on cost containment, better efficacy, demand and supply.

Inventory management is the core of the pharmaceutical supply system (MSH., 2012). The main objective of hospital inventory management and healthcare supply chain research is to reduce health care cost without sacrificing the quality of service to the patient by improving efficiency and productivity of the health care system (Ilma Nurul Rachmania, 2013).

According to Bekele. (2020) the goals of inventory management is to minimize the amount spent on inventory and the procurement and holding costs while balancing the service level and the stock level. Hence, pharmaceutical inventory management is a key factor in success in a pharmacy because efficient inventory management can keep costs down, improve cash flow, and improve service. So poor inventory management results in increased operating and opportunity costs.

5.1.3 Inventory management practices

(Iqbal et al., 2017) described that inventory management is the branch of business management concerned with planning and controlling inventories. The main goal of inventory control in a health care setting is to ensure that sufficient and optimal essential items are properly stored,

controlled, and easily retrievable and distributed to points of uses so that patient care does not suffer due to lack of these pharmaceuticals (Geetha Mani, 2014). This is supported by Tarek Abu Zwaida (2021) that efficient inventory management is considered as a solution to improve the quality of customer service and the health Supply Chain management of hospitals.

An efficient inventory management system overcomes the issues of excess stock, out of stocks, non-movable stocks and also saves the time taken for collecting stock details by the pharmacist and increases the serviceability by fulfilling the customer need (Manivel P, 2016).

The pharmaceutical inventory which is regarded as a hospital medicine supply center needs to be efficiently controlled and managed. An effective pharmaceutical inventory management can not only accurately reflect the consumption status of the medicine but also avoid the problem of expired medicines to keep the safety stock for the use of medicines (Yu-Tso Chen and Hao-Yun Chang. , 2017). Pharmacy inventory management is a complex but critical process within the healthcare delivery system. Without adequate pharmacy inventory management practices, healthcare facilities run the risk of not being able to provide patients with the most appropriate medication when it is most needed (Iqbal et al., 2017).

5.1.4 Multi Criteria Inventory classification

Manivel P (2016) described that multi Criteria Inventory classification methods are used to classify inventory by considering more than one factor that could affect the inventory classification. This would result in comprehensive managerial control of the inventory items leading to reduction in inventory holding costs and increased productivity. Inventory classification based on single criteria sometimes may not provide optimum result so matrix based approach which can be utilized in case of two criteria is to be considered (Desai., 2019). The common inventory classification methods with their criterias and its application are described below in table 1.

Table 1: Common inventory classification method

Techniques	Criteria	Application
ABC (Always, Better, Control) Analysis	Annual Consumption value of the item 'n' (consumption rate * unit price)	To control inventory hotspots.
XYZ Analysis	Closing stock value of inventory at the time of physical stock verification.	To review the store's actual inventories and their uses, at scheduled intervals.
VED (Vital, Essential, Desirable) Analysis	Criticality.	To determine the criticality of stocking level of spare parts for machines and equipment's, drugs.
FSN (Fast, Slow, Non-Movable)Analysis	Consumption pattern of the items.	To control obsolescence. Fast moving items should be kept at high levels.
HML (High, Medium, Low) Analysis	Unit price of the item	To control the purchases and develop vendors. To keep a check on high cost items
SDE (Scarce, Difficult, Easy) Analysis	Procurement difficulties: geography, reliability, etc. Source of Procurement	To keep watch on availability, should be kept in stock keeping in mind difficulty of procurement and may follow forward buying.
SOS (Seasonal, Off- Seasonal) Analysis	Seasonal variation (eg. Soya bean, farm produce, high off season price, low in harvest season).	Procurement/holding strategies for seasonal items like agricultural products.

Adapted from (Manivel P, 2016).

1. ABC Analysis

According to Dr.Y.Lokeswara. (2013) ABC (Always Better Control) analysis is based on Pareto's principle which says 20% of the items contribute to 80% of sales. It implies that a small portion of items in inventory contribute to maximum sales. Typically less than 20% of items classified as A, contribute as much as 80% of the revenue. The next 15% contribution to revenue is done by B class items. The last 5 % revenue is generated by items classified as C.

Moreover, Handanhal Ravinder and Ram B. Misra (2014) stated that ABC analysis is a technique for prioritizing the management of inventory that are categorized into three classes A, B, and C. Most management efforts and supervision are expended on managing A items. C items get the least attention and B items are in-between. However, traditional ABC analysis is based on only a single measurement that is annual dollar usage. While Ng. (2007) suggested that other criteria, such as inventory cost, part criticality, lead time, commonality, obsolescence, substitutability, number of request per year, scarcity, durability, reparability, order size requirement, stock-ability, demand distribution and stock-out penalty, are also important in inventory classification.

A major limitation of the individual implementation of ABC analysis in a pharmaceutical set up is that it is restricted in classifying items based on its usage value. It is evident that some vital and lifesaving drugs which have a low consumption rate might not fall under the first category in the ABC analysis. Further, with the recent advances in medical sciences and pharmaceutical technologies along with drug regulatory laws, it is probable that a significant number of vital drugs are now available at a lower price, and therefore would be categorized under the second or third category in the ABC analysis. It is therefore imperative that the criticality of the drug is also considered to be an important factor for drug categorization (Kaushik Nag, 2016). This initiates the need for using additional multi criteria inventory classification and management techniques.

2. VED Analysis

Yılmaz (2018) described that the vital, essential, and desirable (VED) analysis categorizes goods into three classes based on their level of significance. This analysis, which is based on the importance of the products to human life, is typically used to regulate the use of pharmaceuticals and medical supplies.

VED analysis commonly used in hospital inventory management is based on the criticality of an item. “V” is for vital items without which a hospital cannot function, “E” for essential items without which an institution can function but may affect the quality of the services and “D” stands for desirable items, unavailability of which will not interfere with functioning (Singh et al., 2015).

3. ABC-VED Matrix Analysis

ABC analysis is an effective inventory control system which classifies inventories according to their annual consumption values. Hence more attention is paid on the items which are valued highly, and consumed more. This law states that “only 20% of the activity causes 80% of effect” (Dr.S.Selvabaskar, 2018). However, ABC analysis is one-dimensional, because it is based on a single metric, and may not capture different aspects of criticality. Especially in hospital pharmacies where drug administration is complex and drug shortages can have an impact on human lives, the only use of ABC classification cannot adequately support inventory management functions because it imposes the risk of assigning a low priority to an item because of its low consumption values, despite its critical importance for human lives (Christos Bialas, 2020).

Studies showed that by mixing ABC and VED analysis, three categories are obtained. Category I (AV, AE, AD, BV, & CV) items are both expensive and critically vital for patients’ life and have high consumption value, so strict and continuous managerial control is important. Category II (BE, CE, & BD) items are not as critically vital for patients’ life and holds less consumption value. These need to be controlled periodically. Category III (CD) items are less expensive and less critical. They do not need to be controlled periodically. Moreover, due to the greater annual drug expenditure (ADE) of hospital pharmacy stores it is important to apply scientific inventory

management tools for optimum management of the drug stores to set priorities in an optimum way, timely decision making in purchase of specific drugs and close supervision on drug items belonging to important categories. Thus, ABC and VED analysis can be applied to show the drugs that need strict management control for effective & efficient utilization of hospital funds and elimination of out of stock situations in the hospital pharmacy (Semu., 2018).

Table 2: ABC-VED Matrixes

ABC-VED Matrix	**Vital (V)**	**Essential (E)**	**Desirable (D)**
High consumption value (A)	AV	AE	AD
Medium consumption value (B)	BV	BE	BD
Low consumption value (C)	CV	CE	CD

Therefore inventory management of drugs using ABC and VED analysis is very essential as it adversely affects the consumption rate and purchasing cost of drugs (K.Karthikeyan., 2016). This is supported by Dr. Sabah M. Al-Najjar (2018) idea which described 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. The cross tabulating was shown in Table_2.

4. FSN Analysis

Devarajan and Jayamohan (2016) stated that in any organization, all items are not required with the same frequency. Some products are quite regularly required, yet some others are required very occasionally and some products may have become obsolete and might not have been demanded for years together. FSN analysis groups them into three categories as Fast-moving, Slow-moving and Non-moving (dead stock) respectively.

FSN classification is based on the consumption pattern of the materials. Here the items are classified into fast moving, slow moving and non-moving on the basis of frequency of transaction (Naidu., 2020). Inventory policies and models for the three categories have to be different. While performing this particular analysis the turnover ratio of each item has to be

calculated because the items are sorted and analyzed according to the turnover ratio it possesses (Devarajan and Jayamohan, 2016).

FSN analysis is stock turnover ratio based analysis which is obtained by dividing annual consumption of a material by its average inventory. The items can be classified into three categories: Fast moving (F) those items whose stock turnover ratio is greater than 3, Slow moving (S) those items whose stock turnover ratio is between 1 and 3 and non-moving (N) those items whose stock turnover ratio is below 1. Those items whose turnover is less than 1 are selected to conduct XYZ analysis (Devarajan and Jayamohan, 2016).

5. XYZ Analysis

XYZ analysis is one of the basic supply chain techniques, frequently used to determine the inventory valuation inside Stores. It's also strategic as it intends to enable the inventory manager in exercising maximum control over the highest stocked item, in terms of stock value (Nivethini, 2018).

This analysis is always done for the current stock in inventory and aims at classifying the items into three classes on the basis of their inventory values (Devarajan and Jayamohan, 2016). The results of the XYZ analysis provide information that helps calculate how each inventory part should be supervised and controlled. These controls are typically X class items which are critically important and require close monitoring and tight control while this may account for large values these will typically contain a small percentage of the overall inventory count. Y class is of lower criticality requiring regular controls and periodic reviews of usage. Z class requires the least controls, and are sometimes issued as “free stock” or forward holding (Nivethini, 2018).

6. FSN-XYZ Matrix Analysis

Every product in the industrial sector has a distinct rate of consumption, with some having a high rate and others a low one. FSN aids in the identification of moving, non-moving, and slow-moving objects. Combined XYZ-FSN analysis helps the company to classify items into NX, NY and NZ categories, these categories represent non-moving items which accounts for the bulk of

slow moving or non-moving stock value (Devarajan and Jayamohan, 2016). This joined analysis helps companies to make decisions of removal or disposal regarding non-moving items. Items in the NX category should be disposed of as soon as possible at the best price, according to the policy. The strategy for items in the NY category is that items in this category must be discarded as early as possible and the strategy for items in the NZ category is that items in this category must be discarded as early as possible even if low prices are getting for their disposal (Jobira et al., 2021).

5.2 Empirical literature review

Pharmaceutical items management is important in health facilities to provide the supply of medicines to the user. Hence, scientific inventory control management should be applied to achieve efficient management and patient satisfaction for the efficient management of medical stores (Semu., 2018).

A study conducted on the effect of inventory management practices on organizational Performance in public health institutions in Kenya: at Kenyatta National Hospital showed that appropriate inventory management starts with an understanding of purchasing the right products in the right quantity at the right price, and at the right time from the right vendor. In addition to that the hospital pharmacy management teams should adopt inventory management practices which have positive effects on the performance of the hospital. Using these key concepts and practices to gain insight will enhance pharmacy inventory record accuracy, inventory investment and inventory turnover in the pharmacy purchasing departments and will go a long way to improve best inventory management as well as organizational performance (Dorothy Oballah, 2015).

Multi-criteria inventory classification has been addressed by some studies in the literature. According to Handanhal Ravinder and Ram B. Misra (2014) traditionally, different inventory items have been divided into three groups using the ABC analysis: A, B, and C. This was done using the dollar volume criterion. A single criterion is no longer sufficient as a management tool for inventories in the modern worldwide, hyper-responsive corporate environment, and numerous criteria must be taken into account.

Study conducted on Application of ABC-VED Matrix Analysis to control the inventory of a central pharmacy in a public hospital showed that Category I includes subclasses AV, AE, AD, BV, and CV. This category contains 23 (16.67%) of the drugs population studied, which accounts to 71.47% of the total ADE. Category II consisted of 58.69% (81 drugs) and its annual consumption represents 27.67% of the total ADE. The third category 24.64% (34 drugs) represents 0.86% of the ADE. The study suggested that the hospital should follow the categorization of drugs to control the central pharmacy's drugs, to realize optimal allocation of budget, and avoid stock out cases in the central pharmacy (Dr. Sabah M. Al-Najjar, 2018).

Similar studies done by Singh et al. (2015) on ABC and VED analysis reported that 11.08%, 22.16%, and 66.75% of items are identified in the ABC analysis of the pharmacy shop for the 2009–2010 fiscal year fell into the A, B, and C categories, respectively, and accounted for 70.04%, 19.93%, and 10.02% of the pharmacy's ADE. The VED analysis identified 12.40%, 60.16%, and 27.44% of the pharmacy's ADE as belonging to the V, E, and D categories, respectively, and accounting for 25.05%, 66.91%, and 8.04% of the total. By using ABC and VED analysis to determine which medications require stringent management control, out-of-stock issues in the hospital pharmacy can be avoided and hospital resources are employed as effectively and economically as feasible.

A study from Kuwait that showed the ABC-VED analysis was a beneficial inventory control technique for classifying the medications that needed strict supervision for the optimal use of financial resources and the elimination of out-of-stock problems confirmed the theory. According to the assessment, only 27% of products, or a sizable 71% of yearly prescription spending, were discovered to be pricey and vital. As a result, the remaining items no longer need to be given the same amount of attention, for which low to moderate levels of control may be deemed enough, and must instead receive the highest possible level of control. As a result, such product categorization makes it easier to set priorities, make decisions about purchases and distribution, and keep a close eye on particular things (Kaushik Nag, 2016).

Only the ABC or VED matrix classification is inadequate to maintain the stock at the right level with a minimum amount of shortfall and oversupply, according to a Thailand-based study on the importance of consumption patterns and the ABC/FSN matrix to optimize the management of

important medicine inventories. According to this study, of the total consumption value, items falling into the categories of A were employed (78%), B was utilized (16%), and C was utilized (6%). In light of this, classifying important pharmaceuticals using the ABC/FSN matrix enables hospitals to manage their inventory levels while spending as little money as possible on out-of-date or slow-moving products (Nang Nwe Ni Hlaing, 2017).

According to Devarajan and Jayamohan (2016), it is crucial to perform FSN along with XYZ analysis in order to identify the products that should be thrown away and the amount saved, and the management should give non-moving items more consideration while performing FSN categorization so that decisions can be made regarding whether they will be needed in the future or if they are salvageable. Value of each unused component should be the main consideration while disposing of all non-moving items (N) identified by FSN analysis. To do this, running an XYZ analysis on the N category item is important.

In Ethiopia, a study by Abat (2017) addressed the issues of availability and accessibility of essential drugs for improvement of therapeutic outcome of hospital activity. The objective of the study was to assess the pharmaceutical inventory management system of Tikur Anbessa specialized Hospital (TASH), from 2009 - 2013 using ABC-VED matrix analysis. The study discovered that TASH has a substantial healthcare sector that needs efficient management and control. The proportion of pharmaceuticals in Category I was likewise higher than that of those in Categories II and III. Most Category I drugs also fall within Classes A and V, which need special consideration due to their accessibility and security. The study suggests that in order to successfully and efficiently manages pharmaceuticals; hospital supply chain management should be regularly monitored using ABC-VED matrix analysis.

Similarly, a study on Critical Analysis of Pharmaceuticals Inventory Management Using the ABC-VED Matrix in Dessie Referral Hospital, Ethiopia for the year 2013 to 2017 reported that, Medication in categories I, II, and III also made up 43.68%, 54.79%, and 1.53% of the total, with respective USD medication expenditures of 2,268,405.64 (84.49%), 411,961.18 (15.34%), and 4483.97 (0.17%). A large amount of budget is invested in class A and category I, which indicates the need for strict inventory control to prevent wastage and accumulation of capital in safety stocks and recommended that before initiation of any new procurement, ABC-VEN analysis

should be routinely performed for efficient use of scarce resources (Mohammed and Workneh, 2020).

According to the research done at Hadiya Zone public Health facilities, based on ABC-VED analysis category I accounts for (84.3%) of total pharmaceutical spending (TPS). Only 21 products (4.9%) in category III (CD) made up (0.3%) of the TPS. Individual pairs reported that 124 (29%) of the products were less expensive vital (CV) items, with an annual consumption value (4.4%). (n=39) (9.1%) items totaling (51.8%), or more than half of the budgeted expenditure, were included in the vital costly products (AV). Moreover, the result on FSN - XYZ analysis reported that category I (FX, FY, FZ, SX, & NX) over the period of 2017, 2018, & 2019, category I gained dominance. In 2017 it represented 44.1%, and in 2018 and 2019 it represented 55.1% of items which contributed up to 84.5% of the total pharmaceutical spending. The XF couple, the costly fast-moving items, made up the majority of the spending, up to 60%. The percentages of the second category (SY and SZ) and third category (NZ) didn't reach above 30% (Yohannes et al., 2022).

In addition, the study was conducted on ABC-VED matrix analysis which is supported by FSN-XYZ matrix analysis to evaluate inventory management in selected health facilities of West Arsi Zone, Oromia, Ethiopia. The study explored that there are different inventory control techniques used for inventory management optimization. Based to the ABC-VEN matrix study, class A and class V goods accounted for the majority of Category I items (26.6%) and consumed 84.7% of the annual drug expenditure (ADE). Only 13.2% and 2.1% of the ADE, or the remaining 49.2% and 24.2% of the medicines, fell into categories II and III, respectively. According to the results of the FSN-XYZ matrix study, category I, with a 41% item share, has the greatest budget (on average, 86.5% of values). The XN group in this category non-moving, expensive drugs had the highest value (20%) and required managerial action. Because 25% of the category III items in the ZN group were pharmaceuticals, their value was only 2.2%; this may result in increased wastage, higher inventory holding costs, and a shortage of storage space (Jobira et al., 2021).

There was limited research in Addis Ababa public hospitals, which gives several services for many populations. So this study was conducted on multi-criteria classification of

pharmaceuticals for inventory management optimization in public hospitals, Addis Ababa, Ethiopia.

5.3 Conceptual framework

A conceptual framework is a research tool intended to assist a researcher in developing an understanding of the situation under investigation. In this study, inventory management optimization is conceptualized as being dependent on the inventory classification techniques (ABC-VED Analysis & FSN-XYZ Analysis).

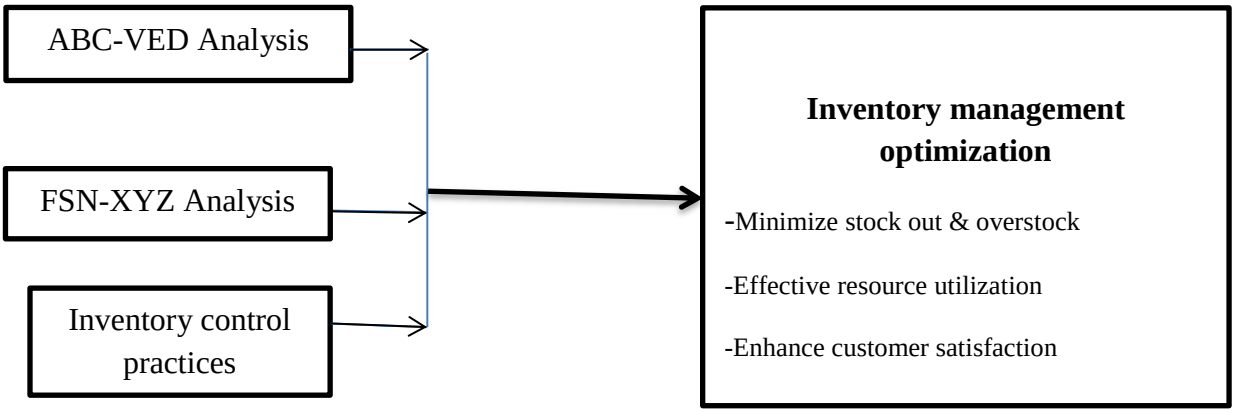

Figure 1: Conceptual Framework

6. Methodology

6.1 Study design and period

This is a facility-based descriptive cross-sectional study design with a sequential mixed research approach. The quantitative approach was used to conduct ABC-VED & FSN-XYZ matrix analysis by reviewing supply chain data from a digital LMIS tool called health commodity management information system (HCMIS/DAGU) and manual records of 2012 - 2013 EFY, as well as to assess the inventory management practices using self-administered questionnaires. The qualitative approach was used to explore the practices and challenges related with inventory management optimization in hospitals. The data collection period was from February – April, 2022.

6.2 Study Setting

This study was conducted in public hospitals of Addis Ababa, capital city of Ethiopia. It is the biggest city in the country having 11 sub cities and 116 woreda, with a total population estimate in 2021 was 5,005,524 with annual growth rate of 4.42 (Prospects.. 2021). Among 14 public hospitals, 7 hospitals are under Addis Ababa City Administration Health Bureau (Zewuditu Memorial, Yekatit 12, Ras Desta, Gandi, Minilik II, Tirunesh bejing and Abebech Gobena hospitals), 7 hospitals are under Federal Ministry of Health (St.Paulos Hospital Millennium Medical College, Addis Ababa Burn, Emergency & Trauma, All African Leprosy Rehabilitation Training Center, St, Peter, Amanueal, Eka Kotebe and Tikur Anbesa Specialized Hospital).

6.3 Source population

All pharmaceuticals purchased by Addis Ababa public hospitals and all documents containing logistics data within the hospitals were the source of population. All hospital staffs working in those public hospitals that are involved in pharmaceutical supply management activities were included for the qualitative study.

6.4 Study population

All pharmaceuticals purchased by revolving drug fund (RDF) in selected public hospitals, selected pharmacy professionals who are working in pharmacy units and manual & electronic Logistics Management Information System (LMIS), like receiving vouchers, issuing vouchers, stock record cards & bin cards and Health Commodity Management Information System (HCMIS) for the year 2012-2013 EFY were considered as a study population.

6.5 Sample procedure

The sample size was determined as per the USAID|DELIVER Project's Logistics Indicator Assessment Tool (LIAT) recommendation with a minimum of 15% of the total health facilities was suggested (John Snow, 2005). Among 14 public hospitals found in Addis Ababa seven hospitals are found under AACAHB. From those hospitals Gandi and Abebech Gobena hospitals were excluded from the study due to its specific service & established less than a year respectively. Among seven hospitals obtained under FMOH, AaBET, Amanueal and Eka Kotebe

were excluded because of the specialized service and their focus on selected health commodities. Finally three (Minilik II, SPHMMC, & ALERT) hospitals were selected by simple random (lottery) method. Participants for a key informant interview were selected by purposive sampling because they are supposed to be information rich than other health professionals in this topic area. From each hospital the pharmacy head, one store manager and DSM officer, a total of 9 key informants were selected.

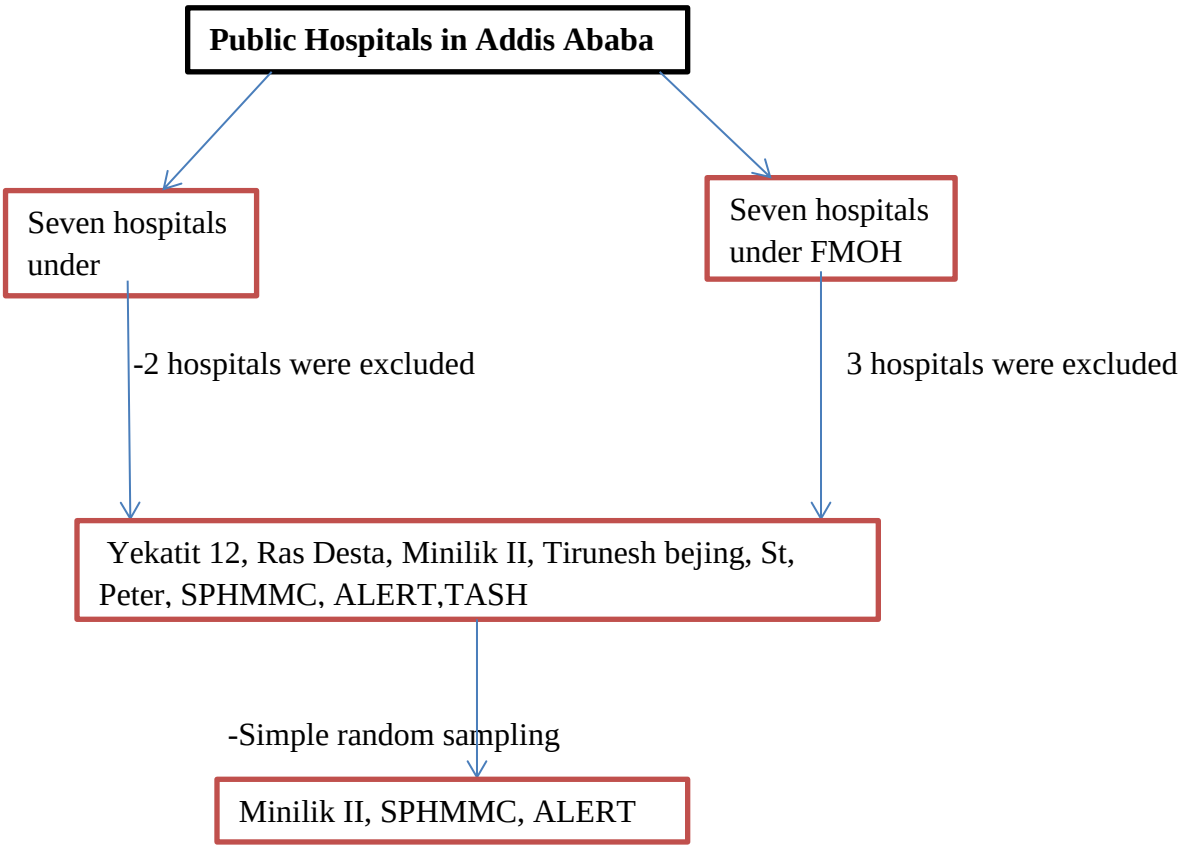

Figure 2: sampling procedures in public hospitals, Addis Ababa.

6.6 Inclusion and Exclusion Criteria

For the quantitative study, pharmaceuticals (medicines, medical supplies & laboratory reagents) that are purchased by the hospitals, procured through Revolving Drug Fund (RDF) and recorded in good receiving vouchers, good issuing vouchers and recorded in DAGU system for the year 2012-2013 EFY were included, but program drugs and medical equipment's were excluded because program drugs were not purchased by hospital budget and medical equipment's are a

fixed asset that cannot be classified. Pharmacy heads, drug supply management case teams (store managers, DSM officers, purchasers, data clerks) and pharmacy unit coordinators were included purposely to fill the self-administered questionnaires. For the qualitative study, head of the pharmacy, DSM officer and one store manager from each hospital were purposely selected and included for the interview as a key informant.

6.7 Data collection method

The study was used both primary and secondary data collection method. Semi-structured questionnaires, observation checklist and interview guides were used to collect the primary data. Manual & electronic LMIS, like receiving vouchers, issuing vouchers, physical inventory report, stock record cards & bin cards and HCMIS were used to collect secondary data.

For ABC analysis the annual received value of pharmaceuticals were obtained from a good receiving voucher and DAGU (HCMIS) & for VED analysis, the categorizations were obtained from hospitals drug list. Data for FSN analysis were obtained by reviewing issuing vouchers (Dagu-facility) and calculating the turnover ratio by excels spreadsheet. Finally for XYZ analysis the data were obtained from physical inventory records for the year 2012- 2013 EFY.

The key informants were interviewed with flexible probing questions to explain the inventory management practices. Logistics system assessment tool (LSAT) developed by USAID was adopted as an interview guide (John snow, 2009). Verbal informed consent was obtained from the participants and to maintain the consistency of the question face to face interview was applied. The average duration of the interview was 35 min, ranging from 24 to 48 min. Tape recorder was used and the records were listened to many times and translated into words.

6.8 Data Analysis

The quantitative data was analyzed by using Microsoft excel spreadsheets and SPSS version 20. For the ABC analysis, the total quantities of each pharmaceutical received during the previous two years were collected, and the average price and total quantities received were multiplied to determine the annual financial value of each pharmaceutical.

Cross-tabulation was used to integrate the ABC and VEN studies to create an ABC-VEN matrix and various drug categories. Three major categories and nine subcategories were derived from the matrix. Category I consists of vital and highly valued items (AV, BV, CV, AE, and AD), Category II consists of essential but less valuable items (BE, BD, and CE), and Category III consists of the remaining items (CD) which consists desirable and less expensive ((Mfizi et al., 2023).

FSN analysis was done based on Turnover Ratio that was calculated by dividing annual demand with average inventory (Devarajan and Jayamohan, 2016). Based on the value of the inventory that was in stock, XYZ analysis was performed. The closing stock values of the goods were determined from the annual physical inventory report by multiplying current stock and the unit cost of each item, sorting the stock value in descending order, and then calculating the percentage of stock value and cumulative stock value. After that, a cut-off point was determined based on the distribution. Typically, the X Class makes up the first 70% of the total inventory value, the Y Class makes up the next 20%, and the Z Class makes up the final 10% of the value (Devarajan and Jayamohan, 2016).

A matrix with nine subcategories and three core categories was produced by merging the findings of the two FSN-XYZ analysis. Category I of these consists of the following: FX, FY, FZ, SX, and NX; category II of these includes SY, SZ, and NY; and category III of these contains NZ, a category that is made up of non-moving and low-value commodities.

Descriptive statistics were used to analyze the data, with the values 0, 1, 2, 3, 4, and 5 on a 5-point Likert scale, denoting I don't know, strongly disagree, disagree, neutral, and agree, respectively. An observation check was made in order to triangulate the findings of the entire investigation. The qualitative data was analyzed thematically (transcription, reading & familiarization, coding, searching for themes, reviewing themes, defining & naming themes), and finalizing the analysis by producing a report.

6.9 Data quality assurance

Data extraction formats were developed by examining different types of literature and were evaluated by relevant & experienced researchers to maintain the data validity. In addition, a

pretest was conducted in Zewuditu Memorial Hospital, which was excluded from the study. After the pretest, the principal investigator reviewed the data extraction format for changes. In addition the consistency and completeness of data was checked every day by the principal investigator.

6.10 Ethical consideration

Before the data collection, ethical approval was obtained from the Ethical Review Committee of the School of Pharmacy, college of health science, Addis Ababa University. Then a support letter was obtained from the department of pharmaceutics and social pharmacy to Addis Ababa health bureau city administration and Federal Ministry of Health to each hospital and submitted to the hospitals to get permission that enable to conduct the study. Ethical clearance was obtained from Addis Ababa public health research and emergency management directorate. Written informed consent was obtained from the participants after explaining the objective of the study. Confidentiality was reserved using codes for all the information given by the participants. All documents which are used for secondary data collection were taken under responsibility. The data obtained from individuals were analyzed in aggregate and individual identifiers were not used.

6.11 Operational definition

Inventory control: is the process of managing inventory in order to meet customer demand at the lowest possible cost and with a minimum investment.

Inventory: is a detailed list of assets held by an organization or institution like goods in stock, drugs and equipment.

Inventory management: is defined as the continuing "process of planning, organizing and controlling inventory" that aims at "minimizing the investment in inventory while balancing supply and demand".

Safety Stock: It is the minimum quantity of inventory which a firm decides to maintain always to protect itself against the risk and losses likely to occur due to interruption in production and loss of sale, due to non- availability of inventory.

ABC Analysis: ABC analysis may be defined as a technique where inventories are analyzed with respect to their value so that costly items are given greater attention and care by the management.

VED Analysis: VED stands for Vital, Essential and Desirable. Highest control is over vital items, medium control is exercised over essential items and least control is inferred over desirable items.

FSN Analysis: FSN stands for Fast Moving (F), Slow Moving (S) and Non Moving (N). Highest control is kept over fast moving items, medium control is exercised over slow moving items and least control is inferred on non-moving items.

XYZ Analysis: It is based on the closing inventory value of different items. Such classification is done every year at the time of annual stock taking and items having highest closing inventory value are classified as 'X', while those with low closing inventory value are termed as 'Z' items. Other items are 'Y items whose inventory value is neither too high nor too low.

Inventory Turn-over rate: measures the number of times the inventory turns over (or is replaced) in a given time period, usually a one-year period, but it can be less than that for larger warehouses.

6.12 Dissemination of results

Results of the study will be disseminated to Addis Ababa Public Hospitals, Addis Ababa City Administration Health Bureau, Ministry of Health, and Department of Pharmaceutics and Social Pharmacy. In addition, maximum effort will be employed to publish the manuscript in peer reviewed journals.

7. Result

This study was conducted in three public hospitals of Addis Ababa, Ethiopia. The finding of the study was presented in aggregate for the three hospitals.

7.1 ABC –VED Analysis

7.1.1 ABC Analysis

From the selected hospitals, in two years between July, 2019, and June, 2021, about 784 pharmaceuticals were received and their cost of estimation was 292,731,102.6 ETB. ABC analysis indicated that 98 (12.50%), 173 (22.07%) and 513 (65.43%) items were categorized as class A, B, & C and constituted around 79.94%, 15.04% & 5.02% of total pharmaceutical expenditures (TPE) respectively (Table_3).

From the 98 A class items 64 (65.31%) were medicines, 31 (31.63%) were medical supplies and 3 (3.06%) were chemicals &reagents. Among the 64 class A medicines 11 (35.48%) were Anti-Infective, 10 (32.25%) were Immunological preparation and 6 (19.35%) were Anti-Neoplastic drugs which accounted for 5.25%, 7.01% & 2.05% of TPE respectively (Table_3). Out of 98 class A items Surgical Glove - Sterile Latex No.7.5, Sodium Chloride (Normal saline) - 0.9% in 1000ml, and Adult Face Mask accounted 20.73% of TPE.

Table 3: ABC analysis of pharmaceuticals at public hospitals in Addis Ababa, 2012-2013 EFY

ABC Analysis	No of Items (%)	Annual value (%)	Medicine	Medical supplies	Chemicals & Reagents
A	98 (12.50%)	234,000,451.7 (79.94%)	64 (65.31%)	31 (31.63%)	3 (3.06%)
B	173 (22.07%)	44,040,805.63 (15.04%)	113 (65.32%)	47 (27.17%)	13 (7.51%)
C	513(65.43%)	14,689845.25 (5.02%)	284 (55.36%)	148 (28.85%)	81 (15.79%)
Total	784 (100.00%)	292,731,102.6 (100.00%)	461 (58.08%)	226 (28.83%)	97 (12.37%)

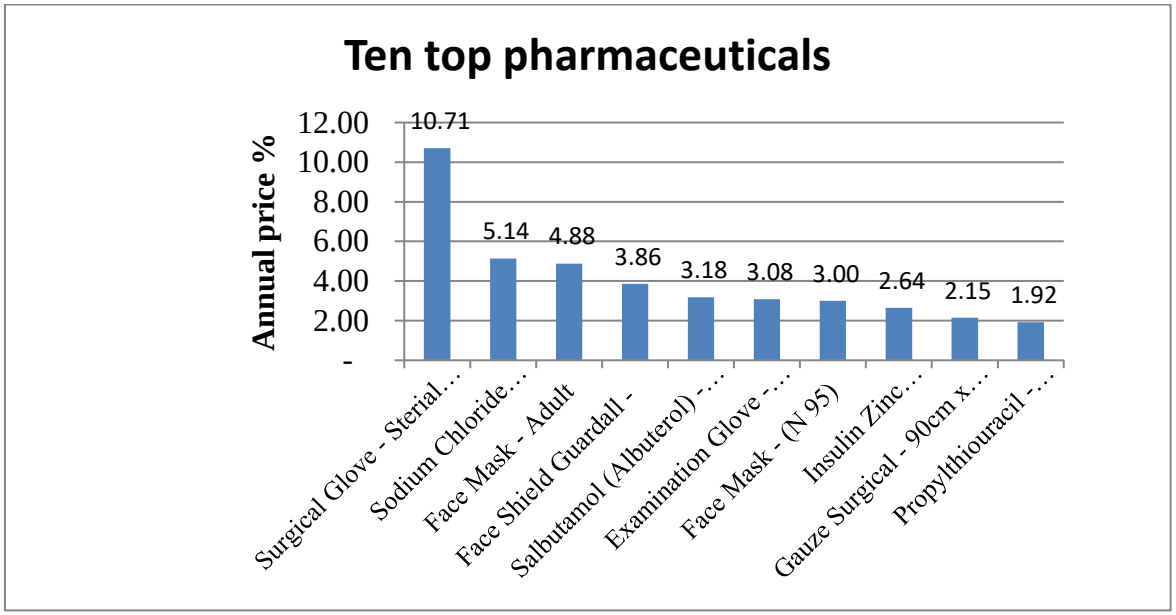

Figure 3: Ten top pharmaceuticals at Public Hospitals in Addis Ababa, 2012-2013 EFY

7.1.2 VED Analysis

The VED analysis indicated that, from a total of 784 pharmaceuticals, 184 (23.47%), 192 (24.49%), & 408 (52.04%) of them were vitals, essentials & desirable that contributed to 20.93%, 36.79%, & 42.28% of TPE respectively. Out of the 184 vital pharmaceuticals, 104 (56.52%) were medicines, 55 (29.90%) were medical supplies and 25 (13.59%) were Chemicals & Reagents (Table_4).

This study showed that among 104 vital medicines 18 (17.31%) were Anti-Infective, 17(16.35%) were Anti-Neoplastic and 15 (14.42%) were central nervous system (CNS) drugs accounted for 2.74%, 4.33% & 8.90% of annual price respectively.

Table 4: VED analysis of pharmaceuticals at public hospitals in Addis Ababa, 2012-2013 EFY

VED Analysis	No of Items (%)	Annual value (%)	Medicine	Medical supplies	Chemicals & Reagents
V	184 (23.47%)	61,277,702.64 (20.93%)	104 (56.52%)	55 (29.90%)	25 (13.59%)
E	192 (24.49%)	107,691,976.1 (36.79%)	121 (15.43%)	46 (5.87%)	25 (3.19%)
D	408 (52.04%)	123,761,423.9 (42.28%)	236 (30.10%)	125 (15.94%)	47 (5.99%)
Total	784 (100.00%)	292,731,102.6 (100.00%)	461 (58.80%)	226 (28.83%)	97 (12.37%)

7.1.3 ABC-VED Matrix

Matrix analysis was done by combining ABC & VED analysis using cross tabulation. The result showed that among 784 pharmaceuticals, 264 (33.67%) of items were include in category Ⅰ (AV, AE, AN, BV, CV), accounted 247,786,818.2 ETB, 84.65% of total annual value and category Ⅱ include 263 (33.55%) of items, that accounted for ETB 37,294,963.18 (12.74%). The rest 257 (32.78%) of the items were grouped under category Ⅲ (CD) which accounted for ETB 7,649,321.23 (2.61%) of total annual price (Figure_4).

7.2 FSN - XYZ Analysis

7.2.1 FSN Analysis

The study revealed that in 2012, 149 out of 558 pharmaceuticals were classified as F class and it holds 53.69% of TPE. Around 184 pharmaceuticals were considered as S class which holds 19.96% of TPE and the rest 225 were N class that accumulates 26.34% of TPE. In the EFY 2013, 111 out of 372 pharmaceuticals were classified as F class that holds 84.63% of TPE and 172, 89 items were S which holds 11.44% of the TPE and the rest 89 items were classified as N which holds 3.93 of TPE (Table_5).

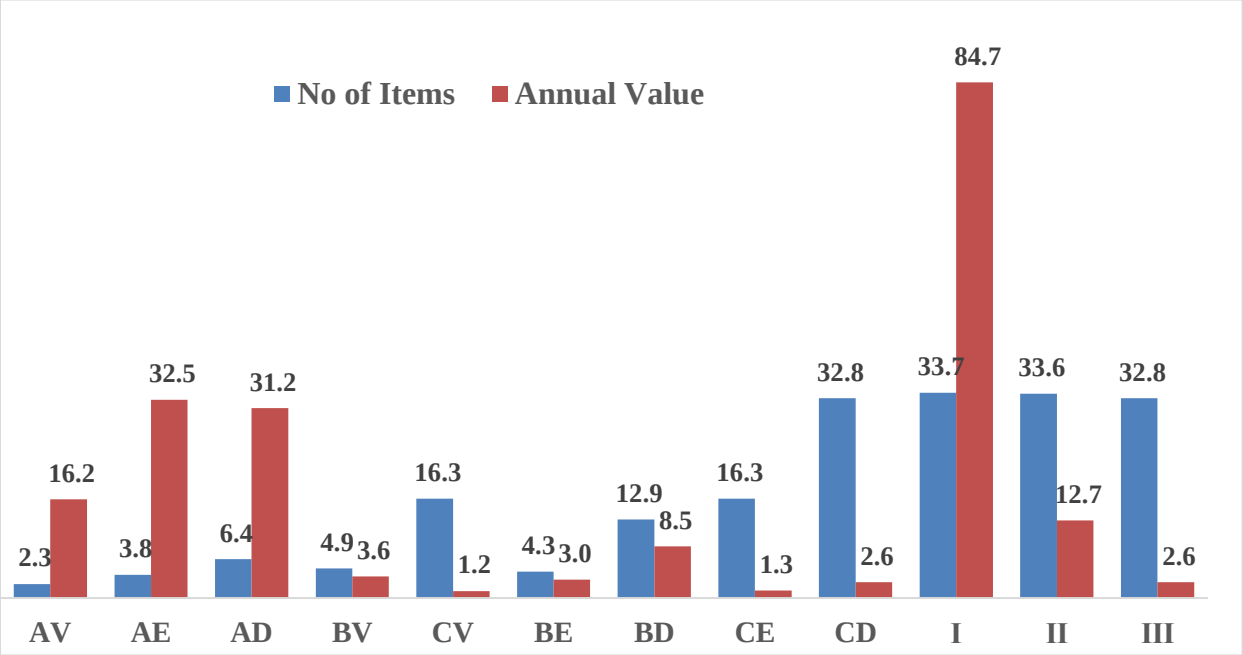

Figure 4: ABC-VED matrix analysis of pharmaceuticals at public Hospital in Addis Ababa, 2012-2013 EFY

7.2.2 XYZ Analysis

The primary goal of XYZ analysis is to keep track of the cost of inventory that is still on hand at the end of each physical year. This study showed that in 2012, 41 out of 558 items were classified as X contributing to 69.8% of total stock value and 98 & 419 items were classified as Y & Z that hold 20.1% & 10.1% of total stock value respectively. In 2013, a few number of total closing items 39 (9.4%) had the highest percentage (69.96%) of total stock value classified as X and in contrast to this a huge number of items 304 (73.25%) had very little amount (10.02%) of total stock value & classified as Z the remaining class Y 72 (17.35%) items were classified as Y and accounts for (20.02%) of the stock value (Table_5).

Table 5: FSN and XYZ analysis of pharmaceuticals at public hospitals in Addis Ababa, 2012-2013 EFY

Classification	TOR	2012				2013			
		No. of items	%	Total value ETB	%	No. of items	%	Total value ETB	%
F	≥3	149	26.7	36,257,270.39	53.69	111	29.84	69,596,209.98	84.63
S	3>X>1	184	32.97	13,481,232.59	19.96	172	46.24	9,406,096.44	11.44
N	<1	225	40.32	17,787,867.97	26.34	89	23.92	3,229,620.39	3.93
Total		558	100	67,526,370.94	100	372	100	82,231,926.82	100
	Total stock value								
X	70%	41	7.35	33,726,338.11	69.8	39	9.4	36,651,747.28	69.96
Y	20%	98	17.56	9,710,384.23	20.1	72	17.35	10,488,268.83	20.02
Z	10%	419	75.09	4,877,339.73	10.1	304	73.25	5,252,133.40	10.02
Total		558	100	48,314,062.07	100	415	100	52,392,149.51	100

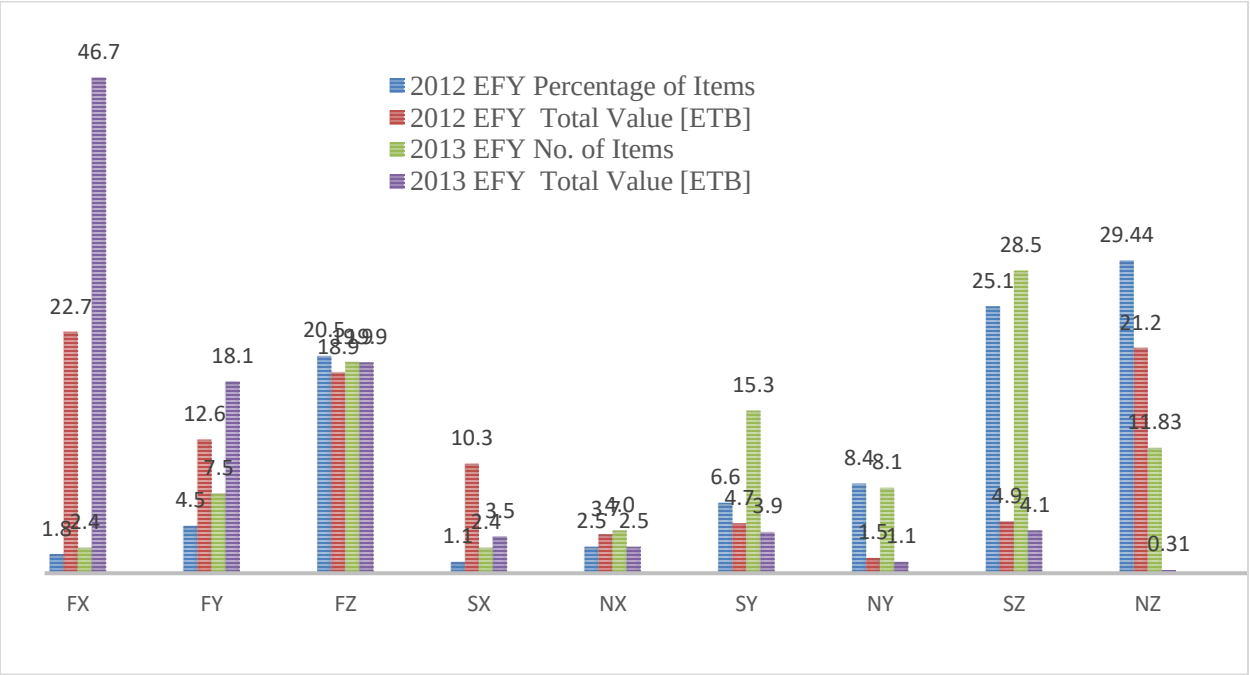

Figure 5: FSN and XYZ analysis of pharmaceuticals at public hospitals in Addis Ababa, 2012-2013 EFY

7.2.3 FSN-XYZ Matrix analysis

The combined result is classified into nine sub-categories and three main categories. (Figure_5). Category I is made up of (FX, FY, FZ, SX, & NX) and contains 30.35% of the items with 68.12% of TPE and 40.21% of items in category II (SY, SZ, & NY), which contains 11.1% of TPE, and category III (NZ) contains the remaining 22.44% of items, which covered 21.2% of TPE in 2012. In the EFY 2013, Category I hold 36.29% of the items that made up 90.64% of TPE, Category II and Category III hold 51.87% and 11.83% of the things that made up 9.05% and 0.31% of TPE, respectively (Figure_6).

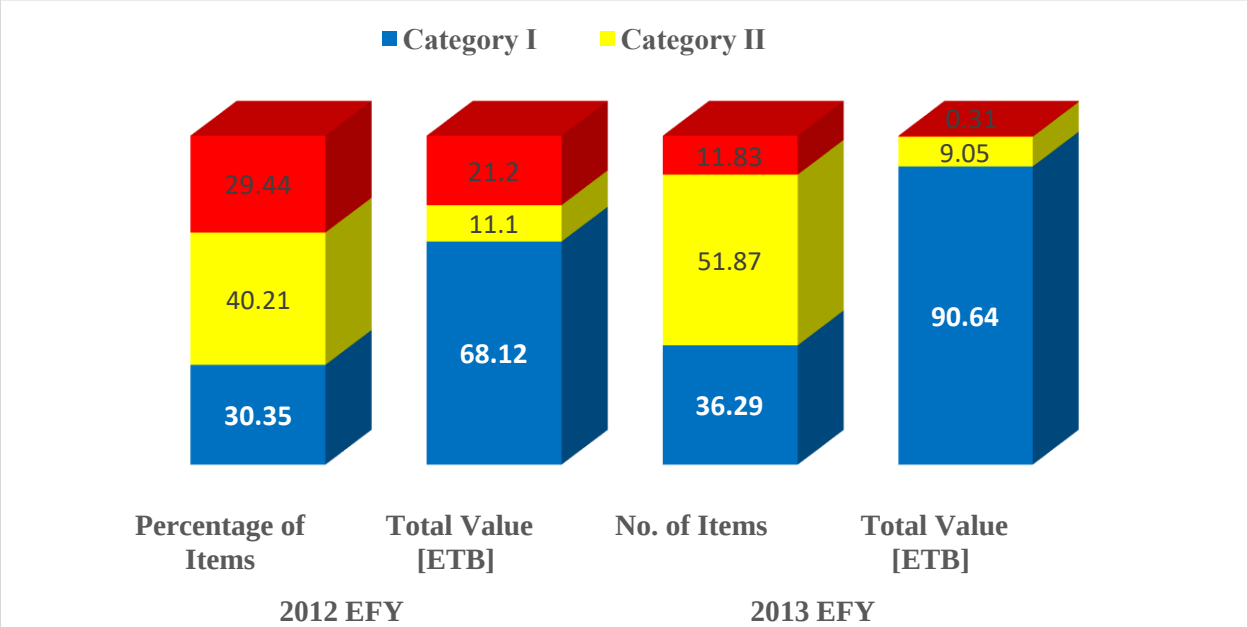

Figure 6: FSN-XYZ Matrix analysis of pharmaceuticals at public hospitals in Addis Ababa, 2012-2013 EFY

7.3 Inventory management optimization practice

Regarding the data utilization practice for pharmaceutical inventory management optimization, the respondents were asked to score their level of agreement using self-administered questionnaires. The findings are presented as follows.

Table 6: Socio-demographic characteristics of the respondent

Socio-demographics	**Socio-demographic characteristics**	**Frequency**	**%**
Sex	Male	15	68.2
	Female	7	31.8
Age	20-29	4	18.2
	30-39	17	77.3
	40-49	1	4.5
Educational Level	Master's Degree	10	45.5
	Degree	12	54.5
Marital status	Single	8	36.4
	Married	14	63.6
Profession	Pharmacy profession	22	100
Experience in their respective hospital	1 -5	11	50
	6 -10	9	40.9
	Greater than 10 years	2	9.1
Total years of experience	1-5	4	18.2
	6-10	14	63.6
	>10	4	18.2
Current position	Pharmacy head	3	13.6
	DSM Case team	6	27.3
	Pharmacy Case team	5	22.7
	Store manager	8	36.4

The majority of the respondents (68.2%) were male while (31.8%) were female. The respondents age in years showed that (4) 18.2% were between ages 20 – 29 years, 17 (77.3%) were between 30 -39 years, 1 (4.5%) were between 40 – 49 years. Among (n=22), 8 (36.4%) were single & 14 (63.6%) were married. The educational level of the respondents showed that, 10 (45.5%) were master's degree and 12 (54.5%) were degree holders. In addition to this 11 (50%) were working between 1 – 5 years with in the hospitals and the rest 9 (40.9%) & 2 (9.1%) were between 6 -10 & above 10 years respectively. Regarding to the total work experience most of the respondents 14 (63.6%) were between 6 – 10 years, 4 (18.2%) were between 1 – 5 years & 4 (18.2%) were above 10 years. Current working position showed that 3 (13.6%) of them were pharmacy heads, 6 (27.3%) of them were DSM case team members, 5 (22.7%) of them were pharmacy case team coordinator & 8 (36.4%) were store managers (Table_6).

The average mean of respondents agreement to the statements related to pharmaceutical inventory control technique was 3.78 (SD± 1.092), indicating that the majority of respondents were in agreement to a high degree regarding the application of inventory control techniques that result in effective pharmaceutical inventory management optimization. The findings demonstrated that the majority of respondents in favor of the statements related to maintaining maximum/minimum, safety stock & reorder levels for pharmaceuticals, successful APTS implementation, use of VED classification before procurement, and that using ABC-VED matrix analysis reduces out-of-stock situations by efficiently managing resources and controlling stock levels (Table_7). When the observation was taking place, ABC and VED analysis was done but not updated. None of the hospitals used the FSN or XYZ analysis, despite the respondents' agreement on the benefits of doing so.

Table 7: Descriptive statistics for inventory control technique practices

Statements	N	Mean	Std. Deviation
The hospital has established optimized stock level techniques that need to be kept in the store (i.e. Maximum, Minimum, Safety stock and Re-order levels).	22	4.00	.873
Auditable pharmaceuticals transaction and services/APTS/ service is well implemented in the hospital	22	3.77	1.110
The hospital frequently uses VED (Vital, Essential& Desirable) classification before any procurement	22	4.05	.899
ABC-VED analysis is used to reduce the likelihood of out-of-stock by controlling stock levels	22	3.91	.811
Use of ABC-VED analysis leads to efficient management of resources	22	3.95	.999
FSN (Fast, slow, &Non Moving) analysis identifies items which may become obsolete & might not have been used for years	22	3.64	1.093
Classifying inventories using different criteria reduces inventory cost & ensures the availability of items that are critical for human life saving	22	3.73	.985
Use of FSN analysis leads to optimize warehouse operation by enhancing the picking, packing &storage space capacity.	22	3.45	1.438
Use of FSN/XYZ analysis leads to take measures on high stock value with non-moving items (avoid losses, damages & misuses)	22	3.68	1.211
The hospital uses Health commodity management information system (HCMIS)	22	3.64	1.497
Average mean and standard deviation		3.78	1.092

The average mean of the respondents agreement to the statements related to stock keeping records & information was 4.32 (SD±0.69), indicating that the majority of respondents were in agreement to a high degree regarding the benefits of updated and accurate information system, updating drug lists, accurate inventory records, use of LMIS system, and classifying inventories that result for inventory management optimization. When the observation was taking place, there was good practice on LMIS and updating of the drug list. However, overstocked and out of stock pharmaceuticals was observed (Table_8).

Table 8: Descriptive statistics for Stock keeping records & Information

Statements	N	Mean	Std. Deviation
Updating the drug list has a positive impact on inventory classification	22	4.18	.958
Accurate inventory record reduces the cost of holding unnecessary items and out-of-stock events	22	4.32	.646
Use of updated and accurate information system is important for inventory management optimization	22	4.50	.598
Proper use of LMIS system is critical for inventory management optimization	22	4.27	.550
Standard operating procedure (SOP) for inventory management is important to guide the staffs	22	4.36	.790
Products should be stored and organized in a manner accessible for first-to-expire, first-out counting and general management	22	4.32	.716
Inventory classification give appropriate consideration to the location and arrangement of inventories	22	4.41	.590
Inventory classification provides you for making better informed supply decision	22	4.45	.596
Inventory classification provides better accuracy of forecasting demands which lead to significantly lower the risk of stock- out	22	4.27	.631
Inventory classification improve customer satisfaction by optimizing inventory levels	22	4.09	.921
There is not sufficient & accurate information system to enhance the inventory tracking system as well as the accuracy of inventory records	22	4.32	.568
Average		4.32	0.699

The average mean of respondents agreement to the statements related to challenges of inventory management was 3.47 (SD±1.23), indicating that most of the respondents were in agreement to a moderate degree regarding the challenges of inventory management. The finding demonstrated that the majority of respondents in favor of the statements related to the absence of a well-designed information system, which is crucial for the optimization of inventory management, and the improvement of the inventory tracking system and the accuracy of inventory records.

Stock outs of important medications are a common occurrence, and bureaucratic procurement practices may result in poor inventory management techniques (Table_9).

Table 9: Descriptive statistics for inventory management challenges

Statements	N	Mean	Std. Deviation
There is no a well-designed information system essential for inventory management optimization	22	3.91	1.019
There is insufficient storage area for pharmaceuticals to be kept in order to maximize inventory management.	22	3.14	1.167
There is insufficient human capacity leads to reduce inventory management optimization	22	3.23	1.307
Enough training was given about inventory management	21	3.00	1.095
There is no good communication between drug supply management staff and health workers for inventory management optimization	22	3.68	.995
The hospital uses manual inventory management system	22	3.32	1.427
The hospital allocates insufficient budget for the procurement	20	3.15	1.496
Overstock of pharmaceuticals is common	22	3.45	1.101
The Stock outs of essential medicine is a regular situation	22	3.91	1.192
Bureaucratic process in procurement is practiced that may lead to poor inventory management practice	22	3.91	1.571
Average mean and SD		3.47	1.23

7.4 Qualitative finding

A pharmacy director, a store manager, and a DSM officer were interviewed as key informants. From the 9 important informants questioned, 6 were men and the other 3 were women. Most of them were in the 25 to 38 age range. Five of them had master's degrees and the others had bachelor's degrees with a mean of 8 years of experience. The qualitative information collected from participants categorized into three themes.

7.4.1 Inventory control practices

All of the key informants agreed that inventory management is essential for supplying decision support tools that improve health policy, public health, patient safety, and strategic decision making in the pharmaceutical supply chain. Additionally, the pharmaceutical supply chain is quite complex and has a big responsibility to make sure that the proper medicines are given to the right patients at the right time and in the right way in order to alleviate their suffering.

Most of the key informants assured that the hospital store unit uses both manual and electronic pharmaceutical recording systems, which are crucial for determining order quantity, order time, and inventory level to ensure that products are accessible at the best price. But there isn't a specified period of time for ordering, order amount, or a safety stock hold, though. Pharmaceuticals supply from EPSS was insufficient, which was the cause of this.

One of the key informants expressed his feeling as;

"*Ordering of pharmaceuticals starts, when there is a new arrival at EPSS or there is shortage of stock with in the store and quantity to order is determined by estimating based on the consumption frequency & storage capacity." (DSM officer, 9 years of experience)*

7.4.2 Practices on pharmaceutical classification

The majority of the key informants indicated that categorizing inventories according to various criteria lowers inventory costs and ensures the availability of items that are essential for saving human lives. However, ABC and VED analysis was performed on-site but was not annually updated. Pharmaceuticals were not classified as fast, slow, & non-moving in the store. At the end of each year, a physical inventory was completed, but XYZ analysis was not done at all.

One of the key informants strengthened this as;

"*I believe that classifying pharmaceuticals using ABC, VED, FSN, & XYZ analysis is crucial. We conduct in our hospital only ABC and VED but it is not sufficient because it fails to detect goods with high stock values and immovable items which are detected by using FSN and XYZ analysis.*

But neither of this was practiced in our institution due to a lack of written instructions to perform those techniques."(Pharmacy head, 10 years of experience).

The other key informant adds on that;

"In my opinion training should be given on inventory classification techniques because most of us do not know how to conduct FSN and XYZ analysis." (Store manager, 6 years of experience).

7.4.3 Shortage and overstock reasons

The majority of respondents concurred that the biggest issues facing hospitals today are the limited availability and overstock of pharmaceuticals. The reason was expressed with one respondent as follows:

"Shortage of pharmaceuticals was due to under supply of EPSS and also the facility didn't reconcile VEN analysis before procurement, the request was based on the consumption frequency that was done traditionally". (DSM officer, 12 years of experience).

With regard to overstock of pharmaceuticals, all key informants stressed that it is a major problem in the hospital due to push delivery of products from EPSS, donation of products, and over estimation of the request order.

One key informant enumerated this issue as;

"Pharmaceuticals used to treat different illnesses were marked down and overstocked at the store when COVID 19 emerged. Whereas once it was controlled and no longer considered as a major public health concern, pharmaceuticals that were bought and given for the treatment of COVID 19 were overstocked". (Store manager, 8 years of experience)

Regarding inventory overstock and under stocks, most of the respondents stated that application of inventory control techniques is mandatory. An overstocked item was tried to transfer to other health facilities and supply chain management seriously monitors the selection & purchasing process to minimize it.

8. Discussion

The final goal of inventory management is to balance the stock out and over stock of essential medicines which are the cause for drop in the quality of patient care, medicines wastage and financial loss. Therefore there should be proper inventory management of pharmaceuticals. This is done by using appropriate inventory classification techniques with in the facilities. This study tried to classified pharmaceuticals using ABC - VED and FSN – XYZ matrix analysis and assessed pharmaceutical inventory management optimization practices at public hospitals.

ABC analysis provides a mechanism for finding items that have a significant impact on over all inventory cost. The present study showed that out of 784 pharmaceuticals 98 (12.5%) of items belonged to class A, that accounted for the highest percentage (79.94%) of TPE. The rest 173 (22.07%) class B and 513 (65.43%) class C items represented (15.04%) & (5.02%) of TPE respectively. This study was aligned with studies in hospitals in India (Singh et al., 2015) in Thailand (Nang Nwe Ni Hlaing, 2017), in Ethiopia (Abat, 2017), (Legese., 2017), (Mohammed and Workneh, 2020).

Out of (n=98) class A products, 64 (65.31%) were medications, 31 (31.63%) were medical supplies, and 3 (3.16%) were chemicals & reagents. It is evident from this that more class A items are medicines. Of the 64 medicines classified in class A, 11 (35.48%) were anti-invectives, 10 (32.25%) were immunologic preparations, and 6 (19.35%) were anti-neoplastic medications, which accounted for 5.25%, 7.01%, and 2.05% of TPE, respectively. The rest (n=37) accounted for 54% classified under other therapeutic categories. This study deviated from the study done in SPHMMC resulted on anti-infective (16.7%), Endocrine medicine (20%), immunologic preparation (8.5%), and water & electrolyte (12.9%) (Legese., 2017). This difference might be due to the exclusion of program items and emergence of COVID 19.

The top ten pharmaceuticals that consumed 40.57% of TPE in the 2012–2013 EFY were surgical gloves, normal saline 0.9%, adult face masks, face shields, salbutamol aerosol, and examination glove medium, and face masks (N95), insulin zinc suspension, gauze surgical 90*100, and propylthiouracin 100mg tablets. The results were some variation with studies conducted in Dessie referral hospital and Tikur Anbessa Specialized Hospital (Mohammed and Workneh, 2020, Abat, 2017).

According to the study done on (VED) analysis, the percentages of vital medicines were 23.47% which is similar to the findings of a study in SPHMMC (Legese., 2017). However there is a significant difference in the percentage of essential & desirable in this study as compared with a study in SPHMMC. This might be due to the aggregation. In this regard, pharmaceuticals belonging to vital group require continuous accessibility and reasonable safety stock, while reducing class E stock level, to minimize overstock. Store managers must regularly monitor class D items (Jobira et al., 2021). The majority of the medications in the VED analysis, grouped to desirable and essential groups, highlighting the fact that, as a result of the absence of important items, pharmaceuticals in hospitals do not aim to meet the population's healthcare needs.

This result showed that among 784 pharmaceuticals, 264 (33.67%) of items were include in category I (AV, AE, AD, BV, CV), that accounted 84.65% of total annual value and category II include 263 (33.55%) of items, that accounted for (12.74%). Only 257 (32.78%) of items were grouped under category III (CD) which accounted for (2.61%) of total annual price. This finding was consistent with the study done by (Mfizi et al., 2023, Kaushik Nag, 2016). Of these, AV, AE, and AD subgroups of category I were made up of 98 (12.51%) expensive medications (79.94%) of TPE, in which lack of availability of those items is intolerable since they are either essential or vital.

Pharmaceuticals with a low cost but high criticality make up 128 (16.33%) of CV products, accounted for 1.15% of the total expenditure. Hence, low safety stock must be kept while keeping a careful eye on the consumption level and the stock on hand in order to prevent capital locking up because of these items. A minimum safety stock, periodic purchase orders, regular stock requires strict supervision by management, accurate based on information demand forecasting, close monitoring of budgetary control, and a wise purchasing, stocking, issuing, and inspection strategy are all requirements for the medications in category A (Mohammed and Workneh, 2020).

Inventory turnover ratio is crucial for accurately estimating the amount of inventory to replace rather than irrationally stocking up. It also makes it easier to track product movement over time. When you have large amounts of inventory and little demand, it will eat up a lot of valuable warehouse space. Based on the frequency of usage or turnover, fast moving items requires

continuous control and consistent monitoring, slow moving items requires periodic monitoring, and non-moving sometimes dead stock items need disposal to create space for new inventory.

By using FSN analysis, 558 medications were divided into three groups based on turnover ratio: fast, slow, and non-moving products. Much more useful than S and N things are objects that move quickly. The analysis showed that 149 (26.7%) of the items were categorized as fast moving which accounted (53.69 %) of the overall value, whereas 184 (32.9 percent) and 225 (40.3%) of the products were slow-moving and non-moving and held 19.96% and 26.34% of the total value, respectively. This number was lower than that reported by (Jobira et al., 2021), and (Gizaw and Jemal, 2021), stated that fast-moving products accounted for 78% and 73.10% of the total value, respectively. The discrepancy may result from the use of a different study environment and methodology.

However, significant portions (40.32%) of immovable items N were seen in 2012. In order to limit the risk of wastage brought on by overstocking, the pharmacy manager is advised to regularly monitor their tracking chart for tracking the expiration dates of their medications. The amount of slow and non-moving items should be kept to a minimal in order to reduce pharmaceutical waste, fill a warehouse for longer, and shorten the time that budget commitments are made to certain products (Yohannes et al., 2022). However, the fraction of non-moving goods in 2013 is small (3.93%). In 2013, 29.8% of items were categorized as fast moving which accounted 84.63% of total value. This outcome is consistent with research conducted in Ethiopia in West Arsi zone, & in Thailand, in which F class items made up 78% & 80% of the overall value, respectively (Jobira et al., 2021). This shows that fast moving items require the managers' full attention.

The value of excess inventory at the end of each fiscal year is better managed thanks to XYZ analysis. It describes the distribution of values among the store's medications. According to this study, just (an average 40%) total closing items had the largest percentage of total closing value (69.8%), while 361 items had the lowest proportion of total closing stock value (10.1%). In order to reduce waste caused by expiration as the items move from year to year, store managers should concentrate on monitoring the consumption of X items in particular and maximum control over it. Regular control and periodic evaluation are required for the items in the Y group. Z group, on

the other hand, requires the minimum management control even if it has a lot of items, but accounts for a small fraction of the closing stock value.

In this result category I (on average 33.2%) of items used highest consumption value (79.38%). This finding is consistent to the findings conducted in Ethiopia, west Arsi zone, which revealed that (on average 41.1%) of items contribute to (86.5%) of consumption value (Jobira et al., 2021), and to the finding conducted on Hadiya Zone, which constituted (85%) of TPE (Yohannes et al., 2022). Greater closing stock value and fast-moving goods were classified under FX, which used the largest budget (22.7%) in 2012 and (46.67%) in 2013, according to the FSN-XYZ matrix study which needs strict supervision.

Regarding to the inventory management practices, the result showed that the majority of the respondents agreed in moderate level on the application & benefits of using different inventory control techniques but the data obtained during observation was confirmed as despite the application of ABC & VED analysis there is no updated and due to a lack of written instructions, FSN & XYZ analysis was not applicable in the hospital pharmacy store. This may have led to ordering a large number of non-movable items and less fast-moving items, which lead to overstocking and under stocking respectively and this, can result in a storage capacity deficit.

9. Conclusion and Recommendation

9.1. Conclusion

This study was analyzed the inventory by using ABC – VED and FSN – XYZ classification methods. ABC-VED matrix analysis of present study showed that category I pharmaceuticals holds large amount (84.65%) of budget that needs greater attention for control which avoids wasting extra funds on the purchase of drugs that are not really necessary. Category I consumed 68.12% and 90.64% of total consumption in 2012 and 2013 respectively, according to the FSN-XYZ matrix study. According to this finding, NZ products spent more budgets in 2012 (21.2) than 2013 (0.3), which contains non-moving and have low closing values, that creates an issue with a lack of available space and a high rate of waste. In 2013, Category I consumed 90.64% of all pharmaceutical spending and required tight manager supervision.

Finally, this study's findings support the neutrality of inventory management practices and the fact that all hospitals perform ABC & VED analyses but do not keep them up to date. FSN & XYZ analysis was not conducted in any of the hospitals.

9.2. Recommendations

The following suggestions have been made in light of the study's findings:

- The pharmacy department of the hospitals should conduct ABC – VED matrix analysis to prioritize and make decisions on how much & when to order pharmaceuticals and it should be done regularly.
- The pharmacy department of the hospitals should perform FSN – XYZ matrix analysis to determine the level of inventory with high value & slow moving items.
- The pharmacy department of the hospitals should reconcile the request with updated VED analysis before any procurement.
- The hospital should give trainings on inventory control techniques and monitors its implementation.

9.3. Limitation of the study

This study was done classification of pharmaceuticals that was purchased though revolving drug fund (RDF), however pharmaceuticals that was received by programme and medical equipment's were not included. Moreover, the classification was based on annual value, criticality, turnover rate, and closing stock value but other criteria's like unit price, seasonal variation, and supplier availability were not considered.

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Annexes

Annex I: Data abstraction format for ABC Analysis

No	List of items	Unit	Unit price	Quantity received	Total stock value	Commodity type	Therapeutic categories
1							
2							
3							

Annex II: Data abstraction format for VED Analysis

NO	List of items	Unit	VED classification	Commodity type	Therapeutic categories
1					
2					
3					

Annex III: Data abstraction format for FSN Analysis

No	List of items	Unit	Unit price	Quantity (consumed)	Beginning inventory	Ending inventory	Commodity type
1							
2							
3							

Annex IV: Data abstraction format for XYZ Analysis

No	Items from physical inventory	Unit	Unit price	Stock Quantity	Total stock value	Commodity type
1						
2						
3						

Annex V: Consent form

Addis Ababa University

School of Pharmacy

Department of Pharmaceutics and Social Pharmacy

Greeting, My name is Mesay Mekonnen. I came from Addis Ababa University School of Pharmacy attending a postgraduate study in Health Supply Chain Management. I am the principal investigator for the study entitled ***"Multi criteria inventory classification of pharmaceuticals for inventory management optimization in public hospitals Addis Ababa, Ethiopia".*** The objective of this study is to conduct ABC-VED and FSN-XYZ matrix analysis and to assess the inventory management practices with in the hospitals. The study will benefit the facility by identifying pharmaceuticals that needs strict managerial control and items which have high value with dead stock that enables the facility for effective utilization of scarce resources. Now I am requesting you your kind voluntariness on giving information according to the developed questionnaires designed for this purpose. The information you provide will be treated with a very high degree of confidentiality and will not be disclosed to anyone. It will only be used for research purposes. The data will be analyzed in aggregate. You are free to withdraw from the study at any time and even if you are not comfortable with any one of the question you are not forced to answer. If you have any question please don't hesitate to ask the data collector. If you need further clarification, you can contact the following persons:

1. Mesay Mekonnen (Principal investigator) 09 11 39 50 31
2. Zelalem Tilahun (Advisor) 09 23 10 95 39

Are you clear with all the information stated in the consent section? If no, discuss with the data collector. If yes, are you volunteer to participate in this study? If yes, please continue to the next questions. If no, please kindly return the questioner to the data collector.

Thank you

Part One: Socio Demographic Data

1. Sex [ ] Male [ ] Female

2. Age _____

3. Educational level

[ ] College Diploma [ ] Master's Degree

[ ] First Degree [ ] PHD and Above

4. Marital status

[ ] Single [ ] Married [ ] Widowed [ ] Divorced [ ] Separated

5. Profession _____

6. Experience in this hospital _____

7. Total experience by this profession _____

8. Current position

[ ] Pharmacy head [ ] Drug supply chain case team [ ] Store manager

[ ] Pharmacy unit team coordinator [ ] others, specify _____

Inventory optimization – is the process of maintaining the right amount of inventory required to meet demand, keep inventory cost low, and avoid common inventory issues such as stock outs, overstocking and backorders (i.e. Product ordered but out of stock and promised to ship when the product becomes available).

Inventory classification - Inventory classification is one of the most important activities in inventory management, whereby inventories are classified into three or more classes. This study focuses on ABC, VED, FSN & XYZ classification techniques based on inventory values, criticality, turnover rate and stock value respectively.

Part Two: Pharmaceutical inventory management practice

Please choose the extent to which you agree with the following as practiced in your hospital. You should rank each statement as follows

1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

Inventory control technique

No	Statements	1	2	3	4	5	I don't know
1	The hospital has established optimized stock level techniques that need to be kept in the store (i.e. Maximum, Minimum, Safety stock and Re-order levels).						
2	Auditable pharmaceuticals transaction and services/APTS/ service is well implemented in the hospital						
3	The hospital frequently uses VED (Vital, Essential& Desirable) classification before any procurement						
4	ABC-VED analysis is used to reduce the likelihood of out-of-stock by controlling stock levels						
5	Use of ABC-VED analysis leads to efficient management of resources						
6	FSN (Fast, slow, &Non Moving) analysis identifies items which may become obsolete & might not have been used for years						
7	Classifying inventories using different criteria reduces inventory cost & ensures the availability of items that are critical for human life saving						
8	Use of FSN analysis leads to optimize warehouse						

	operation by enhancing the picking, packing &storage space capacity.						
9	Use of FSN/XYZ analysis leads to take measures on high stock value with non-moving items (avoid losses, damages & misuses)						
10	The hospital uses Health commodity management information system (HCMIS)						

Stock keeping records & Information

No	Statements	1	2	3	4	5	I don't know
1	Updating the drug list has a positive impact on inventory classification						
2	Accurate inventory record reduces the cost of holding unnecessary items and out-of-stock events						
3	Use of updated and accurate information system is important for inventory management optimization						
4	Proper use of LMIS system is critical for inventory management optimization						
5	Standard operating procedure (SOP) for inventory management is important to guide the staffs						
6	Products should be stored and organized in a manner accessible for first-to-expire, first-out counting and general management						
7	Inventory classification give appropriate consideration to the location and arrangement of inventories						
8	Inventory classification provides you for making						

	better informed supply decision						
9	Inventory classification provides better accuracy of forecasting demands which lead to significantly lower the risk of stock- out						
10	Inventory classification improve customer satisfaction by optimizing inventory levels						
11	Good information system is important to enhance the inventory tracking system as well as the accuracy of inventory records						

Inventory management challenges

No	Statements	1	2	3	4	5	I don't know
1	There is no a well-designed information system essential for inventory management optimization						
2	There is no appropriate and enough storage space for stocking pharmaceuticals for inventory management optimization						
3	There is insufficient human capacity leads to better inventory management optimization						
4	Enough training was given about inventory management						
5	There is no good communication between drug supply management staff and health workers for inventory management optimization						
6	The hospital uses manual inventory management system						
7	The hospital allocates insufficient budget for the procurement						

8	Overstock of pharmaceuticals is common						
9	The Stock outs of essential medicine is a regular situation						
10	Bureaucratic process in procurement may lead to poor inventory management practice						

Thank You

Annex: VI: Semi- Structured guiding for key informant interview

Introduction

I want to thank you for taking time to meet with me today. My name is Mesay Mekonnen. I came from Addis Ababa University School of Pharmacy attending a post graduate study in Health Supply Chain Management. I am the principal investigator for the study entitled "Multi criteria inventory classification of pharmaceuticals for inventory management optimization in public hospitals Addis Ababa, Ethiopia". The objective of this study is to conduct ABC-VED and FSN-XYZ matrix analysis and to assess the inventory management practices with in the hospitals. The study will benefit the facility by identifying pharmaceuticals that needs strict managerial control and items which have high value with dead stock that enables the facility for effective utilization of scarce resources. And I would like to talk with you about pharmaceutical inventory management optimization practices which are important for optimal utilization of resources and saving costs. The interview should take less than an hour. I will be taping the session because I don't want to miss any of your comments. Although I will be taking some notes during the session, I can't possibly write fast enough to get it all down. Because we're on tape, please be sure to speak up so that I don't miss your comments. All responses will be kept confidential. Remember, you don't have to talk about anything you don't want to and you may end the interview at any time.

Are you willing to participate in this interview? Yes ___ No ___

If yes, the interview will be continued

Date of interview _____

A. Background information

1. Gender: _____
2. Age: _____
3. Educational level: _____
4. Job title: _____
5. Work experience: _____Years

B. Guiding questions

1. In your opinion, what is the importance of inventory management for the downward supply chain of pharmaceuticals?

2. What do you think about the inventory classification methods for inventory management optimization?

a) Which type of inventory classification techniques are practicing in your hospital? (ABC, VED, FSN, XYZ)
b) Do you think that the technique that you used is enough for effective and efficient control of inventories?
c) What are the benefits of applying those classification methods for inventory management optimization?

3. What are the challenges that you faced in conducting the above pharmaceuticals classification methods?

4. Is there an overstock or shortage of pharmaceuticals with in your hospital?

a) What are the reason for overstock of pharmaceuticals which leads to expiry and wastage?
b) What are the reasons for shortage of pharmaceuticals which leads to stock out and even missing of life?
c) What measures was used to minimize these problems?

Thank You

Annex VII: Researcher observation Check list

Name of facility…….. Date……..

No	Description	Yes	No
1	Are minimum and/or maximum stock levels calculated for each item in the health facilities?		
2	The hospital develop, utilize and annually update a comprehensive list of pharmaceuticals prioritized by VED analysis		
3	The hospital conduct ABC analysis		
4	The hospital conduct annual physical inventory		
5	The hospital conduct FSN analysis		
6	The hospital conduct XYZ analysis		
7	Pharmaceuticals inventory management follows first-to-expire, first-out (FEFO) counting and general management		
8	Does each item in the store have a bin card?		
9	Is all information in the bin card and stock card up-to-date?		
10	Auditable pharmaceuticals transaction and services/APTS/ system of this hospital is automated		
11	The hospital has a written SOP for inventory control management		
12	Monitoring of expiry dates from when the medication is received, continuously while on the shelves, until issued to patients or wards		
13	The hospital uses Health commodity management information system (HCMIS) to improve inventory management & data visibility		
14	The quantities on the bin cards generally agree with the physical inventory quantities?		
15	Is there an overstocked medicine currently in stock?		
16	Is there under stocked medicines currently in the stock?		
17	Is there an expired medicine currently in the stock?		
18	Is there stock out medicines currently in the stock?		
19	The current space and organization is sufficient for existing products and reasonable expansion.		
20	Is there any medicine stored in direct contact with the floor?		
21	Is the store room dry, clean and well ventilated?		
22	Is medicines storage areas well-lit and temperature controlled?		

Thank You