



ENHANCING HEALTHCARE INVENTORY MANAGEMENT EFFICIENCY USING
AI AND ML IN KANBAN AND NON-KANBAN SYSTEMS

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Abstract

In the healthcare industry, medical supplies availability is critical for patient care. The Kanban inventory system is a famous methodology implemented in supply chain inventory replenishment which is being implemented in several large and medium-scale healthcare facilities where there is a high-volume and low-cost material involved. For the perioperative (perioP) process, the material involved can be high cost and low volume which can be difficult to store with Kanban methodology (while some can be stored with Kanban still). Even though the two bin Kanban system has been proven to be very efficient in replenishment of the orders for healthcare facilities, there are issues with managing this system that makes the replenishment sometimes costly and inefficient for healthcare. Using machine learning (ML) and artificial intelligence (AI) techniques, the inventory management and replenishment process can be analyzed frequently to identify gaps and auto correct issues using data driven insights. This paper discusses the processes, issues and resolutions using artificial intelligence (AI) monitoring.

Keywords: Healthcare inventory, inventory management, Machine learning, Artificial Intelligence, Kanban system, healthcare supply chain.

I. INTRODUCTION

Health systems optimization is a key term used post COVID-19 to identify the systems and processes that take a high share of healthcare cost. [3] The replenishment model of medical supplies in all general and specialized units of a hospital can be classified as a special context for supply chain compared to the general supply chain scenarios, as the purpose of healthcare inventory is to provide care for patients. The absence of these supplies can cause dire consequences in the care of patients. With this kind of sensitivity, nurses can tend to keep a surplus of items on hand, which can lead to challenges like surplus inventory, expired products, lengthened search time for products, and additional space requirements. The result of all these can jeopardize patient safety. [1] According to the survey conducted by the Health Catalyst organization, supply chain costs are around 30% of the overall cost of healthcare for hospitals. [8] The procurement, processing, and use of sterile surgical inventory is a major component of the perioperative care budget which accounts up to 30% of the perioperative cost in North America and has been recognized as an area of operational inefficiency.



II. INVENTORY MANAGEMENT SYSTEM IN HEALTHCARE

Inventory management is one of the systems that requires consistent innovation and optimization to make the healthcare industry more affordable to patients. Healthcare professionals who are trained in healthcare do not have any inventory management expertise. However, they order supplies so they will have what they need when they need it. In a manual inventory system, healthcare professionals make a manual list with product descriptions and try to order with their electronic ordering system, which can lead to mistakes, over-ordering, duplicate orders, and excessive time spent on ordering supplies. This leads to them spending less time with patients, and these tasks are not related to the healthcare professionals' jobs.

A majority of the inventory is perpetual and periodic inventory. Perpetual inventory is the inventory at the wards where the inventory is updated when used for a patient. Periodic inventory is when supplies are replenished in batches and accounted for when the orders are picked from a central warehouse, and replenishment decisions are based on the predefined, scheduled inventory counting.

To fulfill the above inventory needs, there were several methods used in the healthcare industry like requisition, exchange cart, Par level and two-bin. Each has their own advantages and disadvantages. The goal of improving the inventory management process is to decrease the disruptions for nursing staff while caring for patients.

Supply needs can be classified as two broad categories: high volume, low cost items that need small storage space, and low-volume, high-cost items that require more storage space. Through all the research and implementation results in several healthcare organizations, the two-bin Kanban system is proven to be efficient for smaller space items. For the second category which requires high storage space and high cost and less volume two-bin Kanban system is not an efficient model. Hence hospitals try different methods of handling inventory replenishments for both categories.

III. TWO BIN KANBAN INVENTORY SYSTEM

The two-bin Kanban system, widely adopted in healthcare in the past decade, [2] uses periodic reviews to trigger replenishment. The secret sauce for Kanban is visual indicator, the ability to replenish open space available with correct product, right quantity and being able to rotate the inventory as needed. When bins are fully loaded with inventory and the items are being used, the empty bins placed on top shelves for prompt restocking, while full bins are pulled forward for use. If the system is not using bins, there is a visual indicator that is used to indicate the reorder level. The system makes supplies well organized, products are transparent, and labelled for scanners to reorder when the bin is empty. The bin item quantities are set based on the usage and lead-time of delivery from the supplier. [4] Lanza-Leon et al conducted an extensive literature review on the papers presented on the two-bin Kanban system in healthcare facilities. Their search resulted in 262 papers related to inventory management in healthcare facilities. After filtering on the relevance of the papers to the subject, they eliminated 242 papers and they



summarized the study of the 20 papers relevant to Kanban system. Most of the authors' evaluations of the Kanban system resulted in positive improvement of reduction in cost, fewer replenishment cycles, and decrease in expiry of supplies. The Kanban system reduces stock issues and allows healthcare staff to focus on patient care. Some healthcare organizations in the United States expanded their system to include 4 bins while waiting for the two bins to empty for replenishment. [5] Inventory levels are accurately calculated based on barcodes, and the Kanban quantity is calculated based on the usage of product in the healthcare facility.

1. Non-Kanban inventory system

There are several items in healthcare facilities that cannot be stored using a two-bin Kanban system that requires an efficient way to manage the inventory replenishment process. One example of this is the inventory required in the perioperative (PeriOp) setting. In operating rooms, the doctors schedule a patient procedure list the inventory that needs to be used. Some items are so critical that they may be used in a procedure in the near future, but the par level and max levels can be between 1 and 2, storing these with Kanban system can be inefficient and may expire without being noticed by the healthcare professionals. This is a real challenge in across all healthcare organizations.

2. Issues with Kanban and Non-Kanban Inventory system

The study conducted by most of the authors of the Kanban system found employees with lack of knowledge of how to use the system. Other fears noted are that the Kanban system implementation may lead to lack of inventory supplies. A majority of the issues identified are related to staff usage of the system, such as miscoding the optimum levels and max levels of inventory. The issues identified with the non-Kanban system are nursing staff not being able to scan the right item for patient care, which led to wrong reorder levels and duplication of inventory.

IV. MACHINE LEARNING (ML) ALGORITHMS THAT UNDERSTANDS THE GAPS

[7] Many machine learning techniques can be applied to supply chain and inventory systems. One widely used technique is artificial neural networks (ANN), which can be used to find data patterns and insights from a large volume of data processing. With technology advancements, healthcare systems can utilize machine learning algorithms to gather large volumes of data, process the data, and learn the utilization patterns. ML algorithms analyze Kanban and non-Kanban items, identifying issues like premature reorders or data inconsistencies. ML algorithms learn and remember each inventory item for a certain hospital location and track the orders and the quantity of items on hand. The system is configured by the software to set the optimum quantity and maximum quantity levels for each product. Machine learning algorithms:

- a) Learns usage patterns of the items in several procedures.
- b) Identifies reordered line items are set as Kanban or not.
- c) Employees are scanning partially emptied bins for reorder.
- d) Employees scan and override the required order quantity instead of using the system suggested reorder quantity.



Even with non-Kanban inventory, the data volumes are processed through the ML algorithms and remember the materials used in the procedures based on the historical usage. When the reorder was triggered the ordered quantity is verified with on hand quantity and the order is confirmed to avoid over stock.

V. ARTIFICIAL INTELLIGENCE SYSTEM

[6][7] AI improves inventory management by enabling faster, more accurate problem-solving through tools like agent-based systems and predictive algorithms. AI solution help supply chain leadership to understand the potential disruptions with inventory and provide an optimum solution by taking an appropriate action based on the intelligence. This helps the clinical team and inventory leadership work hand in hand in healthcare and provide better patient care. The analysis provides the below advice:

- a) Which healthcare facility has consistent order stock or understock issues
- b) Is Kanban system set up properly for Par levels
- c) % of Bins set up for errors
- d) Order efficiency percentage
- e) Employees that needs training on how to use the system.

1. Advantages of using ML and AI in the inventory management

There are several benefits of implementing AI technologies in the inventory system to generate future demand and optimize the inventory levels through automation, few of those are discussed below.

2. Suggested Min and Max levels

AI use historical inventory levels on each item, learns the usage of the products by the type of care and suggests the optimum quantity and maximum quantity. This prediction is used as an input for reorders through an automated engine.

3. Inventory Ordering with preprogrammed handheld scanners

The innovative technological advancement used in the healthcare facilities is to use the handheld scanners which are preprogrammed with AI suggested par levels for each product. Once the barcode is scanned a replenishment order is triggered and submitted.

4. Forecast substitute items for back orders

AI engine constantly runs through the inventory, upcoming procedures schedules, items on hand quantity, where the item is backordered, AI suggests an alternative source of replenishing the product to meet the procedure timelines.



5. Anomaly detection

The goal of using AI is to understand the abnormality in the replenishment process, identify the data anomalies using ML algorithms, and generate the alerts to notify the inventory managers of the potential over ordering or under the limit orders.

6. Cost reduction

Implementation of AI on the inventory management systems improves overall healthcare system, making it more affordable for patients by reducing the cost of the inventory, providing healthcare professionals the timely inventory needed for patient care, reducing the waste in the medical supplies.

VI. CONCLUSION

Healthcare institutions operate with different kinds of supplies for patient care and they would like to have the surplus amount of supplies on hand, whereas the supply chain organization tries to reduce the cost. Both the departments strive for better patient care, there is a necessity for continuous innovation and review of the process and tools used. AI in inventory management helps reduce cost, improve efficiency of replenishment. With Kanban inventory or non-Kanban inventory applying AI and handled scanners and automation helps drive efficiency. AI suggests optimal level of inventory, helps finding an alternative source of replenishment in the event of backlogs. While the modern healthcare system needs AI in every area of care, inventory management plays a major area of healthcare systems that requires AI support.

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