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Review on Pharmaceutical Inventory Model

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Abstract

An essential function in the pharmaceutical sector is played by the inventory management system. Whether a business is little or large, domestic or worldwide, inventory management is crucial for all of them. Since the raw materials in a pharmaceutical company have an expiration date, it's critical to establish a minimum safety stock for such things. Most businesses strive to maintain a minimal inventory of goods, as this makes easy business tracking possible. The provision of proper care and treatment to patients is the ultimate purpose of healthcare systems. Pharmaceutical Supply Chain in the healthcare system must be functional and efficient in order to achieve it. In this article, we provide an overview of the Pharmaceutical Inventory literature that has been published from the beginning of 1968. The models that have been made available in the pertinent literature have been appropriately categorized. Each subclass's numerous models' reasons and extensions have been thoroughly examined.

Keywords: Inventory, Perishable items, Pharmaceutical inventory, RFID technology, Drug inventory, Blood inventory, Hospital inventory.

Introduction

Pharmaceutical is a very sensitive and important sector that deals with both human and animal life. In this industry, purity is highly regarded. The most crucial aspects to maintain are quality, security, and identification. Inventory refers to the stock of pharmaceutical products kept on hand in order to fulfil future demand in pharmacy operations. The inventory is the pharmacy's most valuable asset, and its value is increasing due to the increased variety and expense of pharmaceutical items. Inventory management is critical in pharmacy from both a financial and operational standpoint. From a financial standpoint, efficient inventory management increases gross and net profits by lowering the cost of acquired pharmaceutical products and associated operational expenses in inventory. There are three kinds of charges involved. The procurement costs are the expenses incurred when procuring things, such as placing and receiving orders, stocking, and paying invoices. Carrying costs are costs associated with product storage, which include costs incurred as a result of crises. The shortfall costs, also known as stock-out costs, are the costs of not having the product available when it is required. There are two primary aims in maintaining a pharmacy's inventory. The first is to ensure that medications are available when patients require them, and the second is to keep medication expenses to a minimal. Proper stock management, such as utilizing prescriptions before they

expire and processing returns on a regular basis, can help keep medication costs low. [1]

A pharmaceutical supply chain typically consists of a collection of manufacturers that fall into one of five categories: contract manufacturers, local manufacturers, multinational manufacturers, generic manufacturers, and biotechnological manufacturers.[2] A group of suppliers, which consists of pharmacies, hospitals, and clinics, as well as a group of buyers, comprising wholesalers and distributors, are also included. A pharmaceutical supply chain's activities include the movement and transformation of medications from raw materials to end users, as well as the flow of related information across the links in the supply chain to provide a long-term competitive advantage.[3] Figure 1 displays an illustration of a classical setup.

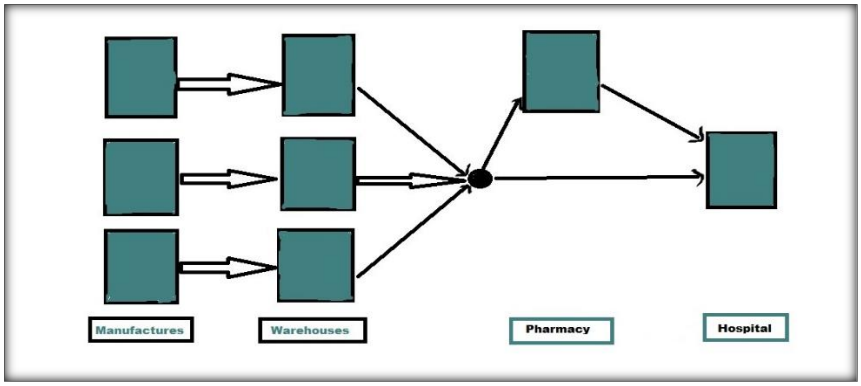

Figure No.: 1. pharmaceutical supply chain organization

Inventory models deal with the quantity of the order as well as the moment at which it should be placed. Advanced inventory models address circumstances where there are constraints on production resources, storage resources, time and/or financial resources. [4]

Types of Inventory

Raw materials, work-in-progress, and finished goods are the three primary categories of inventories.

Raw Materials: During the production process, raw materials are transformed into finished goods. The items that have been purchased and stockpiled for upcoming productions are considered raw material inventories.

Work-in-Progress: Also known as stock-in-progress, work-in-progress. These stockpiles consist of partially made goods. They stand for things that require additional work before they are ready for sale.

Finished goods: Products that have been fully manufactured and are ready for sale are included in finished goods inventory. Production is facilitated by a supply of raw materials and ongoing work. While a ready supply of finished items is necessary for efficient marketing. As a result, inventories connect the production and consumption of products.[5]

Functions of Inventory

1. To satisfy expected demand from customers

Because they are kept to meet anticipated or planned demand, these stockpiles are known as anticipation stocks.

2. To fulfil demands for output

Businesses that face seasonal demand patterns frequently increase inventories during the off-season to accommodate excessive demands during specific seasonal times. Fresh fruit and vegetable processing businesses deal with seasonal inventories.

3. To separate the operations

While the issue is being fixed, other actions can temporarily continue thanks to the buffers. Businesses have utilized buffers of raw materials to protect production from delays in supplier deliveries and finished goods inventory to protect sales operations from delays in manufacturing.

4. To avoid stock shortages

The likelihood of shortages is increased by delayed delivery and unforeseen increases in demand. By keeping safety stocks, which are stockpiles in excess of projected demand, the risk of shortage can be minimized.

5. To benefit from order cycles

A company may buy and create in reasonable lot sizes thanks to inventory storage, which eliminates the need to try to time purchases or production to meet short-term demand requirements.

6. To protect oneself from price increases

Additionally, having extra inventory on hand enables a business to benefit from deals on larger orders.

7. To approve actions

Because production processes take some time, there will usually be some inventory of items that are still being worked on.[6]

Classification of the Pharmaceutical Inventory Models

The related literature contains the pharmaceutical inventory models, which are widely categorized based on medicinal properties. Here, we take into account the subsequent six categories:

1) Models for Pharmaceutical inventory with RFID technology.
2) Models for Pharmaceutical inventory with blood pharmacy.
3) Models for Pharmaceutical inventory with drug pharmacy.
4) Models for inventory management of pharmaceutical with hospital.
5) Models for inventory control techniques for pharmacy.
6) Models for inventory with perishable pharmaceuticals.

1. Pharmaceutical Inventory with RFID technology:

The RFID stands for radio frequency identification and data collection. It recognizes items on its own using radio waves. Gathers information about them. Involves a human to manually enter the data into the computer system.

The maintenance of a sizable inventory is necessary for effective and seamless manufacturing, and the stockpiles should be kept at their ideal level. The pharmaceutical units' inventory management process may benefit from the usage of RFID technology. RFID tags are capable of storing a substantial amount of data about the goods being quarantined, such as the product name, manufacturer, supplier, batch number, date of manufacture, expiration date, etc. In order to avoid accidentally using the wrong category of material, the status of the raw material (authorized, disapproved, or under test) might also be shown on the tag.The information about stock levels contained in the RFID tags can be used to determine the inventory status, including several stock levels like the minimum stock level, safety level, reorder level, or danger level. Therefore, RFID tags can act as practical and efficient substitutes for traditional and intricate inventory control approaches. For managing pharmaceutical inventory, the incremental advantages of RFID technology over barcodes are examined[7] Unlike barcode technology, it allows accurate real-time visibility, which in turn enables a number of

process enhancements.In the essay, [8] the industrial practice of clothing control in healthcare institutions is covered in great length. An analytical analysis determined when RFID systems would surpass bar-coding systems in terms of lowering the amount of safety stock that would be needed. A numerical study[9] of the advantages of RFID is presented that fully disregards the shrinkage problem and differs in that it places more focus on shrinkage due to content expiration. In a radiology practice, an empirical investigation and an analytical comparison of periodic and continuous review policies are coupled to identify the operational issues that can be solved by RFID technology.Since a lot of information can be stored on and read quickly from an RFID tag, a number of pharmaceutical processes [10] have used this technology. Applications could include supply chain management, telemedicine, access control, inventory control, and the fight against fake goods. Despite the fact that actual on-hand inventory[11] differs from the inventory record, which threatens both the inventory record and good inventory management, an inventory tracking is often thought to be accurate. The three main causes of physical stock are shrinkage, misplacement, and transaction errors.The most popular method for maintaining the accuracy of inventory records is to conduct frequent inventory audits. The pharmaceutical sector has supplied its inventory management procedures[12] and launched arena, a simulation program that determines process and production times in the industry as well as the use of radio frequency identification (RFID) technology in inventory management. Barcode and labeling are used to track the inventory of raw materials, finished goods, and products, while traditional identifying methods call for manual data entry and intervention.When the HO may use the data gathered from some connected items to improve its inventory planning, this is referred to as the utilization of information for inventory decision in the healthcare industry.[13] The analysis shows how an appropriately set wholesale pricing contract can achieve Pareto improvement in the HO supply chain and how the RFID system will outperform the bar-coding system when the installation cost and tag cost of the RFID system fall to a level that is comparable with that of the bar-coding system.

The market for smart packaging is expanding, and one of the technologies used in it is radiofrequency identification (RFID). Despite being nothing new, recent advancements in RFID have led to significant uses in the packaging of pharmaceutical and medical device products.According to the assessment, packaging with RFID, which can lessen medical blunders that happen in operating rooms of hospitals and assist stop drug counterfeiting on thillicit market.The label-and-cap security concept for prefilled syringes was created to aid hospitals in advancing their digitization activities, and it now supports automated inventory and supply chain management in addition to digital first-opening indication. The result is improved patient safety and effective and trustworthy product authentication provided by the new Cap-Lock + RFID system. Radiofrequency identification (RFID) is being successfully incorporated into pharmacy inventory management procedures by hospitals and suppliers across the nation. The system, in the opinion of end users, is decreasing waste from expired pharmaceuticals and saving time and money spent monitoring and buying inventory.“ For instance, Norton Children's Hospital in Louisville, Kentucky, has reduced inventory costs for pricey and infrequently used coagulation factors by using an RFID-based consignment program.”

2. Pharmaceutical Inventory in Blood pharmacy

The management of blood inventories necessitates striking a delicate balance between assuring blood availability and minimizing wastage. Ideal inventory management can be understood by identifying and examining the numerous elements that cause waste.

For a hospital blood bank or transfusion service, the optimal decision rule's main application will be to determine minimum cost inventory levels for blood cell inventories. Because the demand for blood is increasing more quickly than the number of available donors,[14] it is crucial for both economic and social reasons that the blood supply is managed effectively. The blood models addressed two main problems: the expiration of blood products and their short shelf lives in comparison to reducing blood extension of some blood products' shelf lives as well as the ability to use synthetic blood products at a premium price. Blood banks are establishments that obtain, store, process, and distribute blood; they also efficiently maintain significant buffer supplies of the blood in the face of unpredictable fluctuations in supply and demand.[15]A realistic model of blood inventories is presented for both the individual and regional cases, and the impacts of several alternative inventory policies are examined. This analysis looks at the whole blood inventory problem at the level of the individual hospital as well as the regional level. In the blood recycling programs considered, the frequency of blood deliveries[16] had no discernible impact on the net amount of blood saved. In-depth discussion is provided on the deployment of an automatic blood recycling program, a workable and efficient strategy for lowering blood outdating in a multi-hospital regional blood system. There have been several methodological advancements in the fields of combinatorial optimization and inventory theory that utilize additional goods or systems.[17]

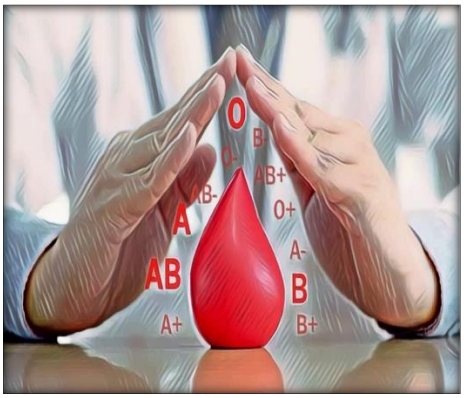

Figure No.2. Blood Transfusion

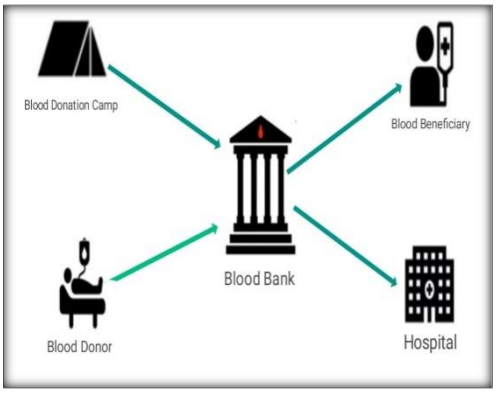

Figure No. 3. Blood Bank Management

The best target inventory levels should be determined by the blood bank administrator using a straightforward equation that takes into account the optimal inventory level,[18] daily demand level, transfusion to crossmatch ratio, crossmatch release period, and age of arriving units that determine the shortage and outdate rate. This rule suggests that if the blood bank administrator takes steps to limit the crossmatch release period and the average transfusion to crossmatch ratio, its application can result in a very low shortage rate and a reasonable low outdate rate. Several writers have created curves

that relate the acceptable whole blood/red blood cell[19] stocking levels and mean daily demand for different specified shortage rates. A simple inventory replenishment and allocation heuristic was developed to reduce the expected total cost in a discrete-time inventory system for a perishable product where demand exists for products of different ages. Blood platelets are an example of such a product. In addition to the traditional costs for inventory holding, outdating, and shortage, the model includes substitution costs incurred when a demand for a certain-aged item is satisfied by a different aged item[20] A second delivery later in the day gives a hospital the flexibility to respond to changes in demand. A standing order is an exact fixed order quantity, and a second delivery option represents the expediting option in the model. A standing order delivery in the morning reduces complexity and workload while ensuring blood supply[21] Platelets have a shelf life of 3 days ,and it has been demonstrated that an optimal inventory policy with dual replenishment methods exists. It also uses the terms Young, Mature, and Old to distinguish between products that expire after 3, 2, and 1 periods, respectively, and uses younger/youngest and fresher/freshest interchangeably with the terms age at the end of each period.The general rule is to keep enough inventory on hand to last 10–11 days of your typical daily need for red blood cells (RBCs) and 2 days of your typical daily need for platelets[22]

There is still a shortage of blood and other components in many Indian healthcare facilities. Nevertheless, this gap has been closing as a result of ongoing efforts by the government and other organizations. In contrast to the need of 12 million units, voluntary donations climbed from 54.4% in 2006–2007 to 83.1% in 2011–2012. By 2016, over 10.9 million units had been donated[23] 14 June is World Blood Donor Day.

3. Pharmaceutical Inventory in Drug pharmacy

An inventory is a comprehensive account of the resources that a company or institution owns, such as its supply of goods, medication, andAn inventory is a comprehensive account of the resources that a equipment. It is a technique for keeping medicine supplies at the lowest possible level in terms of stocking and purchasing costs. Close monitoring of key medications, prevention of theft, and giving priority to the procurement and delivery of medications are all essential components of good and efficient medical store management. By assuring the availability of necessary goods and avoiding stock-outs, an effective inventory control system would serve to maximize the utilization of resources and eventually aid to improve patient care.The physical qualities of the raw materials interact in a multivariate way, which can have a significant impact on the final medicine product's quality. The article provides a thorough explanation of the objective function that was employed and also details the outcomes of applying the strategy to the production of a pharmaceutical medication product in a commercial manufacturing environment.[24]

Figure No.4. Drug Inventry Management

Figure No. 5. Drug Inventory Software

Drugs stored in the pharmacy department[25] according to their cost and criticality to access the inventory of drugs at SKIMS. Since the medical shop[26] is one of the hospital's most frequently utilized facilities, it is crucial that the health managers apply scientific management and patient satisfaction techniques. The article offers a drug inventory control system that is completely integrated with the physician order-entry system, and the control system application enables faster and more effective real-time inventory operations.[27] The price and demand for these medications vary greatly depending on the population served and the quality of the provided medical treatment. Techniques for managing drug inventories that are efficient and based on science are required for effective delivery of healthcare.[28] The health managers apply scientific inventory control management to accomplish effective management and patient satisfaction as well as effective management of medical stores.[29] Drug inventory control is crucial for hospital administration and is crucial for the hospital pharmacy's ability to continuously deliver supportive services.[30] Drug inventory management is crucial since employing ABC and VED analysis has a negative impact on drug consumption rates and purchase costs. Inventory drug management in the healthcare sector, specifically in hospitals, plays an important part in achieving its ideal stage and development suggest improvements in the drug.[31] The Italian healthcare network evaluated the economic sustainability of logistics outsourcing and the data were collected using interviews, documentation, and observations in the hospital pharmacies and wards.[32] The fundamental formulas and calculation techniques used to determine the economic order quantity of pharmaceuticals at the reorder point are presented , along with an economic order quantity of the right time to reorder drugs to keep as an inventory control.When performing an inventory check, if you notice that your stock levels have fallen below the minimum, this is the time to place a new order for stock. This is true whether you manage a real pharmacy or an online one.[33]

4.Pharmaceutical Inventory Management in Hospital

The area of business management devoted to planning and controlling inventories is known as inventory management. The main goals of hospital inventory management and healthcare supply chain research are to increase the effectiveness and productivity of the healthcare system while lowering healthcare costs without compromising patient care quality.

The greatest possible treatment for patients is the main goal of the healthcare industry.[34] Overstock, inappropriate forecasting methods, and a lack of IT assistance have been recognized as the three main problems with current inventory management

practices. The overall inventory value of the oncology medications on hand can be reduced by 50% using the proposed (s,Q) policy's continuous review method. For intravenous fluids, an EOQ model is developed with the presumptions of stationary demand and no waste or shortfall costs.[35] suggests the necessity for a link between inventory systems and the complicated demand patterns in order to determine the best stock levels for medical supplies while taking into account storage space constraints, item criticality , and delivery frequency.[36] Retrospective data from January 2010 to December 2011 were gathere, the percentage of inspected items, the percentage of correctly delivered products, the percentage of destroyed or expired products, the percentage of reserved products, and the percentage of product shortages. By making improvements to the purchasing and inventory management system, the identified purchasing and inventory management issues were resolved.[37]

Facilities of Hospital Pharmacy: Adequate floor space for all pharmaceutical operations with proper electrification and ventilation, waiting area, office or administrative area, sufficient storage area for the drug proper condition of sanitation,(temperature, light, etc.) , Separate store for alcohol and methylated spirit , Refrigerators or cold room, Sterile product room, Manufacturing area, Bulk compounding room, Pre-packaging room, Allergenic product Lab. , Research Lab. , Labrary & filling equipment for Reference books and journals, etc.

Hospitals are intricate organizations that offer a wide range of services to patients, doctors, and staff. These services range from pharmacy to lab to surgery to dietary to linen to housekeeping to office management. Additionally, each area has distinct and frequently one-of-a-kind material and supply needs. The hospital's product line includes both expensive and inexpensive items, as well as durable goods that are used in both large and little quantities.[38] Managing the pharmacy at a hospital presents many difficulties. First, there are significant institutional and regulatory pressures on the pharmaceutical business. The regulatory pressures had an impact on forecasting demand accurately. Because it is so difficult to predict the patients' needs and drug consumption, hospitals operate very differently from other businesses. Third, hospital pharmacies typically keep a lot of safety stock to meet with erratic demand, which results in high operational costs and requires them to deal with issues related to drug expiration.[39]

5. Pharmaceutical Inventory Control Techniques for pharmacy

All of the medications in the hospital's inventory underwent an ABC cost analysis, and the annual drug costs of each medication were arranged in descending order. Both the cumulative percentage of the spending and the cumulative percentage of the number of items were calculated. On the basis of the cumulative cost percentage, the list was then separated into three categories. Approximately % of pharmaceuticals consumed 70% of ADE, 20% of drugs consumed about 20% of ADE, and the remaining 70% of drugs consumed 10% of ADE, forming categories A, B, and C, respectively. As a result, cutoffs were close to 10/20/70 but slightly off. The hospital inventory and drug expenditure by inventory control techniques and include ABC and VED analysis are studied.[40] In the article introduced the annual hospitals budget is spent on buying materials and supplies, including medicines. They bring about substantial improvement in the hospital inventory and expenditures by the inventory control techniques.[41] The

limitation of ABC analysis that it is based only on monetary value and cost of consumption of items and some items of low monetary value are vital or lifesaving are analyzed. The importance cannot be overlooked because they are not in category A. Their criticality according to VED analysis is an additional evaluation factor. The ABC-VED matrix, which combines ABC and VED analysis, can be effectively used to develop a meaningful control over the material supplies. V stands for vital items, without which a hospital cannot function, E for essential items, without which a hospital can function but may affect the quality of the services, and "D" stands for desirable items, whose absence will not interfere with functioning.[42] It was suggested to do an ABC and VED analysis of the pharmacy store at the Post Graduate Institute of Medical Education and Research in Chandigarh, India, to determine which types of products required strict managerial oversight The inventory control techniques and the ABC and VED techniques need to be adopted as a regular practice for optimal resource use and the elimination of out-of-stock situations in the hospital pharmacy.[43] The annual consumption and expenditure incurred on each pharmacy item for the year 2007–2008 was analysed. A hospital's materials manager must design effective inventory system guidelines for daily operations that also guarantee the hospital's capacity to handle unforeseen demand situations.[44] ABC inventory categorization with multiple-criteria employing weighted linear optimization.[45] It has been suggested that an inventory EOQ in conjunction with ABC would be useful and efficient.[46] The low value products (B and C items), which were being bought far too frequently, accounted for the majority of the savings with the ABC-EOQ, according to reports.[47] A hospital has improved the management of its medical supply inventory in the surgical department.[48] Holt's model, which uses trend-corrected exponential smoothing, is offered as the demand forecasting model for the inventory of medical supplies. Using the ABC-VED inventory control approaches, the annual medication expenditure is introduced at the medical stores in a Tertiary care hospital.[49] The CGHS revealed that 172 items (58.1%) were categorized as important, 109 items (36.8%) were regarded desirable, and 15 items (5.1%) were found to be vital. The lack of the critical pharmaceuticals, even for a brief time, can have major consequences for patient care. If there is a prolonged shortage of desirable drugs, such as vitamins, it won't negatively impact patient care or hospital operations. However, if there is a temporary shortage of necessary drugs, such as antibiotics, the hospital's ability to function may suffer.[50] With a total of 600 beds, Tikur Anbessa Hospital is Ethiopia's largest general specialty referral hospital. It also functions as a teaching hospital, offering pre- and in-service training in a variety of disciplines and specialties. The majority of Patients get a prescription that includes one or more medications. This shows that the hospital pharmacy needs to be properly organized in order to manage medications efficiently and effectively.[51] To undertake an economic analysis of the Government Medical College Hospital's drug spending and to determine which drug categories require strict management oversight .To determine which pharmaceuticals need more managerial oversight, a matrix based on the coupling of cost (ABC) analysis and vital/essential/desirable (VED) criticality analysis was developed. It was discovered that there was a disparity between actual spending and spending determined from the inflation component. Regression analysis using NCSS software was used to forecast expenses for upcoming years.[52] The evaluation of various inventory management

strategies and the development of a multi-criteria inventory categorization approach that takes into consideration the criticality, cost, and utilization value of the products are done using a system dynamics model of a hospital logistics system. They assessed the cost of inventory management for items based on the urgency of the need, service level assignments, and consumption rates. They also provided guidelines for the health professionals and decision-makers on how to minimize the cost of inventory management by classifying the items according to their urgency.[53] ABC, VED, and ABC-VED matrix analysis were used to investigate the medication expenditure at the health center. The annual drug expenditure is created at a Rural Health Centre utilizing inventory control procedures.[54]

6.Pharmaceutical Inventory Management in Perishable products

Perishable stock typically refers to food inventories. Meat, dairy products, and produce are a few examples of perishable inventory. However, in addition to food, other goods that can spoil are sometimes referred to as perishable stock. There are two sections to the perishable goods. These products are both time-dependent and time-independent. Green vegetables, fruits, milk, bread, flowers, meat, Christmas trees, greeting cards, and more are examples of time-dependent perishable goods since they have a limited shelf life. Fashion items, such as clothing, mobile phones, laptops, and other items, are examples of time-independent perishable products since they were beneficial to customers for a long time but have a low economic worth.

Several million people receive highly sophisticated medical care from a large-scale, national healthcare system of the supply chain that consists of several hundred medical companies (hospitals, clinics, pharmacies, etc.). These medicinal products in the system are perishable, which means that beyond a specific expiration date, they are no longer usable. The models created combine aspects of outsourcing and perishability under deterministic demand for medical supplies, which includes both perishable and deteriorating commodities. They reflect a multi-echelon, multi-supplier inventory system. Pharmaceutical costs are rising for hospital systems around the country. The development of an inpatient hospital pharmacy's inventory model and ordering procedures for perishable medications included two stages of inventory: raw materials and completed goods (like intravenous).[55] The article introduces a two-phased approach to examine potential hospital pharmacy policy structures and develop a policy that is based on the notion that hospitals can reduce costs and better meet patient demand by using patient mix knowledge to direct their drug preparation and inventory decisions. Over the previous ten years, drug shortages have tripled since 2006.The development of inventory rules is difficult for pharmacy material managers because of shifting consumer demand, a lack of suppliers, and supply-related laws.[56] In the paper, the stochastic 'demand state' proposed as a stand-in for patient condition and developed a Markov decision method to choose the best, state-dependent two-stage inventory and production policies.[57]

Medical inventory management presents unique issues because it is extremely sensitive to storage conditions (temperature, humidity, etc.) and service quality. To address issues with blood bank inventory control, early perishable medical inventory models were created.[58] Since then, numerous models have been created to handle medical inventory management issues that are extremely important from a social and economic standpoint.[59]

Conclusion

We have presented a current survey of the literature on pharmaceutical inventory models in this post. Inventory control can make it simple and efficient, cut down on time spent managing materials, and significantly lower the rate of counterfeit pharmaceutical items. For a pharmacy, maintaining an inventory has two basic objectives. The items that are routinely stocked depend on the requirements of the pharmacy and its clients. While some rarely used, excessively expensive, or burdensome pharmaceuticals may be ordered in as needed, efforts should be made to keep the medications used often in stock and readily available for usage that are not obsolete or damaged. Cost-effective pharmaceutical management is the second objective of inventory control. To lower the price of buying pharmaceuticals, many pharmacies have preferred wholesalers from which to place orders or have pricing agreements with particular pharmaceutical companies. Controlling the cost of medications also involves avoiding profit loss. Medication costs can be reduced by properly maintaining stock, utilizing prescriptions before they expire, and processing returns on a regular basis.

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